CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY

FINAL
INTEGRATED FEASIBILITY REPORT AND PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

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U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

SOUTH FLORIDA WATER
MANAGEMENT DISTRICT

APRIL 1999

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Responsible Agencies: The responsible lead agency is the U.S. Army Corps of Engineers, Jacksonville District. The responsible cooperating agencies are the South Florida Water Management District, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, the National Park Service, the Florida Game and Fresh Water Fish Commission, the U.S. Geological Survey, the Natural Resources Conservation Service, and the Florida Department of Environmental Protection.

Abstract: The south Florida ecosystem is a nationally and internationally unique and important natural resource. It is also a resource in peril, having been severely impacted by human activities for over a hundred years. This report recommends a comprehensive plan for the restoration, protection, and preservation of the water resources of central and southern Florida, including the Everglades. This is a final integrated feasibility report and Programmatic Environmental Impact Statement, which identifies and discusses the plan's proposed project features, its beneficial effects and potential impacts on existing resources. The recommended Comprehensive Plan contains over sixty project features. Principal features of the plan are the creation of approximately 217,000 acres of new reservoirs and wetlands based water treatment areas. These features vastly increase storage and water supply for the natural system, as well as for urban and agricultural needs, while maintaining current Central and Southern Florida Project purposes. The recommended Comprehensive Plan achieves the restoration of more natural flows of water, including sheetflow, improved water quality, and more natural hydroperiods in the south Florida ecosystem. Improvements to native flora and fauna, including threatened and endangered species, will occur as a result of the restoration of hydrologic conditions.

THE OFFICIAL CLOSING DATE FOR THE RECEIPT OF COMMENTS IS 30 DAYS FROM THE DATE ON WHICH THE NOTICE OF AVAILABILITY OF THIS FINAL PROGRAMATIC EIS APPEARS IN THE FEDERAL REGISTER.

If you require further information on this document, contact:

Mr. Russell Reed
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019
Telephone: (904) 232-3967

NOTE: This report includes an integrated Programmatic Environmental Impact Statement (PEIS) within the final feasibility report; sections required for compliance with the National Environmental Policy Act (NEPA) are noted by an asterisk in the Table of Contents.

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SUMMARY

The recommended Comprehensive Plan contained within this report will, when implemented, restore, protect, and preserve a natural resource treasure – the south Florida ecosystem. The greater Everglades ecosystem is nationally significant and unique in the world. If actions are not taken now, irretrievable loss of this extraordinary resource will occur. The Comprehensive Plan affords the opportunity to reverse the course of declining ecosystem health and leave an Everglades legacy for generations to come.

The Central and Southern Florida (C&SF) Project, first authorized by Congress in 1948, is a multi-purpose project that provides flood control, water supply for municipal, industrial, and agricultural uses, prevention of saltwater intrusion, water supply for Everglades National Park, and protection of fish and wildlife resources. The primary system includes about 1,000 miles each of levees and canals, 150 water control structures, and 16 major pump stations.

The C&SF Project Comprehensive Review Study, known as the Restudy, is authorized by Section 309(l) of the Water Resources Development Act of 1992 (P.L.102-580). This study is also authorized by two resolutions of the Committee on Transportation and Infrastructure, United States House of Representatives, dated September 24, 1992. Section 528 of the Water Resources Development Act of 1996 provides specific direction and guidance for the Restudy.

The purpose of this study was to reexamine the C&SF Project to determine the feasibility of modifying the project to restore the south Florida ecosystem and to provide for the other water-related needs of the region. Specifically, as required by the authorizing legislation, the study investigated making structural or operational modifications to the C&SF Project for improving the quality of the environment; protecting water quality in the south Florida ecosystem; improving protection of the aquifer; improving the integrity, capability, and conservation of urban and agricultural water supplies; and improving other water-related purposes.

The following principles guided the development of the recommended Comprehensive Plan:

- The overarching objective of the Comprehensive Plan is the restoration, preservation and protection of the south Florida ecosystem while providing for other water related needs of the region;
- The Comprehensive Plan will be based on the best available science, and independent scientific review will be an integral part of its development and implementation;
- The Comprehensive Plan will be developed through an inclusive and open process that engages all stakeholders;
- All applicable Federal, tribal, state, and local agencies will be full partners and their views will be considered fully; and
- The Comprehensive Plan must be a flexible plan that is based on the concept of adaptive assessment – recognizing that modifications will be made in the future based on new information.

Although this document meets the requirements of Section 404 (r) of the Clean Water Act (Public Law 92-500, as amended), as addressed in Annex C, the Corps will request a Section 401 State water quality certificate during subsequent phases of this project.

The final integrated feasibility report and Programmatic Environmental Impact Statement is being transmitted through the Division Engineer and the Washington-level Federal report review process, which will include reviews by the Chief of Engineers and the Secretary of the Army. The Assistant Secretary of the Army for Civil Works, representing the Secretary of the Army, will coordinate the documents with the Office of Management and Budget, and send them to Congress. The study authority states that the Secretary shall transmit the Comprehensive Plan to Congress not later than July 1, 1999.

MAJOR CONCLUSIONS

The Everglades has molded the regional character of central and southern Florida and sustains the economic and cultural growth of the region. The Everglades has influenced the regional mosaics of space and landscape patterns - urban, agricultural and natural. As such, it epitomizes the region's sense of definition and place. As importantly, the Everglades is unlike any other place in the world.

The remaining Everglades and other natural ecosystems in south Florida no longer exhibit the functions, richness, and spatial extent that defined the pre-drainage systems. There have been substantial and irreversible reductions in the spatial extent of the wetland systems (including an approximately 50 percent reduction in the extent of the true Everglades) and in the total water storage, timing, and flow capacities of these systems. These natural systems will not recover their defining characteristics under current conditions and will not be sustained into the future. Indeed, the health of the ecosystem will continue to decline unless corrective actions are taken. For example, wading birds, whose numbers have already decreased by 85-90 percent, are key indicators of broad, regional patterns of aquatic production. There is a continuing reduction in the total number of birds initiating breeding in south Florida. Fisheries, including economically important recreational and commercial species, continue to decline steadily in many areas of south Florida, affecting the natural and the human environment.

Several of the major unintended impacts to the natural system attributed to the C&SF Project in south Florida include the following:

- extreme fluctuations in high and low water levels in Lake Okeechobee have a major adverse impact on the lake's littoral and pelagic zones and fish and wildlife habitats;
- extreme fluctuations between too much and too little freshwater discharge into the Caloosahatchee and St. Lucie estuaries result in detrimental salinity conditions and physical alterations of fish and wildlife habitat;
- detrimental hydrologic conditions in freshwater wetland habitats cause major adverse impacts on plant and animal communities of the native Everglades; and
- unsuitable freshwater flows to Florida and Biscayne bays and Lake Worth Lagoon adversely impact salinity and physically alter fish and wildlife habitat.

Water quality throughout south Florida has also deteriorated over the past 50 years since construction started on the C&SF Project. Many wetlands that acted as natural filters and retention areas either can no longer serve these purposes or have been lost to drainage or development. Urban and agricultural development and drainage systems result in the rapid discharge of runoff containing pollutants into south Florida's water bodies. As a result, many water bodies throughout south Florida presently do not meet water quality standards. Untreated urban and agricultural storm water that does not meet water quality standards is sometimes sent to natural areas. Excessive nutrients entering the Everglades have led to an overabundance of cattails, a visible sign of unfavorable water quality conditions and a potential decline in ecological productivity. Flood control releases from Lake Okeechobee and runoff discharged via secondary drainage canals in the St. Lucie River Basin have been linked to fish lesions and a decline in estuarine productivity, resulting in substantial ecological and economic impacts.

Adequately and reliably meeting water supply for all sectors is also a problem. Historically, most rainwater soaked into the ground in the region's vast wetlands. As south Florida developed, the canal network worked too effectively and drained too much water off the land too quickly. The result is that not enough water is stored for all uses. Water shortages that occur today are expected to become more frequent without any changes to the water management system. Without the steps outlined in this Comprehensive Plan, conflicts over the allocation of water needed for natural, agricultural, and urban areas will only increase.

Flooding is also a problem. Florida is a low-lying, flat, and wet state. Today, the Project provides flood protection on a regional basis for south Florida, supported by many locally operated canal networks. The Comprehensive Plan will maintain, and in some situations improve, this important protection from flooding.

Altogether, these problems seriously threaten the natural and human environment of the south Florida ecosystem.

What Is Expected to Happen Without the Recommended Comprehensive Plan

Although some level of ecological improvement will occur in the south Florida ecosystem as a result of implementation of projects currently planned outside of the Restudy, the cumulative, regional benefits from these projects would not result in a sustainable south Florida ecosystem. Specifically, based on an evaluation of conditions in the year 2050 without the recommended Comprehensive Plan, it was determined that the overall health of the ecosystem will have substantially deteriorated. This type of assessment was carried out for all planning alternatives evaluated during the course of the Restudy. The analyses show that making modifications to only some portions of the C&SF Project in order to achieve sustainable natural systems will not succeed. Conditions predicted in 2050 fail to meet the basic needs of the south Florida ecosystem.

Demands placed on Lake Okeechobee result in damaging water levels and extreme harm to the littoral zone. Damaging fresh water discharges into the Caloosahatchee and St. Lucie estuaries result in major harm to fisheries. Damaging high flows alter salinity balances in Lake Worth Lagoon. Hydropatterns predicted for the Water Conservation Areas are harmful to tree islands. Everglades National Park does not receive enough freshwater flow to maintain important aquatic habitat in Shark River Slough. Low flows to Florida and Biscayne bays also result in harm to the resources in these areas. These ecological problems would not be corrected solely by implementation of currently planned or ongoing projects.

Relatively greater levels of improvement were identified for water quality conditions in the future compared to existing conditions in south Florida. It is expected that state, tribal, regional, and local programs to improve water quality will be implemented to varying degrees throughout the study area during the next 50 years. Ongoing restoration projects in the Kissimmee River watershed are expected to beneficially affect water quality. Current efforts to reduce inputs of excessive nutrients into the Everglades through the Everglades Construction Project should substantially slow the spread of cattails and other plants with high nutrient tolerances and result in a slow recovery of natural vegetation patterns in some nutrient-stressed parts of the system. Proposed modifications to the Lake Okeechobee regulation schedule and water quality improvement projects suggested by the South Florida Ecosystem Restoration Working Group's Lake Okeechobee, St. Lucie, and Caloosahatchee Issue Teams should improve water quality conditions in those water bodies. Nonetheless, the future without plan condition, while resulting in water quality improvements over existing conditions in certain subregions of the Restudy area, was still determined by the Restudy's water quality team to be unacceptable for sustainable ecosystems.

The future demand for suitable water is expected to exceed the limits of readily available sources. Predictions of water restrictions in the future indicate serious – and probably unacceptable – levels of water supply cutbacks. Modeling of the future "without plan" condition shows that for the Lake Okeechobee Service Area, 24 percent of water supply demands could not be met over a 30-year period. This translates into water supply restrictions every other year. In the Lower East Coast, water restrictions would be expected to occur every other year in Palm Beach, Miami-Dade, and the Florida Keys portion of Monroe County. In Broward County water restrictions would occur on nearly an annual basis. The ability to sustain the region's natural resources, economy, and quality of life depends, to a great extent, on the success of the efforts to enhance, protect, and better manage the region's water resources.

A major advantage of the Comprehensive Review Study is that it has used tools and methods to evaluate the entire C&SF Project area together as an integrated system. Thus, the effects of making modifications in one area on another area were able to be seen and then used to develop a plan that maximized positive system-wide benefits. The South Florida Water Management Model is the tool that demonstrates the hydrologic effects of changes in one region on other regions. The Restudy Team developed measures to evaluate an alternative plan's effect on the entire C&SF Project area. The use of system-wide tools and a science-based analytical approach supports the conclusion, as shown in the following table, that the future without plan condition is not favorable - nor is it sustainable - for the south Florida ecosystem.

PERFORMANCE OF THE COMPREHENSIVE PLAN COMPARED TO THE NO-ACTION ALTERNATIVE

Area	Future Without Plan	Future With Plan
Lake Okeechobee	Y	G
Caloosahatchee Estuary	R	G
St Lucie Estuary	R	G
Lake Worth Lagoon	Y	Y
Holey Land & Rotenberger WMA	Y	G
Loxahatchee National Wildlife Refuge	Y	G
Water Conservation Area 2A		G/Y
Water Conservation Area 2B		R
Northwestern Water Conservation Area 3A		G
Northeastern Water Conservation Area 3A	R	Y
Eastern Water Conservation Area 3A		Y
Central & Southern Water Conservation Area 3A		G/Y
Water Conservation Area 3B		Y
Everglades National Park – Shark River Slough	R	G
Everglades National Park – Rockland Marl Marsh	R	Y
Florida Bay	R	G
Biscayne Bay	Y	G
Model Lands	R	G
Big Cypress National Preserve	Y	G
Lake Okeechobee Service Area	R	G
Urban Lower East Coast	R	G

Green (G) - predicted hydrologic performance will result in recovery and long-term sustainability of ecological or water supply objectives.

Yellow (Y) -marginal or uncertain ability to achieve long-term sustainability of ecological or water supply objectives.

Red (R) -ecological or water supply objectives will not be met.

How the Restudy Team Developed the Recommended Comprehensive Plan

A multi-agency, multidisciplinary team was created to develop plans that addressed the problems within the study area. This team included biologists, ecologists, economists, engineers, geographic information system specialists, hydrologists, planners, public involvement specialists, and real estate specialists from a number of Federal, state, tribal, and local government agencies.

Between September 1997 and June 1998, alternative comprehensive plans were formulated and evaluated. Beginning with a "Starting Point" alternative and continuing until the recommended plan was chosen, each iterative formulation and evaluation cycle built upon the strengths of the previous alternative plan while addressing its shortfalls. The Alternative Evaluation Team, a subgroup of the Restudy Team, evaluated each alternative based on modeling results and comments received from the entire team as well as the general public. The Alternative Development Team, another Restudy subgroup, then used that evaluation to design a better alternative. All modeling results and evaluations were posted on the Restudy web site for the team and general public to review.

Because of its fundamental importance to restoration, much of the emphasis early in the plan formulation process was on increasing regional storage capacity and increasing water management flexibility to meet water quantity objectives. Later iterations addressed the restoration objectives of greater system connectivity (decompartmentalization) and sheetflow. Throughout the formulation and evaluation period, many different decompartmentalization scenarios were modeled. These scenarios gave the team feedback on how the system responded under different conditions. This knowledge was valuable in the effort to improve conditions in the remaining Everglades in the final alternative, which became the basis of the recommended Comprehensive Plan.

The Restudy Team recognized that water quality standards were not being met in many water bodies in the study area. The team recognized the changes in flow patterns, even though beneficial hydrologically, might adversely affect water quality conditions in downstream water bodies. To address this problem, several water quality treatment facilities were included in the recommended Comprehensive Plan to ensure water quality standards would be met. Future implementation of the features of the Comprehensive Plan, including detailed planning and design, will take into account water quality restoration targets as they are developed for specific water bodies in south Florida.

Major Features of the Recommended Comprehensive Plan

The Restudy Team formulated and evaluated 10 alternative comprehensive plans and more than 25 intermediate computer simulations. Alternative D-13R was selected as the Initial Draft Plan. Alternative D-13R along with the series of Other Project Elements, Critical Projects, water quality treatment facilities, and other modifications that further improve performance of the plan, comprise the recommended Comprehensive Plan. The estimated first cost of the recommended Comprehensive Plan is $7.8 billion; and the annual operation and maintenance costs, including adaptive assessment and monitoring, are $182 million. The plan includes the following structural and operational changes to the existing C&SF Project:

Surface Water Storage Reservoirs. A number of water storage facilities are planned north of Lake Okeechobee, in the Caloosahatchee and St. Lucie basins, in the Everglades Agricultural Area, and in the Water Preserve Areas of Palm Beach, Broward and Miami-Dade counties. These areas will encompass approximately 181,300 acres and will have the capacity to store 1.5 million acre-feet of water.

Water Preserve Areas. Multipurpose water management areas are planned in Palm Beach, Broward and Miami-Dade counties between the urban areas and the eastern Everglades. The Water Preserve Areas will have the ability to treat urban runoff, store water, reduce seepage, and improve existing wetland areas.

Manage Lake Okeechobee as an Ecological Resource. Lake Okeechobee is currently managed for many, often conflicting, uses. The lake's regulation schedule will be modified and plan features constructed to reduce the extreme high and low levels that damage the lake and its shoreline. Management of intermediate water levels will be improved, while allowing the lake to continue to serve as an important source for water supply. Several plan components and Other Project Elements are included to improve water quality conditions in the lake. A study is recommended to evaluate in detail the dredging of nutrient-enriched lake sediments to help achieve water quality restoration targets, important not only for the lake, but also for downstream receiving bodies.

Improve Water Deliveries to Estuaries. Excess stormwater that is discharged to the ocean and the gulf through the Caloosahatchee and St. Lucie rivers is very damaging to their respective estuaries. The recommended Comprehensive Plan will greatly reduce these discharges by storing excess runoff in surface and underground water storage areas. During times of low rainfall, the stored water can be used to augment flow to the estuaries. Damaging high flows will also be reduced to the Lake Worth Lagoon.

Underground Water Storage. Wells and associated infrastructure will be built to store water in the upper Floridan aquifer. As much as 1.6 billion gallons a day may be pumped down the wells into underground storage zones. The injected fresh water, which does not mix with the saline aquifer water, is stored in a "bubble" and can be pumped out during dry periods. This approach, known as aquifer storage and recovery, has been used for years on a smaller scale to augment municipal water supplies. Since water does not evaporate when stored underground and less land is required for storage, aquifer storage and recovery has some advantages over surface storage. The recommended Comprehensive Plan includes aquifer storage and recovery wells around Lake Okeechobee, in the Water Preserve Areas, and the Caloosahatchee Basin.

Treatment Wetlands. Approximately 35,600 acres of manmade wetlands, known as stormwater treatment areas, will be built to treat urban and agricultural runoff water before it is discharged to the natural areas throughout the system. Stormwater treatment areas are included in the recommended Comprehensive Plan for basins draining to Lake Okeechobee, the Caloosahatchee River Basin, the St. Lucie Estuary Basin, the Everglades, and the Lower East Coast. These are in addition to the over 44,000 acres of stormwater treatment areas already being constructed pursuant to the Everglades Forever Act to treat water discharged from the Everglades Agricultural Area.

Improve Water Deliveries to the Everglades. The volume, timing, and quality of water delivered to the south Florida ecosystem will be greatly improved. The Comprehensive Plan will deliver an average of 26 percent more water into

Northeast Shark River Slough over current conditions. This translates into nearly a half million acre-feet of additional water reaching the slough, and is especially critical in the dry season. More natural refinements will be made to the rainfall-driven operational plan to enhance the timing of water sent to the Water Conservation Areas, Everglades National Park, and the Holey Land and Rotenberger Wildlife Management Areas.

Remove Barriers to Sheetflow. More than 240 miles of project canals and internal levees within the Everglades will be removed to reestablish the natural sheetflow of water through the Everglades. Most of the Miami Canal in Water Conservation Area 3 will be removed and 20 miles of the Tamiami Trail (U.S. Route 41) will be rebuilt with bridges and culverts, allowing water to flow more naturally into Everglades National Park, as it once did. In the Big Cypress National Preserve, a north-south levee will be removed to restore more natural overland water flow.

Store Water in Existing Quarries. Two limestone quarries in northern Miami-Dade County will be converted to water storage reservoirs to supply Florida Bay, the Everglades, Biscayne Bay, and Miami-Dade County residents with water. The 11,000-acre area will be ringed with an seepage barriers to ensure that stored water does not leak or adjacent groundwater does not seep into the area. A similar facility will be constructed in northern Palm Beach County.

Reuse Wastewater. The recommended Comprehensive Plan includes two advanced wastewater treatment plants in Miami-Dade County capable of making more than 220 million gallons a day of the county's treated wastewater clean enough to discharge into wetlands along Biscayne Bay and for recharging the Biscayne Aquifer. This reuse of water will improve water supplies to south Miami-Dade County as well as reducing seepage from the Northeast Shark River Slough area of the Everglades. Given the high cost associated with using reuse to meet the ecological goals and objectives for Biscayne Bay, other potential sources of water to provide freshwater flows to the central and southern bay will be investigated before pursuing reuse.

Pilot Projects. A number of technologies proposed in the Comprehensive Plan have uncertainties associated with them -- either in the technology itself, its application, or in the scale of implementation. While none of the proposed technologies are untested, what is not known is whether actual performance will measure up to that anticipated in the Comprehensive Plan. The pilot projects, which include wastewater reuse, seepage management, Lake Belt technology, and three aquifer storage and recovery projects are recommended to address uncertainties prior to full implementation of these components.

Improve Fresh Water Flows to Florida Bay. Improved water deliveries to Shark River Slough, Taylor Slough, and wetlands to the east of Everglades National Park will in turn provide improved deliveries of fresh water flows to Florida Bay. A feasibility study is also recommended to evaluate additional environmental restoration needs in Florida Bay and the Florida Keys.

Southwest Florida. There are additional water resources problems and opportunities in southwest Florida requiring studies beyond the scope of the Restudy recommended Comprehensive Plan. In this regard, a feasibility study for Southwest Florida is being recommended to investigate the region's hydrologic and ecological restoration needs.

Comprehensive Integrated Water Quality Plan. The recommended Comprehensive Plan includes a follow-on feasibility study to develop a comprehensive water quality plan to ensure that the Comprehensive Plan leads to ecosystem restoration throughout south Florida. The water quality feasibility study would include evaluating water quality standards and criteria from an ecosystem restoration perspective and recommendations for integrating existing and future water quality restoration targets for south Florida water bodies into future planning, design, and construction activities to facilitate implementation of the recommended Comprehensive Plan. Further, water quality in the Keys is critical to ecosystem restoration. The Florida Keys Water Quality Protection Plan includes measures for improving wastewater and stormwater treatment within the Keys. Implementation of the Keys Water Quality Protection Plan is critical for restoration of the south Florida ecosystem.

Overall, the recommended Comprehensive Plan will capture and store much of the water that is now lost to the ocean and gulf. This will provide enough water in the future for both the ecosystem, as well as urban and agricultural users. It will continue to provide the same level of flood protection as it does at present, if not more, for south Florida. The Comprehensive Plan is a system-wide solution for ecosystem restoration, water supply, and flood damage reduction. It is a necessary step towards a sustainable south Florida.

What the Comprehensive Plan Will Accomplish

Implementation of the recommended Comprehensive Plan will result in the recovery of healthy, sustainable ecosystems throughout south Florida. It is a plan that will lead to a much improved environment, for people and for the plants and animals that depend upon the natural system for their survival. The Comprehensive Plan contains all of the essential components to achieve this goal. There are many reasons for having confidence that it will be successful. No other plan, especially one on a smaller scale or one lacking the appropriate balance between ecosystem restoration and future urban and agricultural water supply objectives, would achieve a similar level of success.

The Comprehensive Plan does not provide all the answers – no plan could. The plan, however, contains an aggressive adaptive assessment strategy that includes independent scientific peer review and a process for identifying and resolving uncertainties. Because it is acknowledged that all the answers cannot be known at this time, and that inaction is not an option, adaptive assessment provides the means to allow restoration to move forward. A major strength of the current plan is that its flexibility allows for efficient and successive opportunities to make further improvements as we refine our plans and obtain new information.

The focus of the recommended Comprehensive Plan has been on recovering the defining ecological features of the original Everglades and other south Florida ecosystems. What made these ecosystems unique was their topographic flatness and expansiveness, and that they formed hydrologically integrated systems from boundary to boundary. What this means in a healthy ecosystem is that water patterns in one part of the system could be used to predict the patterns throughout the system. Animals living in the Everglades would "read" the water patterns, and "know" where to go to find the food and water that they needed for successful reproduction and survival under a range of natural conditions. It was the combination of connectivity and space that created the range of habitats needed for the diversity of plants and animals. The construction of the many levees and dikes designed to compartmentalize the Everglades and separate Lake Okeechobee from its natural overflow, and the canals that drained water to the coast, disrupted these natural patterns, and destroyed the ability of many animals to find the dependable habitat needed for their survival at the right time.

The recommended Comprehensive Plan, by removing over 240 miles of internal levees in the Everglades, and approaching recovery of the natural volume of water in the remaining wetlands, will restore these essential defining features of the pre-drainage wetlands over large portions of the remaining system. The plan also includes water storage and water quality treatment areas that will improve water quality conditions in the south Florida ecosystem. In response to this substantial improvement, the characteristic animals of these ecosystems will show dramatic and positive responses. At all levels in the aquatic food chains, the numbers of such animals as crayfish, minnows, sunfish, frogs, alligators, herons, ibis, and otters, will markedly increase. Equally important, animals will respond to the recovery of more natural water patterns by returning to their traditional distribution patterns.

The recommended Comprehensive Plan will support the return of the large nesting "rookeries" of wading birds to Everglades National Park, and the recovery of several endangered species to more certain and optimistic futures. Wading birds, e.g., herons, egrets, ibis and storks, are symbolic of the overall health of the Everglades. As recently as the 1950s and 1960s, large "super colonies" of nesting waders remained in the park; none have been there since. Wading birds, perhaps more than any other animal, assess the quality of habitats over the entire basin of south Florida wetlands, before making “decisions” about where and when, or even whether, to nest. The recovery of the super colonies will be a sure sign that the entire ecosystem has made substantial progress towards recovery. Of the endangered species, the wood stork, snail kite, Cape Sable seaside sparrow, and American crocodile, among others, will benefit and increase. Undoubtedly, implementation of the recommended Comprehensive Plan will once again allow us to witness what is now only a fading memory of the former abundance of wildlife in the Everglades.

It is important to understand that the “restored” Everglades of the future will be different from any version of the Everglades that has existed in the past. While it certainly will be vastly superior to the current ecosystem, it will not completely match the pre-drainage system. This is not possible, in light of the irreversible physical changes that have made to the ecosystem. It will be an Everglades that is smaller and somewhat differently arranged than the historic ecosystem. But it will be a successfully restored Everglades, because it will have recovered those hydrological and biological patterns which defined the original Everglades, and which made it unique among the world’s wetland systems. It will become a place that kindles the wildness and richness of the former Everglades.

Lake Okeechobee will once again become a healthy lake. The littoral and pelagic zones within the lake, essential to the lake’s commercial and recreational fishery and other aquatic species, will be greatly enhanced by the water levels projected in the recommended Comprehensive Plan. Water quality will also be improved significantly. The lake provides huge regional benefits to wildlife, including waterfowl, other birds, and mammals.

The Comprehensive Plan provides major benefits to the Caloosahatchee and St. Lucie estuaries, and Lake Worth Lagoon. The plan eliminates almost all the damaging fresh water releases to the Caloosahatchee and most detrimental releases to the St. Lucie. The plan makes substantial improvements to Lake Worth Lagoon. As a result, grassbeds and other submerged aquatic vegetation will benefit and thus provide abundant favorable habitat for the many aquatic species that depend on these areas for food, shelter, and breeding grounds, thereby enhancing the productivity and economic viability of estuarine fisheries. The recommended Comprehensive Plan also includes several water storage and treatment areas to improve water quality conditions in the Indian River Lagoon and the St. Lucie and Caloosahatchee estuarine systems.

The recommended Comprehensive Plan makes improvements in fresh water deliveries to Florida and Biscayne bays. These bays will benefit from more natural water deliveries. Appropriate fresh water regimes will result in substantial improvements in aquatic and semi-aquatic habitats; fish and wildlife will respond favorably to these beneficial changes. Mangroves, coastal marshes, and seagrass beds interacting together to produce food, shelter, and breeding and nursery grounds will support more balanced, productive fish, shellfish, and wildlife communities.

South Florida does not have to follow the fate of some states that suffer severe water shortages, creating tension between natural resource protection and water supply. The recommended Comprehensive Plan expands the storage capability of the C&SF Project, enabling the system to better meet ecosystem and urban water supply needs in the future. Frequency of water restrictions expected with the recommended Comprehensive Plan are greatly reduced compared to the Without Plan Condition. This will be accomplished by more effectively providing adequate flows from the regional system to recharge the surficial aquifer. This will help offset withdrawals from public water supply wellfields and other users in the urbanized Lower East Coast Region. Such recharge also protects the surficial aquifer from saltwater intrusion, allowing it to remain a productive source of fresh water in the future.

The recommended Comprehensive Plan will significantly increase the capability to supply water from the regional system to agricultural users. This will provide better protection from economically harmful water supply cutbacks and allow agriculture to remain productive. Storage facilities associated with Lake Okeechobee such as those north of the lake, and Lake Okeechobee aquifer storage and recovery will enable the lake to remain an important source of water supply while keeping lake stages at more ecologically desirable levels. Additional storage facilities built throughout the system will diversify sources of water for many users and enable recycling of water within a basin to meet dry season demands, significantly improving the reliability of agricultural water supply in the future.

The recommended Comprehensive Plan also assures that the quality of south Florida's water bodies will be restored to achieve overall ecosystem restoration. The recommended Comprehensive Plan includes many features to assure that water quality standards will be met and water quality conditions are improved or not degraded. The Comprehensive Plan includes the development of a comprehensive integrated water quality plan, which will lead to recommendations for water quality remediation programs and the integration of water quality restoration targets into future design, construction, and operation activities as features of the recommended Comprehensive Plan are implemented.

How the Comprehensive Plan Will Be Implemented

No plan can anticipate fully the uncertainties that are inherent in predicting how a complex ecosystem will respond during restoration efforts. For example, the remaining Everglades are only one-half as large as the original and current boundaries do not logically follow natural ground elevations or habitat patterns. For these and many other reasons, the ways in which this ecosystem will respond to the recovery of more natural water patterns almost certainly will include some surprises. The recommended Comprehensive Plan anticipates such surprises and is designed to facilitate project modifications that take advantage of what is learned from system responses, both expected and unexpected, and from future restoration targets as those become more refined. For example, future water quality restoration targets will be integrated into the detailed design, construction, and future operation of all recommended Comprehensive Plan features.

A new type of reporting document will be prepared as the implementation process begins. Project Implementation Reports will bridge the gap between the Comprehensive Plan and the detailed design necessary to proceed to construction. In addition to supplemental National Environmental Policy Act documentation, the Project Implementation Report process will allow for continuing public participation on each feature. In this more detailed phase of analysis, Comprehensive Plan components will be further investigated and appropriate actions recommended.

The Comprehensive Plan includes an aggressive adaptive assessment strategy. This strategy ensures that new information about the natural system, learned from continuing research and from measuring responses to implementation of plan components, can be used to increase the ultimate level of success of the overall restoration program. Specifically, adaptive assessment uses a well focused, regional monitoring program to measure how well each component of the plan accomplishes its objectives. This, in turn, sets up opportunities for refinement of succeeding components. Such adaptive assessment and regional monitoring are essential features of the recommended Comprehensive Plan and ensure its overall success. Independent scientific peer review is an integral part of this process.

Pilot projects to demonstrate the effectiveness of technologies such as aquifer storage and recovery, seepage management, and wastewater reuse are a part of the implementation strategy. Three new feasibility studies, Florida Bay and the Florida Keys, Southwest Florida, and a comprehensive integrated water quality plan, will also be undertaken to assure that full implementation of the Comprehensive Plan leads to overall ecosystem restoration in south Florida. The use of the best available science and extensive outreach and public involvement, both of which have been an essential part of the Restudy, will continue during the implementation process.

The recommended Comprehensive Plan described in this report will serve as a framework and guide for modifications to the Central and Southern Florida Project. The pilot projects and a set of specific key components are recommended for initial authorization. The estimated total cost of these initial features are $1,198,000,000 (October 1999 price levels) and an annual cost of $20,000,000 for operation and maintenance. The estimated Federal cost is $599,000,000 with estimated annual operation and maintenance costs of $10,000,000; and the estimated non-Federal cost is $599,000,000 with estimated annual operation and maintenance costs of $10,000,000.

Further, the Water Resources Development Act of 1996 provided authorization for Critical Restoration Projects in order to expedite implementation of the restoration effort. A similar programmatic authority is recommended to help expedite implementation of some components in the recommended Comprehensive Plan. This programmatic authority would be limited to those components of the Comprehensive Plan that have a total project cost of $70,000,000 with a maximum Federal cost of $35,000,000.

Authorization for the remaining components of the Comprehensive Plan will be sought after completion of more detailed planning and submission of Project Implementation Reports to Congress. Each Project Implementation Report will also contain an analysis of the Comprehensive Plan and any recommendations concerning modifications to the plan.

AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

During the course of the Restudy, a number of important issues have emerged. Many have been resolved, but some remain. For example:

Scientific Models. Many scientific and engineering models were used in developing the recommended Comprehensive Plan. The models employed in the Restudy are state-of–the-art, and represent the best understanding of the hydrology of both the pre-drainage and current C&SF system (Natural System Model and South Florida Water Management Model) as well as species responses to hydrology (Across Trophic Landscape System Simulation). But by their very nature, models are uncertain because they are simplifications of reality. The South Florida Water Management Model and the Natural System Model have undergone technical peer review. The conclusions that can be drawn from them are only as good as the basic understandings and information that are the foundations of the models. Most importantly, such conclusions must be understood in the context of model uncertainty and appropriateness of scale, and are best utilized to compare performance among alternative plans. The Natural System Model, for example, depicts the hydrologic response of the pre-drained system to rainfall and other hydrologic conditions of the period from 1965 through 1995. It does not depict the conditions of the pre-drained Everglades system, although there is a misconception that it does; such data does not exist. This model was used to help define performance measures for the natural system and to evaluate the performance of different alternative plans. However, defining acceptable performance of any particular alternative plan by ridged adherence to outs from the Natural System Model is an improper use of such output.

Water Quality Restoration Targets. Many water bodies in south Florida are not currently meeting water quality standards. The State of Florida and the Miccosukee and Seminole Tribes are required under the Federal Clean Water Act to identify those water bodies periodically. Total maximum daily loads for those pollutants causing those water bodies to not meet standards and remediation programs to assure that standards will be met must be developed. The current schedule for developing these standards has the potential to delay implementation of certain features of the recommended Comprehensive Plan until those targets are developed and remediation programs are implemented. In addition to this program, several water bodies have been prioritized by the state's Surface Water Improvement and Management Program, including the development of pollutant load reduction goals. There is some concern as to the degree to which remediation programs have been limited, and that some load reduction goals may not be protective enough to achieve ecosystem restoration. The comprehensive integrated water quality plan feasibility study included in the recommended Comprehensive Plan will include prioritizing the development of both water quality standards and pollution load reduction goals consistent with the Restudy implementation schedule. Recommendations will be made for optimizing the design, construction, and operation of plan features to assure that water quality restoration targets are achieved. Existing water quality criteria will be reviewed, and additional water quality criteria may be developed to complement future detailed planning and design activities undertaken to implement recommended Comprehensive Plan components.

Technology Uncertainties. Most of the recommended Comprehensive Plan's features are tested and proven reliable means to manage water. However some of the facilities proposed such as aquifer storage and recovery and seepage control have not been implemented on such a large scale. A series of pilot projects are proposed in the recommended Comprehensive Plan to address the uncertainties of these technologies. Results from these studies will help direct future detailed planning and design related to implementation of these types of facilities.

This Comprehensive Plan makes no claim that all the questions have been answered, that all the uncertainties have been addressed, or that all the issues have been resolved. No plan could do all these things. We have improved our understanding of this complex system and know that there is much more to learn. The Comprehensive Plan is a roadmap -- and a very important one -- that provides critical direction and organizational structure for restoring and protecting the south Florida ecosystem. The Implementation Plan contained in this Comprehensive Plan recommends a phased approach to project construction that provides for substantial region-wide benefits and a feedback mechanism through adaptive assessment to ensure that implementation of project features continues to achieve desired objectives. The adaptive assessment and monitoring process, including independent scientific peer review, will serve as a system “check” as projects are constructed and operated. Enough flexibility has been built into the Implementation Plan such that project design and sequencing will take into account system responses and new information as it becomes available.

WHY RESTORE THE EVERGLADES?

Why restore the Everglades? The answers to this question are overwhelming. The Everglades is to south Florida what the Rockies are to many western states; the old growth forests are to the Pacific northwest; the Adirondack, White and Green Mountains are to the northeast; and the Mississippi River is to the nation's heartland. The Everglades epitomizes the region's sense of definition and place, both substantially and spiritually (by providing clean water and recreation and by providing a sense of hope for the quality of the region's future). The Everglades is unlike any other place in the world. It attracts the eyes of the world.

We are now at an important crossroad in our efforts to restore this internationally important ecosystem. If we act now with courage and vision to implement this technically sound comprehensive restoration plan, we will be successful and we will leave a proud Everglades legacy. If we fail to act, our legacy will be one of lost opportunities for all future generations. The world is indeed watching as we make this choice.

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CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY

FINAL
INTEGRATED FEASIBILITY REPORT
AND
PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

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Note: * Required for NEPA compliance

SECTION 1
INTRODUCTION

The Central & Southern Florida (C&SF) Project extends from south of Orlando to the Florida Keys and is composed of a regional network of canals, levees, storage areas and water control structures. First authorized by Congress in 1948, the project serves multipal purposes. The authorized purposes of the project include flood control, regional water supply for agricultural and urban areas, prevention of salt water intrusion, water supply to Everglades National Park, preservation of fish and wildlife, recreation and navigation. For close to 50 years, the C&SF Project has performed its authorized functions well. However, the project also has had unintended adverse effects on the unique natural environment that constitutes the Everglades and south Florida ecosystem.

In the late 1800s and early 1900s, the principal impediment to development in south Florida was flooding. Flood control works were necessary to realize the economic potential of the state's exceptional natural resources. As a result, major drainage projects were initiated first by the State of Florida and then later in partnership with the federal government, through the Corps of Engineers. This partnership worked to control the hydrologic conditions that were hampering economic development. The emphasis on economic goals clearly focused the design of the C&SF Project towards development of the region with little understanding of or concern for the consequences to the Everglades ecosystem.

To meet project objectives, the C&SF Project impacted a significant portion of the natural system. The Kissimmee River was channelized. Lake Okeechobee was diked to prevent uncontrolled overflows from the lake. The region of the Everglades immediately south of Lake Okeechobee, now called the Everglades Agricultural Area, was drained and ground water levels were managed to reduce flood damages to agricultural production. A drainage system was constructed in the lower east coast to allow for urban, suburban and agricultural development. Central portions of the Everglades were diked to create the Water Conservation Areas, serving the dual purposes of storing water for human needs in the lower east coast and for deliveries to Everglades National Park. While some fish and wildlife value was expected to remain in the Water Conservation Areas, the only area intended for preservation in its natural state was Everglades National Park.

Land use and water management practices over the past 100 years in south Florida have resulted in either the loss or extensive alteration of the defining characteristics of the pre-drainage ecosystem. Loss of spatial extent of natural areas has been most severe in the past 50 years with the construction of the C&SF Project as nearly half of the original Everglades ecosystem has been converted to agricultural and urban uses. The ecological effects of this loss in spatial extent include:

- a substantial reduction in habitat options for wildlife,
- reduction in the system-wide levels of primary and secondary production, and
- changes in the proportions of community types within the remaining system.

The hydrology of the remaining Everglades has also been substantially altered by the operation of the C&SF Project, which has reduced average annual flows and surface water stages and lowered regional ground water in the natural system. Depending on location, annual hydroperiods have either increased or decreased, geographically relocating long- and short-hydroperiod wetlands. Additionally, average salinity levels in estuaries have been raised.

Overall, the construction and operation of the C&SF Project and its subsequent modification of the natural system have:

- contributed to the substantial reduction in spatial extent and system resiliency,
- provided a network of canals and levees that have accelerated the spread of polluted water and exotic species,
- greatly reduced the water storage capacity within the remaining natural system, and
- created an unnatural mosaic of impounded and over-drained marshes throughout the natural system.

The lack of storage in the system, particularly during wet periods, has led to ecological damage of Lake Okeechobee's littoral zone and damaging regulatory releases to the St. Lucie and Caloosahatchee estuaries. Conversely, in dry periods, this lack of storage has led to water supply shortages for both the human and natural environment. The Governor's Commission for a Sustainable South Florida in its October 1995 *Initial Report* (GCSSF, 1995) stated that "*South Florida is not sustainable on its present course.*"

Sustainability, according to the Governor's Commission, requires a balance between the resource requirements of the environment, the economy, and society, which are interdependent. Society is dependent upon the natural system for public health, safety, and welfare as well as an enhanced quality of life. Economic vitality is dependent upon a healthy ecosystem. A self-sustaining natural system is largely dependent upon the wisdom and actions of its human inhabitants. Actions taken by society today should not deplete the resources needed for tomorrow. The ability to restore the health of the remaining Everglades ecosystem and achieve sustainability in water resources for all needs depends on the ability to protect and manage the resource successfully.

Protection and enhancement of the water resources in south Florida is one step towards moving the region in the direction of sustainability. The C&SF Project is the predominant feature that affects this resource. Accordingly, the C&SF Project Comprehensive Review Study, better known as the Restudy, has looked at the existing project, its physical features and operations, with a view towards recommending structural and/or operational changes to better meet the goals of south Florida ecosystem restoration and the continued provision of safe, reliable water supply and flood protection for the people who live there. Ensuring sustainable water resources for the future, or "getting the water right," – the right quantity, quality, timing, and distribution – is what the Restudy is about.

This section describes the study's authority, purpose and scope, and organization of the report; discusses compliance with the National Environmental Policy Act; and provides a brief overview of the study area and a list of prior studies and reports.

1.1 STUDY AUTHORITY

The C&SF Project Comprehensive Review Study, known as the Restudy, is authorized by Section 309(l) of the Water Resources Development Act of 1992 (Public Law 102-580) which states:

> *"(1) CENTRAL AND SOUTHERN FLORIDA. -- The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as House Document 643; 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation."*

This study is also authorized by two resolutions of the Committee on Transportation and Infrastructure, United States House of Representatives, dated September 24, 1992. The first resolution states:

> *"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations*

contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes."

The second resolution states:

"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes for Florida Bay, including a comprehensive, coordinated ecosystem study with hydrodynamic modeling of Florida Bay and its connections to the Everglades, the Gulf of Mexico, and the Florida Keys Coral Reef ecosystem."

The Water Resources Development Act of 1996 was enacted on October 12, 1996. Section 528 of the Act (Public Law 104-303) entitled "Everglades and South Florida Ecosystem Restoration" authorizes a number of ecosystem restoration activities and also provides specific direction and guidance for the Restudy. The provisions of Section 528 concerning the Restudy are:

"(b) RESTORATION ACTIVITIES-

(1) COMPREHENSIVE PLAN-

(A) DEVELOPMENT-

(i) PURPOSE- The Secretary shall develop, as expeditiously as practicable, a proposed Comprehensive Plan for the purpose of restoring, preserving, and protecting the South Florida ecosystem. The Comprehensive Plan shall provide for the protection of water quality in, and the reduction of the loss of fresh water from, the Everglades. The Comprehensive Plan shall include such features as are necessary to provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project.

(ii) CONSIDERATIONS- The Comprehensive Plan shall--

(I) be developed by the Secretary in cooperation with the non-Federal project sponsor and in consultation with the Task Force; and

(II) consider the conceptual framework specified in the report entitled "Conceptual Plan for the Central and Southern Florida Project Restudy", published by the Commission and approved by the Governor.

(B) SUBMISSION- Not later than July 1, 1999, the secretary shall--

(i) complete the feasibility phase of the Central and Southern Florida Project comprehensive review study as authorized by section 309(l) of the Water Resources Development Act of 1992 (106 Stat. 4844), and by 2 resolutions of the Committee on Public Works and Transportation of the House of Representatives, dated September 24, 1992; and

(ii) submit to Congress the plan developed under subparagraph (A)(i) consisting of a feasibility report and a programmatic environmental impact statement covering the proposed Federal action set forth in the plan.

(C) ADDITIONAL STUDIES AND ANALYSES- Notwithstanding the completion of the feasibility report under subparagraph (B), the Secretary shall continue to conduct such studies and analyses as are necessary, consistent with subparagraph (A)(i).

(2) USE OF EXISTING AUTHORITY FOR UNCONSTRUCTED PROJECT FEATURES- The Secretary shall design and construct any features of the Central and Southern Florida Project that are authorized on the date of the enactment of this Act or that may be implemented in accordance with the Secretary's authority to modify an authorized project, including features authorized under sections 315 and 316, with funds that are otherwise available, if the Secretary determines that the design and construction--

(A) will accelerate the restoration, preservation, and protection of the South Florida ecosystem;

(B) will be generally consistent with the conceptual framework described in paragraph (1)(A)(ii)(II); and

(C) will be compatible with the overall authorized purposes of the Central and Southern Florida Project.

(3) CRITICAL RESTORATION PROJECTS-

(A) IN GENERAL- In addition to the activities described in paragraphs (1) and (2), if the Secretary, in cooperation with the non-Federal project sponsor and the Task Force, determines that a restoration project for the South Florida ecosystem will produce independent, immediate, and substantial restoration, preservation, and protection benefits, and will be generally consistent with the conceptual framework described in paragraph (1)(A)(ii)(II), the Secretary shall proceed expeditiously with the implementation of the restoration project.

(B) INITIATION OF PROJECTS- After September 30, 1999, no new projects may be initiated under subparagraph (A).

(C) AUTHORIZATION OF APPROPRIATIONS-

(i) IN GENERAL- There is authorized to be appropriated to the Department of the Army to pay the Federal share of the cost of carrying out projects under subparagraph (A) $75,000,000 for the period consisting of fiscal years 1997 through 1999.

(ii) FEDERAL SHARE- The Federal share of the cost of carrying out any 1 project under subparagraph (A) shall be not more than $25,000,000.

(4) GENERAL PROVISIONS-

(A) WATER QUALITY- In carrying out activities described in this subsection and sections 315 and 316, the Secretary--

(i) shall take into account the protection of water quality by considering applicable State water quality standards; and

(ii) may include in projects such features as are necessary to provide water to restore, preserve, and protect the South Florida ecosystem.

(B) COMPLIANCE WITH APPLICABLE LAW- In carrying out the activities described in this subsection and subsection (c), the Secretary shall comply with any applicable Federal law, including the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.).

(C) PUBLIC PARTICIPATION- In developing the Comprehensive Plan under paragraph (1) and carrying out the activities described in this subsection and

subsection (c), the Secretary shall provide for public review and comment on the activities in accordance with applicable Federal law.

(c) INTEGRATION OF OTHER ACTIVITIES-

(1) IN GENERAL- In carrying out activities described in subsection (b), the Secretary shall integrate such activities with ongoing Federal and State projects and activities, including--

(A) the project for the ecosystem restoration of the Kissimmee River, Florida, authorized by section 101 of the Water Resources Development Act of 1992 (106 Stat. 4802);

(B) the project for modifications to improve water deliveries into Everglades National Park authorized by section 104 of the Everglades National Park Protection and Expansion Act of 1989 (16 U.S.C. 410r-8);

(C) activities under the Florida Keys National Marine Sanctuary and Protection Act (16 U.S.C. 1433 note; 104 Stat. 3089); and

(D) the Everglades Construction Project of the State of Florida.

(2) STATUTORY CONSTRUCTION-

(A) EXISTING AUTHORITY- Except as otherwise expressly provided in this section, nothing in this section affects any authority in effect on the date of the enactment of this Act, or any requirement of the authority, relating to participation in restoration activities in the South Florida ecosystem, including the projects and activities specified in paragraph (1), by--

(i) the Department of the Interior;

(ii) the Department of Commerce;

(iii) the Department of the Army;

(iv) the Environmental Protection Agency;

(v) the Department of Agriculture;

(vi) the State of Florida; and

(vii) the South Florida Water Management District.

(B) NEW AUTHORITY- Nothing in this section confers any new regulatory authority on any Federal or non-Federal entity that carries out any activity authorized by this section.

(d) JUSTIFICATION-

(1) IN GENERAL- Notwithstanding section 209 of the Flood Control Act of 1970 (42 U.S.C. 1962-2) or any other provision of law, in carrying out the activities to restore, preserve, and protect the South Florida ecosystem described in subsection (b), the Secretary may determine that the activities--

(A) are justified by the environmental benefits derived by the South Florida ecosystem in general and the everglades and Florida Bay in particular; and

(B) shall not need further economic justification if the Secretary determines that the activities are cost-effective.

(2) APPLICABILITY- Paragraph (1) shall not apply to any separable element intended to produce benefits that are predominantly unrelated to the restoration, preservation, and protection of the South Florida ecosystem.

(e) COST SHARING-

(1) IN GENERAL- Except as provided in sections 315 and 316 and paragraph (2), the non-Federal share of the cost of activities described in subsection (b) shall be 50 percent.

(2) WATER QUALITY FEATURES-

(A) IN GENERAL- Except as provided in subparagraph (B), the non-Federal share of the cost of project features to improve water quality described in subsection (b) shall be 100 percent.

(B) EXCEPTION-

(i) IN GENERAL- Subject to clause (ii), if the Secretary determines that a project feature to improve water quality is essential to Everglades restoration, the non-Federal share of the cost of the feature shall be 50 percent.

(ii) APPLICABILITY- Clause (I) shall not apply to any feature of the Everglades Construction Project of the State of Florida.

(3) OPERATION AND MAINTENANCE- The operation and maintenance of projects carried out under this section shall be a non-Federal responsibility.

(4) CREDIT- Regardless of the date of acquisition, the value of lands or interests in land acquired by non-Federal interests for any activity described in subsection (b) shall be included in the total cost of the activity and credited against the non-Federal share of the cost of the activity. Such value shall be determined by the Secretary."

1.2 STUDY PURPOSE & SCOPE

1.2.1 Study Purpose

The purpose of the Restudy is to reexamine the C&SF Project to determine the feasibility of structural or operational modifications to the project essential to the restoration of the Everglades and the south Florida ecosystem, while providing for other water-related needs such as urban and agricultural water supply and flood protection in those areas served by the project. The intent of the study is to evaluate conditions within the study area and make recommendations to modify the project to restore important functions and values of the Everglades and south Florida ecosystem and plan for the water resources needs of the people of south Florida for the next 50 years.

Planning by the U.S. Army Corps of Engineers (Corps) for water resources projects is accomplished in two phases: a reconnaissance phase and a feasibility phase. The reconnaissance phase is conducted at full Federal expense, while the cost of the feasibility phase is shared between the Federal government and the non-Federal sponsor. The non-Federal sponsor for this study is the South Florida Water Management District.

The reconnaissance phase defines problems and opportunities, identifies potential solutions, and determines if planning should proceed further into the feasibility phase based on Federal interest and identification of a non-Federal sponsor willing to support further study. The reconnaissance phase of this study was initiated in June 1993 and the reconnaissance report was completed in November 1994. The objective of the reconnaissance study was to identify problems and opportunities, formulate alternative plans, evaluate conceptual alternative plans, and recommend, if feasible, further detailed studies. The reconnaissance study helped to frame issues and set the direction for further detailed studies carried out in partnership with the local sponsor during the feasibility study.

Feasibility studies further develop the most promising alternatives and recommend a plan for authorization by Congress. The feasibility phase for this study was initiated in August 1995 following approval of the Project Study Plan by the Corps' headquarters and the Governing Board of the South Florida Water Management District. As a result of the passage of the Water Resources Development Act of 1996, a revised Project Study Plan was approved in May 1997.

The recommended plan is designed in greater detail during the preconstruction engineering and design phase, necessary real estate is then acquired, and then the project is constructed.

Figure 1-1 outlines the steps necessary to develop and implement a typical Corps project.

FIGURE 1-1
STEPS IN CORPS OF ENGINEERS PROJECT DEVELOPMENT

Reconnaissance Study	Feasibility Study	Preconstruction Engineering and Design	Real Estate Acquisition	Construction	Operation and Maintenance
Define the problems and opportunities in the study area; assess Corps and local roles in solving the problems; and develop and evaluate preliminary concepts to address the problems.	Describe and evaluate alternative plans to address the problems and realize the opportunities and fully describe a recommended project.	Complete all of the detailed technical studies and design needed to begin construction of the project. Usually overlaps the end of the Feasibility Study phase.	The non-federal sponsor acquires the necessary real estate by purchase, donation, or condemnation so that the project can be constructed, operated, and maintained. (Overlaps with construction phase).	Features that have been agreed to by the Corps, the sponsors' and other project interests are built and begin to function as needed.	All of the activities needed to allow the project to solve the problems and realize the opportunities for which the project was built are conducted. Monitoring is also included in this phase.

1.2.2 Study Scope

The purpose of this feasibility study is to develop a Comprehensive Plan for the overall regional C&SF system and the tools necessary to evaluate the Comprehensive Plan as well as separable and incremental portions of the project. This study represents the first thorough, system-wide update since the project's original inception. The Comprehensive Plan will include such features as are necessary to provide for the regional water-related needs of the region; including flood control, the enhancement of water supplies, and other objectives served by the C&SF Project. This feasibility study included hydrologic modeling, environmental modeling, water quality analyses, and water supply studies that refined the information developed in the reconnaissance study. The feasibility study was conducted to identify a Comprehensive Plan for the C&SF Project and an adaptive implementation and operational strategy based on monitoring, evaluation, and modeling.

The Comprehensive Plan presented in this report is similar in scope to that contained in the 1948 Comprehensive Report for the Central and Southern Florida Project (House Document 80-643). This feasibility report does not include the normal level of detail that is expected from much smaller projects, such as the identification of specific sites for proposed project facilities. The Comprehensive Plan identifies components needed to restore the south Florida ecosystem, which includes the needs of all users, and the formulation process that produced them, from the viewpoint of hydrologic impacts of the regional water management system. This report also documents the uncertainties in plan selection and future tasks that will be needed to minimize these uncertainties. Engineering and real estate cost estimates are based on the analyses and assumptions made during the process of formulating and developing the components of the Comprehensive Plan. Uncertainties in design details and uncertainties in the exact location of components could impact future alternative analyses and subsequent design and cost estimates.

1.2.3 Report Organization

This feasibility report consists of a main report with an integrated Programmatic Environmental Impact Statement and appendices. The main report provides an overview of the study effort and summarizes information found in the appendices. The appendices provide detailed supporting information for all of the investigations and tasks conducted for the Restudy. In addition, a separate summary report has also been prepared

1.3 STUDY AREA

The study area encompasses approximately 18,000 square miles from Orlando to the Florida Reef Tract with at least 11 major physiographic provinces: Everglades, Big Cypress, Lake Okeechobee, Florida Bay, Biscayne Bay, Florida Reef Tract, nearshore coastal waters, Atlantic Coastal Ridge, Florida Keys, Immokalee Rise, and the Kissimmee River Valley. The Kissimmee River, Lake Okeechobee and the Everglades are the dominant watersheds that connect a mosaic of wetlands, uplands, coastal areas, and marine areas. The study area includes all or part of the following 16 counties: Monroe, Miami-Dade, Broward, Collier, Palm Beach, Hendry, Martin, St. Lucie, Glades, Lee, Charlotte, Highlands, Okeechobee, Osceola, Orange, and Polk.

The C&SF Project, which was first authorized by Congress in 1948, is a multi-purpose project that provides flood control; water supply for municipal, industrial, and agricultural uses; prevention of saltwater intrusion; water supply for Everglades National Park; and protection of fish and wildlife resources throughout the study area. The primary system includes about 1,000 miles each of levees and canals, 150 water control structures, and 16 major pump stations. The Central and Southern Florida Project is shown on ***Figure 1-2***.

The Upper St. Johns River Basin has been excluded from this study because it is a separate hydrologic basin which is not a part of the Everglades and south Florida ecosystems. C&SF Project works in the Upper St. Johns River Basin which are expected to meet the water resources needs of that basin are nearing completion.

The following sections provide details on each of the regions that comprise this large study area. The study regions are the Kissimmee River Basin, Lake Okeechobee, Upper East Coast, Everglades Agricultural Area, Water Conservation Areas, Lower East Coast, Biscayne Bay, Everglades National Park, Florida Bay, Whitewater Bay and the Ten Thousand Islands, Florida Keys, Big Cypress Basin, and Lower West Coast. A map of the study regions is shown on ***Figure 1-3***.

1.3.1 Kissimmee River Basin

The Kissimmee River Basin is comprised of 3,013 square miles, and extends from Orlando southward to Lake Okeechobee. The watershed, which is the largest source of surface water to the lake, is about 105 miles long and has a maximum width of 35 miles.

Project works in the basin for flood control and navigation were constructed by the Corps as part of the C&SF Project. Upper Basin works consist of channels and structures that control water flows through 18 natural lakes into Lake Kissimmee. The Lower Basin includes the channelized Kissimmee River (C-38) as a 56-mile earthen canal extending from Lake Kissimmee to Lake Okeechobee.

The northern portion of the basin is comprised of many lakes, some of which have been interconnected by canals. This large sub-basin, often termed the “Upper Basin” or “Chain of Lakes”, is bounded on the southern end by State Road 60, where the largest of the lakes, Lake Kissimmee, empties into the Kissimmee River.

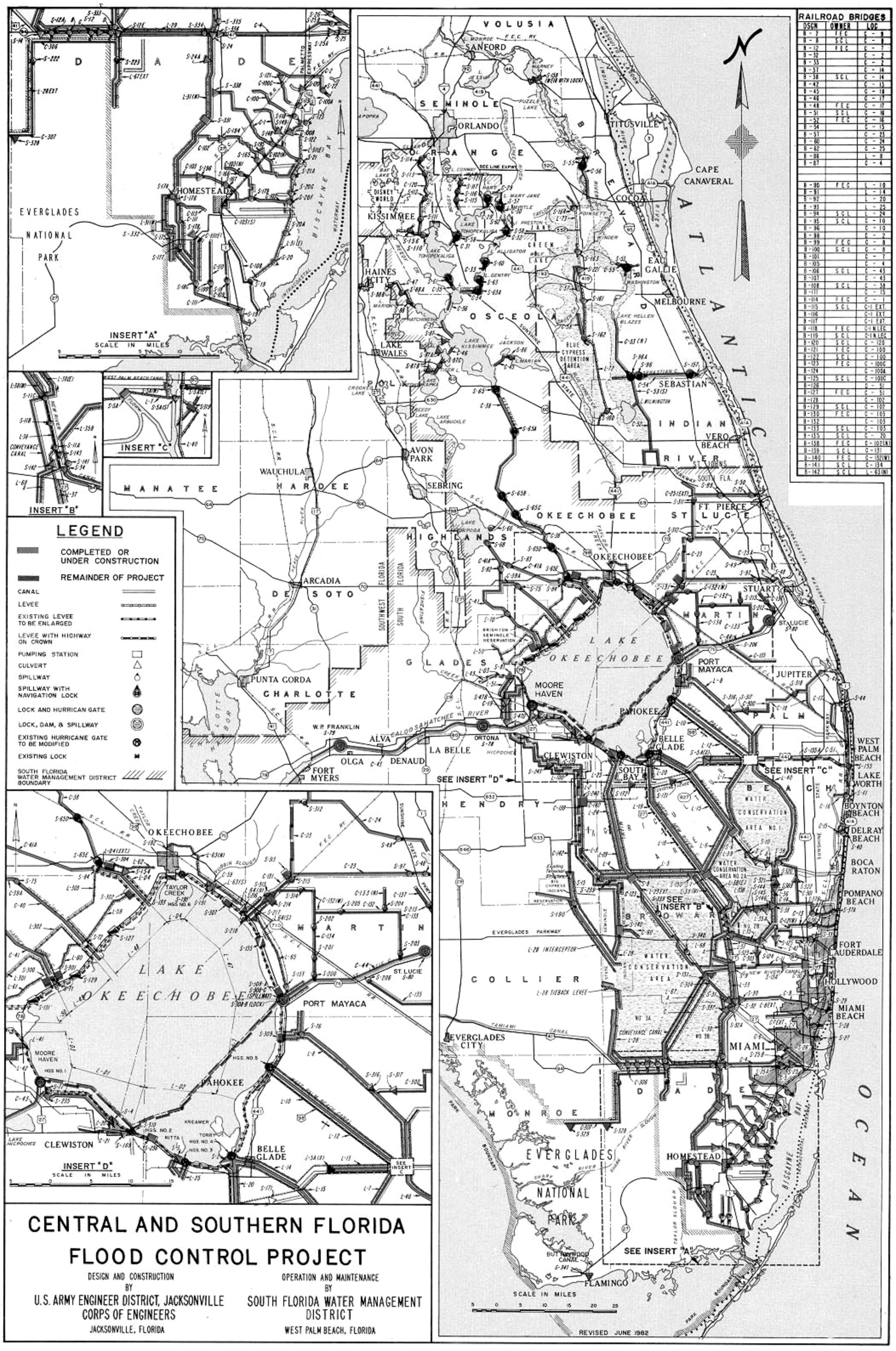

FIGURE 1-2 C&SF PROJECT MAP

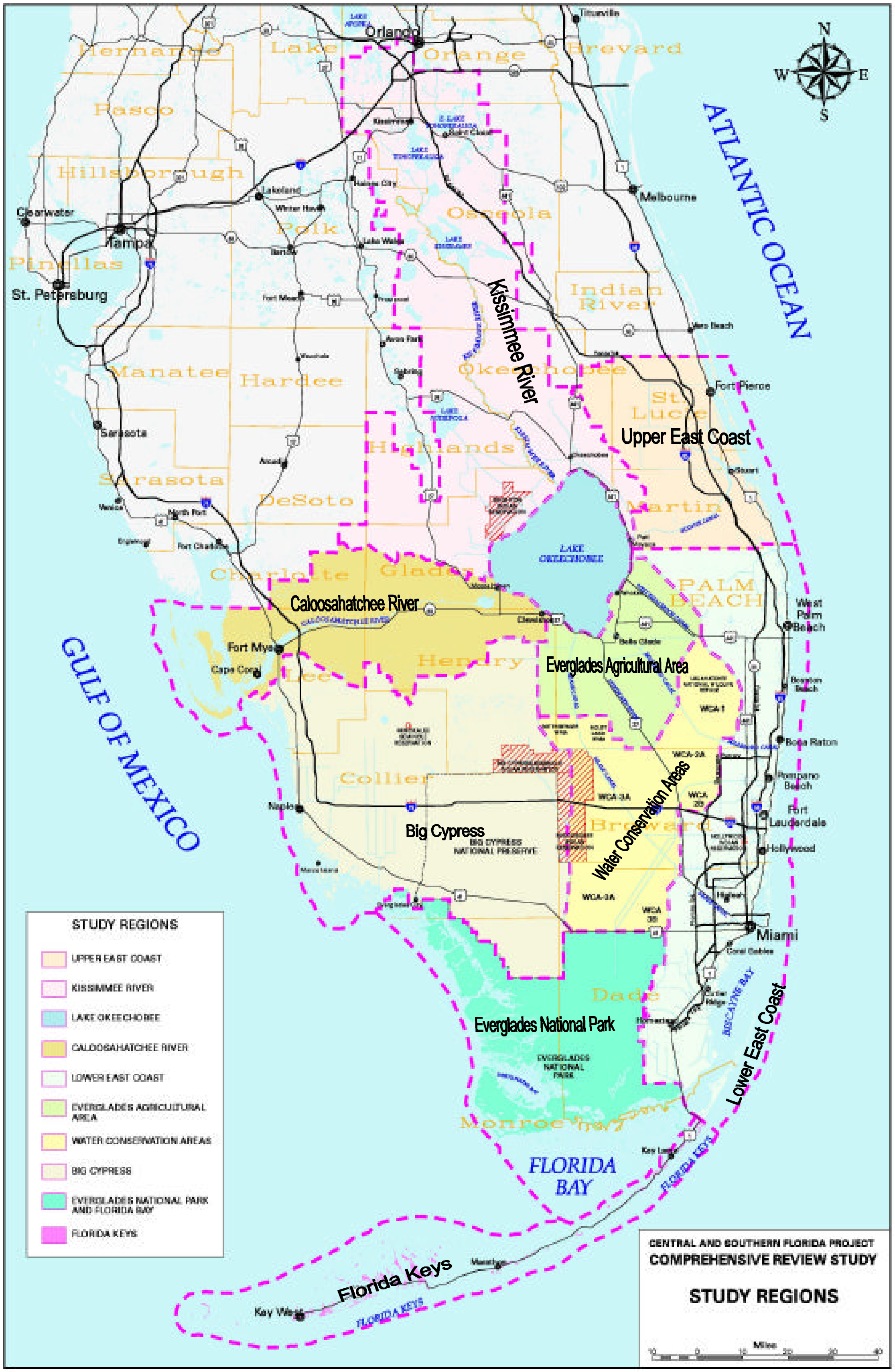

FIGURE 1-3 STUDY REGIONS

The Upper Basin is 1,633 square miles and includes Lake Kissimmee and the east and west Chain of Lakes area in Orange and Osceola Counties. A 758-square-mile Lower Basin includes the tributary watersheds of the Kissimmee River between the outlet in Lake Kissimmee and Lake Okeechobee. The 622-square-mile Lake Istokpoga area provides tributary inflow to the Lower Basin.

1.3.2 Lake Okeechobee

Lake Okeechobee lies 30 miles west from the Atlantic coast and 60 miles east from the Gulf of Mexico in the central part of the peninsula. Lake Okeechobee is a broad shallow lake occurring as a bedrock depression. The large, roughly circular lake, with a surface area of approximately 730 square miles, is the principal natural reservoir in southern Florida.

The lake's largest outlets include the St. Lucie Canal eastward to the Atlantic Ocean and the Caloosahatchee Canal and River to the Gulf of Mexico. The four major agricultural canals – the West Palm Beach, Hillsboro, North New River, and Miami Canals - have a smaller capacity, but are used whenever possible to release excess water to the Water Conservation Areas, south of the lake, when storage and discharge capacity are available. When regulatory releases from the lake are required, excess water can be passed to the three Water Conservation Areas up to the capacity of the pumping stations and agricultural canals, with the remainder going to the Atlantic Ocean and Gulf of Mexico.

The waters of the lake are impounded by a system of encircling levees, which form a multi-purpose reservoir for navigation, water supply, flood control, and recreation. Pumping stations and control structures in the levee along Lake Okeechobee are designed to move water either into or out of the lake as needed.

Other surface water bodies include the Kissimmee River, Fisheating Creek, and Taylor Creek that flow into the lake from the north; the Caloosahatchee River that flows out of the lake to the west; the St. Lucie and West Palm Beach Canals that flow out of the lake to the east; and the Hillsboro, North New River, and Miami Canals that flow out of the lake to the south. The hydroperiod of the lake is partially controlled, permitting water levels to fluctuate with flood and drought conditions and the demand for water supply.

1.3.3 Upper East Coast

The Upper East Coast area encompasses approximately 1,139 square miles and includes most of Martin and St. Lucie Counties as well as a portion of eastern Okeechobee County. Martin and St. Lucie Counties are bounded to the east by the Atlantic Ocean, and a substantial portion of Martin County's western landmass borders Lake Okeechobee. Urban development is primarily located along the coastal areas while the central and western portions are used primarily for agriculture where the main products are citrus, truck crops, sugarcane, and beef and dairy products.

The land is generally flat, ranging in elevation from 15 to 60 feet NGVD[1] in the western portion with an average elevation of 28 feet. The coastal area ranges from sea level to 25 feet. The coastal sand hills adjacent to the Atlantic Intracoastal Waterway are higher than most parts of the county and reach a maximum elevation of 60 feet. This feature is known as the Atlantic Coastal Ridge.

The natural drainage has been significantly altered by the construction of canals, drainage ditches and numerous water control structures which predominately direct stormwater discharge to the east coast. The area contains the C&SF Project Canals C-23[2], C-24, and C-25 drainage basins and the drainage area served by C-44 (St. Lucie Canal).

The St. Lucie Canal is Lake Okeechobee's eastern outlet, extending 25.5 miles from Port Mayaca to the city of Stuart, where it terminates at the south fork of the St. Lucie River. The St. Lucie River Basin is part of a much larger southeastern Florida basin that drains over 8,000 square miles. The St. Lucie River, composed of the North and South forks, lies in Martin and St. Lucie Counties in the northeastern portion of the basin. The South Fork is a relatively short stretch of river. The North Fork, designated as an aquatic preserve by the State of Florida, begins south of Fort Pierce and flows past the city of Port St. Lucie to the St. Lucie River Estuary.

The St. Lucie Estuary is part of a larger estuarine system known as the Indian River Lagoon. The Indian River Lagoon has been designated an estuary of national significance and is a component of the U. S. Environmental Protection Agency sponsored National Estuary program. The Indian River Lagoon is also designated as a state priority water body for protection and restoration under the state's Surface Water Improvement and Management (SWIM) Act. The Surface Water Improvement and Management Act Plan identifies excessive freshwater runoff from the St. Lucie Estuary watershed as a problem within the St. Lucie Estuary.

Much of the St. Lucie River has been channelized and many drainage canals empty into the river, particularly the St. Lucie Canal, C-23 and C-24. The St. Lucie Canal, the largest overflow canal for Lake Okeechobee, is a navigation channel 8 feet deep and 100 feet wide connecting the Atlantic Intracoastal Waterway in Stuart with Lake Okeechobee at Port Mayaca.

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1 National Geodetic Vertical Datum

2 C&SF Project feature designations: C for canals, L for levees, and S for water control structures and pumping stations.

1.3.4 Everglades Agricultural Area

The lands located immediately south and southeast of the lake are known as the Everglades Agricultural Area. This area of about 700,000 acres is rich, fertile agricultural land. A large portion of the Everglades Agricultural Area is devoted to the production of sugarcane. The average ground elevation is about 12 feet.

The occurrence of surface water in the area is now a direct result of the construction of the numerous conveyance and drainage canals. The primary canals consist of the Miami, the North New River, the Hillsboro, and the West Palm Beach Canals, which traverse the area north south, and the Bolles and Cross Canal, which extends east-west. Water levels and flows are stringently manipulated in the canals to achieve optimum crop growth. Major surface impoundments in the area are non-existent.

1.3.5 Water Conservation Areas

The Water Conservation Areas are an integral component of the Everglades and freshwater supplies for south Florida. The Water Conservation Areas, located south and east of the Everglades Agricultural Area, comprise an area of about 1,350 square miles, including 1,337 square miles of the original Everglades, which averaged some 40 miles in width and extended approximately 100 miles southward from Lake Okeechobee to the sea.

The Water Conservation Areas provide a detention reservoir for excess water from the agricultural area and parts of the Lower East Coast region, and for flood discharge from Lake Okeechobee. The Water Conservation Areas also provide levees needed to prevent Everglades floodwaters from inundating the Lower East Coast, while providing water supply for Lower East Coast agricultural lands and Everglades National Park; improving water supply for east coast communities by recharging the Biscayne Aquifer (the sole source of drinking water for southern Palm Beach, Broward, Miami-Dade, and Monroe Counties); retarding salt water intrusion in coastal well fields; and benefiting fish and wildlife in the Everglades.

Water Conservation Area 1 is designated as the Arthur R. Marshall Loxahatchee National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service. Water Conservation Areas 2 and 3 are public hunting and fishing areas comprising the Everglades Wildlife Management Area maintained by the Florida Game and Fresh Water Fish Commission. The Seminole and Miccosukee Tribes each have reserved rights within Water Conservation Area 3.

1.3.5.1 Water Conservation Area 1

Water Conservation Area 1 (Loxahatchee National Wildlife Refuge) is about 21 miles long from north to south and comprises an area of 221 square miles. The

West Palm Beach Canal lies at the extreme northern boundary, and on the south the Hillsboro Canal separates Water Conservation Area 1 from Water Conservation Area 2. Ground elevations slope about five feet in 10 miles, both to the north and to the south from the west center of the area, varying from over 16 feet in the northwest to less than 12 feet in the south. The area, which is enclosed by about 58 miles of levee (approximately 13 miles of which are common to Water Conservation Area 2), provides storage for excess rainfall, excess runoff from agricultural drainage areas of the West Palm Beach Canal (230 square miles) and the Hillsboro Canal (146 square miles), and excess water from Lake Okeechobee. Inflow comes from rainfall and runoff from the Everglades Agricultural Area through canals at the northern end. Release of water for dry-season use is controlled by structures in the West Palm Beach Canal, the Hillsboro Canal, and in the north-south levee which forms the eastern boundary of the area. When stages exceed the regulation schedule, excess water in Water Conservation Area 1 is discharged to Water Conservation Area 2.

1.3.5.2 Water Conservation Area 2

Water Conservation Area 2 is comprised of two areas, 2A and 2B, measures about 25 miles from north to south, and covers an area of 210 square miles. It is separated from the other Water Conservation Areas by the Hillsboro Canal on the north and the North New River Canal on the south. Ground elevations slope southward about two to three feet in 10 miles, ranging from over 13 feet NGVD in the northwest to less than seven feet NGVD in the south. The area is enclosed by about 61 miles of levee, of which approximately 13 miles are common to Water Conservation Area 1 and 15 miles to Water Conservation Area 3. An interior levee across the southern portion of the area reduces water losses due to seepage into an extremely pervious aquifer at the southern end of the pool and prevents overtopping of the southern exterior levee by hurricane waves.

The upper pool, Water Conservation Area 2A, provides a 173-square-mile reservoir for storage of excess water from Water Conservation Area 1 and a 125-square-mile agricultural drainage area of the North New River Canal. Storage in Water Conservation Area 2A provides water supply to the east coast urban areas of Broward County. Water enters the area from Water Conservation Area 1 and the Hillsboro Canal on the northeast side, and from the North New River Canal on the northwest side. Water in excess of that required for efficient operation of Water Conservation Area 2A is discharged to Water Conservation Area-3 via structures into C-14, the North New River Canal, and Water Conservation Area 2B.

Water Conservation Area 2B has ground elevations ranging from 9.5 feet NGVD in the northern portions down to 7.0 feet NGVD in the southern portions of the area. The area experiences a high seepage rate, which does not allow for long term storage of water, and as a result, water is not normally released from the area.

1.3.5.3 Water Conservation Area 3

Water Conservation Area 3 is also divided into two parts, 3A and 3B. It is about 40 miles long from north to south and comprises about 915 square miles, making it the largest of the conservation areas. Ground elevations, which slope southeasterly 1 to 3 feet in 10 miles, range from over 13 feet NGVD in the northwest to 6 feet NGVD in the southeast. The Miami Canal traverses the area from northwest to southeast, and the North New River Canal separates it from Water Conservation Area 2. The area is enclosed by about 111 miles of levee, of which 15 miles are common to Water Conservation Area 2. An interior levee system across the southeastern corner of the area reduces seepage into an extremely pervious aquifer.

The upper pool, Water Conservation Area 3A, provides a 752-square-mile area for storage of excess water from Water Conservation Area 2A; rainfall excess from approximately 750 square miles in Collier and Hendry Counties and from 71 square miles of the former Davie agricultural area lying east of Pumping Station S-9 in Broward County; and excess water from a 208-square-mile agricultural drainage area of the Miami Canal and other adjacent areas to the north. Water enters Water Conservation Area 3A from various sources on the northern and eastern sides. The storage is used to meet the principal water supply needs of adjacent areas, including urban water supply and salinity control requirements for Miami-Dade and Monroe County, irrigation requirements, and water supply for Everglades National Park.

1.3.6 Lower East Coast Area

The Lower East Coast area, which consists of the coastal ridge section in Palm Beach, Broward, and Miami-Dade Counties, is a strip of sandy land which lies east of part of the Water Conservation Areas. The ground surface of the flatlands in the west ranges from about 25 feet NGVD in the upper part of the region to about five feet NGVD in lower Miami-Dade County. The Atlantic Coastal Ridge is comprised of broad, low dunes and ridges with elevations ranging from 10 to 25 feet NGVD. This ridge area ranges from two to four miles in width at its northern edge to its southern edge in Miami. South of Miami the ridge becomes less pronounced but significantly wider.

The Lower East Coast area is the most densely populated part of the state. The largest population centers are near the coast and include the cities of Miami, West Palm Beach, Fort Lauderdale, and Hollywood. Water levels in coastal canals are controlled near the coastal shoreline to prevent overdrainage and to resist salt water intrusion. Low water levels in these canals may enable salt water to migrate into the ground water, well fields, and natural freshwater systems upon which the urban areas depend for a potable water supply.

This area is characterized by sandy flatlands to the west, the sandy coastal ridge, and the coastal marsh and mangrove swamp areas along the Atlantic seaboard. The northern portion, generally that part north of Miami-Dade County, marks the shore of a higher Pleistocene Sea and occurs as one or more relict beach ridges. The southern portion appears to be marine deposited sands or marine limestones.

Extensive development has resulted in nearly complete urbanization of the coastal region from West Palm Beach southward through Miami, and these physiographical characteristics of the region have been greatly overshadowed. South of Miami, in Miami-Dade County, this coastal area widens as the Everglades bends to the west to include urban areas and agricultural areas that extend almost to the southern coast. Miami-Dade County's agricultural industry covers more than 83,000 acres in the southwest of the coastal metropolitan area. Vegetables, tropical fruits, and nursery plants are grown in this area.

1.3.7 Biscayne Bay

Biscayne Bay is a shallow, tidal sound located near the extreme southeastern part of Florida. Biscayne Bay, its tributaries and Card Sound are designated by the state of Florida as aquatic preserves, while Card and Barnes sounds are part of the Florida Keys National Marine Sanctuary. A significant portion of the central and southern portions of Biscayne Bay comprise Biscayne National Park.

The original areal extent of Biscayne Bay approximated 300 square miles, but it has since undergone major areal modifications, particularly in its northern portions, as a result of development. The bay extends about 55 miles in a south-southwesterly direction from Dumfoundling Bay on the north to Barnes Sound on the south. It varies in width from less than 1 mile in the vicinity of the Atlantic Intracoastal Waterway passage to Dumfoundling Bay, to about 10 miles between the mainland and the Safety Valve Shoals to the east.

While there has been extensive dredging and filling within northern Biscayne Bay, the area still supports a productive and healthy seagrass bed and a few tracts of natural shoreline remain. Northern Biscayne Bay's headwaters are now considered to include dredged areas known as Maule Lake and Dumfoundling Bay, near the northern boundary of Miami-Dade County.

Central and, in particular, southern Biscayne Bay have been impacted less by development than northern Bay. For instance, mangrove-lined coastal wetlands extend from Matheson Hammock Park south along the entire shoreline of Biscayne National Park, Card and Barnes Sounds, a distance of approximately 30 miles. These coastal wetlands are the largest tract of undeveloped wetlands remaining in south Florida outside of Everglades National Park, the Big Cypress Preserve, and the Water Conservation Areas.

Biscayne National Park, in southern Biscayne Bay was established in 1980 to protect and preserve this nationally significant marine ecosystem consisting of mangrove shorelines, a shallow bay, undeveloped islands, and living coral reefs. The park is 180,000 acres in size and 95 percent water. The shoreline of southern Biscayne Bay is lined with a forest of mangroves and the bay bottom is covered with dense seagrass beds. The park has been designated a sanctuary for the Florida spiny lobster. Biscayne Bay and Biscayne National Park support a multitude of marine wildlife such as lobster, shrimp, fish, sea turtles, and manatees. The coral reefs within the Biscayne National Park support a diverse community of marine plant and wildlife.

Depending upon the flood stages reached, all C&SF Project canals in adjacent Miami-Dade County can carry floodwaters to Biscayne Bay. However, much of the time, discharges from project canals represent primarily runoff or seepage from within the flood protected area of the county. These flows originate in the extensive networks of secondary drainage canals and storm sewers that discharge into the project canals. Supplementing the complex system of project canals and secondary drainage systems are many hundreds of other stormwater drainage canals and storm sewer outfalls within Miami-Dade County that discharge freshwater directly into Biscayne Bay.

1.3.8 Everglades National Park

Everglades National Park encompasses 2,353 square miles of wetlands, uplands, and submerged lands at the southern end of the Florida peninsula. The topography is extremely low and flat, with most of the area below four feet NGVD. The highest elevations are found in the northeastern section of the park and are from six to seven feet NGVD. The saline wetlands, including mangrove and buttonwood forests, salt marshes, and coastal prairie that fringe the coastline are subject to the influence of salinity from tidal action.

Everglades National Park, authorized by Congress in 1934 and established in 1947, was established to protect the unique tropical biological resources of the southern Everglades ecosystem. It was the first national park to be established to preserve purely biological (vs. geological) resources. The park's authorizing legislation mandated that it be managed as "…wilderness, [where] no development… or plan for the entertainment of visitors shall be undertaken which will interfere with the preservation intact of the unique flora and fauna and the essential primitive natural condition now prevailing in this area." This mandate to preserve wilderness is one of the strongest in the legislative history of the National Park System.

Everglades National Park has been recognized for its importance, both as a natural and cultural resource as well as for its recreational value, by the international community and the national and state government. At the international level, the park is a World Heritage Site, an International Biosphere Reserve, and a Wetland of International Significance. In 1978, Congress designated much of the park, (86%) as Wilderness under the Wilderness Act of 1964. In 1997, this area was redesignated the Marjory Stoneman Douglas Wilderness. Hell's Bay Canoe Trail and the Wilderness waterway are designated National Trails. The State of Florida has designated the Park an Outstanding Florida Water.

The Park preserves a unique landscape where the temperate zone meets the subtropics, blending the wildlife and vegetation of both. The landscape includes sawgrass sloughs, tropical hardwood hammocks, offshore coral reefs, mangrove forests, lakes, ponds, and bays, providing habitat for dozens of threatened and endangered species of plants and animals. It is the largest designated wilderness, at 1,296,500 acres, east of the Rocky Mountains. It protects the largest continuous stand of sawgrass prairie in North America, the most significant breeding grounds for tropical wading birds in North America, over 230,100 acres of mangrove forest (the largest in the western hemisphere), a nationally significant estuarine complex in Florida Bay and significant ethnographic resources, revealing 2,000 years of human occupation.

1.3.9 Florida Bay, Whitewater Bay, and the Ten Thousand Islands

Florida Bay and the Ten Thousand Islands comprise 1,500 square miles of Everglades National Park. The bay is shallow, with an average depth of less than three feet. To the north is the Florida mainland and to the south lie the Florida Keys. Sheet flow across marl prairies of the southern Everglades and 20 creek systems fed by Taylor Slough and the C-111 Canal provide direct inflow of fresh surface water and groundwater recharge. Surface water from Shark River Slough, the sub-region's largest drainage feature, flows into Whitewater Bay and also may provide essential groundwater recharge for central and western Florida Bay. Exchange with Florida Bay occurs as this lower salinity water mass flows around Cape Sable into the western subregion of the bay.

1.3.10 Florida Keys

The Florida Keys are a limestone island archipelago extending southwest over 200 miles from the southern tip of the Florida mainland to the Dry Tortugas, 63 miles west of Key West. They are bounded on the north and west by the relatively shallow waters of Biscayne Bay, Barnes and Blackwater Sounds, Florida Bay - all areas of extensive mud shoals and seagrass beds – and the Gulf of Mexico. Hawk Channel lies to the south, between the mainland Keys and an extensive reef tract 5 miles offshore. The Straits of Florida lie beyond the reef, separating the Keys from Cuba and the Bahamas.

The Keys are made up of over 1,700 islands encompassing approximately 103 square miles. They are broad, with little relief, have a shoreline length of 1,865 miles, and are inhabited from Soldier Key to Key West. Key Largo and Big Pine Key are the largest islands. The Keys are frequently divided into three regions: 1) the Upper Keys, north of Upper Matecumbe Key; 2) the Middle Keys, from Upper Matecumbe Key to the Seven Mile Bridge; and 3) the Lower Keys, from Little Duck Key to Key West.

The Florida Keys National Marine Sanctuary encompasses approximately 3,668 square miles of submerged lands and waters between the southern tip of Key Biscayne and the Dry Tortugas Bank. North of Key Largo it includes Barnes and Card Sounds, and to the east and south the oceanic boundary is the 300-foot isobath. The Sanctuary also contains part of Florida Bay and the entire Florida Reef Tract, the largest reef system in the continental United States. The Sanctuary contains components of five distinct physiographic regions: Florida Bay, the Southwest Continental Shelf, the Florida Reef Tract, the Florida Keys, and the Straits of Florida. The regions are environmentally and lithologically unique, and together they form the framework for the Sanctuary's diverse terrestrial and aquatic habitats.

1.3.11 Florida Reef Tract

The Florida Reef Tract is an arcuate band of living coral reefs paralleling the Keys. The reefs are located on a narrow shelf that drops off into the Straits of Florida. The shelf slopes seaward at a 0.06 degree angle into Hawk Channel, which is several miles wide and averages 50 feet deep. From Hawk Channel, the shelf slopes upward to a shallower area containing numerous patch reefs. The outer edge is marked by a series of bank reefs and sand banks that are subject to open tidal exchange with the Atlantic. The warm, clear, naturally low-nutrient waters in this region are conducive to reef development.

1.3.12 Big Cypress Basin

Big Cypress Swamp spans approximately 1,205 square miles (771,000 acres) from southwest of Lake Okeechobee to the Ten Thousand Islands in the Gulf of Mexico. The 570,000-acre Big Cypress National Preserve was established by *Public Law 93-440* in 1974 to protect natural and recreational values of the Big Cypress watershed and to allow for continued traditional uses such as hunting, fishing, and oil and gas production. It was also established to provide an ecological buffer zone and protect Everglades National Park's water supply. In 1988, Congress passed the *Big Cypress National Preserve Addition Act* which will add 146,000 acres to the preserve.

1.3.13 Lower West Coast

The Lower West Coast region covers approximately 4,000 square miles in Lee, Hendry, Glades, and Collier Counties and a portion of Charlotte County. This area is generally bounded by Charlotte County to the north, Lake Okeechobee and the Everglades Agricultural Area to the east, the Big Cypress National Preserve to the south, and the Gulf of Mexico to the west. The area is characterized by the sandy flatlands region of Lee County, which give way to sandy though more rolling terrain in Hendry County; and the coastal marshes and mangrove swamps of Collier County.

The Caloosahatchee River sub-watershed includes an area of 550,900 acres in parts of Lee, Glades, Charlotte, and Hendry Counties. From a hurricane gate on the southwest shore of Lake Okeechobee at Moore Haven, the Caloosahatchee Canal drains westerly for about five miles through a very flat terrain into Lake Hicpochee. From there the canal joins the upper reach of the Caloosahatchee River. On its way to the Gulf of Mexico, the river is controlled by navigation locks at Ortona (15 miles downstream from Moore Haven) and at Olga near Fort Myers. Downstream from Ortona Lock, many tributaries join the river along its course to the Gulf. The Caloosahatchee River serves as a portion of the cross-state Okeechobee Waterway, which extends from Stuart on the east coast via the St. Lucie Canal, through Lake Okeechobee and the Caloosahatchee River to Fort Myers on the Gulf of Mexico. The river has been straightened by channelization through most of its 65-mile course from the Moore Haven Lock to Fort Myers.

The J. N. "Ding" Darling National Wildlife Refuge Complex includes Pine Island NWR, Island Bay NWR, Matlacha Pass NWR, and Caloosahatchee NWR, all located on the lower west coast. The health of the estuarine ecosystem they embody is directly tied to the water quality, quantity and timing of flows from the Caloosahatchee watershed and those watersheds which drain into the Caloosahatchee River (i.e. Kissimmee River and Lake Okeechobee watersheds).

1.4 NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

The National Environmental Policy Act of 1969, as amended, is the nation's charter for environmental protection. The National Environmental Policy Act establishes policy, sets goals, and provides means for carrying out the policy. Section 102(2) of the Act contains action-forcing provisions to make sure that Federal agencies act according to the letter and spirit of the Act, including a provision to prepare a detailed statement - now called an Environmental Impact Statement - on the effects of a proposed Federal action. The Federal regulations for implementing the procedural provisions of the National Environmental Policy Act were published by the Council on Environmental Quality in the Code of Federal

Regulations (CFR) as 40 CFR Parts 1500-1508 (43 Federal Register 55978-56007, November 29, 1978).

This report documents the Corps study of modifications to the C&SF Project to restore the south Florida ecosystem while providing for the other water-related needs of the region in compliance with the National Environmental Policy Act requirements. It employs two concepts established in the Council on Environmental Quality's National Environmental Policy Act regulations - integration and tiering - that are not frequently used, but are appropriate to the planning and design process and schedule for modifications to the C&SF Project that result from the Restudy.

Integration is based on the Council on Environmental Quality provision to combine documents, which states that *"any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork"* (40 CFR 1506.4). The Corps regulations permit an Environmental Impact Statement ("environmental document") to be either a self-standing document combined with and bound within a feasibility report ("agency document"), or an integration of National Environmental Policy Act-required discussions in the text of the report. In view of the ecosystem restoration aspect of the C&SF Project Restudy, and to reduce paperwork and redundancies, and consolidate documentation into one consistent report, the Corps elected to integrate discussions that normally would appear in an Environmental Impact Statement into the feasibility report. Sections in this integrated report that include National Environmental Policy Act-required discussions are marked with an asterisk in the Table of Contents to assist readers in identifying such material.

Tiering was established by the Council on Environmental Quality to provide *"coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basin-wide program statements or ultimately site-specific statements).... Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review"* (40 CFR 1508.28 and 1502.20). Tiering has been applied to proposed Federal actions for modifying the C&SF Project as follows:

> *This document is a Programmatic Environmental Impact Statement, which addresses at a general level, the alternatives and environmental effects of the overall project, to the affected environment. Due to the conceptual nature of the Comprehensive Plan and the associated uncertainties, many subsequent site-specific environmental documents will be required for the individual separable project elements. These documents will be either Supplemental Environmental Impact Statements or Environmental Assessments building upon this integrated document, and addressing the individual project separable elements in sufficient detail for final*

decision making and for full compliance with the National Environmental Policy Act requirements.

1.5 STUDY PROCESS

Because of the public, political, and media interest in the restoration of the south Florida ecosystem, the process used to accomplish this study was considered carefully. At the inception of the reconnaissance study in 1993, it was recognized that a “not business as usual” approach was needed to successfully manage and accomplish a system-wide study that addresses all of the water resource problems and opportunities in the region. This approach was continued in the feasibility phase of the Restudy.

Accomplishment of this feasibility study was primarily the responsibility of the Corps of Engineers, Jacksonville District, and the non-Federal cost sharing partner, the South Florida Water Management District. The Restudy Team consisted of an interdisciplinary/interagency professional staff drawn from the technical disciplines necessary to accomplish the study. In February 1995, the Governing Board of the South Florida Water Management District adopted a resolution directing staff to further develop its strong interagency coordination effort to ensure that the South Florida Water Management District’s water supply planning efforts and the Restudy were consistent and cohesive. In furtherance of this resolution, key members of the South Florida Water Management District’s Lower East Coast Regional Water Supply Planning Team joined the Restudy Team to maximize the integration of these processes.

A multiagency approach was used to staff the Restudy Team due to the complexity of the problems to be considered and the continued desire to utilize the skills of specialists in other agencies. Multiagency staffing was essential to facilitate the flow of needed information among agencies, and, more importantly, to achieve approval and ownership by the key public agency stakeholders. This multi-agency approach also fits into the cooperative spirit fostered by the South Florida Ecosystem Restoration Task Force and the Governor’s Commission for a Sustainable South Florida discussed in other sections of this report. The Restudy Team included personnel from other Federal agencies such as the National Park Service, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the United States Geologic Survey, the Natural Resources Conservation Service, and the U.S. Environmental Protection Agency. Tribal participation included the Seminole and Miccosukee Tribes. State agency participation included the Florida Game and Fresh Water Fish Commission, the Florida Department of Environmental Protection, and the Florida Department of Agriculture and Consumer Services. Local governments including Miami-Dade County, Broward County, Palm Beach County, Martin County and Lee County also participated.

1.6 THE CENTRAL AND SOUTHERN FLORIDA PROJECT

In 1947, 100 inches of rain fell on south Florida, more than tripling the region's total rainfall for 1945 and ending one of the worst droughts in Florida history. In a few weeks, the rain had drenched farmland and filled lakes and canals. Then in the space of just 25 days, two hurricanes and a tropical disturbance dumped more water on an already saturated area. When the rains finally ceased, 90 percent of southeastern Florida, from Orlando to the Keys, was under water. The Corps estimated the total damage of this disaster at more than $59,000,000.

Following the disastrous flood in 1947, the problems of the area came to a climax. This flood, coupled with the experiences of the drought in 1945 and the intrusion of saltwater into the aquifer made it imperative that immediate corrective action be started. These actions were needed to prevent further loss of life and damage to property because of floods, and to conserve water for beneficial uses during periods of drought.

Acting upon the requests of many local agencies concerned with flood control and water conservation, and under the authority of various flood control acts, river and harbor acts of Congress, and resolutions of appropriate congressional committees, the Corps' Jacksonville District conducted public hearings throughout the area to determine the desires of the many local interests and to collect data from which to formulate a plan.

Views expressed during the public hearings stated that the problems were too large and complex for the capabilities of either the State of Florida or local agencies acting alone, therefore making it practically impossible for either to draft a plan that would be satisfactory to all. A Comprehensive Plan for flood control and water conservation, which would encompass the entire area, while satisfying the major needs expressed by the various agencies, would be beneficial to the greatest number and to the largest portion of the area, and be performed by the Federal government, with local cooperation, seemed to offer the best solution.

A comprehensive report was prepared by the Corps and submitted to higher authority on December 19, 1947. This report stated that the problems of flood protection, drainage, and water control were considered to be physically inter-related, and that the St. Johns, Kissimmee, Lake Okeechobee, Caloosahatchee, and Everglades drainage areas all formed a single economic unit. Accordingly, it recommended a comprehensive program in the interest of *"flood control, drainage and related purposes."*

Congress approved the plan as part of the *Flood Control Act of June 30, 1948*, and the report was published in *House Document No. 643, 80th Congress, Second*

Session. The basic purpose of the overall Central and Southern Florida Flood Control Project, quoted from *House Document No. 643,* reads:

> *"In its natural state the part of central and southern Florida considered in this report was a vast wilderness of water, forest, prairie, and marshland. The forces of nature had combined to establish a fine balance which supported the vegetable, animal and human life that prevailed and resulted in building up the land to the condition in which white man first found it. A large part of this land, the Everglades, was still in a formative stage when its development began. The inherent fertility of the area and its resources made its development and use inevitable. This development, however, resulted in physical changes which altered the natural balance between water and soil, and much of the development was undertaken without any real knowledge of the area or of the hazards involved. The parched prairies and burning mucklands of the Everglades in 1945, the flooding of thousands of acres of farms and communities in 1947, and the intrusion of salt water into land water supplies of the east coast are basically the results of altering the balance of natural forces. The basic problem of this area is, therefore, to restore the natural balance between soil and water in this area insofar as possible by establishing protective works, controls, and procedures for conservation and use of water and land."*

The Governor of Florida approved the plan for the State of Florida in February 1948. The following year, the Florida State Legislature formed the Central and Southern Florida Flood Control District, later to become the South Florida Water Management District, to act as a single agency with which the Federal government could deal on all matters of local cooperation.

The C&SF Project, first phase, was authorized by the *Flood Control Act of June 30, 1948* for the purposes of flood control, water level control, water conservation, prevention of salt water intrusion, and preservation of fish and wildlife. The first phase consisted of most of the works necessary to afford flood protection to the agricultural development south of Lake Okeechobee and to the highly developed urban area along the Lower East Coast of the State. The second phase, consisting of all remaining works of the original *Comprehensive Plan*, was authorized by the *Flood Control Act of September 3, 1954.*

Improvements in Hendry County and Nicodemus Slough (just west of Lake Okeechobee) were added to the project by the *Flood Control Acts of July 3, 1958, and July 14, 1960,* respectively. Improvements in Boggy Creek, Cutler Drain Area, Shingle Creek, South Miami-Dade County, and West Palm Beach Canal were added to the project by the *Flood Control Act of October 23, 1962*. Improvements in southwest Miami-Dade County were added to the project by the *Flood Control Act of October 27, 1965*; the same act also modified the 1958 authorization for the Hendry County improvements.

The Flood Control Act of 1968 expanded the project to provide for increased storage and conservation of water and for improved distribution of water throughout much of the project area and added recreation as a project purpose. Flood control measures for Martin County were added. The 1968 modifications would also facilitate increased delivery of water to Everglades National Park.

Section 2 of Public Law 91-282 enacted June 19, 1970, authorized appropriations for the Corps to accelerate:

> *"construction of borrow canal L-70, canal C-308, canal C-119W, and pumping station S-326, together with such other works in the plan of improvement as the Director of the National Park Service and the Chief of Engineers agree are necessary to meet the water requirements of the Everglades National Park: Provided further, That as soon as practicable and in any event upon completion of the works specified in the preceding proviso, delivery of water from the central and southern Florida project to the Everglades National Park shall be not less than 315,000 acre-feet annually, prorated according to the monthly schedule set forth in the National Park Service letter of October 20, 1967, to the Office of the Chief of Engineers, or 16.5 per centum of total deliveries from the project for all purposes including the park, whichever is less."*

Section 104 of the Everglades National Park Protection and Expansion Act of 1989 (Public Law 101-229) directed the Corps:

> *"to construct modifications to the Central and Southern Florida Project to improve water deliveries into the park and shall, to the extent practicable, take steps to restore the natural hydrological conditions within the park."*

The *Water Resources Development Act of 1992* (Public Law 102-580) authorized modifications to the C&SF Project for ecosystem restoration of the Kissimmee River. Both the Kissimmee River Restoration and the Headwaters Revitalization Projects were authorized.

The authorizing acts require that local interests provide all lands, easements, and rights-of-way; pay for relocations of highways (with certain exceptions), highway bridges, and public utilities which may be required for construction of project works; hold and save the United States free from damages resulting from construction and operation of the works; maintain and operate all works (except certain major regulating structures) after completion and make a cash contribution for each part of the work prior to its initiation.

Construction of the Federal project was began in January 1950. The project provides for an east coast protective levee extending from the Homestead area north to the eastern shore of Lake Okeechobee near the St. Lucie Canal. There are three conservation areas for water impoundment in the Everglades area, west of the east coast protective levee, with control structures to transfer water as necessary. There are also local protective works along the Lower East Coast with an encirclement of the Lake Okeechobee agricultural area by levees and canals. Enlargement of portions of the Miami, North New River, Hillsboro, and West Palm Beach Canals and existing Lake Okeechobee levees are part of the project. Also included are construction of new levees on the northeast and northwest shores of Lake Okeechobee; increased outlet capacity for improved control of Lake Okeechobee; floodway channels in the Kissimmee River Basin, with suitable control structures to prevent overdrainage; and facilities for regulation of floods in the Upper St. Johns River Basin.

The project also provides water control and protection from the recurrence of flood waters for the highly developed urban area along the Lower East Coast of Florida and for the agricultural areas around Lake Okeechobee (including the towns around the lake), in the Upper St. Johns and Kissimmee River Basins, and in south Miami-Dade County. Another project function is the conservation of flood waters for beneficial uses during dry seasons. In accordance with *Public Laws 91-282 and 101-229*, the project also delivers water to Everglades National Park according to a set schedule.

The Corps operates and maintains project works on the St. Lucie Canal; Caloosahatchee River; Lake Okeechobee levees, channels, locks, and major spillways; and the main outlets for Water Conservation Areas 1, 2A, and 3A. The South Florida Water Management District operates the remainder of the project in accordance with regulations prescribed by the Corps. The non-Federal sponsor has an essential role with the Corps in developing water management criteria for the C&SF Project. The non-Federal sponsor is responsible for allocation of water from project storage, except where mandated by Federal law.

1.7 OTHER STUDIES, REPORTS, AND PROJECTS

1.7.1 C&SF Project Authorizations

As noted in the previous section, since its initial authorization in 1948, there have been a number of additional authorizations that have modified the C&SF Project. These authorizations to the project were based on many studies conducted by the Corps. In addition, a number of discretionary changes have been made to the authorized project features in accordance with the discretionary authority granted to the Chief of Engineers by Congress. ***Appendix L - Prior Studies, Reports, and Projects*** provides a detailed description of all the modifications to the project. ***Table 1-1*** summarizes the project authorizations and the project purposes added or modified by these authorizations.

TABLE 1-1
C&SF PROJECT AUTHORITIES

PROJECT PURPOSE	1948 PL 80-858	1954 PL 83-780	1958 PL 85-500	1960 PL 86-645	1962 PL 87-874	1965 PL 89-298	1968 PL 90-483	1970 PL 91-282	1970 HD 91-394	1983 PL 98-181	1988 PL 100-676	1989 PL 101-229	1992 PL 102-580	1996 PL 104-303
Flood Control	X	X	X	X	X	X	X			X		X		X
Drainage/Water Control	X	X	X	X	X	X	X							
Groundwater Recharge	X	X			X	X								
Salinity Intrusion	X	X			X		X							
Everglades National Park Water Supply	X	X					X	X		X		X		X
Fish/Wildlife Preservation	X	X	X		X		X							
Navigation	X	X					X		X					
Water Supply	X	X					X							
Environmental Protection/ Restoration											X	X	X	X
Recreation	X				X		X							
Irrigation							X							
Hydrologic Ecosystem Model											X			

PL 80-858 - Flood Control Act of 1948
PL 83-780 - Flood Control Act of 1954
PL 85-500 - Flood Control Act of 1958
PL 86-645 - Flood Control Act of 1960
PL 87-874 - Flood Control Act of 1962
PL 89-298 - Flood Control Act of 1965
PL 90-483 - Flood Control Act of 1968
PL 91-282 - River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970
HD 91-394 - Central and Southern Florida Small-Boat Navigation (Authorized under Section 201 of the Flood Control Act of 1965)
PL 98-181 - Supplemental Appropriations Act, 1984
PL 100-676 - Water Resources Development Act of 1988
PL 101-229 - Everglades National Park Protection and Expansion Act of 1989
PL 102-580 - Water Resources Development Act of 1992 modifications to the project.
PL 104-303 – Water Resources Development Act of 1996.
Table 1-1 summarizes the project authorizations and the project purposes added or modified by these authorizations.

1.7.2 Other Studies

There are a number of ongoing studies being conducted by the Corps and other agencies that may contribute to restoration of the south Florida ecosystem. Some of the major efforts are discussed in this section.

The Corps is currently conducting a feasibility study of Biscayne Bay in order to investigate effects on water circulation, biological communities, and water quality of dredging and filling, spoil islands, and freshwater inputs in northern Biscayne Bay from existing Federal canals. The study would propose solutions to alleviate adverse factors affecting the bay and help to develop guidelines for future management of Biscayne Bay's natural resources. The non-Federal sponsor is Miami-Dade County.

The South Florida Ecosystem Restoration Task Force observed that the restoration effort needed to be founded on scientific information and mandated that it take an ecosystem approach. In support of this effort, the Science Sub-Group completed a report in 1996 entitled South Florida Ecosystem Restoration Scientific Information Needs (Science Subgroup, 1996), which provides information in support of the ecosystem approach. It was the first step in the development of an ecosystem-based South Florida Comprehensive Science Plan that includes monitoring and modeling. The Science Coordination Team (formerly the Science Sub-group) is in the process of developing a science plan to supply the information needs for ecosystem restoration.

The science plan developed by the Florida Bay Interagency Working Group, initiated by Everglades National Park in January 1993, focused upon the research, monitoring, and modeling objectives that must be addressed to guide the restoration of Florida Bay. It represents a synthesis of research plans prepared over past years by several Federal and state agencies. This science plan will serve as the basis for restoration of the Florida Bay portions of Sub-regions 3 and 6 under the aegis of the South Florida Ecosystem Restoration Task Force.

The South Florida Water Management District has undertaken the development of regional and sub-regional level water supply plans to provide for better management of south Florida's water resources. The Lower West Coast Water Supply Plan was completed in February 1994 (SFWMD, 1994b). The Interim Plan for Lower East Coast Regional Water Supply (SFWMD, 1998d), which addresses water-related needs and concerns of southeastern Florida through the year 2010, and the Upper East Coast Water Supply Plan (SFWMD, 1998b), which evaluates future 2020 water demands and supplies for the Upper East Coast of Florida were completed in 1998. A Lower East Coast Plan with a 2010 horizon will be developed by April 2000.

SECTION 2
PRE-DRAINAGE CONDITION

This section provides an overall characterization of the conditions that existed in the south Florida ecosystem prior to drainage and development activities. A significant portion of the information in this section (portions of subsection 2.1 and most of subsections 2.2, 2.3, and 2.4) is taken directly from the Science Sub-Group Report (1993) which was undertaken to provide information to the Corps of Engineers to assist in the reconnaissance study. It is important to understand how the pre-drainage south Florida ecosystem functioned in order to understand how natural system functioning has been impacted. This section also provides an overview of historic water quality conditions in the study area.

2.1 INTRODUCTION

The pre-drainage wetlands of southern Florida covered an area estimated at approximately 8.9 million acres. This region was a complex system of hydrologically interrelated landscapes, including extensive areas of ridge and slough landscape and sawgrass plains, as well as, cypress swamps, mangrove swamps, and coastal lagoons and bays. Prior to drainage, the characteristics of this network of wetland landscapes could be described by a set of physical and ecological features that were present across regional scales, and which gave definition to these ecosystems. It was the defining physical characteristics of this region that provided the spatial and temporal framework necessary for the existence of the components and relationships that defined the ecological characteristics of these southern Florida wetlands.

As a result of land use and water management practices during the past 100 years, the regional wetlands of southern Florida either have been lost or have been substantially altered. It is the premise of the Restudy that an understanding of these defining characteristics, and the factors which caused their loss or alteration, provide focus for setting restoration goals and priorities for the southern Florida wetlands. While it is true that the pre-drainage wetlands can not be fully restored, a successful restoration program will be one that recovers to the extent possible these defining characteristics of the former system. Achievement of this goal should result in the recovery of ecologically viable systems that functionally resemble the pre-drainage Everglades and its interrelated wetland systems.

The fundamental tenet of south Florida ecosystem restoration is that hydrologic restoration is a necessary starting point for ecological restoration. Water built the south Florida ecosystem. Water management changes have adversely affected this ecosystem. Restoration begins with the reinstatement of the natural distribution of water in space and time. The spatial extent of the hydrologically restored area is critical to ecological restoration. Water quality improvement must be an integral part of all hydrologic restoration. The focus is on the wetlands because the greater part of the pre-drainage south Florida ecosystem was wet.

2.2 DESCRIPTION OF THE NATURAL SYSTEM

The study area encompasses approximately 18,000 square miles comprising at least 11 major physiographic provinces, including the Everglades, the Big Cypress, Lake Okeechobee, Florida Bay, Biscayne Bay, the Florida Reef Tract, nearshore coastal waters, the Atlantic Coastal Ridge, the Florida Keys, the Immokalee Rise, and the Kissimmee River Valley. The watersheds of the Kissimmee River, Lake Okeechobee, and the Everglades dominate the system. The system functions as an interconnected mosaic of wetlands, uplands, coastal areas, and marine areas. Wetlands dominated the pre-drainage landscape. Prior to drainage, wetlands covered most of central and southern Florida. The Everglades region was characterized by an extremely low gradient (1 - 2 inches/mile), yet heterogeneous landscape mosaic sculpted by 5,000 years of evolution of hydrologic and biologic forces on a Pleistocene limestone platform. The 1850 era military map (Ives, 1856), which defines the "pre-drainage" system discussed in the Science Sub-Group Report (1993), gives some indication of the pre-drainage hydrologic structure and elevation in the study area.

2.3 FUNDAMENTAL CHARACTERISTICS OF THE PRE-DRAINAGE SYSTEM

The pre-drainage wetland landscapes consisted of swamp forest; sawgrass plains; mosaics of sawgrass, tree islands, and sloughs dominated by *Nymphaea*; marl-forming prairies and cypress strands. The upland landscapes consisted of pine flatwoods, pine rocklands, tropical hardwood hammocks, and xeric hammocks dominated by oaks. The natural seascapes of south Florida consisted of shallow seagrass beds, riverine and fringe mangrove forests, intertidal flats, coral reefs, hard bottom communities, mud banks, and shallow, open inshore waters. These were all interconnected on a topographic gradient that ranged from about 20 feet NGVD at Lake Okeechobee to below sea level at Florida Bay.

The pre-drainage wetland ecosystems of south Florida had three essential characteristics:

- A hydrologic regime that featured dynamic storage and sheet flow
- Large spatial scale, and
- Heterogeneity in habitat.

2.3.1 Dynamic Storage and Sheet Flow

The structure contributing to dynamic storage included the very shallow elevation gradient, the vast expanses of emergent vegetation, the thick peat substrates, sand hills, and highly permeable limestones. The water masses were constantly progressing downslope but so slowly that, in effect, water was stored in the system during one season to use in the next season. Transportion of water masses within a structural element varied from a number of months to a number of years.

Throughout the system, groundwater seepage, driven by hydraulic gradients, provided the base flow of creeks, rivers, and possibly even surface runoff across the mangrove zone. Base flow is the river or stream flow provided entirely by seepage from groundwater sources. For example, in the Kissimmee River in the upper part of the watershed, prior to drainage and channelization, 80 percent of annual river flow was base flow (Burns, 1975; Burns and Taylor, 1979).

The all-important extended hydroperiods of the natural system depended more on the large dynamic storage capacity and delayed flow-through that were natural hydrologic features of this system than on the immediate effects of rainfall. Because of the dynamic storage and slow rate of water flow throughout the natural system, wet season rainfall kept the wetlands flooded and maintained freshwater flow to the estuaries well into the dry season. The carry-over effect of the enormous dynamic storage capacity of the natural system was so great that a year of high rainfall maintained surface water in wetlands and freshwater flow to estuaries even into one or more subsequent drought years (Walters et al., 1992; Fennema et al., 1994; Browder, 1976). The dynamic storage made wetlands and estuaries less vulnerable to south Florida's spatially and temporally variable rainfall.

2.3.2 Large Spatial Scale

The vastness of the pre-drainage wetland extent made it possible for the natural ecosystem to: (1) support genetically viable numbers and sub-populations of species with large feeding ranges or narrow habitat requirements, (2) provide the aquatic production to support large numbers of higher vertebrate animals in a naturally nutrient-poor environment, and (3) sustain habitat diversity through natural disturbance. Population resiliency is undoubtedly proportional to the area of these wetlands because habitat diversity, the amount of seasonal refugia, and the number of dispersal options are proportional to wetland area.

In the pre-drainage era, the nutrients that were the basis of primary production were derived principally from rainfall. The nutrients in water entering from upstream were scrubbed by the vegetation and soils and not available downstream. Sheet flow enhanced the uptake of nutrients from the water column.

The periphyton community, made up of microscopic algae, not only assimilated available nutrients from the water column but also created an environment that precipitated phosphorus, along with calcium carbonate, into the substrate. The system was extremely oligotrophic, given the nutrient loading, spread over the entire areal extent. During seasonal dry-down, topographic depressions (e.g., alligator holes) became areas of concentrated aquatic biomass, producing localized feeding opportunities for large carnivores, including wading birds. The higher vegetation, as well as the periphyton, had adaptations for surviving under low nutrient conditions.

2.3.3 Heterogeneity in Habitat

Habitat heterogeneity maintained by micro-topographic features, small-scale climatic variation, and natural disturbances such as freezes, fire, and storms, acting on the large spatial scale of the wetlands, was a major contributor to biotic diversity and the persistence of populations. The mosaic of habitat types and water depths provided the spatial framework for the production and survival of animals under a wide seasonal and annual range of hydrologic conditions.

The vegetative landscape resulting from this vast, low relief, low gradient landform was a diverse mosaic of plant communities. These communities varied in extent from patches on the order of tens of meters to areas approaching physiographic provinces. The larger expanses had more long-term resiliency than the patches. Large spaces were necessary to maintain resiliency under conditions that changed on scales from seasons to decades. To some extent, maps from the 1800s, when compared with maps of the 1980s, reveal large scale persistence of landscape patterns, even in the face of major anthropogenic disturbance.

2.4 RELATIONSHIPS WITH SPATIAL AND TEMPORAL VARIATION

The diverse and large number of aquatic biota that these systems once supported were maintained by the complex annual and long-term hydrologic patterns of the natural system, as expressed in wet-dry cycles, drying and flooding rates, surface water and water depth patterns, annual hydroperiods, flow volumes, and, at the coast, salinity and mixing patterns. For most animals, annual patterns of production, dispersal, and survival were seasonally regulated by the annual periodicity of wet-dry cycles and by the rates of drying and flooding. Primary and secondary production, including that in the key periphyton communities, depended on depth and duration of surface water.

The production of food for consumption by larger predators was largely a function of surface water area and flooding duration during the annual wet period. Food availability was then determined by the amount of forage produced and the rate and degree that it became concentrated into a smaller space during the annual dry season. The distribution and persistence of large animal populations was further influenced by the seasonal patterns of surface water distributions and, in the coastal wetlands and estuaries, salinity patterns, superimposed over major habitat, or plant community, patterns. For example, large, historic wading bird nesting colonies were once clustered in wetlands adjacent to estuaries, presumably because the prey base for these birds was greatest and most reliable at the estuarine/freshwater interface.

Colonial wading birds were extremely abundant in pre-drainage south Florida and were conspicuously present even into the 1960s and, to a lesser extent, the 1970s. Wood storks, White ibis, Great and Snowy egrets, and other species nested in vast numbers in mangrove swamps along the southern rim of the Everglades and at various interior locations, particularly Corkscrew Swamp in southwest Florida and along the Kissimmee River. Other large predators such as alligator, panther, and bear were common. Fish such as snook, tarpon, sea trout, and red drum were abundant in the estuaries. The Florida Reef Tract supported a healthy living coral reef and a rich diversity of associated fish and other organisms, including snappers, groupers, and spiny lobster.

The estuaries of south Florida had salinity concentrations naturally ranging from about 18 parts per thousand to 36 parts per thousand or slightly greater and lower salinity concentrations (0-18 parts per thousand) in the mangrove zone. These estuaries were naturally well mixed, rather than stratified. They had horizontal salinity gradients, with salinity increasing in an offshore direction and a lower salinity range throughout the estuary during the wet season. Parts of the more enclosed estuaries may have infrequently experienced salinity concentrations of between 36 and 40 parts per thousand during the dry season. The estuaries received freshwater across a broad front, flowing across the mangrove zone, as well as from creeks and rivers, which provided some freshwater inflow throughout the year.

Salinity shifted gradually from high flow to low flow conditions because of the enormous dynamic storage capacity of the upstream system. Shallow, oligotrophic waters promoted the growth of seagrass beds, which supported a resident fauna and the juveniles of many species that spawn offshore but depended upon estuarine nursery grounds. The prop roots of mangroves lining the estuaries and tidal creeks also provided habitat for estuarine life. Schooling coastal migratory species such as Spanish mackerel, bluefish, and pompano entered the estuaries during higher salinity times of the year.

2.5 OVERVIEW OF HISTORIC WATER QUALITY CONDITIONS

The following is a summary of the water quality conditions believed to exist within the study area prior to all historic drainage activities. For a more detailed discussion of the pre-drainage water quality see ***Appendix H: Water Quality, Attachment E: Overview of Historic Water Quality Conditions***.

Prior to efforts to drain portions of the Kissimmee River-Lake Okeechobee-Everglades system in the early 1880's, water quality conditions in this 18,000 square mile wilderness watershed were undisturbed and considered pristine. Over the past 120 years, efforts to drain, dike and convert wetlands and watercourses for urban and agricultural uses throughout the watershed, have resulted in substantial degradation to water quality conditions across the fresh water lakes and marshes, estuaries and coastal marine environments of the area.

2.5.1 Kissimmee River Basin

The general land elevation in the Upper Kissimmee River Basin headwaters area is about 100 feet NGVD. Historic water flows across this area were likely slow and seasonal with surface sheet flows highest during the annual wet season. Due to the long residence time of surface and ground waters in contact with the moist sandy and organic soils, water quality conditions were likely low in dissolved nutrients, high in color with a strong diel dissolved oxygen pattern. Historically, the Kissimmee River flowed south from Lake Kissimmee to Lake Okeechobee over a 98-mile long, shallow, sluggish meandering path with water depths of one to two feet in many locations. An extensive 50,000-acre wetland floodplain moderated high water and wet season flows and sequestered nutrients and sediments before releasing water flows to Lake Okeechobee.

2.5.2 Lake Okeechobee

Lake Okeechobee, a broad, shallow lake with average depths of nine feet, historically was much less eutrophic then its current water quality condition indicates. In the late 1800’s, Lake Okeechobee had a larger, more extensive wetland littoral zone along the shoreline which extended from the lake's northwestern and southern shorelines. In the late 1960’s and early 1970’s, total phosphorus concentrations as low as 50 parts per billion were measured in the Lake (Joyner, 1974). Currently total phosphorus concentrations in the lake have been measured in the 100 parts per billion range (James et al, 1995). It is likely that historic in-lake turbidity was much lower than current conditions as well.

Before the recent development of south Florida and construction of the C&SF Project, Lake Okeechobee had a larger pelagic zone, a littoral zone that extended nearly 20 kilometers to the west of the present lake shore, and the Lake was contiguous with the Florida Everglades to the south. Output from the District's "Natural Systems Model" indicates that lake levels fluctuated between 17 and 23 feet NGVD, as compared to today's fluctuations between 11 and 17 feet NGVD. In the natural system, these fluctuating water levels may have periodically flooded the exposed areas of an expansive, low gradient marsh. However, under both high and low conditions, there likely was abundant submerged and exposed habitat for fish and other wildlife. Today's Lake is constrained within a dike, and the much smaller littoral zone occurs on a sand-bottomed shelf between the dike and a relatively deep drop-off to open water. As a result, water levels above 15 feet NGVD flood the entire littoral region, leaving no habitat for wildlife that require exposed ground. When water levels are below 11 feet NGVD the entire marsh is dry, and not available as a habitat for fish and other aquatic life. During the years following construction of the Herbert Hoover Dike the Lake has experienced numerous occasions when water levels have been above 15 or below 11 feet NGVD for prolonged periods of time (Havens et al., 1996).

2.5.3 Upper East Coast

Prior to drainage activities, the St. Lucie River Basin and southern Indian River Lagoon area (Upper East Coast area) was a low, flat coastal region. It contained poorly drained sandy soil uplands intermixed with numerous scattered isolated freshwater wetlands grading to a broad, shallow coastal lagoon. Tidal flushing throughout the southern Indian River Lagoon was more limited historically and the lagoon waters would have exhibited a much lower salinity than current conditions. Historic lagoon substrates were dominated by freshwater plants rather then the current seagrasses. Water depths in the southern lagoon averaged only three to four feet and contained a luxuriant growth of rooted aquatic plants. The aquatic plants efficiently trapped dissolved and suspended particles and nutrients, and helped to maintain low turbidity in lagoon waters. The major freshwater inflows to the southern Indian River Lagoon were dominated by wet season flows from the St. Lucie River and the Loxahatchee River systems.

2.5.4 The Central Everglades

In the Central Everglades Basin, the Everglades ecosystem developed under extremely low rates of total phosphorus supply. Historically, nutrient inputs to Everglades marsh waters were derived primarily from atmospheric deposition of rainfall and dry fallout. Total phosphorus concentrations in rainfall to the Everglades marsh, in water column concentrations and throughout the central Everglades region was low, ranging from five to 10 parts per billion (McCormick et al., in preparation). Relative to other key water chemistry features, the interior Everglades marsh, Water Conservation Area 2 and 3, and Everglades National Park, were slightly basic and highly mineralized when compared to the northeastern Everglades region, Loxahatchee National Wildlife Refuge area. This northern region was slightly acidic and contained extremely low concentrations of major ions, a condition which reflects the rainfall-driven hydrology of the area (McCormick et al., in preparation). Concentrations of nitrogen and other macronutrients in interior Everglades surface waters were relatively high when compared to total phosphorus. These concentrations varied in the surface water from location to location within the Everglades. However, they would not generally be considered limiting compared with the extremely low total phosphorus concentrations in the Everglades marsh.

2.5.5 Lower East Coast and Biscayne Bay

Water quality conditions in the Lower East Coast would have varied considerably depending on salinity, substrate and nutrient input conditions; however, it can be inferred that water quality conditions were pristine simply because significant pollutant sources were non-existent. Coastal rivers were likely highly stained and low in nutrients while water quality conditions in the shallow freshwater coastal water bodies were likely nutrient poor with high color and low turbidity. Drainage and dredging activities in this area irrevocably and significantly modified salinity conditions in Lake Worth, a coastal freshwater lake.

Historical accounts of Biscayne Bay indicate that prior to inlet dredging and navigational channel dredging, the northern and central portion of the bay had much lower salinity conditions. Biscayne Bay water quality in the late 1800s can be characterized as low in nutrients, low in turbidity and high in light transmittance promoting luxuriant seagrass meadows on the bay bottom.

2.5.6 Florida Bay and the Florida Keys

Florida Bay is a subtropical estuary, averaging three feet in depth. Historically, these estuarine waters could be characterized as warm and very clear with the presence of lush seagrass beds on the bay bottom. Historically, both Florida Bay and Florida Keys estuarine and marine habitats evolved under very low nutrient conditions and were sensitive to increased levels of nutrients. Water quality in Florida Bay was highly variable with substantial variability in bay turbidity and salinity conditions relating to climatological events such as hurricanes and cold fronts, and large freshwater inflows from the southern Everglades during annual wet seasons. In the deeper marine waters off of the Florida Keys, water clarity was excellent with visibility through the water column routinely exceeding 100 feet.

2.5.7 Big Cypress Basin

The Big Cypress Basin is a large, flat area with maximum elevations of 22 feet above mean sea level in the northern region which gradually grades south to sea level in the coastal mangrove region of the Ten Thousand Islands area, on the Gulf of Mexico (Duever et al., 1979). Historic water quality conditions in this region were tied to the predominant carbonate marl soils of the area. Organic peats were found in the low-lying north-south sloughs and strands and in the coastal mangrove areas; however, they covered a relatively small portion of the entire basin. The single largest physiographic region in the Big Cypress was the slightly elevated interior Pineland region indicative of a juvenile karst terrain (Duever et al., 1979) suggesting substantial interaction of rainfall derived surface waters and the surficial aquifer.

Due to the topography, soils and vegetation of the area, water quality conditions had relatively high levels of dissolved constituents, such as calcium, chloride, sodium, potassium, hardness, specific conductance, and dissolved solids (Duever et al., 1979). Watercolor was highly stained with tannins and turbidity would have been relatively low. Historic nutrient concentrations in Big Cypress Basin were relatively oligotrophic in phosphorus and nitrogen compounds (Odum, 1953; Klein et al., 1970; Carter et al., 1973). However, total phosphorus and nitrogen compound levels in Big Cypress surface waters would have been substantially higher than total phosphorus and total nitrogen concentrations in the central Everglades marshes due to differing soil conditions.

2.5.8 Caloosahatchee River Basin

Prior to early drainage work, the Caloosahatchee River was a shallow, meandering river. Water quality was likely dominated by high color and high organics exhibiting the highly stained tannic nature of many south Florida coastal rivers. Dissolved oxygen levels in the river likely fluctuated widely with a daily pattern. In the lower Caloosahatchee River near its convergence with San Carlos Bay, the Caloosahatchee Estuary likely exhibited luxuriant seagrass beds with high light transmittance to the substrate and low nutrient and suspended solids conditions.

SECTION 3
EXISTING CONDITIONS

Southern Florida today is characterized by highly productive agricultural regions and rapidly growing urban areas. These areas directly abut extensive aquatic and wetland ecosystems that are in serious states of decline, largely as a result of water management activities required to support the agricultural and urban systems. A burgeoning urban population occupies most of the higher elevation areas of the Lower East Coast. Extensive agricultural areas cover much of the interior of the peninsula north and south of Lake Okeechobee and along the western fringes of the Lower East Coast. Both urban and agricultural land uses require increasing levels of water supply and flood control.

A channelized and degraded Kissimmee River is currently undergoing ecological restoration. A diked and highly regulated Lake Okeechobee has been reduced in area by half with the loss of extensive littoral wetlands. It now requires frequent regulatory water releases to maintain lowered water levels defined by water regulation schedules. The regulatory releases severely damage the St. Lucie and Caloosahatchee estuarine ecosystems.

The Everglades have also been reduced in area by half due to agricultural and urban expansion. The remaining Everglades ecosystem is in a continuing state of decline largely as a result of altered water regimes and degraded water quality, as evidenced by vegetation change, declining wildlife populations and organic soil loss. In contrast, the Big Cypress region, although modified from its natural condition through major man-caused disturbances (eg. logging, oil and gas exploration, residential development, recreation uses and agriculture). is in relatively good condition as an ecosystem. At the downstream end of the system, Florida Bay, the Gulf of Mexico, and Biscayne Bay estuarine ecosystems experience altered salinity regimes due to decreased freshwater heads and inflows from the Everglades, with damaging effects on habitats, nursery grounds, and estuarine fauna.

The situation in south Florida today, as summarized here, can be attributed largely to a diminished capacity to retain the huge volume of water that once pooled and sheet flowed across the pre-drainage landscape. These waters are now either discharged in massive volumes through canal systems to tide or are stored at unnaturally high levels in remnant diked wetlands of the Everglades. In hindsight, many of these problems are now recognized to be unanticipated effects of the existing Central and Southern Florida (C&SF) Project. They are exacerbated by the inescapable reality that people continue to move to south Florida at one of the highest rates in the nation. The result is a currently non-sustainable system of urban, agricultural and natural environments in south Florida that exceeds the capacity of, or is hampered by, the existing system of water management.

The following discussion is a brief summary of the existing physical, ecological, and socio-economic conditions within the study area. It does not attempt to provide comprehensive coverage of all resources or concerns; rather its purpose is to provide a summary account of the baseline resources present in the study area and which may be affected by implementation of the Comprehensive Plan. Further information on existing conditions within the regional system, and the ten study regions is available in ***Appendix J***. Detailed information on existing water quality is available in ***Appendix H***, existing air quality in ***Appendix I***, and socio-economics in ***Appendix E***.

3.1 GEOLOGY AND SOILS

The geology and soils of south Florida represent many of the opportunities, constraints and impacts of regional water management. The high transmissivity of the Biscayne Aquifer allows rapid recharge of Lower East Coast well fields while it sets the stage for water competition between the Everglades and Biscayne Bay regarding the issue of seepage control. The loss of peat soils of the Everglades provides an indicator of ecosystem change due to drainage activities. The geology and soils of south Florida are important aspects of the hydrologic and ecological framework for the Restudy. Peat soils predominate in previously flooded areas. Peat soils have subsided as a result of oxidation due to drainage, which has affected local topography and hydroperiods. “With peat breakdown, there has been a release of stored phosphorus (previously contained in the peat) into the system.

The Kissimmee River Basin is poorly drained due to the low permeability of fine to medium grained Pamlico sands that were deposited as marine and estuarine terraces during the Pleistocene to Holocene age. Lake Okeechobee and much of the Everglades are underlain by peat and muck that developed in a shallow basin with poor natural drainage under prolonged conditions of flooding on top of the Fort Thompson Formation of Pleistocene interbedded sand, shell and limestone. Bedrock in the Everglades is almost entirely limestone.

The Big Cypress Basin developed on top of sandy, marly, fossiliferous limestone and sand of the Tamiami Formation of Pliocene age. Fine sand and loamy soils with poor natural drainage and scattered areas of rock outcrop overlie the limestone of the Big Cypress Basin. The sandy and loamy soils of the upper East Coast and the Caloosahatchee River Basin lie on top of the Anastasia Formation of variably shelly and sandy limestone and provide moderate natural drainage.

The Lower East Coast on the Atlantic Coastal Ridge is mostly underlain by thin sand and Miami Limestone that are highly permeable and moderately to well drained. To the west of the coastal ridge, soils of the Lower East Coast contain fine sand and loamy material and have poor natural drainage. Rockland areas on the coastal ridge in Miami-Dade County are characterized by weathered limestone surfaces and karst features such as solution holes and sinkholes. Higher elevation marshes of the southern Everglades on either side of Shark River Slough are characterized by calcitic marl soils deposited by calcareous algal mats and exposed limerock surfaces with karst features such as solution pits and sinkholes.

Florida Bay is underlain by burrowed bryozoan facies of Miami Limestone with a highly variable sediment cover consisting of sand, exposed bedrock and mudbanks. Ten Thousand Islands consists of sand that creates barrier islands underlain primarily by the Tamiami Formation. Because of the low relief, numerous marshy backbays or lagoons, such as Whitewater Bay, occupy exposed limestone surfaces behind the slightly higher sand buildup of Cape Sable. The Florida Keys are made up of the highly permeable Key Largo Limestone in the upper Keys and the less permeable Miami Oolite on the lower Keys.

South Florida contains three major carbonate aquifer systems. The surficial aquifer system comprises rocks and sediments from the land surface to the top of an intermediate confining unit. The discontinuous and locally productive water bearing units of the surficial aquifer include the Biscayne Aquifer, the undifferentiated surficial aquifer, the coastal aquifer of Palm Beach and Martin Counties and the shallow aquifer of southwest Florida. Practically all municipal and irrigation water is obtained from the surficial aquifer system. The intermediate aquifer system consists of beds of sand, sandy limestone, limestone and dolostone that dip and thicken to the south and southwest. In much of south Florida, the intermediate aquifer represents a confining unit that separates the surficial aquifer system from the Floridan aquifer system. The Floridan aquifer system is divided by a middle confining unit into the Upper and Lower Floridan aquifers. North of Lake Okeechobee, the Floridan aquifer system yields fresh water, although it is more mineralized along coastal areas and to the south. In the Upper East Coast, the Upper Floridan aquifer is used for drinking water supply. In the Lower East Coast, from Jupiter to south Miami, the Upper Floridan aquifer is being considered for storage of potable water in an aquifer storage and recovery program. In the Lower Floridan aquifer there are zones of cavernous limestones and dolostones with high transmissivities. However, because these zones contain saline water, they are not used for drinking water supply and are used primarily for injection of treated effluent wastewater.

3.2 CLIMATE

The subtropical climate of south Florida, with distinct wet and dry seasons, high rates of evapotranspiration, and climatic extremes of floods, droughts and hurricanes, represents a major physical driving force that sustains the Everglades while creating water supply and flood control issues in the agricultural and urban segments. South Florida's climate, in combination with low topographic relief, delayed the development of south Florida until the Twentieth Century, provided the main motivation for the creation of the C&SF Project 50 years ago, and continues to drive the water management planning of the Restudy today.

Seasonal rainfall patterns in south Florida resemble the wet and dry season patterns of the humid tropics more than the winter and summer patterns of temperate latitudes. Of the 53 inches of rain that south Florida receives annually on the average, 75 percent falls during the wet season months of May through October. During the wet season, thunderstorms that result from easterly tradewinds and land-sea convection patterns occur almost daily. Wet season rainfall follows a bimodal pattern with peaks during May-June and September-October. Tropical storms and hurricanes also provide major contributions to wet season rainfall with a high level of interannual variability and low level of predictability. During the dry season, rainfall is governed by large-scale winter weather fronts that pass through the region approximately weekly. High evapotranspiration rates in south Florida roughly equal annual precipitation. Recorded annual rainfall in south Florida has varied from 37 to 106 inches, and interannual extremes in rainfall result in frequent years of flood and drought. Multi-year high and low rainfall periods often alternate on a time scale approximately on the order of decades.

3.3 AIR QUALITY

The existing air quality within south Florida is considered good, and the region attains all National Ambient Air Quality Standards. An air quality concern that is not addressed by National Ambient Air Quality Standards is the atmospheric deposition of mercury. Detailed information on existing air quality is available in ***Appendix I***.

3.4 NOISE

Within the major natural areas of south Florida, external sources of noise are limited and of low occurrence. Rural areas have typical noise levels in the range of 34-70 decibels, and urban areas may attain 90 decibels or greater. Noise is not considered to be an issue in the development of the Comprehensive Plan.

3.5 VEGETATION

The location of south Florida between temperate and subtropical latitudes, its proximity to the West Indies, the expansive wetland system of the greater Everglades, and the low levels of nutrient inputs under which the Everglades evolved, all combine to create a unique flora and vegetation mosaic. Today nearly all aspects of south Florida's native vegetation have been altered or eliminated by the development, altered hydrology, nutrient inputs, and spread of exotics that have resulted directly or indirectly from a century of water management.

Riparian plant communities of the Kissimmee River and its floodplain are recovering from channelization and drainage. The macrophyte communities of the diminished littoral zone of Lake Okeechobee are now contained within the Hoover Dike. They remain essential for the ecological health of the Lake but are stressed by extreme high and low lake levels and by the spread of exotics. Below the Lake, all of the pond apple swamp forest and most of the sawgrass plain of the northern Everglades have been converted to the Everglades Agricultural Area. Also eliminated is the band of cypress forest along the eastern fringe of the Everglades that was largely converted to agriculture after the eastern levee of the Water Conservation Areas cut off this community from the remaining Everglades. The mosaic of macrophyte and tree island communities of the remaining Everglades within the Water Conservation Areas and Everglades National Park is altered even in seemingly remote areas by changes in hydrology, exotic plant invasion, and/or nutrient inputs.

The problems of the Everglades extend to the mangrove estuary and coastal basins of Florida Bay, where the forest mosaics and submerged aquatic vegetation show the effects of diminished freshwater heads and flows upstream. These problems are exacerbated by sea level rise. The upland pine and hardwood hammock communities of the Atlantic coastal ridge, interspersed with wet prairies and cypress domes and dissected by "finger glades" water courses that flowed from the Everglades to the coast, remain only in small and isolated patches that have been protected from urban development. In contrast, much of the vegetation mosaic in Big Cypress Swamp to the west of the Everglades remains relatively intact. The importance of south Florida's vegetation, in regard to its unique and diverse composition as well as to its critical linkage to the region's fauna, makes its current state of degradation a major concern and objective in any ecological restoration initiative.

More detailed documentation of existing vegetation focuses on wetland systems that have been most seriously degraded and that receive most benefits from the Restudy. Those systems include the Everglades peatland, the Everglades marl prairie and rocky glades, and the mangrove estuaries and coastal basins of Florida Bay and southern Biscayne Bay. Other natural systems in south Florida that already have restoration plans, that have lesser impacts from man, or that are not addressed by the Restudy are described in the Appendix. These systems include the Kissimmee River, where restoration is already in progress, Lake Okeechobee, for which a revised regulation schedule has been developed to protect littoral macrophyte communities, Big Cypress National Preserve, where vegetation impacts and fixes are relatively minor compared to the Everglades, and the Atlantic coastal ridge, where pinelands and hardwood hammocks are little affected by the Restudy.

The Everglades peatland that remains in the Water Conservation Areas and in Shark River Slough of Everglades National Park consists of a mosaic of sawgrass (*Cladium jamaicense*) plains, wet prairies, sloughs and tree islands that are oriented in the directions of flow patterns in the pre-drainage system. Sawgrass commonly forms monospecific strands throughout Everglades peatlands. Cattail (*Typha* spp.) has replaced sawgrass in phosphorus enriched areas, and the exotic melaleuca *(Melaleuca quinquenervia*) has invaded sawgrass in peripheral and overdrained areas.

A less dense wet prairie community characterized by spikerush (*Eleocharis* spp.), maidencane (*Panicum hemitomon*) and other emergent macrophytes grows at slightly lower elevations than sawgrass. The wet prairie blends into a more open water floating and aquatic community characterized by white water lily (*Nymphaea odorata*) and bladderwort (*Utricularia* spp.) in the lowest elevation water courses between the sawgrass ridges.

Wet prairies and sloughs support a luxuriant growth of attached algal communities known as periphyton, which form an important base of aquatic food webs and which are also diagnostic of water quality and hydrologic conditions in the Everglades. Wet prairies and sloughs also provide habitat for aquatic fauna and for feeding wading birds. Sawgrass is filling in wet prairies and sloughs in much of the remaining Everglades peatlands, probably as a result of lowered water levels. Sawgrass has been observed to revert to wet prairie after peat-burning fires. Cattail is filling wet prairies and sloughs in phosphorus enriched areas.

Tree islands dot the landscape in the form of either teardrop-shaped larger islands or round smaller islands. The heads of larger teardrop-shaped islands support swamp forest trees such as red bay (*Persea borbonia*), wax myrtle (*Myrica cerifera*) and dahoon holly (*Ilex cassine*) in the Water Conservation Areas and tropical hardwood trees such as gumbo limbo (*Bursera simaruba*), pigeon plum (*Coccoloba diversifolia*) and West Indian mahogany (*Swietenia mahogani*) in Everglades National Park and southern WCA-3A and WCA-3B. The tails of the islands often support willow (*Salix caroliniana*) and other more water-tolerant species. The smaller round islands are referred to as battery islands or bay heads and support willows or swamp forest species. The larger islands originated approximately 1,200 years ago, while the smaller ones are about 700 years old.

Tree islands provide valuable habitat for their unique forest plant assemblages and also for the vertebrate species that depend upon them, particularly during high water. Tree islands have been destroyed or damaged by lowered water levels, which have resulted in tree island and underlying soil burnout, as well as by unnaturally high water levels that have killed the less water tolerant tree species.

The higher elevation wetlands that flank either side of Shark River Slough in Everglades National Park support the highly diverse landscape of the marl prairie and rocky glades. This mosaic of short stature sawgrass, wet prairie, muhly prairie, and tropical hammock tree islands grows on marl and exposed limestone substrate in areas where the marsh naturally would dry for two to four months during most years. The wet prairie community of the marl prairie and rocky glades shares some species with the wet prairies described above for Everglades peatlands, but it grows under drier conditions and includes the most species rich wetland plant assemblage in the Everglades.

The wetland communities of the marl prairie and rocky glades support a distinct calcareous periphyton mat from which the marl substrate is formed. The periphyton mat is an important base for aquatic food webs and protects aquatic fauna from desiccation during dry periods. The muhly prairie community is particularly important as critical habitat for the endangered Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*). Tree islands in this landscape support a diverse assemblage of tropical hardwood species mixed with temperate species. Shortened annual duration of flooding in the marl prairie and rocky glades landscape presently supports a primarily terrestrial community that is flooded briefly each year rather than a primarily aquatic community that dries briefly each year. Impacts to vegetation include the loss of species richness in wet prairie communities, the conversion of muhly prairie to sawgrass, the invasion of woody and exotic trees and shrubs into prairie communities, and tree island burnout.

The mangrove estuary between the freshwater Everglades and Florida Bay and southern Biscayne Bay supports a mosaic of mangrove forests, tidal creeks, salt marshes, coastal lakes, tropical hardwood hammocks, and coastal basins. Red mangrove (*Rhizophora mangle*) swamp dominates the landscape along with stands of buttonwood (*Conocarpus erectus*), black mangrove (*Avicennia germinans*) and white mangrove (*Laguncularia racemosa*). Tidal creeks dissect the mangrove forests and are often bordered by salt marsh communities of black sedge (*Schoenus nigricans*) and cord grass (*Spartina* spp.). Tropical hardwood hammocks with canopy trees such as West Indian mahogany, Jamaica dogwood (*Piscidia piscipula*), strangler fig (*Ficus aurea*) and holly grow on elevated coastal embankments.

Coastal lakes and basins support seasonally variable beds of submerged aquatic macrophytes that range from low-salinity to marine communities of bladderwort, widgeon grass (*Ruppia maritima*), Cuban shoal grass (*Diplanthera* *wrightii*) and turtle grass (*Thalassia testudinum*). Reduction in freshwater heads and flows from the Everglades, in concert with sea level rise, has caused community shifts in the submerged aquatic vegetation of the coastal lakes and basins and apparently has contributed to the filling in of tidal creeks. A salinity regime favoring an increased frequency of high salinity events and a decreased frequency of low salinity events in the coastal lakes and basins has resulted in the loss of the low-to-moderate salinity macrophyte communities that seasonal populations of migratory waterfowl once utilized. Tidal creeks, with open water, visibly high flow velocities, and freshwater flora and fauna that were observed earlier this century, have filled with red mangroves to the point they are no longer recognizable today.

3.6 FISH AND WILDLIFE

The life cycles, community structures and population densities of the fauna of south Florida are intricately linked to regional hydrology. The current status of fish and wildlife has been strongly influenced by the cumulative effects of drainage activities early this century, the Central and Southern Florida Project, and the ensuing agricultural and urban development that was made possible by those activities. A major emphasis of the Restudy is to remedy many of the hydrologic aspects of the flood control project that in hindsight have been deleterious to fish and wildlife. Likewise the major emphasis in this section is on those faunal groups that appear to have declined as a result of hydrologic changes caused by the Central and Southern Florida Project and that are expected to benefit from the Restudy. The major linkages between hydrologic alterations and fauna that are addressed by the Restudy and emphasized here include the collapse of aquatic food webs and populations of higher level consumers that depend upon them, shifts in habitats to those less favorable to faunal communities, and the reduction in the spatial extent of the undeveloped greater Everglades wetland system. This section integrates our best current understanding of those linkages, with the recognition that our understanding will continue to improve but will always be incomplete. Thus the information presented here represents many converging lines of evidence that together have produced a sound hypothetical framework of how the south Florida wetland and estuarine systems presently function under the current management system. A more comprehensive catalog of all faunal groups in the region is found in ***Appendix J***.

A critical link in the aquatic food webs, and one that appears to have been broken by hydrologic alterations, is the intermediate trophic level of the small aquatic fauna. The small marsh fishes, macroinvertebrates and herpetofauna form the link between the algal and detrital food web bases of the Everglades and the larger fishes, alligators and wading birds that feed upon them. Aquatic animal populations are currently diminished due to two factors related to water management. Reduction in the spatial extent of Everglades wetlands by half has resulted in a proportional reduction in habitat of aquatic organisms, and changes in the hydrology in remaining wetlands has further reduced their populations.

In the freshwater Everglades, population densities of marsh fishes such as the golden topminnow (*Fundulus chrysotus*), bluefin killifish (*Lucania goodei*), sailfin molly (*Poecilia latipinna*), mosquitofish (*Gambusia affinis*), flagfish (*Jordanella floridae*) and small sunfish are directly proportional to the duration of uninterrupted flooding. This fish assemblage proliferates under extended periods of flooding and may reach maximum population densities only after five to six years of continuously flooded conditions in Shark River Slough. In adjacent areas of higher elevation marl marshes and rocky glades that tend to dry annually, survivors must repopulate each year after retreating into refugia that hold water through the dry season such as alligator holes, solution holes in exposed limestone, algal mats, and longer-hydroperiod marshes of Shark River Slough. The existing duration of uninterrupted flooding in Shark River Slough averages less than two years, compared to more than 15 years pre-drainage. In the marl marshes and rocky glades, where the duration of uninterrupted flooding currently averages only about three months compared to nearly ten months pre-drainage, the refugia that once enabled the survival of aquatic fauna during droughts now often dry completely, and repopulation requires longer distance migration from the longer-hydroperiod marshes of Shark River Slough which also dry frequently. Existing conditions thus keep the marsh fish populations of Shark River Slough and the marl prairies and rocky glades at perpetually low densities compared to pre-drainage conditions.

Aquatic macroinvertebrates live in close association with marsh fishes in the freshwater aquatic community. The amphipod (*Hyallela aztecus*), the freshwater prawn (*Palaemonetes paludosus*), the crayfish (*Procambarus alleni*), and the apple snail (*Pomacea paludosa*) represent ubiquitous and highly abundant processors of detritus and algae that must play key roles as prey species and in the cycling of energy and nutrients through the aquatic food webs of the Everglades and other south Florida wetlands. The crayfish is particularly important in the diet of white and glossy ibis. The apple snail is the sole food of the snail kite (*Rostrhamus sociabilis plumbeus*). The habitat requirements, life histories and population dynamics of these organisms remain largely unknown.

Also abundant in the freshwater aquatic community are amphibians and reptiles including the squirrel tree frog (*Hyla squirella*), green treefrog (*H. cenerea*), ranid frogs such as the pig frog (*Rana grylio*) and southern leopard frog (*R. utricularia*), legless siren (*Siren lacertina*) and amphiuma salamanders (*Amphiuma means*), swamp snakes, water snakes and cottonmouths (*Agkistrodon piscivorus*), and the red-bellied (*Pseudemys nelsoni*), and mud turtles (*Kinosternon subrubrum steindachneri* and *K. baurii*). Amphibia and their larvae represent important prey species for larger predatory fishes, alligators (*Alligator mississippiensis*) and wading birds. Turtles, snakes and amphiuma are commonly consumed by alligators. The pig frog is commercially harvested for frog legs. The high numbers of herpetofauna in the Everglades, particularly of such ubiquitous and abundant species as the squirrel tree frog, suggest that they function as critical energy pathways in food webs. Anecdotal accounts of the Everglades from early this century describe a much greater abundance of amphibians and reptiles compared to densities observed today.

Included in the freshwater aquatic community of south Florida are the larger sport species such as the largemouth bass (*Micropterus salmoides*), sunfishes, black crappie (*Lepomis nigromaculatus*) and important non-sport predators such as Florida gar (*Lepisosteus platyrhincus*) and bowfin (*Amia calva*). Lake Okeechobee is renowned for the trophy bass from its littoral zone and for an abundant black crappie fishery. Largemouth bass also naturally inhabit the deeper-water sloughs and wet prairies of the Everglades, where they grow at a rate of one pound per year of uninterrupted flooding. Wet prairies, sloughs and alligator holes are also the natural habitat of gar and bowfin. Shortened hydroperiods in much of the Everglades in combination with compartmentalization presently confine larger bass mostly to canals, which provide a popular recreational fishery. Unfortunately, Everglades bass contain high body burdens of mercury, presumably through biomagnification in the food chain, which make them unsuitable for frequent human consumption. Restoration of hydroperiods in the Everglades should expand the canal fishery for the largemouth bass to the sloughs and wet prairies where it historically occurred, create new fisheries in water preserve area reservoirs, and displace some existing fisheries in canals that will be filled. Bass fisheries in remaining canals should be substantially improved due to their proximity to marshes with lengthened hydroperiods.

The American alligator is a keystone species in the Everglades. Holes that are excavated by alligators form ponds where aquatic fauna survive droughts, and mounds of sediment that are excavated from the holes create higher-elevation habitat upon which willow and other swamp forest trees grow. In addition to its keystone role in the creation of alligator holes, the American alligator is the top predator in the Everglades and feeds at various stages in its life on every level of the food chain, from small fishes to wading birds.. Everglades alligators construct nests from mounds of vegetation and organic sediment that they excavate from the holes. Eggs are laid at the beginning of the wet season at elevations in the nests that are not likely to be flooded as water levels rise throughout the remaining wet season. Under current conditions, alligators have abandoned the marl prairie and rocky glades landscape where they were once most abundant, and where aquatic fauna were dependent on alligator holes for survival through dry seasons, because shortened hydroperiods have rendered the marl prairie and rocky glades a mostly terrestrial system where the alligator can no longer survive. Presently alligators and their holes are found mostly in the Water Conservation Areas and Shark River Slough, although reproduction is suppressed there. Water level fluctuations and impoundment effects in the Water Conservation Areas and regulatory water releases into Everglades National Park thwart the alligator's ability to lay their eggs at nest elevations that will not be flooded later in the wet season. The result is an increased frequency of drowned nests under current conditions.

In the brackish-water estuarine transition between the Everglades and Florida and Biscayne Bays, a low-salinity mangrove fish assemblage including the sailfin molly, topminnows, sheepshead (*Archosargus probatocephalus*), rainwater killifish, and small sunfishes achieves highest densities under conditions of freshwater and salinity less than five to eight parts per thousand. Under current conditions, decreased freshwater heads and flows upstream in the Everglades frequently allow elevated salinities above the optima for this fish assemblage and infrequently result in saltwater conditions in the estuarine transition. As a result, population densities of the small marsh fishes of the estuarine transition appear to be depressed and more erratic today in comparison to pre-drainage conditions.

The most conspicuous indicators of ecosystem health in the Everglades are the plummeting populations of wading birds, which are presently only ten percent of previous numbers of nesting birds, and which appear to continue to decline. The coastal nesting colony locations where most wood stork (*Mycteria americana*), white ibis (*Eudocimus albus*) and other wading bird species once nested are now abandoned. These locations are in the mangrove estuary of Florida Bay, where the juxtaposition of estuarine environments and persistent freshwater pools at the lower end of the Everglades once assured a dependable food supply throughout most breeding seasons. Particularly critical food bases include larger fishes at least in their second year of life for wood stork, and a wide variety of fishes, other vertebrates and invertebrates for other species, with a particular importance of crayfish to white ibis. These food bases are mostly contained in the freshwater marsh fish assemblage of the Everglades and the low salinity mangrove fish assemblage of the estuarine transition zone that are described above. Abandonment of the traditional coastal breeding colony locations by wading birds is largely attributed to depletion of these food bases in the southern Everglades. This depletion is due to abbreviated hydroperiods in Shark River Slough and the marl prairie/rocky glades, the loss of drought refugia in alligator holes in these regions, and the less desirable salinity regimes in the mangrove estuarine transition.

Under current conditions, most Everglades wading bird nesting colonies are located to the north in the Water Conservation Areas, in areas that were not traditional colony locations. Nesting birds appear to have been drawn to the Water Conservation Areas by persistent pools of water, and populations of prey species, at the lower end of each impoundment. Successful nesting there depends on the persistence of those pools, and on a steady water level recession to condense prey organisms and to provide suitable depth ranges for feeding, throughout dry seasons.

Unfortunately those conditions are not predictable under current operations of the Water Conservation Areas, and wading bird nesting success is low most years.

Another aspect of wading bird reproduction that is diminished under current conditions is the formation of "super colonies" of as many as 75,000 pairs of white ibis in coastal colony locations. Super colonies that traditionally nested in the coastal colonies have shifted to the Water Conservation Areas, where fewer numbers of breeding pairs have uncertain and relatively low reproductive success. Super colonies recur approximately every five to ten years. They coincide with the resumption of relatively normal annual rainfall and water levels during the first year following a drought. Causal factors of super colonies are poorly understood.

Roseate spoonbills (*Ajaia ajaja*) traditionally nested in eastern Florida Bay and fed upon smaller invertebrates in the low salinity coastal marshes of the Taylor Slough basin. Spoonbills have shifted colony locations to current nesting sites in central and western Florida Bay, presumably in response to declining food sources in their previous feeding grounds.

In addition to the abandoned coastal wading bird nesting colonies and depleted populations of low-salinity mangrove fishes, impacts to the mangrove estuarine transition due to diminished freshwater heads and flows upstream include degraded habitats for the American crocodile, migratory waterfowl, and nursery grounds of sport fishes and pink shrimp (*Penaeus duorarum*). Juveniles of the endangered American crocodile (*Crocodylus acutus*) seek low salinity areas of the mangrove estuary, which occur less frequently today, and their survival and growth is reduced at salinity levels above 25 parts per thousand, which occur more frequently today. The winter aggregations of more than 50,000 coots (*Fulica americana*), widgeon and other waterfowl that fed on beds of Chara and widgeon grass in the coastal lakes and basins no longer utilize these areas in large numbers since higher salinities have reduced the abundance of their food plants. Nursery ground suitability for juvenile sport fishes such as spotted seatrout (*Cynoscion nebulosus*), tarpon (*Megalops atlanticus*) and red drum (*Sciaenops ocellatus*) is diminished under the increased frequency of hypersaline conditions in the coastal basins. The same applies to pink shrimp in Whitewater Bay, which contribute to a multi-million annual Tortugas fishery (Sheridan, 1996). Spotted seatrout recruitment is adversely affected at salinity levels above 25 parts per thousand.

The white-tailed deer (*Odocoileus virginianus*) is widespread in most of the Everglades and the Big Cypress Basin. A healthy deer population persists in the Big Cypress basin. In the Everglades, the deer herd currently is higher than it was under pre-drainage conditions because it has benefited from lower water levels. However, during high water periods, massive mortality can occur when the deer are stranded on over-browsed tree islands, and starve. The restoration of the Everglades will reduce deer populations in the Everglades to densities closer to pre-drainage levels, but it will also reduce mortality due to unnaturally high water events.

3.7 THREATENED, ENDANGERED AND STATE LISTED SPECIES

The U.S. Fish and Wildlife Service, by letters dated February 20, 1997 and April 8, 1998 identified 18 Federally listed plant and animal species that would likely be affected by Restudy alternatives within the study area (***Table 3-1***). Of the listed species, Critical Habitat has been designated for the West Indian manatee (*Trichechus manatus*), snail kite, Cape Sable seaside sparrow and American crocodile.

For a description of these critical habitat geographic designations and a complete species description, taxonomy, distribution, habitat requirements, management objectives, and current recovery status, refer to the draft Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida, Volume I (USFWS, 1998b) or the U.S. Fish and Wildlife Service endangered species web site at ***http://www.fws.gov/r9endspp/endspp.html***. For a complete listing of all the Federally listed threatened and endangered plant and animal species occurring or thought to occur within the study area, reference the above web site. The Florida Game and Fresh Water Fish Commission correspondence dated February 23, 1998 and December 14, 1998 provided information on state listed species likely to be affected by the Restudy or present within the study area (***Table 3-1*** and ***Appendix J***). For a detailed description of existing conditions for the 18 Federally listed species see ***Appendix J***.

TABLE 3-1
THREATENED, ENDANGERED & SPECIES OF SPECIAL CONCERN PLANTS AND ANIMALS LIKELY TO BE AFFECTED BY THE C&SF RESTUDY

Scientific Name	Common Name	USFWS	GFC
Trichechus manatus	West Indian Manatee	E*	E
Felis concolor	Florida panther	E	E
Rostrhamus sociabilis plumbeus	Snail kite	E*	E
Mycteria americana	Wood stork	E	E
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	E*	E
Crocodylus acutus	American crocodile	E*	E
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E	E
Picoides borealis	Red-cockaded woodpecker	E	T
Haliaeetus leucocephalus	Bald eagle	T	T
Polyborus plancus	Audubon's crested caracara	T	T
Drymarchon corais couperi	Eastern indigo snake	T	T
Aphelocoma coerulescens	Florida scrub-jay	T	T
Cucurbita okeechobeensis	Okeechobee gourd	E	
Amorpha crenulata	Crenulate lead-plant	E	
Euphorbia deltoidea	Deltoid spurge	E	
Galactia smallii	Small's milkpea	E	
Polygala smallii	Tiny polygala	E	
Euphorbia garberi	Garber's spurge	T	
Falco sparverius paulus	American kestrel(SE subsp.)		T
Grus canadensis pratensis	Florida sandhill crane		T
Mustela vison evergladensis	Everglades mink		T
Sciurus niger avicennia	Big Cypress fox squirrel		T
Ursus americanus floridanus	Florida black bear		T
Rana capito	Gopher frog		SSC
Gopherus polyphemus	Gopher tortoise		SSC
Pituophis melanoleucus mugitus	Florida pine snake		SSC
Aramus guarauna	Limpkin		SSC
Egretta caerulea	Little blue heron		SSC
Egretta thula	Snowy egret		SSC
Egretta tricolor	Tricolored heron		SSC
Eudocimus alba	White ibis		SSC
Speotyto cunicularia	Burrowing owl		SSC
Blarina carolinensis shermani	Shermans short-tailed shrew		SSC
Podomys floridanus	Florida mouse		SSC
Sciurus niger shermani	Sherman's fox squirrel		SSC
Liguus fasciatus	Florida tree snail		SSC

E Endangered
T Threatened
* Designated Critical Habitat
SSC State listed Species of Special Concern

3.8 WATER MANAGEMENT

For this section, the Central and Southern Florida Project has been broken down into four hydrologically related geographical areas consisting of: (1) the Kissimmee River – Istokpoga Basin; (2) the Lake Okeechobee and Everglades Agricultural Area; (3) the Water Conservation Areas, Everglades National Park, and Everglades National Park - South Miami-Dade Conveyance Canals; and (4) the East Coast Canal watersheds.

3.8.1 Kissimmee River – Istokpoga Basin

The Kissimmee River – Lake Istokpoga Basin portion of the project includes most of Osceola and Okeechobee and parts of Orange, Polk, Highlands, and Glades Counties. It is bounded on the north by the lakes of the Orlando area, on the west by the Peace River watershed, on the south by Lake Okeechobee and on the east by the Upper St. Johns River Basin and the Taylor Creek-Nubbin Slough Basin. The project purposes include flood control, water supply, navigation, and fish and wildlife. The project protects the lands adjacent to the lakes and along the Kissimmee River from frequent and prolonged flooding. It provides water supply for agricultural uses in the area in and around the lakes and the Kissimmee River. It also provides for navigation on the Kissimmee River and all lakes in the Middle and Upper Kissimmee River Basin. Locks are provided at control structures on the main watercourse between east Lake Tohopekaliga and Lake Okeechobee. Boatlifts are provided at all other structures. Maintaining lake stages at a desirable level for fish and wildlife and for recreational purposes is also important.

The Kissimmee Basin is an integrated system of lake storage capabilities and structure outlet capacities. The Upper Kissimmee Basin structures are operated according to regulation schedules. The regulation schedule essentially represents the seasonal and monthly limits of storage that guide the regulation of the project for the planned purposes. The regulation schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. The lakes are drawn down in the spring to provide flood control storage and for fish and wildlife enhancement. The minimum levels are set to provide for sufficient flood control storage and navigation depths. The amount of seasonal fluctuation was derived by determining the effect of various water levels on the flood control, low water regulation, groundwater, fish and wildlife, and recreation. Runoff during the wet season is stored for use in the dry season. The regulation schedules take into account these varying, and often, conflicting purposes.

The Lake Istokpoga Project works were primarily designed to protect lands adjacent to the lake from flooding by lake waters, and provide water supply for agricultural use in areas around the lake and in the Indian Prairie area. At the same time, project works maintain the lake at a desirable level for fish and wildlife, navigation, and for recreational purposes.

The project has decreased the area inundated by major floods with floodwaters being passed for storage in Lake Okeechobee. It also prevents longer duration of low to no-flow water conditions during prolonged periods of drought in the lower basin. This is accomplished by conserving or storing waters within both the controlled pools behind the existing structures and in the channelways for drought protection. Other effects include year-round small boat navigation of the system from Lake Tohopekaliga to Lake Okeechobee with boat access to the Kissimmee River for fishing and recreation. The C-38 pools add to the total volume of water available for aquatic species support. The C&SF Project has, in effect, stabilized lake and river levels, removing both the highest (flood) and lowest (dry down) levels providing year-round navigability.

3.8.2 Lake Okeechobee and Everglades Agricultural Area

Lake water levels in Lake Okeechobee are regulated by a complex system of pumps, spillways and locks. The regulation schedule attempts to achieve the multiple-use purposes as well as provide seasonal lake level fluctuations. The schedule is designed to maintain a low lake stage to provide both storage capacity and flood protection for surrounding areas during the wet season. The schedule is also a guide for the management of high lake stages that might threaten the integrity of the Herbert Hoover Dike and thereby risk flooding of downstream lands. During the winter, lake levels may be increased to store water for the upcoming dry season. The general plan of operation for Lake Okeechobee is based on the following: 1) flood protection from lake waters and hurricane-driven wind tides for lands adjacent to the lake; 2) maintenance of an 8-foot navigation channel across Lake Okeechobee, as part of the Okeechobee Waterway and; 3) storage of water to meet the requirements of the agricultural area south and east of the lake.

Flood control works on Lake Okeechobee consist of a system of about 1,000 miles of encircling levees, designed to withstand a severe combination of flood stage and hurricane occurrence, plus the regulatory outlets of St. Lucie Canal and the Caloosahatchee River. The design discharge of Moore Haven Spillway is 9,300 cfs; that of St. Lucie Spillway is about 16,000 cfs. Following removal of local runoff from the agricultural areas south of the lake, an additional regulatory capability of several thousand cfs is available through the Miami, North New River, Hillsboro, and West Palm Beach Canals by pumping into the three Water Conservation Areas. The crest elevation of the levee system surrounding the lake ranges from 32 to 45 feet, NGVD. The likelihood of overtopping the levees from excess storage is almost non-existent. Possible flooding due to overtopping of levees within the Herbert Hoover Dike system is limited to short duration events involving wave runup in addition to hurricane-induced storm surge. The likelihood of such events is remote and the expected extent of flooding is minimal.

3.8.3 Water Conservation Areas

The primary purposes for the Water Conservation Areas and their appurtenant levees, canals, structures, and pump stations include flood control, water conservation, prevention of salt-water intrusion, recreation, preservation of fish and wildlife, and water supply for Everglades National Park. The Water Conservation Areas are completely contained by levees, except for about seven miles on the west side of Water Conservation Area-3A, which has a tieback levee. There are also levees on the east side of the East Everglades, which protect the agricultural and industrial areas, which otherwise would have been short hydroperiod wetlands, from inundation. This whole region is managed with a system of canals, multiple pump stations, and control structures. The main canals are West Palm Beach Canal, Miami Canal, Bolles and Cross Canals, North New River Canal, South New River Canal, Hillsboro Canal, and Tamiami Canal.

The Water Conservation Areas provide a detention reservoir for excess water from the Everglades Agriculture Area and parts of the East Coast region, and for flood discharge from Lake Okeechobee to the sea. The Water Conservation Areas provide levees to prevent Everglades floodwaters from inundating the east coast urban areas; provide a water supply for east coast areas and Everglades National Park; improve the water supply for east coast communities by recharging underground freshwater reservoirs; reduce seepage; ameliorate salt-water intrusion in coastal wellfields; and provide mixed quality habitat for fish and wildlife in the Everglades.

The regulation schedules contain instructions and guidance on how project spillways are to be operated to maintain water levels in the Water Conservation Areas. The regulation schedules essentially represent the seasonal and monthly limits of storage which guides project regulation for the planned purposes. The schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. This seasonal range permits the storage of runoff during the wet season for use during the dry season. In addition, it serves to maintain and preserve plant cover in the Water Conservation Areas, which is essential to fish and wildlife and the prevention of wind tides. Regulation schedules must take into account various, and often conflicting, purposes. Conceptually, reservoir storage is commonly divided into the inactive zone, the water supply (conservation) zone, and the flood control zone. The distribution of water between the flood control and water supply zones varies seasonally in the Water Conservation Areas. The regulation schedules for Water Conservation Area 1, Water Conservation Area 2A, and Water Conservation Area 3A include a minimum water level, as measured in the borrow canals, below which water releases are not permitted unless water is supplied from another source. Note that this does not mean that a minimum stage is maintained in the Water Conservation Areas. When water levels fall below the minimum levels, transfers from Lake Okeechobee or upstream Water Conservation Areas are made to meet water supply demands.

3.8.4 East Coast Canal Watersheds

The East Coast Canals are the flood control and outlet works that extend from St. Lucie County southward through Martin, Palm Beach and Broward Counties to Miami-Dade County, a distance along the Atlantic Coast of about 170 miles. The East Coast Canal watersheds encompass the primary canals and water control structures located along the Lower East Coast of Florida and their hydrologic basins. The main design functions of the project canals and structures in the East Coast Canals area are to protect the adjacent coastal areas against floods; store water in conservation areas west of the levees; control water elevations in adjacent areas; prevent salt-water intrusion and over drainage; provide freshwater to Biscayne Bay and provide water for conservation and public consumption. There are 40 independently operated canals, one levee, and 50 operating structures, consisting of 35 spillways, 14 culverts, and one pump station. The project works to prevent major flood damages. However, due to urbanization, the existing surface water management system now has to handle greater peak flows than in the past.

The South Miami-Dade Conveyance System provides a way to deliver water to areas of south Miami-Dade County. This canal system was overlain on top of the existing flood control system. Many of these canals are used to remove water from interior areas to tidewater.

Areas become flooded during heavy rainfall events due to antecedent conditions that cause saturation and high runoff from both developed and undeveloped areas. When areas become flooded, excess water is removed through the canals. Automatic controls installed on some of the water control structures allow the canal levels to fall into a lower range which provides limited extra storage in the lakes and canals. Thus, during a heavy rainfall event, extra storage is available for the secondary canal system to drain into the larger canals. The automatic controls also allow for frequent gate changes that keep the water levels in the safe range. Saltwater intrusion has declined considerably at coastal structures since the installation of salinity dams downstream and the placement of salinity monitoring sensors near the structures. Damage to agriculture, citrus, and pasturelands due to flooding has been reduced as a result of the effective drainage capabilities of the canals.

The project works maintain optimum stages for the purposes of flood control, water supply, groundwater recharge, and prevention of salt water intrusion. The coastal canals and control structures between St. Lucie and Miami-Dade Counties are designed to permit rapid removal of floodwaters from their immediately adjacent drainage area. The degree of flood protection provided by outlet capacity is dependent on whether the protected area is urban or agricultural. Maximum rates of removal vary from 40-percent to 100-percent Standard Project Flood. The canals and structures are regulated automatically or manually, as designed, in accordance with the optimum water control and design elevations, with the exception of hurricane or tropical storm regulation.

The network of canals and control structures provides for water and salinity control in the area. Wellfields, which are the source of municipal water supplies, are significantly recharged by water from the Water Conservation Areas. Water stored in the Water Conservation Areas can be used to maintain groundwater levels in the coastal area for public water supply, to irrigate the vast agricultural areas interspersed within the project area, and to maintain a freshwater head along the Lower East Coast for salinity control.

The construction and operation of the East Coast Canals for flood protection and the lowering of the ground water table on the east coast ridge significantly affected freshwater deliveries to Biscayne Bay and Biscayne National Park. The patterns of freshwater discharge changed from long, slow releases over a broad front to “pulse” releases from canals following rain events.

3.9 WATER QUALITY

Water quality in the study area is significantly influenced by development. The C&SF Project has led to significant changes in the landscape by opening large land tracts for urban development and agricultural practices, and by the construction of extensive drainage networks. Natural drainage patterns in the region have been disrupted by the extensive array of levees and canals such that nonpoint source (stormwater) runoff and point sources of pollution (wastewater discharges) are now entering the system in many areas. Several pollutants of concern in the study area have been identified. These include:

- Metals - mercury, copper, cadmium, lead, zinc, arsenic, and tributyltin (TBT)
- Pesticides - DDT and derivatives, atrazine, simazine, ametryn, endosulfan compounds, ethion, bromacil, 2,4-D, aldecarb, and fenamiphos
- Nutrients - phosphorus, nitrite/nitrate, and ammonia/un-ionized ammonia
- Biologicals - fecal coliforms and pathogens, and chlorophyll-a
- Physical parameters - pH, dissolved oxygen, conductivity, turbidity, oil and grease, temperature, and salinity
- Other constituents - Polycyclic Aromatic Hydrocarbons (PAHs), dioxins and furans, sulfate, chloride, Polychlorinated Biphenyls (PCBs), and Volatile Organic Carbons (VOCs).

Of this list, phosphorus, pesticides and mercury are considered to be the most important water quality pollutants of the region and are discussed below. A much more thorough discussion of existing water quality conditions including the Federal, State, and Tribal water quality regulations and standards are provided in ***Appendix H***.

Phosphorus: Historically, south Florida waters were low in nutrients (oligotrophic). Due to human activities including the ditching and draining of wetlands and the expansion of agriculture waterbodies from the Kissimmee River southward have become nutrient-enriched to various degrees. The farming areas surrounding Lake Okeechobee in general have contributed to elevated nutrients in the Kissimmee River, Lake Okeechobee, the Caloosahatchee River, and the Everglades. In addition, urban storm water runoff is another potential source of phosphorus to the Everglades and south Florida coastal systems.

In general, the trend for phosphorus concentrations is a decrease from north (Kissimmee River and Everglades Agricultural Area) to south (Everglades National Park) since there are major anthropogenic sources in the agricultural areas in the north. Nutrient removal from marsh water is due to the natural water quality treatment processes associated with south Florida wetlands, notably the Everglades. According to the Florida Surface Water Improvement and Management (SWIM) Act Plan for Lake Okeechobee (SFWMD, 1997f), the highest average phosphorus concentrations (up to over 700 parts per billion (ppb) are measured in waters discharged from the Lower Kissimmee River (S-65D Basin = 770 ppb), Taylor Creek/Nubbin Slough (S-154 Basin = 610 ppb), and the Everglades Agricultural Area (East Beach Drainage District = 560 ppb). The lowest concentrations (about 10 ppb) in the study area are reported for marsh stations within the Everglades National Park (USGS, 1996).

Elevated phosphorus loading of waterbodies and the resulting increased water phosphorus concentrations (eutrophication) may have various ecological effects. These effects may include increased primary productivity, loss of water column dissolved oxygen, algal blooms, changes in vegetation and biodiversity, and accumulation of phosphorus in sediments and muck. The significance of such phosphorus loading may be the reduction or loss of a waterbody's habitat and/or recreational value.

Pesticides: An extensive array of pesticides is applied to (or persists in) south Florida waters, sediments and/or soils. The south Florida region is unique in that a very large and sensitive ecosystem exists in the midst of an ever growing urban population and an extensive and intensive agricultural production area. A variety of pesticides are used in this area for a number of different reasons. Major uses are ground and/or aerial applications related to agricultural production, mosquito control, aquatic plant growth in local waterways, golf course maintenance, and lawn and vegetation maintenance. Pesticides used in these ways are effective in controlling the pests of concern. However the use of pesticides may also pose possible threats to the sensitive ecosystems and human health in Florida. This is due to the intense year-round use of pesticide compounds, coupled with intense storm events, the shallow water tables and the ever-increasing urban sprawl into previously undisturbed areas.

Mercury: Mercury is a toxic heavy metal. Levels of mercury in water, animal tissue, sediments, periphyton, air, and soil have been shown to be elevated in certain areas of south Florida. However, the sources, distribution, magnitude, transport, transformations and pathways of mercury through the Everglades ecosystem are poorly understood. Among the possible mercury sources in south Florida are natural mineral and peat deposits (Rood et al., 1995), and atmospheric deposition from global, regional and local (e.g., fossil-fuel-fired electrical generating plants, municipal waste incinerators, and medical waste incinerators) sources. Sources of mercury are now believed to be primarily from atmospheric deposition. Once elemental mercury is methylated by microbial action, it becomes biologically available for bioaccumulation at various levels of the food chain and for biomagnification up the food chain to top carnivores such as the Florida panther.

3.9.1 Regional Overview of Water Quality Conditions

Under Section 303(d) of the Federal Clean Water Act (CWA) states develop Total Maximum Daily Loads (TMDLs) for their water bodies that are not meeting designated standards under technology-based controls for pollution. For the study area, over 160 priority waterbodies/segments were listed by Florida Department of Environmental Protection. Using basin names designated in the annual Florida Department of Environmental Protection 305(b) reports (prepared for the U.S. Environmental Protection Agency pursuant to Section 305(b) of the Federal CWA), the approximate number of priority listings by basin were as follows.

- Kissimmee River Basin (29)
- Lake Okeechobee (12)
- Caloosahatchee River Basin (11)
- Everglades-West Coast or Big Cypress Basin (14)
- Southeast Florida Basin (95)
- Florida Keys (0)

Lake Okeechobee is at the center of the south Florida drainage system, receiving flow from the Kissimmee River Basin, and to a lesser extent from Everglades Agricultural Area backpumping. It discharges east through the C-44 Canal into the St. Lucie River Estuary, west through the Caloosahatchee River via the C-43 Canal, and south through four major canals into the Water Conservation

Areas. The Lake may be considered an historically nutrient rich water body that is becoming hypereutrophic, due primarily to nutrient inputs from the Kissimmee River and the Taylor Creek/Nubbin Slough Basins. Water quality conditions in the upper Kissimmee River appear to be improving, primarily due to re-routing of wastewater flows from the river to reuse and ground-water discharge sites. However, large quantities of nutrients are still discharged from Lake Tohopekaliga to Lake Kissimmee and other downstream areas. Water quality improves from Lake Kissimmee to near Lake Okeechobee, where the channel flows mostly through unimproved rangeland; however, pollutant loadings significantly increase as cattle and dairies grow more numerous Lake Okeechobee. The lake's total phosphorus levels have doubled in the last 20 years, due in large part to agricultural runoff. This same runoff also has contributed to frequent and widespread algal blooms and at least one major fish kill.

Even with the extensive pollutant abatement programs implemented in Lake Okeechobee watersheds during the past 15 years (i.e., reduction of Everglades Agricultural Area backpumping, dairy buyouts, the Florida Department of Environmental Protection Dairy Rule, the South Florida Water Management District Works of the District Regulatory Program), recent lake water nutrient concentrations and loads show no substantive signs of improvement. Further, because the lake's phosphorus is internally recycled, and a vast reservoir of the nutrient is stored in lake sediments as well as the lake's wetlands and watershed canal sediments, phosphorus levels in lake waters may not reach acceptable levels for many decades.

The Caloosahatchee River forms the major basin to the west of the lake. Water quality conditions are degraded in the upper and lower areas of the basin, due to agricultural and urban runoff, respectively. The channelized section of the river also shows degraded water quality conditions, due to agricultural inputs, as compared to tributaries lying in less developed areas of the basin. Problems associated with the degraded areas of the basin are typified by low dissolved oxygen levels, elevated conductivity, and decreased biodiversity. Conditions in the urbanized sections of the basin are influenced by nonpoint storm water flows, and are manifested in the river by elevated chlorophyll levels, algal blooms, periodic fish kills, and low dissolved oxygen levels.

Extensive agricultural Best Management Practices have been implemented in the Everglades Agricultural Area in the past several years which have reduced the phosphorus load leaving the Everglades Agricultural Area; however, this area remains a primary source of pollutants for the Water Conservation Areas. The Water Conservation Areas are the remaining wetlands in the northern section of the Everglades system. These areas have been isolated from contiguous lands by a series of levees and pump stations. Water moving south from Lake Okeechobee and the Everglades Agricultural Area is pumped into the Water Conservation Areas canals, effectively making these areas act as nutrient filters. The highly altered hydroperiod, resulting from the levees and pump operations, may exacerbate water quality conditions in the Water Conservation Areas, as evidenced by a general degradation of water quality in the areas along the canals and adjacent to pump stations, as compared to conditions in the central portions of the basins. Construction of the Stormwater Treatment Areas upstream of the Water Conservation Areas is expected to improve water quality conditions in the Water Conservation Areas through time.

Water quality conditions in the Upper East Coast are generally good in less developed areas of the basin. However, conditions are degraded in urbanized areas and along the extensive network of canals that drain this area. The worst water quality conditions in the basin are reported in the St. Lucie River and the canals leading from the Everglades Agricultural Area. Other major problem areas are found in Five-Mile and Ten-Mile Creeks (in the areas near Port St. Lucie), the main channel of North Fork in Port St. Lucie, and Manatee Pocket (a small embayment on the St. Lucie Estuary). Although the Savannas State Preserve, a 15-mile-long freshwater marsh between Ft. Pierce and Stuart, has fairly good water quality, mercury concentrations in fish tissue were high enough to warrant a no-consumption advisory for largemouth bass. The major sources of pollution in this basin are urban runoff, agricultural and rangeland runoff, boat discharges, and sewage overflows.

Waterbodies in the Lower East Coast Region are seriously degraded in the heavily urbanized areas, including the numerous man-made canals associated with the coast and drainage canals. For example, water quality in Lake Worth is good near the inlet and fair to good north of the inlet, but poorer to the south, especially in the area between the inlet and the West Palm Beach Canal (C-51 Canal). Water quality in Lake Worth improves again near the South Lake Worth Inlet. A small section of the North Fork of the Loxahatchee River has low dissolved oxygen levels, and in the last decade, seagrass beds in the estuarine portion of the Loxahatchee River have declined dramatically. Canals and waterbodies in and around Ft. Lauderdale are particularly degraded by urban runoff and historical wastewater treatment discharges, and by agricultural runoff in the westernmost areas on the canals. Problems associated with these pollutants are manifested by the dense growth of undesirable aquatic vegetation, low overall biological diversity, and the occurrence of exotic plants and animals. The New River and Miami River run through highly urbanized areas of Ft. Lauderdale and Miami, respectively. Both are polluted by improperly functioning septic tanks, discharges from vessels, industrial activities, improper sewer connections, and storm water runoff. These discharges result in high nutrient concentrations, high coliform bacteria counts, and high concentrations of heavy metals such as tin, copper, zinc, and chromium in sediments at all marina sites. Biscayne Bay has good water quality in the open water areas of its central and southern portions, and degraded conditions in its northern portion north of the Miami River.

In the central Everglades, phosphorus concentrations entering the Everglades National Park were lower in 1997 (Walker, 1998: internet) than the interim and long term limits established by the 1992 Settlement Agreement. While no significant trends in annual average mercury concentrations in water, sediment, or fish have been observed for the past five years, mercury concentrations in fish tissue were high enough to warrant a no-consumption advisory for largemouth bass throughout most of the eastern two thirds of the Everglades National Park, and a recommendation of limited consumption for the southeast corner of the Park. The best water quality conditions in the Everglades National Park were found in the central Shark River Slough and along the coastal regions of the basin.

Some parts of Florida Bay have experienced a massive seagrass and mangrove die-off during the late 1980's and early 1990's that likely stems from a lack of circulation, high water temperatures, and increased levels of salinity. Water diverted into the Lower East Coast primary canal network has reduced freshwater flows, and the salinity of bay water has been recorded as high as 70 parts per thousand. The 1997 Everglades Annual Report states that for 1997, the highest observed salinity levels occurred in Whipray Basin, and ranged from 40.6 parts per thousand to 42.3 parts per thousand (water conditions in the bay are considered hypersaline when salinity exceeds 35 parts per thousand). Hypersaline conditions were observed throughout most of the western portion of the bay during the dry season; however, they decreased below hypersaline levels once freshwater inputs increased in June 1997.

Water quality conditions in the Keys are generally good in areas open to the Atlantic or Gulf. However, many nearshore areas, man-made canals and marinas have water-quality problems that are exacerbated by poor circulation. Most of these problems are localized and generally can be attributed to wastewater plants and small “package plants” discharging to poorly flushed canals; septic tanks and cesspools; marinas lacking facilities to pump out waste from boats; fish processors; and storm water runoff, especially into the canals.

3.9.2 Groundwater Conditions

Ground water in south Florida consists of the surficial Biscayne Aquifer and the Floridan Aquifer. Both are critical to the ecology and economy of south Florida. The Biscayne Aquifer has been classified as a Sole Source Aquifer under the Federal Safe Drinking Water Act based on the aquifer’s susceptibility to contamination and the fact that it is a principal source of drinking water. The Floridan Aquifer system is one of the most productive aquifers in the world and is a multiple-use aquifer system. Where it contains freshwater, it is the principal source of water supply. In several places where the Floridan Aquifer contains saltwater, such as along the southeastern coast of Florida, treated sewage and industrial wastes are injected into it.

Because the Biscayne Aquifer is highly permeable and is at or near the land surface in many locations, it is readily susceptible to groundwater contamination. Major sources of contamination are saltwater intrusion and infiltration of contaminants carried in canal water. Additional sources include direct infiltration of contaminants, such as chemicals or pesticides applied to or spilled on the land, or fertilizer carried in surface runoff; leachate from landfills, septic tanks, sewage-plant treatment ponds; and wells used to dispose of storm water runoff or industrial waste.

Numerous hazardous waste sites (e.g., Superfund and Resource Conservation and Recovery Act (RCRA) sites) have been identified in the area underlain by the Biscayne Aquifer. Remedial action to clean up existing contamination is underway at many of these sites. Waste management practices are generally monitored to prevent further contamination. Additional information on groundwater conditions and contamination in south Florida is presented in ***Appendix H and K***, including specific Superfund (National Priority List: NPL) and RCRA hazardous waste sites in south Florida. Trichloroethylene (TCE) and vinyl chloride are examples of ground-water contaminants of concern.

3.10 WATER SUPPLY

One of the primary functions of the C&SF Project is to provide a highly-efficient flood control system designed to keep urban and agricultural areas dry in the wet season by discharging excess water to tide or into the Water Conservation Areas and Everglades National Park. Rapid wet season flood releases, coupled with the lack of retention in Lake Okeechobee, the reduced area of northern historical sawgrass plains, and loss of the eastern peripheral wetlands and sloughs, have severely reduced storage within the system causing excessive dry season demands on the regional system. The sawgrass plains, for example, once stored and slowly passed on much of the water that overflowed from Lake Okeechobee. Today, a large portion of the sawgrass plains habitat that was converted to agriculture within the Everglades Agricultural Area quickly passes excess runoff to the Water Conservation Areas and the coast during the wet season. Releases of Lake Okeechobee water are then periodically necessary to meet dry season demands. The reduction of storage over multiple years, not the lack of water, is a problem.

Minimum stages are maintained in Lower East Coast canals, principally to provide the volume of water needed to protect the Biscayne Aquifer from saltwater intrusion, a major threat to this water resource. The head created in the canals raises groundwater levels, recharging the aquifer and the urban wellfields. During the wet season, wellfields are recharged by local rainfall and by the regional system that provides ongoing seepage from the Water Conservation Areas and the canals. During the dry season, they are more dependent on the regional system. Unfortunately, during the wet season, "excess" storm water is passed through the canals and out to tide, when it should be stored and used during the next dry season. Without sufficient storage, it has been difficult to have water available during the dry season without causing flooding during the wet season.

Water users within the urban areas argue that the Lower East Coast is largely self-sufficient and efficient because the groundwater seeping through the Lower East Coast would eventually reach coastal waters were it not withdrawn by the utilities. The South Florida Water Management Model illustrates how this works. As demands increase, the volume of water that reaches coastal waters decreases. In the South Florida Water Management Model, at Snake Creek, north of Miami, 121,000 acre-feet of water were lost through groundwater seepage during the wet season in the 1995 base. That amount decreased to 114,000 acre-feet in the 2050 base as urban water supply demand increased. In the Miami River, in the 1995 base, over 192,000 acre-feet were unrecoverable (wet and dry season total). In the 2050 base, only 121,000 acre-feet were unrecoverable.

Others argue that the urban area is far from self-sufficient. The pattern described above occurs during wet seasons and during normal rainfall years. During extremely dry years, no water reaches the coast and the urban wellfields depend heavily on deliveries from the Water Conservation Areas (including the ongoing seepage from these areas) and Lake Okeechobee via the primary canals for water supplies. Even during normal dry seasons when flood releases are minimal, the high demands on the system from urban water supply may be withdrawing water from the natural environment that should be kept in the system for late winter and spring biological rejuvenation. In addition, during drought years, the urban and agricultural areas create additional demands as the need for irrigation increases. Also, a significant percentage of water consumed is used for landscape maintenance, primarily watering lawns from shallow wells.

Another concern is that, at present, the flow of water along the eastern protective levee is from the wetlands to the coast. Keeping the water levels high west of the Atlantic Coastal Ridge, and keeping levels low to the east of it, results in large groundwater losses from the remnant Everglades throughout the year. This situation has also reduced the coastal groundwater flows into estuaries like Biscayne Bay and has made it necessary to import regional water to the Lower East Coast to maintain adequate coastal groundwater levels to prevent saltwater intrusion.

Due to efficiency in application, the amount of water needed to recharge urban wellfields is small compared to the tremendous volumes needed to prevent saltwater intrusion. Preventing saltwater intrusion is important for several reasons. For example, if significant saltwater intrusion occurred even once, the easternmost wellfields would be contaminated indefinitely and would be replaced with wells further west. This situation has already occurred in Metro-Miami-Dade County.

Although significant, the amount of water needed to prevent saltwater intrusion is much less than the wet season coastal releases. It is possible that those flows alone, if captured and stored, would be more than sufficient to maintain the dry season salinity barriers without the need to take water from the natural system. Also, storing coastal outflows in the lower east coast region and maintaining higher groundwater levels along the coastal ridge would allow large quantities of regional water to remain in the C&SF system and to be used for dry-season environmental benefits.

Within the Lower East Coast, there are also ecological benefits in maintaining groundwater levels. Lower groundwater levels can and have caused serious negative effects on estuaries and coastal and freshwater wetlands. Biscayne Bay for example, has suffered the consequences of both ground and surface water losses, including increased salinity, lower visibility, and lower water quality. In Miami-Dade, Broward and Palm Beach Counties, lowered groundwater levels have caused wetland desiccation and produced shifts in vegetation types.

3.11 SOCIO-ECONOMICS

Florida's economy is characterized by strong wholesale and retail trade, government and service sectors. The economy of south Florida is based on services, agriculture, and tourism. Florida's warm weather and extensive coastline attract vacationers and other visitors and help to make the state a significant retirement destination for people from all over the country.

The 16 south Florida counties that make up the study area had a 1990 population of 6.3 million, accounting for nearly half (about 49 percent) of Florida's total. This share has changed very little over the past 20 years and recent U.S Department of Commerce projections predict it will remain stable over the next 50 years. Over 60 percent of this south Florida population is in the three Lower East Coast Counties of Palm Beach, Broward, and Miami-Dade. The study area population is expected to reach over 11 million by 2050, with the Lower East Coast population expected to reach over 6.9 million by then.

Slightly over half of Florida's employment and earnings takes place in the study area. Nearly two thirds of this is concentrated in the populous Lower East Coast three-county area. Excluding the northernmost counties of Polk, Orange, and Osceola, which are technically part of the study area, but which are outside the main focus of the Restudy, the tri-county Lower East Coast area accounts for about 80 percent of the regional aggregate socio-economic activity with in the study area.

Employment and income in the south Florida study area have continued to grow in recent decades faster than the national average. Growth, though slower than that of the Lower East Coast, has been significantly greater in the southwest counties and the Florida Keys (taken as a group--Monroe, Collier, Hendry, Lee, and Charlotte), and in the Counties around Lake Okeechobee (Glades, Highlands, Martin, Okeechobee, and St. Lucie) than in the northernmost counties of the study area.

3.12 LAND USE

The existing use of land within the study boundaries varies widely from agriculture to high-density multi-family and industrial urban uses. A large portion of south Florida remains natural, although much of it is disturbed land. The dominant natural features are the federally protected Everglades National Park, Biscayne National Park, and Big Cypress National Preserve at the southernmost tip of the peninsula, Lake Okeechobee, Biscayne Bay, the state protected Water Conservation Areas in the westernmost reaches of the Lower East Coast counties, and remnant freshwater and coastal wetland and upland systems within and adjacent to the developed areas along the coasts. Generally, urban development is concentrated along the lower east coast from Palm Beach County to Miami-Dade County, in the central Florida / Orlando area, and on the Lower West Coast from Fort Myers to Naples.

Most of the interior of the study area is in agricultural use, which includes sugarcane (the dominant crop) and vegetable farms in the Everglades Agricultural Area of western Palm Beach County and Hendry County; the Agricultural Reserve Area of Palm Beach County; and the south Miami-Dade agricultural area where vegetable crops dominate, especially tropical varieties. There are citrus groves in every county, but citrus is concentrated in St. Lucie and Martin counties on the east coast and Hendry, Highlands, Collier, and Glades Counties on the west. Cattle and dairy farms predominate in Glades, Highlands, and Okeechobee Counties.

In the northern portion of the system, around Orlando, tourism and its attendant service-oriented land uses (for example, hotels/ motels, convenience stores, souvenir shops) make up a significant portion of the landscape. Agriculture, however, continues to play an important role in the region, with over two million acres being farmed, half of which is pastureland. The area surrounding Lake Okeechobee, is largely rural, with agriculture the prevailing land use. There are over 700,000 acres of irrigated farm land in the Everglades Agricultural Area south of the lake. Farm products produced there include sugarcane, the predominant crop, rice, row crops, and sod. There is also extensive pastureland both west and north of the lake. Directly south of the Everglades Agricultural Area lie the Water Conservation Areas. The Water Conservation Areas cover about 878,080 acres and consist mainly of sawgrass marshes and tree islands. The Water Conservation Areas were created by the 1948 C&SF Project for the conservation of water supplies for the Lower East Coast.

The Upper East Coast includes St. Lucie and Martin Counties; the landscape is dominated by agricultural uses. Significant natural resources, the St. Lucie Estuary and Indian River Lagoon, are also contained within this area. Urban land use, which makes up 17 percent of the Upper East Coast, is mainly concentrated along the seaboard coastal and lagoon shorelines. The Lower East Coast extends approximately 100 miles through the coastal portions of Palm Beach, Broward, and Miami-Dade Counties. As the most densely populated subregion in the state, the Lower East Coast is home to one third of the state's population, more than 4.5 million people. The subregion is primarily an urban megalopolis, but it also contains substantial agricultural acreage, particularly in southwestern Miami-Dade County (90,000 acres) and western Palm Beach County (29,000 acres). Rapid population growth and land development practices have resulted in notable western urban sprawl; the predominant land use is single-family residential. The once significant rural population in the western areas of Broward County has practically disappeared, resulting in an urbanized makeup in population. Miami-Dade and Palm Beach Counties are not far behind.

The Florida Keys are made up of over 1,700 islands that encompass approximately 100 square miles, and contains the largest coral reef system in the United States. While a majority of Monroe County is designated as conservation land, due to the land falling within either Everglades National Park, the Big Cypress National Preserve, or the National Key Deer Refuge, land use is primarily either residential or geared towards supporting the region's main industry (tourism). Monroe County's fragile natural resources and vulnerability caused the State of Florida to designate the area as an Area of Critical State Concern in 1975; such designation is intended to protect such resources from degradation by strictly regulating development.

The southwestern counties of Collier and Lee are the fastest growing in terms of population in the state. Population growth is mainly due to the in-migration of retirees, not a high birthrate. The coast has become highly urbanized, with development spreading eastward into agricultural and natural lands. Agriculture is however, a major industry, especially in Lee County where citrus predominates.

The Big Cypress Basin, which encompasses a large, relatively pristine natural area, is threatened by a rapidly growing human population and advancing agricultural development, particularly from the north in Hendry County.

3.13 RECREATION RESOURCES

Recreation opportunities abound in the study area. Central and south Florida is rich in water resources, with easy access to fresh, estuarine and marine resources for fishing, boating, swimming, diving, camping, and sightseeing. Within the upper basin of the Kissimmee River region are dozens of freshwater lakes, popular for boating and fishing. Marinas, fishcamps, and public facilities (boat launching, picnicking, bank fishing) are located around many lakes in the region. Thirty-six miles of the Florida Scenic Trail were designated in June 1990 with additional trail section designations to follow. Lake Kissimmee State Park, Three Lakes, Kissimmee River and Kicco Wildlife Management Areas, and Prairie Lakes Preserve provide upland and water based recreation resources for the region.

Lake Okeechobee is the second largest freshwater lake within the continental United States and is a nationally recognized bass and pan fishing resource. Thousands of "snow birds" flock to the shores of Lake Okeechobee where they spend winter months fishing and enjoying the south Florida weather. The Lake offers other recreational amenities as well. Air boat and swamp buggy rides, bike riding, hiking, picnicking, camping, and nature interpretation are popular land based recreation activities in the region.

The urbanized east coast includes good quality marine based recreation activities such as underwater diving, salt water and estuary fishing, boating, surfing and, of course, the beach. County and state parks, scenic rivers, state reserves and forests, and Federal refuges provide wildlife viewing, nature interpretation, hiking, and canoeing opportunities. The Atlantic Intracoastal Waterway provides a diverse water-based recreation resource opportunity in the region. The Loxahatchee National Wild and Scenic River, Indian River Lagoon, DuPuis Reserve State Forest, J.W. Corbett Wildlife Management Area, and the Loxahatchee River – Lake Worth Creek Aquatic Preserve provide high quality recreation opportunities for boating, fishing, and nature interpretation activities within the coastal region.

Recreation resources in the Water Conservation Area region are inland water and upland resources that include the Arthur R. Marshall Loxahatchee National Wildlife Refuge Rotenberger and Holey Land Wildlife Management Areas, and (FDEP, 1994). These areas provide high quality boating, fishing, and nature interpretation activities. The Miccosukee State Indian Reservation is within the Water Conservation Area region boundary. Hunting, boating, and fishing occur within the reservation. Fishing, hunting, boating and airboating are popular activities within the Water Conservation Areas. North of the Water Conservation Areas, in the Everglades Agriculture Area, there is the CREW Wildlife and Environmental Area and the Lake Harbor Public Waterfowl Area. The L-29 Borrow Canal which divides Water Conservation Area 3 from Everglades National Park is a popular fishing destination for residents of the Lower East Coast region. The L-67A and L-67C Canals are sport fishery resources of state-wide importance and support several bass fishing tournaments throughout the year.

Biscayne Bay offers among the highest quality recreation opportunities within the study area including fishing, shellfishing, sailing, motorboating, swimming, snorkeling, and canoeing. Biscayne National Park provides opportunities for birdwatching, recreational hiking, boating, fishing, snorkeling, diving and picnicking.

Everglades National Park and Florida Bay offer unique and diverse opportunities for a variety of natural resource and wilderness based recreational activities. Day use and camping (front and backcountry) facilities are available throughout the Park. There are over 150 miles of walking and canoe trails, including 2 miles of elevated boardwalk trails and three campgrounds with over 420 campsites and an additional 48 backcountry campsites in the Park. Recreation activities include: hiking, boating and canoeing, fishing, bird and wildlife viewing, and guided interpretive tours.

Everglades National Park has been designated a World Heritage Site, and International Biosphere Reserve, and a Wetland of International Significance. In addition, 86% of the Park is designated Wilderness under the Wilderness Act of 1964. The State of Florida has designated the Park an Outstanding Florida Water.

Diverse ecosystems from sawgrass prairie to pinelands and hammocks to the estuarine environment of Florida Bay area easily accessible from the main park road or the Shark Valley tram road. The main park road ends at Flamingo, a former fishing village, and a main port of entry to Florida Bay, where a variety of self-guided, concession or ranger led walks and boat tours are available. U.S. 29 leads to Everglades City and the Gulf Coast Visitor Center where the island-bay-mangrove ecosystems of the 99 mile Wilderness Waterway and Chokoloskee Bay, Turner River, and the Ten Thousand Islands area can be accessed. Chekika, a former state park, offers a slightly different experience with opportunities for a soak in a sulfur pool as well as for picnicking and hiking. Nearby is the Southern Glades Wildlife and Environmental Area which is managed by the Florida Game and Freshwater Fish Commission.

The Florida Keys, are world renowned as diving and sportfishing destinations. Boating, fishing, diving, and nature interpretation are some of the many recreation opportunities in the region. Five wildlife refuges are located in the region and one of the busiest parks in the state. Several state parks are also within the region including John Pennekamp Coral Reef State Park, Key Largo National Marine Sanctuary, designates for the protection of the delicate reefs outside of Pennekamp, which is also a popular diving destination. Diving is the most popular recreation activity followed by fishing, and bird watching.

The Big Cypress region provides a unique wilderness area where recreation is primarily wetland based with some upland access and facility use. Air boating, fishing, hunting, and nature interpretation are all very popular recreation activities in the region. Camping facilities are also found within the region. Five state parks and recreation areas are located in the region as is a state preserve, the Panther National Wildlife Refuge, and National Audubon Society's Corkscrew Swamp Sanctuary.

The Caloosahatchee River provides approximately 67 miles of navigable waterway with ten Corps recreation facilities that include boating, fishing, picnicking, and camping. The J.N. “Ding” Darling National Wildlife Refuge, a popular birding area, administers Caloosahatchee National Wildlife Refuge, Matlacha Pass National Wildlife Refuge, Island Bay National Wilderness area and Pine Island National Wildlife Refuge, all located near the region’s western edge. In Charlotte county there is the Fred C. Babcock/Cecil M. Webb Wildlife Management Area. Boca Grande Pass is world renowned for record tarpon, Sanibel Island is reported among the top shelling destinations in the Western Hemisphere,

3.14 AESTHETICS

The visual characteristics of the central and south Florida region can be roughly described for the dominant three land use categories (natural areas, such as those areas within the Everglades Protection Area, agricultural lands, and urban areas). Regional aesthetics depends in a large part on one's personal perspective. Where one lives, spends recreational time, makes a living, and who one perceives oneself to be, contributes to a personal perspective and opinion of what is aesthetically pleasing, and what is not.

Very briefly, the natural areas are composed of a variety of upland and wetland based ecosystems including lakes, sloughs, ponds, and vast expanses of marsh and wet prairie with varying vegetative components. Uplands are often dominated by pine, although other sub-tropical and tropical hardwoods such as fig, gumbo limbo, and cypress occur within their ecotone. Overall the land is remarkably flat, with few natural topographic rises such as hills or other geographic undulations. Much of the visible topographic features are man-made, including ubiquitous canals and levees. Additional man-made features of the landscape include pump stations, navigation locks, secondary and primary roads, highways, electrical wires, communication towers, occasional buildings (some abandoned), borrow pits and other features which may or may not detract from the regional aesthetic. Views, when possible from a high perspective such as atop a levee, offer pleasant and unspoiled perspectives on Everglades marsh, often dotted with tree islands, and numerous birds and other wildlife.

One of the most prominent levees in the C&SF Project system is the Herbert Hoover Dike, over 140 miles of levee surrounding Lake Okeechobee. The impact of this levee on the lake's regional aesthetics has been permanent and profound. What is otherwise a scenic and immense natural water body with a profusion of wildlife along the shoreline, is nearly invisible to the casual observer because the Herbert Hoover Dike effectively blocks one's view. This is an example of the types of aesthetic impacts to key regional and local natural resources that the Restudy must strive to avoid.

Other key natural areas of particularly high aesthetic quality include among others, the Loxahatchee Slough, large areas of the Big Cypress National Preserve, the interior of some of the Water Conservation Areas, Loxahatchee National Wildlife Refuge, the Ten Thousand Islands, Everglades National Park, Florida Bay, and Biscayne Bay. The Florida Keys and the coral reef tract provide important aesthetic qualities to the state as well as some of the most significant underwater aesthetics in the world.

Agricultural lands occur throughout the system outside of the Everglades Protection Area. They are comprised largely of open pastureland north of Lake Okeechobee, in the Caloosahatchee region and northern Big Cypress region, where dairy and beef cattle operations predominate. The Kissimmee River region, for instance, is primarily pasture, with patchy natural areas, that function to retain water for the regional system. The Lower Basin of the Kissimmee River region is largely undeveloped and presents a panoramic landscape largely untouched by mankind for miles. The C-38 Canal is straight and wide and in the process of being "restored". Project earth moving equipment, as well Avon Park Bombing Range aircraft, break the panoramic scenery and detract from the otherwise high visual quality.

In the Everglades Agriculture Area, sugarcane production, and to a lesser extent sod, vegetables and rice lend a uniform and organized appearance to the landscape, largely devoid of trees and other non-agricultural vegetation. The view is rather monotonous and of marginal value. Agriculture in the Upper East Coast and in South Miami-Dade County is somewhat less intensive than the Everglades Agriculture Area and so a more traditional agricultural landscape, with more diverse crops such as citrus and a variety of tropical trees, shrubs and landscape plants predominates. Both the natural areas described above, and the agricultural areas are relatively open, with low population density, few buildings and other structures interspersed across the landscape, and are generally quiet.

The urban areas, other than the scattered small to medium sized municipalities characteristic of the interior regions, occur mostly along the highly urbanized east coast. This includes such sprawling, mostly low level cityscapes as Stuart, Fort Pierce, West Palm Beach, Boca Raton, Pompano Beach, and nearby urban areas. Fort Lauderdale and Miami and their surrounding suburban areas epitomize the highly urbanized scene described above, only with significant high rise buildings in the downtown area nearest the coast or on nearby barrier islands. These cities are visually congested with immense residential areas, composed mostly of one or two story buildings, well-trafficked roads, seemingly endless impervious surfaces, parking lots, strip malls, high rise hotels, and industrial and commercial enterprise. The urbanized east coast begins more or less at the Florida Turnpike, and extends eastward to the coast. It includes intensively developed residential communities, highways and heavily used roads, and other development immediately adjacent or nearby to protected natural areas or agricultural lands. Visual aesthetics are marginal except in areas where urban landscaping assumes a high priority.

Along the coast, the Atlantic Ocean and Atlantic Intracoastal Waterway shorelines provide panoramic aesthetic views from many locations. White shoreline sand contrasts sharply with blue and green waters of the ocean and Atlantic Intracoastal Waterway in the region. High-rise structures, often hotels to serve the tourist industry, restrict visual access to the ocean's panoramic scenery and tend to diminish the visual experience from the shoreline. Visual access to the scenic Atlantic Intracoastal Waterway is also limited.

3.15 CULTURAL RESOURCES

The earliest widely accepted date of occupation of Florida is around 12,000 years ago. This earliest cultural period is termed the Paleo-Indian stage and lasted until about 7500 B.C.

The Archaic stage (ca. 7500 B.C. - ca. 500 B.C.) is thought to be a reflection of man's adaptation to the changing environment at the start of the Holocene, when our basically modern climate and biota were established. Foraging and hunting are the main subsistence activities throughout the Archaic stage, with Late Archaic people exploiting a larger territory and wider range of aquatic and terrestrial food resources.

In the Okeechobee Basin, the Belle Glades culture sequence (ca. 500 B.C. - A.D. 1500) is subdivided into four periods based on ceramic and other material remains. A complex political system practiced by the Calusa was recorded in the late Belle Glades sequence. Objects of Spanish origin obtained from European contact or shipwreck salvage have been recovered from sites dating to the late periods of the Belle Glades.

The Caloosahatchee River is often identified as a separate cultural area. During the pre-Columbian period the river likely served as a vital transportation route to the Okeechobee Basin and the Glade culture areas. Large shell mound and shell midden sites characterize the Caloosahatchee coastal area. Sand burial mounds and shell and earth middens are typically found inland along the river. Smaller dirt middens are found on interior hammocks near freshwater marshes.

During the early historical period, beginning with the first Spanish colonial period (1513 - 1763), European contacts were limited to the coastal areas. It is estimated that approximately 10,000 Calusas inhabited southern Florida prior to contact with Europeans. The Calusas were hunters and gatherers concentrated primarily in coastal areas, subsisting by fishing, collecting shellfish, and gathering wild plants for food.

Interaction between Spanish and French explorers and the Calusas occurred during the 16th century. The European settlers attempted to convert the Native Americans to Christianity and alter their social structure. The Spanish retreated from Florida in the 1570's, leaving the Calusas undisturbed during the 1600's. Approximately 6,000 Calusas remained, but disease and occasional European invaders continued to reduce the population.

The Miccosukees are descendants of the Hitchiti-speaking Lower Creeks, and the Seminoles of the Muskogee-speaking Upper Creeks. These groups migrated to Florida in the 18th and 19th centuries from Georgia and Alabama. Then as now, the ethnic distinction between the Miccosukees and Seminoles stems mainly from a difference in language.

By the early 1800's, the migrant Native American population of Florida had grown to about 5,000. Miccosukee and Seminole Indians settled primarily in Northern Florida originally. Removal and relocation of many Indians to reservations west of the Mississippi River occurred as a result of the Seminole Wars of the 1800's and the Indian Removal Act of 1830. Following the United States government policy of Indian removal, the remaining Miccosukees and Seminoles moved farther south and established themselves in the Everglades, Big Cypress Swamp, and the Ten Thousand Islands. Most of the people lived on upland tree islands (hammocks), and used dugout canoes for transportation, hunting, and trading. Dwellings, called chickees, were constructed of cypress logs and palm fronds. The traditional lifestyle endured for the remainder of the century and still endures to a certain extent.

The first efforts to drain and reclaim the Everglades began in 1881. Agriculture began in the Everglades, south of Lake Okeechobee, after drainage projects of the 1906-1927 era. During this period, the first settlements, Okeelanta and Glade Crest were established just south of the lake. By 1921, there were 16 settlements on or near Lake Okeechobee, with a total estimated population of 2,000. Settlement and agricultural activities escalated during the subsequent decades.

By the early 20th century, hundreds of sport and commercial hunters were exploiting the Everglades resources. The opening of Tamiami Trail in 1928 ensured easy access for hunters and trappers to the southern Everglades. Permanent homes were rare, and the isolation and harsh environment compelled people to be self-reliant. Although soils in the area were fertile, it was the exploitation of fishery resources, along with animals and birds for skin and feathers, which was most economically important.

3.16 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

A preliminary Phase I Hazardous, Toxic and Radioactive Waste (HTRW) assessment was conducted in August 1998 to address the existence of potential for occurrence of HTRW on lands, including structures and submerged lands, in the study area. The assessment included a project review, review of site literature and Alternative D-13R project features, database search, review of available records and aerial photography, site inspections and interviews. The following potential indicators were looked for: landfills, dumps, disposal areas, aboveground and underground storage tanks, vats, containers of unidentified substances, spills, seepage, slicks, odors, dead or stressed vegetation, water treatment plants, wells, ditches, abandoned buildings, and transport areas (such as boat yards, harbors, rail yards, airports, truck terminals, and fueling stations).

The assessment covered all Restudy regions, within the general vicinity of proposed project features or existing features proposed for significant modification. Several site visits were conducted over the past few years, with the most recent field survey having been performed during the week of 10-14 August 1998. The project conditions assume that any HTRW found during any phase of the project would be remediated in accordance with local, state and Federal laws. The results of the Phase I assessment and data base search are included in ***Section 8*** and ***Appendix K***.

SECTION 4
FUTURE "WITHOUT PLAN" CONDITION

This section provides a definition as to what is meant by the future "without plan" condition and how and why it is developed. In the context of the Restudy, the term "plan" refers to alternative comprehensive plans and not to the existing C&SF Project (although Project modifications will be important parts of the alternative plans).

4.1 "WITH AND WITHOUT" COMPARISONS

The U.S. Water Resources Council's *Principles and Guidelines* provides the instructions and rules for Federal water resources planning (USWRC, 1983). One *Principles and Guidelines* requirement is to evaluate the effects of alternative plans based on a comparison of the most likely future conditions with and without those plans. In order to make this kind of comparison, descriptions - often called forecasts - must be developed for two different future conditions: the future without plan condition, and the future with-plan condition.

The future without plan condition describes what is assumed to be in place if none of a study's alternative plans are implemented. The without-plan condition is the same as the alternative of "no action" that is required to be considered by the Federal regulations implementing the *National Environmental Policy Act of 1969 (NEPA).*

Future "with plan" conditions describe what is expected to occur as a result of implementing each alternative plan that is being considered in a study. With plan conditions are developed for each alternative plan; therefore, there are as many with plan conditions as there are alternative plans.

The differences between the "without plan" condition and the "with plan" condition are the effects or impacts of the plan. Note that the plan referred to in this context is any one of the alternative plans that have been considered in the Restudy. The formulation of alternative plans is described fully in ***Section 7*.**

4.1.1 "With-and-Without" Versus "Before-and-After"

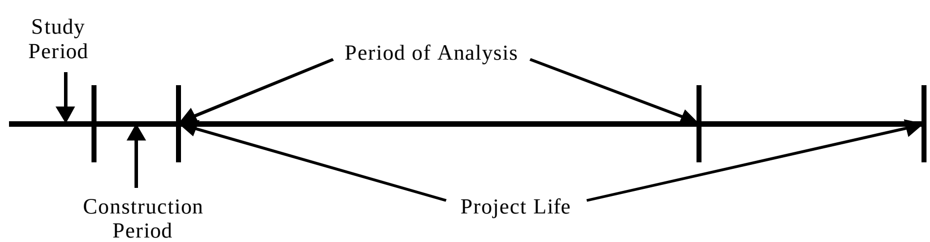
Many people typically think about the effects of alternative plans in terms of "before and after"; that is, they compare the condition that exists now, before it is changed by a plan, to the condition they expect to exist in the future after it has been changed by a plan. For example, if a proposed levee were to cover four acres of an existing 10-acre wildlife habitat, then, using a before-and-after comparison, the levee could be said to result in a loss of four acres of that habitat.

Another way to think about effects is to compare the conditions that are expected to exist in the future if no alternative plan is implemented, the without plan condition, to the conditions that are expected to exist in the future if a particular plan is implemented. Returning to the example, let's say that the 10-acre wildlife habitat is already included in a residential development plan that would convert three of its acres to residential sites. Now suppose that a proposed levee would cover four acres of the 10-acre site, including the same three acres that would be converted to residential sites. Using a “with-and-without” comparison, the levee would be said to result in a loss of only one acre since three of the four acres would be affected even if the levee were never constructed. With-and-without comparison recognizes that the future is often different from the existing condition; and, unlike before-and-after comparisons, accounts for future changes in the comparison.

4.2 PLANNING HORIZON

The planning horizon encompasses the feasibility study period, the construction period, the economic analysis period, and the effective life of the project. How long a time period should be used when forecasting future without-project and with-project conditions, and considering the impacts of alternative plans? This time frame is called the period of economic analysis, and is also known as the period of analysis. It is the period of time over which we think it is important to extend our analysis of plan impacts. This time period is frequently confused with the planning horizon, which is a longer and more encompassing concept. ***Figure 4-1*** shows that the period of analysis is part of the planning horizon.

Figure 4-1: Planning Horizon



The period of analysis for water resources projects is usually 50 years and never over 100 years. Forecasting conditions and impacts beyond 100 years is pure guessing, even if some structural projects may last more than 100 years.

If significant impacts do not last 50 years, the period of analysis should be restricted to the duration of the significant impacts. One of the most common measures of impacts has to do with the time value of money. Future dollar values, whether benefits or costs, are worth less than current dollar values. Discounting is the process used to place dollar values incurred at different times on an equivalent time basis. After 50 years, the discount factor alone reduces monetary values to a mere fraction of their former value. Unless the future dollar values being discounted are large there is no apparent point to continue to include these values among project impacts. Therefore, the period of economic analysis for the purposes of this study will be 50 years.

4.3 CLIMATE

The hydrologic data used for modeling in this study are based on a 31-year period of record. For the modeling effort, the climatic record from 1965 to 1995, was used for both the existing (1995) condition, and the future (2050) without plan condition. This climatic record is considered appropriate in that it includes wet, dry and average years which are and have been typical of conditions in south Florida. The wet years are considered to be 1969-1970, 1982-1983 and 1994-1995, the dry or drought years are 1971, 1975, 1981, 1985 and 1989 and a typical, average year is 1984. Rainfall and potential evapotranspiration are the key climatic inputs. This same record was used in the evaluation of plan alternatives. For the purpose of this study, it is assumed that the 31-year period of record used for the hydrologic modeling is representative of conditions that are expected to occur in the study area in the future.

4.4 SEA LEVEL RISE

The U.S. Environmental Protection Agency (EPA) completed a study of the probability of sea level rise in 1995 (USEPA, 1995). Some conclusions from this study follow. "Many climatologists believe that increasing atmospheric concentrations of carbon dioxide and other gases released by human activities are warming the Earth by a mechanism commonly known as the 'greenhouse effect". The Earth's average surface temperature has risen approximately 0.6^0 C (1^0 F) in the last century, and the nine warmest years have all occurred since 1980. Global warming is most likely to raise sea level 15 cm (0.48 ft) by the year 2050 and 34 cm (1.09 ft) by the year 2100." The report estimates that "*along most of the U.S. Atlantic and Gulf coasts, there is a 50 percent chance that sea level will rise at least one foot by the year 2050, and two feet by the year 2100.*"

The Environmental Protection Agency published historic rates of sea level rise at various locations in the United States. Those of interest to the study area are shown in ***Table 4-1***. Estimates of sea level rise in future years for specific locations within the study area are shown ***Table 4-2***. These normalized projections estimate the extent to which future sea level rise will exceed what would have happened if current (historic) trends in ***Table 4-1*** simply continued.

TABLE 4-1
HISTORIC RATE OF SEA LEVEL RISE

Atlantic Coast		Gulf Coast	
Mayport, FL	2.2 mm/yr	Key West	2.2 mm/yr
Miami Beach, FL	2.3 mm/yr	St. Petersburg	2.3 mm/yr

Source: Sea Level Variations for the United States1855-1986, National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD., Lyles, S.D., Hickman, L. E., Debaugh, H. A., 1987

TABLE 4-2
ESTIMATING SEA LEVEL RISE AT SPECIFIC LOCATION
Normalized Sea Level Projections, Compared with 1990 Levels (cm)

Cumulative Probability	Year 2025	Year 2050	Year 2100
10	-	-	1
20	1	3	10
30	3	6	16
40	4	8	20
50	5	10	25
60	6	13	30
70	8	15	36
80	9	18	44
90	12	23	55
95	14	27	66
97.5	17	31	78
99	19	38	92
Mean	5	11	27
Standard Deviation	6	10	23

To estimate sea level rise at a particular location, the historic sea level rise is added to the projected rise that would occur if current trends were to continue. For example, the historic rate of sea level rise at Miami Beach is 2.3 mm per year (***Table 4-1***). Under current trends, sea level will rise 14 cm between 1990 and 2050. Adding 14 cm to the normalized values in ***Table 4-2***, the median estimate for 2050 is 25 cm, with a one percent chance of a 52 cm rise, and a 50 percent chance that sea level will rise at least 24 cm.

Most coastal areas of the United States are moving vertically as the result of tectonic forces, glacial rebound, the consolidation of sediments, or the extraction of water, gas and oil. Therefore, the evaluation of the impacts of sea level change require the development of sea level projections that are relative to the land motion. Rates of land elevation change for the study area are shown in ***Table 4-3***.

TABLE 4-3
RATES OF LAND ELEVATION CHANGE

	Trend		
Location	mm/yr	cm/yr	ft/yr
Mayport, FL	+1.0	+0.10	+0.0032
Miami Beach, FL	+1.1	+0.11	+0.0035
Key West, FL	+1.0	+0.10	+0.0032
St. Petersburg, FL	+0.8	+0.08	+0.0026

Source: Sea Level Variations for the United States1855-1980, National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD., Lyles, S.D., Hickman, L. E. Jr., Debaugh, H. A., 1983

To estimate relative sea level rise at a particular location, the rate of land elevation change is added to the sea level rise that would occur if current trends and future projections were true. For example, at Miami Beach, land elevation change is estimated to be +6.6 cm by the year 2050. Therefore, the median relative sea level rise estimate at Miami Beach for 2050 is 18.4 cm (0.59 ft), with a one percent chance of an 45.4 cm (1.46 ft) relative rise, and a 50 percent chance that sea level will rise at least 17.4 cm (0.56 ft).

To determine the sensitivity of the C&SF Project to sea level rise a modeling scenario was completed for the future without plan condition utilizing a 15 cm rise in sea level so that the impacts of such a change on the performance of the water management system can be assessed. The sea level rise changes the boundary conditions of the South Florida Water Management Model in the Lower East Coast. The South Florida Water Management Model assumptions for the rise are as follows: specific coastal canals were maintained higher, flood control releases were delayed to allow a higher maintenance level, but the water level at which maximum releases were made was not altered, and trigger levels for water supply cutbacks were also raised by 15 cm with the exception of one interior trigger in Palm Beach County. Analysis of this scenario showed that the sea level rise had the most impact on the coastal canals and communities with loss of flood protection and salt water intrusion being the primary impacts. Lower East Coast water supply cutbacks are expected to increase significantly as well as deliveries to Lower East Coast service area. Coastal ecosystems and estuaries were adversely affected and would require additional deliveries of fresh water. The performance measures for the interior of south Florida did not appear to be influenced by the sea level rise. This was probably due to the higher ground elevations than those found along the coast. A detailed description of this modeling scenario can be found in ***Appendix B.***

4.5 POPULATION AND SOCIO-ECONOMIC CONDITIONS

The south Florida 16-county study area is characterized by higher average incomes, and greater economic and population growth than the rest of the State and the Nation. This is particularly true of the Lower East Coast (Palm Beach, Broward, and Miami-Dade Counties), and while true in average terms for the study area as a whole, some localities do not share in this overall trend. The important features of the economic landscape are agricultural activity, construction, fishing, tourism, and recreation. This picture is expected to continue to be the case for 2050.

The south Florida study area is home to just over six million people, about half of Florida's population. This relationship between the study area's population and that of the state has been so for some time and is likely to continue. Population growth tends to exceed the national rate of growth, a trend expected to continue, although at a declining rate from that of the past.

The Lower East Coast population is expected to grow by 72 percent from just over four million in 1990 to nearly seven million by 2050 (G.E.C., 1996). The 16-country study area counties are expected to experience population growth during this period from 6.3 million to 11 million. The Monroe County population is projected to grow from 78,000 in 1990 to 126,000 by 2050.

Florida's economy is characterized by strong wholesale and retail trade, government and service sectors. Florida's warm weather and extensive coastline attracts vacationers and other visitors and helps to make the state a significant retirement destination for people from all over the country. Agricultural production and fisheries are also important sectors of the state's economy, and are especially significant to portions of the study area. While compared to the national economy, the manufacturing sector has played less of a role in Florida, but high technology manufacturing has begun to emerge as a significant sector in the State over the last decade. Total employment in the study area is expected to grow from about three million in 1990 to about five million by 2050. Lower East Coast employment by 2050 is projected to be about 2.7 million.

Most of the population and economic activity in the study area is concentrated along the Lower East Coast (Miami-Dade, Broward, and Palm Beach Counties). Per capita income for the study area as a whole is above that for the State. The three-county area's per capita income is even higher. These relationships will likely continue to 2050.

The Lower East Coast three-county area comprises about 9.5 percent of the State's land area but is home to 31 percent of Florida's population. Population growth is fueled by in-migration, as it continues to be both a leading location for retirement as well as a haven for refugees from such places as Cuba and Haiti. By contrast, the group of primarily agrarian counties bordering the shores of Lake Okeechobee (Glades, Highlands, Martin, Okeechobee, St. Lucie, and Hendry Counties, but excluding Palm Beach County), while similar in size to Lower East Coast counties, comprise only about three percent of the study area's population.

The Big Cypress and Caloosahatchee River regions (Lee, most of Collier and Hendry, and part of Charlotte and Glades Counties) are two of the fastest growing regions in the nation. The estimated total population of these counties for 1990 was 632,000. The total population is projected to increase 63 percent to 1,032,000 by the year 2010. It is expected to continue to increase through 2050 at a lower rate to 1,401,000.

Population in the Upper East Coast region, Martin and St. Lucie Counties, is expected to more than double by 2050. Despite this anticipated population growth, the region is not expected to have the large population like its neighboring counties to the south. The population in 2050 will be 529,000 or five percent of the study area.

Although there is population growth anticipated in the Big Cypress, Caloosahatchee, and Upper East Coast regions by the year 2050, the Restudy modeling effort was not sensitive to changes in these regions. These regions are outside of the modeling domain of the South Florida Water Management Model.

The population growth rate for the south Florida study area is expected to continue to exceed the national rate, but this trend is expected to lessen. By the year 2050, the population of the study area is estimated to still be about half of the state's population of 23 million people. Over 60 percent of this population are expected to inhabit the three southeast coast counties of Palm Beach, Broward, and Miami-Dade. To accommodate this growth, urban development will continue.

4.6 LAND USE AND LAND COVER

Land use in the future without plan condition is expected to be characterized by the continued urbanization of the developable lands which lie east of the Water Conservation Areas in the Lower East Coast, and continued urbanization of the Osceola and southern Orange County area associated with the development of Disney's properties. Southwest Florida is currently experiencing a very rapid rate of population growth; this trend is expected to continue.

For the coastal basins, 2050 land use projections were based on local government Comprehensive Plans. The Florida Legislature adopted the Local Government Comprehensive Planning Act in 1975 requiring each local governmental jurisdiction to prepare and adopt a local Comprehensive Plan. The

Future Land Use Element is a major component of the local plan designed to guide the future disposition of land use. Urban land use coverage in the future without plan condition was developed from the 2010 Comprehensive Plans and modified to include estimated decreases in agriculture, increases in golf course coverages, and other changes, such as identifying areas approved for development.

The urban portion of Palm Beach County to the east is home to a fast growing population. Palm Beach County is expected to become much denser as the population grows by over 600,000 people by 2050. This represents an almost doubling of the 1995 population. The amount of land available is somewhat limited since the other land-uses, agriculture, water conservation areas and publicly owned lands compete for space with urban development. Conversion of vacant, agricultural and low-density areas to higher density land use is expected throughout the county. North Palm Beach County may experience greater expansion into vacant or open areas since this portion of the county is not associated with the large population centers of West Palm Beach or Boca Raton, yet is expected to grow more rapidly.

In Palm Beach County, the majority of the agricultural areas is inland, and includes most of the Everglades Agricultural Area. The size of the Everglades Agricultural Area has been projected to decline somewhat as areas have been identified and scheduled to be used for Stormwater Treatment Areas by 2006. A total of approximately 44,000 acres will be shifted to that use. Another agricultural area, namely the Agricultural Reserve, is located adjacent to the urbanized eastern areas. The amount of land available for agriculture is limited and under high pressure to be developed in the future. The Agricultural Reserve is not expected to expand in the future.

In Broward County, suitable land for any type of development is limited. Almost all of the conversion from open or vacant land to urbanized development has already taken place. It is expected that most of the development to accommodate an additional projection of 800,000 persons will either infill small vacant parcels east of the levee or significantly increase the density in highly attractive areas adjacent to the coast. Greenhouse and nursery operations accounted for approximately 3,000 acres in 1995 and are expected to remain somewhat constant. The Water Preserve Areas project may accelerate the rate of infill and increases in density as the only remaining significant tracts of land are purchased.

Miami-Dade County is expected to continue to urbanize and become more dense within its urban development boundary as the greatest increase in the number of persons within the study area are expected to live here. Miami-Dade County's population will grow by approximately 1.1 million by 2050. Much of the growth will be accommodated on already developed lands; however, expansion into south Miami-Dade County and its agricultural areas as well as into areas west of the existing urban core will also occur. Urban development in south Miami-Dade

County and the strip west of the urban core will entail conversion of agricultural lands and wetlands. Increased flood protection, loss of storage in the surficial aquifer and the addition of pollutants associated with urban development will affect the hydrology of these areas.

Land use in the Upper East Coast, Martin and St. Lucie Counties, has been predominately agricultural and is expected to remain so in the future. However, the percentage of agricultural land use in Martin and St. Lucie Counties is anticipated to decrease while urban land uses increase as a result of anticipated population growth. Urban growth will cause conversion of some of the geographically desirable agricultural areas as well as expansion into vacant or natural areas.

Citrus is by far the dominant irrigated crop in this area and occupies over four-fifths of the irrigated agricultural acreage in the region. Irrigated citrus in this area is projected to grow by 32 percent in just the first 25 years of the planning horizon, from 134,000 acres in 1990 to 176,000 acres in 2020. Agricultural water demand is not projected to grow as rapidly although citrus, a high water use crop, is expected to remain the dominant crop.

Land use in the Big Cypress and Caloosahatchee River regions is projected to intensify to accommodate the growing population and demands on water resources will increase proportionately. However, agricultural demand is projected to remain the single largest category of land use in Big Cypress and Caloosahatchee River regions. In addition, agriculture is expected to remain the largest type of demand for water in southwest Florida over the planning horizon.

Citrus is the largest category of agricultural land use in the Big Cypress and Caloosahatchee River regions, and has been the fastest growing citrus acreage of any area in Florida. Recently, sugarcane acreage has begun to increase significantly as well. The initial clearing, draining, and planting and subsequent water withdrawals required to establish agricultural operations replaces natural habitats and modifies the natural hydrology of the area. Urban growth in Lee and Collier Counties also has the potential to impact the region's environmental and water resources. Drainage of wetlands for urban expansion, loss of natural surface water storage areas and contamination from urban land use are the major water related issues in urban areas.

Agriculture, predominately citrus and sugarcane, is expected to expand in the Lake Okeechobee Service Area, but at a slower rate than in the Big Cypress and Caloosahatchee River region. The expected increase in population and resulting urban development are not expected to significantly alter the current land uses. Much of the growth may not be centralized and will be more rural in nature.

Land cover (vegetation classes and spatial distribution) within the Everglades Protection Area in the future without plan condition is not expected to be greatly different at regional scales, from the vegetation patterns for the existing (1995) condition. Changes that could occur are expected to be local, and could include the continued invasion by exotic and native woody species into overdrained marl prairies and the northern portions of the Water Conservation Areas, and the continued loss of natural marsh communities in overponded portions of the Water Conservation Areas.

4.7 WATER QUALITY

The future without plan condition assumes no further hydrologic restoration actions beyond the presently planned/approved construction or maintenance actions in the study area, including those contained within the 1992 Settlement Agreement to the Federal lawsuit (United States et al v. South Florida Water Management District et al, Case No. 88-1886-CIV-Hoeveler) and the State of Florida's 1994 Everglades Forever Act (Stormwater Treatment Areas, Everglades Agricultural Area Best Management Practices and Phase 2 water quality technology).

The following subsections describe the projects by region that affect water quality and that are assumed to be in place in the future without plan condition.

4.7.1 Kissimmee River Region

Several planned and ongoing environmental restoration projects are expected to be completed which would beneficially affect water quality in the Kissimmee River watershed. Of particular importance is the Kissimmee River Restoration Project (including the Headwaters Revitalization and Modified Level II Backfilling projects). The Kissimmee River Restoration Project is expected to result in the restoration of approximately 26,500 acres of former wetlands in the vicinity of the Kissimmee Chain of Lakes (USACE, 1996) and at least 24,000 acres of former (drained) wetlands south of Lake Kissimmee (USACE, 1991).

4.7.2 Lake Okeechobee

Several watershed and in-lake cleanup projects are currently proposed (flow diversion projects for four Florida Statutes Chapter 298 Water Control Districts, diversion of flows from the 715 Farms area, and a critical project authorized pursuant to Section 528 of the Water Resources Development Act of 1996 – the Lake Okeechobee Water Retention/Phosphorus Removal Critical Project) to incrementally reduce inputs of nutrients to the lake. However, to sustain water quality improvements brought about by in-lake cleanup projects, pollutant source reduction programs (e.g., agricultural land acquisition, and implementation of best management practices) in the lake watershed must be implemented concurrently. The Florida Department of Environmental Protection is at present developing a Total Daily Maximum Load pollutant loading program which is expected to result in additional pollutant load reduction activities in watersheds flowing to Lake Okeechobee.

4.7.3 Upper East Coast

Several ongoing watershed management/planning programs in the Upper East Coast and Indian River Lagoon area are expected to be completed which would beneficially affect water quality conditions in the St. Lucie River and estuary, Indian River Lagoon and other freshwater waterbodies in the area. The South Florida Water Management Districts' Indian River Lagoon Surface Water Improvement and Management Plan has developed numerous programs and objectives to improve water quality conditions in the area. Many of the water quality remediation activities being implemented by the Surface Water Improvement and Management Plan focus on reducing agricultural pollutant loads in the Indian River Lagoon watershed and urban/suburban pollutant loads in the rapidly developing coastal region surrounding the St. Lucie Estuary and Indian River Lagoon. Implementation of more environmentally sensitive Lake Okeechobee regulation schedules should also reduce pollutant loading to the St. Lucie Estuary/ Indian River Lagoon systems. The Indian River Lagoon National Estuary Program, jointly administered by the U.S. Environmental Protection Agency and the State of Florida will also result in water quality improvement activities and a reduction of pollutant loads to the Indian River Lagoon in the future. In summary, as a result of these ongoing watershed management programs, water quality in the Upper East Coast is expected to improve in the future.

4.7.4 Everglades Agricultural Area

Recent monitoring results indicate that phosphorus loads in Everglades Agricultural Area runoff have declined approximately 51 percent (three year average, SFWMD, 1997b). The current average concentration of total phosphorus contained in Everglades Agricultural Area runoff is approximately 100 parts per billion (Havens, 1997). Construction of the Everglades Construction Project involves converting approximately 44,000 acres of existing agricultural land. The construction project is explained in more detail below.

4.7.4.1 Everglades Forever Act

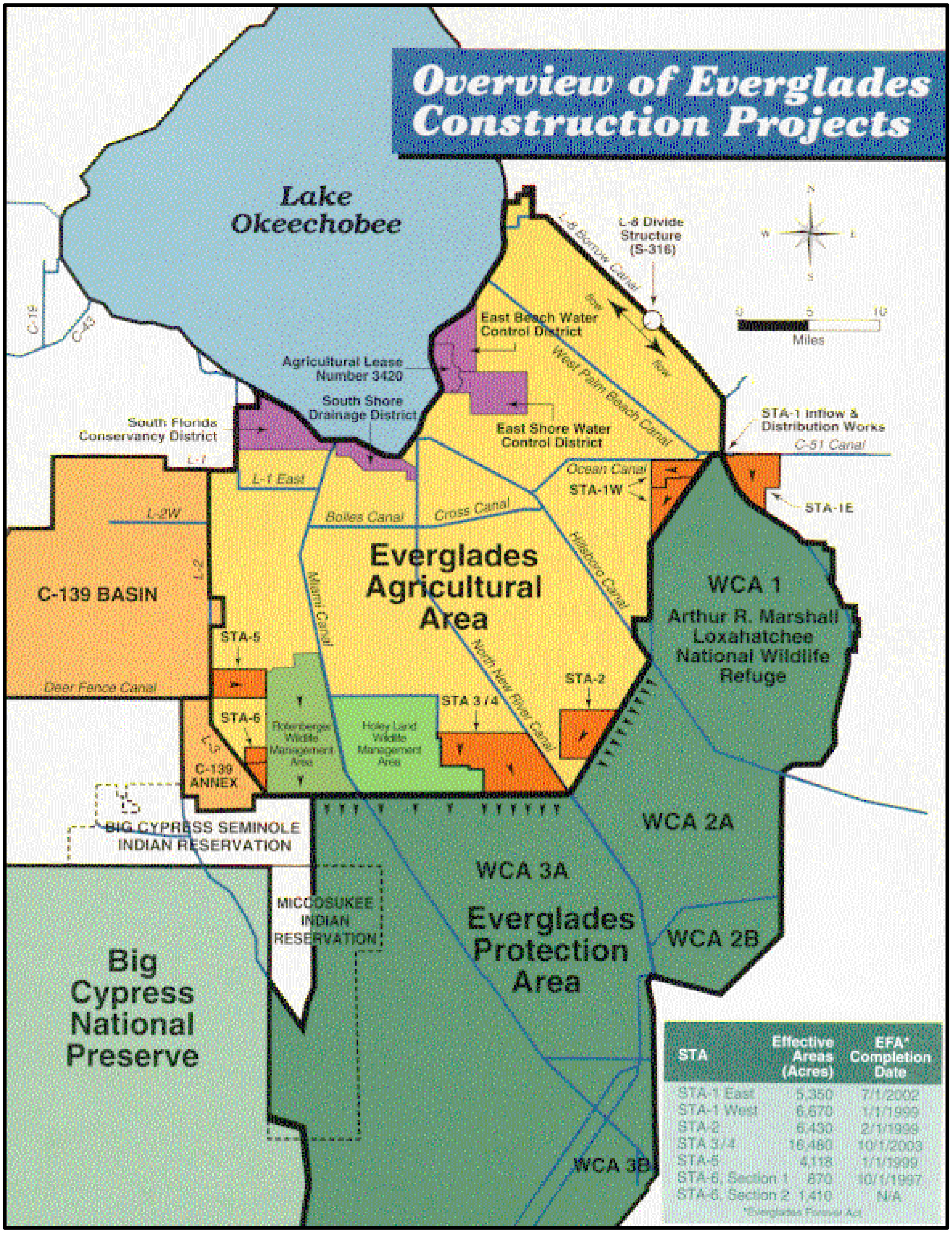
The Everglades Forever Act's principal water quality treatment strategy for improving water quality in the Everglades Protection Area which includes the Water Conservation Areas 1 (Loxahatchee National Wildlife Refuge), 2A and 3A; the Rotenberger Wildlife Management Area and the Holey Land Wildlife

Management Area centers around five requirements: The Everglades Construction Project, Everglades Agricultural Area Best Management Practice programs, Everglades research and monitoring program, evaluation of water quality standards and long-term compliance permits. Each element is further examined below.

The Everglades Construction Project consists of six large wetlands treatment facilities deemed Stormwater Treatment Areas containing approximately 44,000 acres of land previously used for agricultural purposes. These areas are designed to treat Everglades Agricultural Area runoff prior to discharge into the Everglades Protection Areas (***Figure 4-2***).

The Everglades Construction Project is designed to treat Everglades Agricultural Area runoff to meet an interim phosphorus concentration target of 50 parts per billion in discharges to the Everglades Protection Area (Burns and McDonnell, 1994). Stormwater Treatment Areas 1 East and 1 West will discharge into the L-7 and L-40 borrow canals in the Loxahatchee National Wildlife Refuge (WCA-1). Stormwater Treatment Area 2 will discharge to Water Conservation Area 2A via the L-6 borrow canal. Stormwater Treatment Area 3/4 will discharge to Water Conservation Area 3A via the L-5 borrow canal. Stormwater Treat Area 5 will discharge to Rotenberger and Holey Land Wildlife Management Areas and Water Conservation Area 3A along the L-4 borrow canal. Stormwater Treatment Area 6 discharges to Water Conservation Area 3A through the L-4 borrow canal. Stormwater Treatment Area 6 Section 2 will discharge to Rotenberger Wildlife Management Area. The future base condition assumes all of the treatment areas are completed and operational with the exception of Stormwater Treatment Area 6 Section 2. Stormwater Treatment Area 6 Section 2 was not included in hydrologic regional modeling since the conceptual design for the Stormwater Treatment Area did not include this element (Burns and McDonnell, 1994).

Another component of the Everglades Construction Project targeted for completion in 2003 is the diversion of runoff from five special districts (four chapter 298 districts and the 715 Farms area established under Florida Statutes). These special districts are located adjacent to Lake Okeechobee north of the Everglades Agricultural Area. Currently, the districts discharge directly to Lake Okeechobee. According to the Everglades Forever Act, approximately 80 percent of the historic flow volumes and total phosphorus loads are to be diverted away from the lake. The future base condition assumes that the diversion of flows and loads has been completed.



STA	Effective Areas (Acres)	EFA* Completion Date
STA-1 East	5,350	7/1/2002
STA-1 West	6,670	1/1/1999
STA-2	6,430	2/1/1999
STA 3/4	16,480	10/1/2003
STA-5	4,118	1/1/1999
STA-6, Section 1	870	10/1/1997
STA-6, Section 2	1,410	N/A

*Everglades Forever Act

Figure 4-2 Everglades Construction Project Features

According to the Everglades Forever Act, based upon research, field-tests and expert review, the Everglades Agricultural Area Best Management Practices are determined to be the most effective and practicable on-farm means of improving water quality to a level that balances water quality improvements and agricultural productivity. The act establishes monitoring programs, permit requirements, research, field-testing and evaluation programs designed to improve water quality prior to discharge into conveyance canals in the Everglades Agricultural Area. The act provides a tax incentive for phosphorus concentration reductions of 25 percent or more. As a consequence, the future base condition assumes a 25 percent phosphorus concentration reduction from best management practices.

In addition to the Everglades Construction Project and best management practices, the Everglades Forever Act directs that an Everglades Research and Modeling program shall seek means of optimizing the design and operation of the Stormwater Treatment Areas. This program shall include research to reduce outflow concentrations and identify other treatment and management methods and regulatory programs that are superior to Stormwater Treatment Areas in achieving the intent and purposes of the act. The research and monitoring program is also directed toward development of a permanent (threshold) phosphorus criterion in the Everglades Protection Area by the Florida Department of Environmental Protection and evaluation of existing state water quality standards applicable to the Everglades area. The criterion is to be adopted by December 31, 2003 or a default criterion of 10 parts per billion total phosphorus will be established. Currently, research efforts have not drawn any conclusions that affect treatment area designs, planned operations or the threshold phosphorus criterion. Research to determine superior or supplemental technologies and the threshold phosphorus standard is on going.

The Everglades Forever Act does specify that compliance with water quality standards shall be based upon a long-term geometric mean of concentration levels to be measured at sampling stations reasonably representative of receiving waters in the Everglades Protection Area. Discharges to the Everglades Protection Area from outside the Everglades Agricultural Area (non-Everglades Construction Project structures) also require evaluation to determine appropriate strategies. The act requires the South Florida Water Management District and the Florida Department of Environmental Protection to take such action as may be necessary so that water meets state water quality standards in all parts of the Everglades Protection Area.

The Everglades Forever Act further directs that long-term compliance permit requirements shall be modified to achieve compliance with the phosphorus criterion cited in the paragraph above. If the Florida Department of Environmental Protection has not adopted this criterion by rule prior to December 31, 2003, then the phosphorus criterion shall be 10 parts per billion in the Everglades Protection Area. This default criterion or the criterion adopted by the Department (phase II) is to be imposed by 2006. The act specifies that as of December 31, 2006, no permittee's discharges shall cause or contribute to any violation of water quality standards in the Everglades Protection Area. In view of the fact that the phase II phosphorus criterion has not been established, the future base condition assumes that the default standard of 10 parts per billion has been attained.

Design of the Everglades Construction Project was initiated in 1995 and construction in 1997. Stormwater Treatment Area 6 Section 1 was completed in October 1997 and operation was initiated in December 1997. Construction is currently underway at Stormwater Treatment Areas 1 West, 2 and 5 with completion scheduled on or before September, November and July 1999, respectively. Scheduled construction completion for Stormwater Treatment Area 1 East and 3/4 is set for July 1, 2002 and October 1, 2003, respectively.

A demonstration-scale wetlands treatment area project of nearly 3,800 acres has been operating adjacent to Water Conservation Area 1 (Loxahatchee National Wildlife Preserve) on the same site as future Stormwater Treatment Area 1 West since 1994. Stormwater Treatment Area 1 West will encompass the demonstration project when completed. The Everglades Nutrient Removal project was designed to reduce phosphorus from an inflow concentration of 190 parts per billion to an outflow concentration of 50 parts per billion. The settling rate constant for the demonstration project was set at 10.2 meters per year. These were the same parameters established for the Everglades Construction Project Stormwater Treatment Area design. Three years cumulative data from the demonstration project reflects that these criteria have been significantly exceeded. Additionally, on-farm best management practices have averaged 51 percent, considerably higher than the projected 25 percent contained in the future base condition for the Everglades Agricultural Area.

It is too early to predict what conclusions research and analyses will drive with regard to the findings outlined above. An optimistic one is that the best management practices reduction in phosphorus concentrations will increase Stormwater Treatment Area operations such that concentrations lower than the interim criterion will be achieved. Also, the higher settling rate constant and low phosphorus concentration outflows could significantly improve performance of the Stormwater Treatment Areas; thus, reduce phase II treatment needs. Only time and further operations of the treatment areas will judge whether the long-term findings will be supportive of the optimism suggested by current best management practices and Everglades Nutrient Removal findings. The current findings certainly should affect the research into what supplemental technologies may be necessary to achieve the phase II phosphorus criterion.

During the alternative development and evaluation phase of the Restudy, a preliminary study was conducted by Walker (Walker, 1998) to evaluate the performance of the Stormwater Treatment Areas based upon Restudy generated flows from the South Florida Water Management Model in the future base condition and the preferred alternative. A phosphorus removal model developed by Walker was used in the study. Modeling results indicated that some of the Stormwater Treatment Areas did not meet the interim phosphorus criteria of the Everglades Forever Act under either the future base condition or the preferred alternative. A closer examination reveals some of the reasons for the apparent underachievement. First, the periods of records differ. The Everglades Construction Project used a 10-year period of record from 1979 to 1988. The Restudy uses the 31-year period from 1965 to 1995. Second, the operational concepts differ. The Restudy uses rain-driven operational procedures whereas the Everglades Construction Project uses the current calendar-based regulation schedule. Third, because Stormwater Treatment Area 6 Section 2 was not modeled in the Restudy, the treatment area was not considered in the phosphorus modeling. Therefore, a treatment area totaling nearly 2,000 acres was not considered and the inflows scheduled for this area were all routed through Stormwater Treatment Area 5. Finally, although the period of record was changed from ten years to 31 years, the fixed parameters of the settling rate of 10.2 meters per year and targeted outflow concentration of 50 parts per billion remained unchanged from the Everglades Construction Project.

These two parameters (settling rate constant and outflow phosphorus concentration target) are two of the three most significant factors in determining the required area of treatment cells. Walker's study did indicate that when the 51 per cent best management practice phosphorus reduction rate experienced over a three-year period was used in lieu of the 25 percent estimate, all Stormwater Treatment Areas met or bettered the interim phosphorus criterion with the exception of Stormwater Treatment Area 5. Stormwater Treatment Area 5 did not meet the criteria in the modeling outcome due to the third reason cited in the preceding paragraph.

At first blush, the reasons cited above appear to mitigate the Walker findings of Stormwater Treatment Area underachievement. Although only time and continued operation of the treatment areas will provide proof, the findings should, in any case, direct research efforts toward ensuring that phase II treatment technologies are sufficient to meet the adopted threshold standard. Regardless of the Walker study or the demonstration project findings, the fact remains that the phase II (threshold) phosphorus standard must be met by 2006. The default criterion of 10 parts per billion is the target assumed in the 2050 future base condition. At that point, the interim standard becomes obsolete. When research efforts determine the optimal method of operation and supplemental technologies needed to meet the Everglades Forever Act permanent (phase II) phosphorus criterion, both the Everglades Construction Project and treatment elements of the

Restudy components must be modified to attain the designated water quality standard.

4.7.5 Natural Areas

The natural areas of the study area include the Rotenberger and Holey Land Wildlife Management Areas, the Loxahatchee National Wildlife Refuge, Water Conservation Areas 2 and 3, Big Cypress National Preserve, and Everglades National Park. The Rotenberger and Holey Land Wildlife Management Areas are adjacent to the Everglades Agricultural Area and are contained within the same hydrologic basin. The Everglades Construction Project, which is part of the future without plan condition, is designed to achieve hydrologic restoration objectives for the Rotenberger and Holey Land tracts by redirecting Everglades Agricultural Area runoff through Stormwater Treatment Areas into those areas to create preferred hydropatterns.

A fundamental underlying assumption for the Restudy is the full implementation of the State of Florida's Everglades Program contained in the Everglades Forever Act (F.S. 373.4592) by December 31, 2006. Implementation of the Everglades Forever Act includes completion of construction of the Stormwater Treatment Areas as described in the conceptual design for the Everglades Construction Project (Burns and McDonnell, 1994; scheduled to be completed in 2003), setting of a numeric phosphorus criterion for the Everglades Protection Area, by December 31, 2003, and compliance with that criterion by December 31, 2006.

In addition to the Everglades Construction Project and water quality treatment facilities developed as a result of the non-Everglades Construction Project requirements of the Everglades Forever Act, the currently authorized C-111 Project and the Modified Water Deliveries to Everglades National Park Project are assumed to be implemented in 2050.

4.7.6 Lower East Coast and Biscayne Bay

The major watershed management/planning program ongoing in the Lower East Coast region that will beneficially effect future water quality conditions is the State's Biscayne Bay Surface Water Improvement and Management Plan (SFWMD, 1995). The Biscayne Bay Surface Water Improvement and Management Plan has developed numerous water quality improvement related strategies and projects to reduce pollutant loading in Biscayne Bay and its tributaries. The extent to which this program is implemented, however, is limited due to funding constraints. Also, the Lake Worth Lagoon Management Plan will result in water quality improvement projects being implemented in the Lake Worth Lagoon area. Although implementation of these water quality improvement activities will result in beneficial effects to Lower East Coast waterbodies, the net future condition of waterbodies in this region is not expected to improve due to the dramatic additional urban development, and associated additional pollutant loads, projected to occur in this region.

4.7.7 Florida Bay

Both the Modified Water Deliveries to Everglades National Park and C-111 Projects are assumed to be completed in the future without plan condition. The first project to be implemented is the C-111 Project. Notably, the C-111 spoil (dredged material) mounds in the marsh on the southern leg of the C-111 Canal were removed in 1997. The purpose of that project was to promote overland flow out of the canal into the marshes in the northeastern part of Florida Bay. In addition, two other features of the C-111 Project are scheduled to be completed in the near future which would beneficially affect water quality in Florida Bay. A new pump station, S-332D, is scheduled to begin pumping operations to deliver increase stages in the L-31W borrow canal, preventing seepage from Everglades National Park from draining east into the canal network and downstream to tide. Operation of S-332D is intended to promote overland flow during high water conditions. Also, the existing single-span bridge over Taylor Slough in Everglades National Park is to be replaced with two longer-span bridges and two box culverts. Removing sections of an existing fill road (Ingraham Highway) across Taylor Slough will augment the bridge replacement project.

Furthermore, agricultural non-point pollution sources in the C-111 Basin are currently being investigated as required by the non-Everglades Construction Project structures requirements of the Everglades Forever Act and the C-111 / Modified Water Deliveries projects implementation process.

4.7.8 Florida Keys

The major ongoing water quality improvement program in the Florida Keys, which is expected to result in improved water quality conditions in the future, is the Water Quality Protection Program of the Florida Keys National Marine Sanctuary Program. The U.S. Environmental Protection Agency and the Florida Department of Environmental Protection are jointly responsible for implementing water quality improvement activities throughout the Florida Keys region as part of the Water Quality Protection Program. Implementation of these activities will result in improved water quality conditions in the Florida Keys in the future.

4.7.9 Big Cypress Basin

The South Florida Water Management District has identified the S-190 water control structure (a gated culvert at the confluence of the North Feeder and West Feeder Canals) as a structure discharging into the Everglades Protection Area that requires an assessment of pollution loads and the development of a water quality improvement strategy in accordance with the non-Everglades Construction Project structures requirement of the Everglades Forever Act. South Florida Water Management District water quality data (SFWMD, 1998a) indicate that agricultural areas upstream of the Seminole Reservation contribute significant nutrient loads (particularly phosphorus) into the canal system that drains into the North and West Feeder Canals and ultimately across the northeast corner of Big Cypress National Preserve. Water quality improvements required under the Everglades Forever Act are to be completed by December 31, 2006, to assure that all water quality standards are met in the Everglades Protection Area.

4.7.10 Caloosahatchee River Region

The South Florida Water Management District's Caloosahatchee River Water Management Plan is the main ongoing watershed management program that is likely to result in water quality improvement activities in the basin. In the future, although implementation of new Lake Okeechobee regulation schedules and the Caloosahatchee River Water Management Plan will reduce pollutant loading to the Caloosahatchee River/estuary, in general, water quality conditions throughout the basin in the future without plan condition are expected to be similar to current water quality conditions

4.8 URBAN AND AGRICULTURAL WATER SUPPLY DEMANDS

Future water supply demands for urban and agricultural areas that utilize the C&SF Project for water supply were projected for the study area.

4.8.1 Lower East Coast Region

The urban area of the Lower East Coast has been subdivided into four service areas. The North Palm Beach Service Area includes northeastern Palm Beach County east of the L-8 Canal and north of the C-51 Canal. Service Area 1 includes central and southern Palm Beach County as well as portion of northern Broward County. Service Area 2 includes central and southern Broward county and a small portion of northern Miami-Dade County. Service Area 3 is made up of the remainder of northern, central and southern Miami-Dade County and Monroe County. For the urban areas of the Lower East Coast projections are based on the use of the IWR-MAIN water demand forecasting software; underlying population and economic growth assumptions are a combination of the University of Florida Bureau of Economic and Business Research (short term) and Bureau of Economic Analysis, U.S. Department of Commerce (long term) growth projections. For Service Area 3 public water supply demands have been increased to reflect Miami-Dade

County's estimation of its future population growth as influenced by recent immigration legislation and other factors.

Two projections of future water consumption for the year 2050 have been made for the Lower East Coast study area. The two scenarios differ in terms of the assumed level of water use conservation. The higher estimate, Projection A (***Table 4-4***), is based on the same percentage distribution and usage of conservation flow devices, and irrigation restrictions, in effect in 2050 as in 1990. The lower estimate, Projection B (***Table 4-5***), is based on the full implementation of existing South Florida Water Management District mandatory regulations and programs.

The higher Projection A estimate for the year 2050 is about 1,450 millions of gallons per day. The lower Projection B estimate is about 1,200 millions of gallons per day, approximately 18 percent less than Projection A. In this study, the 2050 base condition (the without plan condition) assumes a more moderate application of conservation practices and effectiveness, representing a level of consumption about 12 percent below the 2050 Projection A estimate.

The Projection A average daily Municipal and Industrial demand for water use in the year 2050 is summarized in ***Table 4-4***. The table shows that water use is fairly evenly distributed among the Lower East Coast counties. The Service Areas that coincide mainly with the developed portion of Palm Beach County account for 30 percent of total forecast Municipal and Industrial use. Service Area 2, which roughly coincides with Broward County accounts for a little over 29 percent of use. Service Area 3 use, representing demand in most of Miami-Dade County and the Florida Keys (Monroe County), is somewhat higher in terms of its share of the total.

TABLE 4-4
SUMMARY 2050 MUNICIPAL AND INDUSTRIAL DEMANDS BY SERVICE AREA – PROJECTION A

Area	Million Gallons Per Day (MGD)	Percent of Total
North Palm Beach Service Area	101.25	7
Service Area 1	349.20	24
Service Area 2	422.24	29
Service Area 3	577.00	40
Total	1449.69	100

As stated above these 2050 Projection A estimates reflect a level of conservation practices that is the same as estimated to be in place in 1990. That is, the same percentage distribution of the use of restrictive flow devices among all uses in place in 1990 is assumed to be in place for the 2050 usage, and therefore probably can be viewed safely as an upper bound forecast estimate.

Another set of forecast use estimates, full implementation of the South Florida Water Management District's mandatory water conservation program for all consumers by 2050, was also made. The 2050 summary results of this conservation Projection B scenario, which can be viewed as a lower bound forecast estimate, are shown in ***Table 4-5***.

TABLE 4-5
SUMMARY 2050 MUNICIPAL AND INDUSTRIAL DEMANDS BY SERVICE AREA – CONSERVATION PROJECTION B

Area	Million Gallons Per Day (MGD)	Percent Reduction [1/]
North Palm Beach Service Area	83.66	17.37
Service Area 1	294.18	15.76
Service Area 2	345.72	18.12
Service Area 3	474.80	17.71
Total	1198.36	17.34

[1/]From Projection A

The IWR-MAIN forecasts have been categorized by residential, commercial, industrial, public administration, and unaccounted-for uses. The following percentage breakdown (***Table 4-6***) provides a profile of these uses in the study area for 2050 for Projection A. As the tabulation shows, this profile is generally similar throughout the study area, although residential use is more heavily weighted in southern areas.

TABLE 4-6
PERCENTAGE DISTRIBUTION OF 2050 DEMAND BY END USE AND BY SERVICE AREA

End Use	NPB	SA1	SA2	SA3	Total
Residential	47	49	56	58	54
Commercial & Industrial	36	37	28	22	29
Public & Other	17	14	16	20	17
Total	100	100	100	100	100

The demand projections made using IWR-MAIN are made by large areas because the projections are driven by economic and demographic projections, which have been made at the county-wide level. But the South Florida Water Management Model input requires that the demand input be in the form of well withdrawals, by month, in millions of gallons per day, spatially identified by grid-cell location. This information has been developed for existing well pumpages. The conversion of the above projected service area water use into grid-cell based well withdrawal data has been developed using known existing well field locations, and the likelihood of future locations and operations.

The IWR-MAIN estimates excluded golf courses and landscape irrigation (estimated by the South Florida Water Management Model simulation as a part of the evapotranspiration simulation calculation runs), deep well withdrawals from the brackish Floridan aquifer, and some other uses which are not consumptive. For example, water is used in rock mining operations, but it is returned immediately after use (consisting mainly of washing rock cuttings), and therefore such use is not really a consumptive use. Instead, it is more representative of moving water from one place to another in the system. Floridan aquifer withdrawals do not represent a withdrawal from the water system modeled by the South Florida Water Management Model and are outside of the Everglades system.

Total irrigation demands for the Lower East Coast areas are projected to increase by 21 percent by the year 2050 to a total annual average demand of 707,800 acre-feet. Irrigation demands have been divided into three general categories; landscape, golf course and agriculture.

Landscape irrigation demands are supplied by either public water supply utilities or self-supplied sources such as wells or canals. Those demands provided by public water supply utilities have been included in the IWR-MAIN estimates. Self-supplied landscape irrigation demand estimates are based on future land use maps developed for local government comprehensive plans. Future self-supplied landscape irrigation is estimated to increase by 48 percent with average annual demands of 499,000 acre-feet.

Golf course irrigation that uses self-supplied sources for irrigation is estimated to increase by 31 percent with average annual demand of 71,800 acre-feet.

Agricultural irrigation in the Lower East Coast area includes irrigation for row crops, citrus, tropical fruits and nurseries. Overall, most agricultural irrigation is expected to decline in the future with the exception of nursery irrigation, which is expected to increase. Total agricultural irrigation demands for the Lower East Coast are estimated to decline by 28 percent to a total annual average demand of 136,600 acre-feet. Nursery irrigation is estimated to increase by 164 percent to a total annual average demand of 52,900 acre-feet.

4.8.2 Everglades Agricultural Area Region

The only source for irrigation water in the Everglades Agricultural Area is surface water. Irrigation demands for the Everglades Agricultural Area are not expected to increase in the future. The demand of the Everglades Agricultural Area is estimated to be 430,000 acre-feet per year on an average annual basis.

4.8.3 Upper East Coast Region

The Upper East Coast region is approximately 1,200 square miles and includes most of Martin and St. Lucie Counties and a small part of Okeechobee County. There is a transition in land use in the region from urban in the east to agricultural in the west.

The Upper East Coast Region municipal and industrial water demand forecast by sector is shown in ***Table 4-7***. Figures are based on University of Florida Bureau of Economic and Business Research population and employment projections. A range of projected water supply usage is provided to reflect water usage based on implementation of the South Florida Water Management District mandatory regulations and programs. The data is shown for both restricted and unrestricted water usage for the Upper East Coast region for 1990 and 2050. Overall, municipal and industrial water supply demands are projected to increase up to as much as 125.8 million gallons per day by the year 2050 from 53.6 million gallons per day in 1990. This is a 135 percent increase over the 60-year period. In the Upper East Coast Region groundwater is the predominant source of water for municipal and industrial uses. This trend is expected to continue in the future.

TABLE 4-7
UPPER EAST COAST MUNICIPAL AND INDUSTRIAL DEMANDS
(MILLION OF GALLONS PER DAY)

End Use	2050 Range of Unrestricted to Restricted Demand
Residential	83.6 –70.1
Commercial & Industrial	33.5 – 31
Public & Other	8.7 - 7.9
Total	125.8 – 108.9

Agriculture is the predominate land use of the Upper East Coast region, accounting for 85 percent of the overall water demand. Currently, citrus crops occupy four-fifths of the irrigated agricultural acreage in the region (Gulf South Research Corp. & G.E.C. Inc, 1998). St Lucie Canal (C-44) Basin demands are estimated to be approximately 28,000 acre-feet on an average annual basis; these demands are not expected to increase in the future (Gilpin-Hudson et al., 1998a). The same trend is expected for the remainder of the Upper East Coast Region with irrigation demands remaining stable in the future (Gilpin-Hudson et al., 1998b).

The primary source of water for agriculture in the Upper East Coast Region is surface water however, in some areas the Floridan Aquifer System is an important source of water (SFWMD, 1998c).

4.8.4 Big Cypress and Caloosahatchee River Regions

The Big Cypress and Caloosahatchee River regions extend across approximately 4,300 square miles in southwest Florida. The regions include all of Lee county and portions of Charlotte, Collier, Glades, Hendry, Miami-Dade and Monroe Counties. Total water demand in these regions is estimated to increase by approximately 26 percent over the next 20 years. Urban demand is projected to increase by 84 percent, while agricultural demand is projected to increase by 13 percent (SFWMD, 1998b). In the Big Cypress and Caloosahatchee Regions groundwater is the predominant source of water for municipal and industrial uses with the exception of the City of Ft. Myers and Lee County Utilities, which withdraw water from the Caloosahatchee River. Lee County estimates that future demand for this source of water will be 50 cubic feet per second. The predominant source of water for agriculture in these regions is ground water and with the exception of the Caloosahatchee River Region have not been included in the modeling analysis for this plan.

In the Caloosahatchee River Region surface water from the Caloosahatchee River is the primary source of irrigation and has been included in the modeling analysis for the future without plan condition. The Caloosahatchee River Region demands are estimated to increase by 40 percent by 2050 to a total average annual demand of 125,000 acre-feet. (Gilpin-Hudson et al., 1997) These demand estimates are based on analysis of the suitability of land for growth in irrigation and land ownership (Mazzotti et al., 1992).

4.9 PHYSICAL FACILITIES AND OPERATIONS

This section discusses the physical facilities operational changes that are planned for the study area and are assumed to be in place for the future without plan condition.

4.9.1 C&SF Project Modifications

The C&SF Project was authorized by the Flood Control Act of 1948 and modified by subsequent acts, as a plan of improvement for flood control, drainage, and other purposes covering a 18,000 square mile area of both central and southern Florida. A number of efforts are currently underway by the Corps of Engineers to modify the project for environmental improvement. The following is an inventory of C&SF Project modifications either in the planning, design, or construction phase.

For the purpose of evaluating effects of alternative plans, they are included in the future without plan condition.

4.9.1.1 Kissimmee River Restoration

In the future without plan condition, the Kissimmee River restoration project will be in place and functioning. The restoration project, authorized by the Water Resources Development Act of 1992, will create a more natural physical environment in the lower Kissimmee River Basin. The major components of the project include: (1) reestablishment of inflows from Lake Kissimmee that will be similar to historical discharge characteristics (headwaters component), (2) acquisition of approximately 85,000 acres of land in the lower Kissimmee Chain of Lakes and river valley, (3) continuous backfilling of 22 miles of canal, (4) removal of two water control structures, and (5) recarving of nine miles of former river channel. The Kissimmee River Basin contributes about 30 percent of the water input to Lake Okeechobee. The supply of water to Lake Okeechobee is anticipated to be reduced by about 1.60 percent due to the implementation of this project.

As a component to the Kissimmee River Restoration project, the modification of the Upper Chain of Lakes regulation schedules and associated canal and water control structure modifications, known as the Headwaters Revitalization Project, will restore the ability to simulate the historic seasonal flow from Lake Kissimmee to the Lower Basin, and provide higher fluctuations of water levels in the lakes. The project will result in the expansion of the lakes' littoral zones by up to 18,500 acres, and improved habitat to fish and wildlife on Lakes Kissimmee, Hatchineha, Cypress, Tiger, and Jackson. The project will also increase spatial and temporal dynamics produced through long-term fluctuations of seasonal water levels.

The Headwaters Revitalization Project will meet two hydrologic conditions (criteria) that must be reestablished to restore the Lower Basin ecosystem. These conditions are; the reestablishment of continuous flow with duration and variability characteristics comparable to prechannelization records; and reestablishment of stage hydrographs that result in flood plain inundation frequencies comparable to prechannelization hydroperiods, including seasonal and long-term variability characteristics.

4.9.1.2 C-111 Project

Plan 6a, recommended in the Corps' General Reevaluation Report dated May 1994, will create the operational capability and flexibility to provide restoration of the ecological integrity of Taylor Slough and the eastern panhandle areas of the Everglades and maintain flood protection to the agricultural interests adjacent to C-111.

In the future without plan condition, C-111 Plan 6a will protect the natural values of a portion of Everglades National Park, and will maintain flood damage prevention within the C-111 Basin, east of L-31N and C-111. The project, which consists of both structural and non-structural modifications to the existing project works within the C-111 Basin, will restore the hydrology in 128 square miles of Taylor Slough and its headwaters in the Rocky Glades. In addition, the hydroperiod and depths in 1,027 square miles of Shark River Slough are beneficially impacted by the higher stages in the Rocky Glades, resulting in a net increase in water volume within Shark River Slough. The project will provide adequate operational flexibility to incorporate management strategies that will evolve as a result of continued monitoring and studies.

4.9.1.3 Modified Water Deliveries to Everglades National Park

The Modified Water Deliveries to Everglades National Park Project was authorized by the Everglades National Park Protection and Expansion Act (Public Law 101-229). The purpose of the project is to provide for structural modifications to the C&SF Project to enable the restoration of more natural water flows to Shark River Slough in Everglades National Park. The project is being implemented by the Corps in conjunction with the acquisition of about 107,600 acres of land by the Department of Interior. Land acquisition for the levee, canal, and pump station for the flood mitigation system in the 8.5-square-mile area is underway.

This project is presently in the design and construction phase. Project construction is scheduled for completion in 2003. In the future without plan condition, the Modified Water Deliveries Project will provide more natural flows to Shark River Slough in Everglades National Park. Water flows will be spread across a broader section of Shark River Slough to include the East Everglades between L-67 Extension and L-31N.

The addition of water control structures and culverts will help to reestablish the natural distribution of water from Water Conservation Area 3A into Water Conservation Area 3B. Outlets from Water Conservation Area 3B (S-355A & B) will be constructed to discharge into Northeast Shark River Slough. An existing levee and canal (L-67 Extension) along the eastern edge of the existing Everglades National Park boundary will also be removed. A Miccosukee Indian camp has been flood-proofed to avoid periodic flooding that would otherwise be caused by the project.

In order to prevent adverse flood impacts to the 8.5-square-mile residential area, the authorized project includes the construction of a seepage levee and canal around the western and northern edges of the area and a pump station (S-357) to remove excess seepage water. These project features are designed to maintain the existing level of flood protection in the residential area after the Modified Water

Deliveries to Everglades National Park project returns water levels in Northeast Shark Slough to higher levels. A second pump station (S-356) will be constructed to pump excess seepage water from the L-31N borrow canal and residential area into the L-29 borrow canal. This water will then flow through culverts under US Highway 41 into Northeast Shark River Slough. A locally preferred option which would modify the project features in the 8.5-square mile area is currently under consideration.

The structural modifications were designed to provide for maximum operational flexibility so that as more is learned through the continued iterative testing program, the operation of the project can be adjusted accordingly.

4.9.1.4 C-51 Project

The current Design Memorandum was completed in February 1998 and submitted for review and approval and contains the same National Economic Development plan as the June 1992 Detailed Design Memorandum but references an “authorized” plan, which includes the replacement of the 2.5-square-mile detention area with Stormwater Treatment Area 1E from the Everglades Construction Project. The “authorized” plan is also a product of the Technical Mediated Plan, which has been agreed to by Department of Justice, Department of Interior, Department of Army, the State of Florida, and the South Florida Water Management District. The State of Florida's Everglades Forever Act is based, in part, on the Technical Mediated Plan. The current “authorized” plan was authorized by the Water Resources and Development Act of 1996. The Act included language for the western C-51 project that additional work, as described in the “Everglades Construction Project”, shall be accomplished at full Federal cost.

The authorized plan is recommended in the C-51 Design Memorandum and has many of the same physical features proposed in the 1992 Detailed Design Memorandum. It is described below. The project will provide 10-year flood protection for the western basin of C-51. The major physical difference between the 1992 Detailed Design Memorandum National Economic Development plan and the authorized plan is the replacement of the 1,600 acre detention area with the 5,350 acre “locally preferred” Stormwater Treatment Area 1 East. The most significant modification will be the reduction of discharges to Lake Worth, with C-51 West Basin runoff directed instead to Water Conservation Area 1 (Arthur R. Marshall Loxahatchee Wildlife Refuge). Runoff from the C-51 West Basin will pass through Stormwater Treatment Area 1 East for water quality improvement prior to its discharge to Water Conservation Area 1. In addition to the flood damage reduction benefits provided by the 1992 plan, the authorized plan would provide water quality improvement, reduction of damaging freshwater discharges to Lake Worth, and increased water supply for the Everglades and other users.

4.9.1.5 Manatee Protection

The West Indian manatee (*Trichechus manatus*) is listed as a Federally endangered species and is one of the most endangered species in Florida. As a response to recent manatee mortality trends associated with water control structures, this project will provide operational changes and implement the installation of a manatee protection system at seven sector gates at navigational locks near Lake Okeechobee. The beneficial outcome of this project will be the reduction of risk, injury, and mortality of the manatee. The seven sector gates include S-193 at Okeechobee and S-310 at Clewiston on Lake Okeechobee; St. Lucie Lock and Port Mayaca Lock on the St. Lucie Canal; and Moore Haven Lock, Ortona Lock, and W. P. Franklin Lock on the Caloosahatchee River.

The mechanism proposed would use hydroacoustic and pressure sensitive devices that will immediately stop the gates when an object is detected between the closing gates. These systems will transmit an alarm and signal to stop the gate movement when a manatee is detected. When an object or manatee activates the gate sensors, the gate will stop and open approximately six inches to release a manatee. As a result, a manatee will be able to travel between the open gates. After the gate opens, the operator can fully close the gate unless an object remains between the gates. Then the opening process will repeat the cycle as the sensors are activated again. Due to these structural modification, manatees will be at a significantly less risk as they encounter locks with sector gate.

The future without plan condition assumes that the automatic gate sensor devices are installed these lock sector gates.

4.9.1.6 Emergency Interim Plan

Legislation known as the Emergency Interim Plan for Florida Bay (Chapter 373.4593 FS) was passed by the Florida Legislature in May of 1994. Its purpose was to *"...provide for the release of water into Taylor Slough and Florida Bay by up to 800 cfs, in order to optimize the quantity, timing, distribution & quality of fresh water, and promote sheet flow into Taylor Slough."*

Section 2(e) called for acquisition of the western three sections of the agricultural area known as the Frog Pond in Miami-Dade County. The South Florida Water Management District took title to all eight sections of the Frog Pond in February of 1995. This effectively became phase 1 of the Emergency Interim Plan, as acquisition of this land eliminated land use conflicts between Everglades National Park and farming taking place in the Frog Pond. Elimination of these conflicts prevented the unnatural reduction in canal stages that had previously taken place each year in the fall to facilitate those farming activities. In addition, it allows greater flexibility in implementation of a rainfall driven plan for water levels in L-31W.

Phase 2 of the Emergency Interim Plan was designed to provide additional pumping capability into the L-31W canal, which formed the western boundary of the Frog Pond. Pump Station S-332D (C-111 Project and Experimental Program of Water Deliveries to Everglades National Park) was built for this need and expanded to 500 cfs.

4.9.1.7 Lake Okeechobee Regulation Schedule

Lake Okeechobee has undergone numerous changes since the initial construction of Herbert Hoover Dike. Today, the Lake Okeechobee's water level is managed to provide a range of desired purposes including, flood protection, water supply and environmental protection using "regulation schedules." In 1995, the South Florida Water Management District requested the Corps of Engineers to study a range of regulation schedules intended to be more responsive to lake ecosystem, down stream users and receiving water bodies. Those studies are currently underway. Due to the uncertainty of the recommendation that will result from that study, the Restudy assumed the current schedule, known as Run 25, for hydrologic modeling of the future without plan condition.

4.9.2 Critical Projects

The Water Resources Development Act (WRDA) of 1996 authorizes the Secretary of the Army to expeditiously implement restoration projects that are deemed critical to the restoration of the south Florida ecosystem. These projects are referred to as "Critical Projects." This authority resulted in an expedited study to identify projects that would meet the criteria set forth in the authorizing legislation. A total of 35 projects were nominated as Critical Projects under this authority by the Working Group of the South Florida Ecosystem Restoration Task Force (***Section 11***). This nomination process involved considerable input from the Governor's Commission for a Sustainable South Florida (***Section 11***) and the public. Based on the priorities developed during the nomination process, the U.S. Army Corps of Engineers conducts an abbreviated study and produces a letter report that is transmitted to the Secretary of the Army to obtain approval for construction of the project.

For the Critical Projects, the future without plan condition is defined as those Critical Projects that have Secretary of the Army approval and are anticipated to be funded under the Critical Projects program. To date, the following twelve Critical Projects have received approval:

- East Coast Canal Structures
- Tamiami Trail Culverts
- Melaleuca Eradication Project – New Facility

- Florida Keys Carrying Capacity Study
- Western C-11 Water Quality Treatment
- Seminole Tribe Big Cypress Water Conservation Plan (west)
- Southern Golden Gate Hydrologic Restoration
- Southern Crew Project Addition/Imperial River Flowways
- Lake Okeechobee Water Retention/Phosphorous Removal
- Ten Mile Creek Water Preserve Area
- Lake Trafford Restoration
- L31-East Flow Redistribution

Of these twelve approved projects, it is anticipated that the top five will be funded through the Critical Projects program:

- East Coast Canal Structures
- Tamiami Trail Culverts
- Melaleuca Eradication Project – New Facility
- Florida Keys Carrying Capacity Study
- Western C-11 Water Quality Improvements

Furthermore, it is anticipated that the North Fork of the New River Restoration Critical Project will receive approval and can be funded through the remainder of the Critical Projects program funds. Accordingly, the following seven Critical Projects are included in the without plan condition:

- East Coast Canal Structures
- Tamiami Trail Culverts
- Melaleuca Eradication Project – New Facility
- Florida Keys Carrying Capacity Study
- Western C-11 Water Quality treatment
- L31-East Flow Redistribution
- North Fork of the New River Restoration

Appendix A5 contains additional information about the Critical Projects Program.

4.9.3 Interim Plan for Lower East Coast Regional Water Supply

The Interim Plan for Lower East Coast Regional Water Supply, produced by the South Florida Water Management District, identified water resources and water supply development projects, both structural and non-structural, that should be initiated before 2000 to help meet the growing needs of the region (SFWMD, 1998d). The Interim Plan also identified local basin planning and other analytical programs to support the Lower East Coast 2020 Plan development and the Restudy.

The analyses conducted during the Lower East Coast Regional Water supply planning process demonstrated the need for increased storage capabilities throughout the system to help meet the increasing agricultural, environmental and urban demands.

The following components of the interim plan are included in the future without plan condition.

4.9.3.1 Wellfield Expansion in Service Areas 1 and 2

This component provides for relocation of future and some existing withdrawals from existing (1995) wellfields. Demands of the following utilities were evaluated assuming new wellfield locations: Lake Worth, Manalapan, Lantana, Boca Raton, Fort Lauderdale, Hollywood and Hallandale. The evaluations assumed that, for these utilities, demands shifted to new wellfields were the same as those identified in the Draft Lower East Coast Regional Water Supply Plan (SFWMD, 1997g). Generally this means that 1995 levels of demands continued to be met from existing facilities while the portion of new demands beyond 1995 levels were met from the newly expanded wellfields. The new wellfields were generally evaluated as being located along the western boundary of each utility's service area.

4.9.3.2 Northeastern Broward Secondary Canal Recharge Network

This component includes pump stations and structures that would maintain higher levels in secondary canals in eastern Broward County between the Hillsboro and the North New River Canals during the dry season. The control of seasonally higher canal elevations along the coast could help recharge the aquifers being used by local public water supply wellfields, and further reduce saline encroachment into the coastal fresh water aquifers. The selected canals are located where recharge from the canals would help to hold back the salt water front and protect the production capability of wellfields to the east.

4.9.3.3 Miami-Dade County Utility Aquifer Storage and Recovery

This component includes aquifer storage and recovery wells and related facilities that would be installed associated with wellfields of the Miami-Dade Water and Sewer Authority Department. These facilities would be operated to store water in the Floridan Aquifer in the wet season and recover this water in the dry season. For the future without project condition, the evaluations were for a daily injection and recovery capacity of approximately 150 million gallons per day, a maximum recovery percentage of injected water of 90 percent, an annual injection period of seven months and an annual recovery period of five months.

4.9.3.4 Selected Elements of L-8 Project

The goal of the selected elements of the L-8 project is to redirect runoff from the southern L-8 Basin away from Water Conservation Area 1 and the C-51 canal to the West Palm Beach Water Catchment Area and the Loxahatchee Slough via the M Canal and the C-18 Canal. Subsequently, this water may be used to meet urban water supply demands for West Palm Beach, to meet environmental water demands of the Catchment Area and Loxahatchee Slough, and may provide recharge for the Jupiter and Seacoast Utilities Authority wellfields. In addition, this project would be expected to reduce the incident and volume of harmful freshwater releases into Lake Worth lagoon via the C-51 Canal. The project includes: an improved structural connection from the West Palm Beach Water Catchment Area to the Loxahatchee Slough aquifer storage and recovery wells at the West Palm Beach Water Catchment Area or the Indian Trails Improvement District impoundment and a coastal recharge delivery system.

4.9.3.5 Minimum Flows and Levels

This component involves operational adjustments associated with the establishment of minimum flows and levels for the Biscayne Aquifer and the Everglades. Minimum levels for the Biscayne Aquifer involves maintaining water levels in coastal canals to prevent saltwater intrusion. Minimum flows and levels for the Everglades focuses on preservation of hydric soils. No net outflow from Water Conservation Areas are allowed if water levels are less than minimum level marsh triggers or less than minimum operating criteria in the canals of the Loxahatchee National Wildlife Refuge (Water Conservation Area 1): 14 feet, Water Conservation Area 2A: 10.5 feet, Water Conservation Area 3A: 7.5 feet. Marsh level triggers will be those used in the Interim Plan for Lower East Coast Regional Water Supply.

4.9.3.6 Modify Pump Station G-404

This component involves increasing the capacity of proposed pump station G-404 as part of the Everglades Construction Project to increase its capacity from 570 cfs to 1,000 cfs. This will provide the ability to deliver more water from L-5 to L-4, which will in turn improve Everglades hydropatterns in the northwest corner of Water Conservation Area 3A.

4.9.3.7 Water Conservation Areas and Everglades National Park Rainfall-Based Rainfall Water Delivery Plans

In the future without plan condition, the rainfall delivery plan is based on antecedent rainfall and natural system hydropatterns for Water Conservation Area

2A and 3A and Everglades National Park, with quantities to approximate Best Management Practices Replacement water quantities.

4.9.4 Northwest Dade Lake Belt Area

This component assumes that the conditions caused by the currently permitted mining exist and that the affects of any future mining are fully mitigated by the mining industry.

4.9.5 East Cape and Homestead Canals

The East Cape and Homestead Canals, located within Everglades National Park, were constructed by local interests in the early 1900s to assist in the drainage of the Everglades prior to authorization of the park in 1936. After the Everglades National Park was established, the canals were plugged to prevent overdrainage of upstream fresh water systems and saltwater intrusion during high tides in the dry season. The passage of Hurricane Andrew resulted in extensive damage to both plugs. The project repaired the plugs in August 1997.

4.10 LAND ACQUISITION PROGRAMS

Besides land acquisition for ongoing C&SF Project Modifications, the State of Florida, the South Florida Water Management District, Miami-Dade County, and the Federal government have land acquisition programs or are funding land acquisitions within south Florida through a variety of funding sources or programs. Lands within the study area have been acquired and will continue to be acquired by these entities for a variety of purposes.

4.10.1 Save Our Rivers Program, Preservation 2000 and Conservation and Recreation Lands

In 1981, the State of Florida enacted the Resource Rivers Act, also known as the Save Our Rivers Program, Florida Statutes section 373.59. The Act created the Water Management Lands Trust fund. The program uses bond proceeds, supported by the general revenue portion of the State's Documentary Stamp Tax, to acquire lands for the purposes of water management, water supply, and the conservation and protection of the State's water resources. Manageability, surface and ground water systems, and the formation of corridors for the critical interaction of wildlife populations are major considerations in the land acquisition process. Prime requisites in managing these public lands are to ensure that the water resources, fish and wildlife populations, and native plant communities are maintained in an environmentally acceptable manner, and made available for appropriate outdoor recreational activities consistent with their environmental sensitivity. The

Preservation 2000 Act (Florida Statutes 375.045) enacted by the State of Florida in 1990 also added land acquisition funds to the Save Our Rivers Program. The South Florida Water Management District is allocated 30 percent of the yearly moneys in the Water Management Lands Trust Fund. To date the District has acquired more than 330,000 acres with the Save Our Rivers Program funding.

Florida Statutes section 259.032 entitled Conservation and Recreation Lands Trust Fund, established within the Department of Environmental Protection a nonlapsing, revolving fund to fund the Land Acquisition Trust Fund for the Save Our Rivers Program and to purchase other lands for state-designated parks, recreation areas, preserves, reserves, historic or archaeological sites, geologic or botanical sites, recreational trails, forests, wilderness areas, wildlife management areas, urban open space, or other state-designated recreation or conservation lands.

All of the above programs assume that the lands can be purchased from willing sellers.

The South Florida Water Management District's P-2000 needs and priority study, identified an additional 491,000 acres of priority projects; however, available funding from P-2000, plus funds from other federal, state and local programs will allow for the purchase of 316,000 acres. The South Florida Water Management District has other 50 identified projects.

One of the projects directly related to the Restudy is the East Coast Buffer. The East Coast Buffer consists of approximately 66,400 acres in Palm Beach, Broward and Miami-Dade Counties and was approved for acquisition under Save Our Rivers by the South Florida Water Management District Governing Board in June 1995 with the understanding that the concept would be incorporated into the Restudy. In July 1997 the Board approved an expansion of the buffer by 5,657 acres. To date, approximately 16,000 acres have been acquired. The East Coast Buffer, as evaluated during the South Florida Water Management District's Lower East Coast Regional Water Supply planning process and incorporated into the Restudy process as the Water Preserve Areas, is a series of marshes, reservoirs, and groundwater recharge areas along the east side of the Water Conservation Areas. The function of the buffer, once constructed, is to reduce the impacts of development on the Everglades, reduce levee seepage from the Everglades, increase ground water recharge, capture stormwater discharged to tide, and enhance wetland areas east of the conservation areas. The Without Plan Condition assumes that a portion of the lands for the East Coast Buffer are in public ownership; however, the Without Plan Condition does not assume that all the lands needed for the East Coast Buffer are in public ownership or that the physical facilities necessary for the operation of the storage of water on these land are constructed.

Another of the projects directly related to the Restudy Project is the Model Lands Basin. This land acquisition project is located in southern Miami-Dade County. The project includes the acquisition of approximately 42,000 acres, of which only 1,270 acres have been acquired. These lands form a contiguous habitat corridor with the Everglades National Park, the Southern Glades Save Our River project, Biscayne National Park, Crocodile Lakes National Wildlife Refuge, John Pennekamp State Park, and the existing National Marine Sanctuary.

4.10.2 Miami-Dade County Environmentally Endangered Lands Program

In 1990, Miami-Dade County approved a program to fund the acquisition, protection and maintenance of environmentally endangered lands. The Miami-Dade County Environmentally Endangered Lands Program specifically established an Environmentally Endangered Lands Management Trust Fund in Chapter 24A of the Code of Miami-Dade County, providing for:

> *" ...the preservation, enhancement, restoration, conservation and maintenance of environmentally endangered lands which either have been purchased with monies from the EEL Acquisition Trust Funds, or have otherwise been approved for management pursuant to Section 24A-8(2)." (Appendix X, Chapter 24A, Code of Miami-Dade County)."*

The Environmentally Endangered Lands program considers acquisition of sites proposed by the public and by other government agencies. Sites are inspected and then recommended for acquisition. Once approved for acquisition, the seller must be willing to sell the land to Miami-Dade County. No land is acquired from those landowners unwilling to sell. For the Without Plan condition, it is assumed that lands purchased through this program will be managed in accordance with Chapter 24A of the Miami-Dade County code.

4.10.3 Farm Bill

The U.S. Congress on April 4, 1996 enacted the Federal Agriculture Improvement and Reform Act of 1996 (Public Law 104-127). Section 390 entitled Everglades Ecosystem Restoration, provides the Secretary of the Interior with $200,000,000 to: conduct restoration activities in the Everglades ecosystem in south Florida, which shall include the acquisition of real property and interests in real property located within the Everglades ecosystem; and to fund resource protection and resource maintenance activities in the Everglades ecosystem. The Secretary of Interior can also transfer funds to the State of Florida, the Army Corps of Engineers or the South Florida Water Management District. The Secretary of Interior has executed Grant Agreements with the South Florida Water Management District designed to provide land acquisition funds for the purchase of lands within the East Coast Buffer and in the Everglades Agricultural Area. The Secretary of Interior has also executed a Grant Agreements with the State of Florida Department of

Environmental Protection for the purchase of lands within Southern Golden Glades Estates. The Department of Interior is also providing funds to purchase the Talisman Property in the Everglades Agricultural Area.

4.11 RECREATION

South Florida's climate and unique ecosystem offer a wide variety of recreational opportunities. Due to the region's high population growth rate, more recreational facilities and opportunities will be needed in the future. Without the plan, hunting, fishing, boating and wildlife viewing will continue; however, the quality of these recreational activities can be expected to decline concurrent with ecosystem decline. Given the likelihood of an increased demand in these activities occurring in direct proportion to the growth in population in the south Florida area, the impacts of the potential loss of recreational opportunities due to ecosystem decline is predictable.

SECTION 5
PROBLEMS AND OPPORTUNITIES

Water resources projects are planned and implemented to solve problems, meet challenges, and seize opportunities. In the planning setting, a problem can be thought of as an undesirable condition, while an opportunity offers a chance for progress or improvement. The identification of problems and opportunities gives focus to the planning effort and aids in the development of planning objectives. Planning objectives are statements of what a plan is attempting to achieve; they communicate to others the intended purpose of the planning process. Problems and opportunities can also be viewed as local and regional resource conditions that could be modified in response to expressed public concerns. This section describes the problems and opportunities in the study area and the planning goals and objectives developed for the study.

5.1 PUBLIC CONCERNS

At the heart of the identification of problems and opportunities process is an understanding of the public's concerns. As part of the reconnaissance phase of the study, an extensive public program was designed to determine the public's concerns through responses to three questions:

Question #1 - What are the **important resources** in the south Florida ecosystem?
Question #2 - What do you think are the **problems and opportunities** in the ecosystem?
Question #3 - How will you recognize **successful restoration** of the ecosystem?

Ten public workshops to address these questions were conducted across the study area in December 1993; about 2,200 people attended these workshops. Additional responses to the three questions were received through the mail primarily during January and February 1994.

All of these responses were read to identify the public's ideas about important resources, problems, opportunities and success. These ideas were grouped in ten general categories that covered the full range of concerns expressed by the public. While it is not possible to provide a count of the number of times any given concern was stated, the review provided a very good sense of the public's perception of the magnitude of each concern. Based on this review, the magnitude of public concerns can be grouped as follows:

Most people identified concerns about:
ecosystem health
uncontrolled growth

Many people identified concerns about:
water quality
water supply
balance
"they're the problem"

Some people identified concerns about:
flood control
recreation
economy
social considerations

A technical analysis of conditions in south Florida was conducted concurrent with the identification of public concerns. The technical analysis was designed to investigate and verify the dimensions of the concerns identified by the public, as well as to reveal other problems and opportunities that had not been identified by the public. The analyses covered:

- Ecosystem health
- Water quality
- Water supply
- Flood control
- Recreation
- Economic and social considerations

The public also expressed concerns about growth, “they’re the problem”, and balance that did not result in technical analysis.

Management of local and regional growth issues, including changes in population and development, is the responsibility of state, county, city, and other local interests. Although, in this study, alternative plans were not formulated to address public concerns about growth, the possible effects of alternative restoration plans on population, development, and other growth issues were evaluated and presented in the assessment of the effects of alternative plans.

The study team recognized many people's views about other interests being the cause of one or more problems, especially the view that government is "the problem" in south Florida. This study has been designed to elicit and use ideas and information from as many individuals and interest groups as desired to participate. It is through this extensive program of public involvement that the study hopes to build better understanding among all the concerned interests, and demonstrate the Corps' commitment to responsive public service.

One of the major steps in the planning process is the evaluation of the effects of alternative plans. Evaluation will reveal the plans' important effects, including effects that reflect progress toward meeting the objectives and constraints, as well as effects that are of interest for other reasons. Evaluation will cover the full range of effects on the human environment, including ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social and health effects, whether direct, indirect, or cumulative (Council on Environmental Quality, 1978). This information about the plans effects will provide interested members of the public and responsible decision makers with a basis for judging trade-offs within and among alternative plans; that is, for determining what they individually believe is a "balance" in view of likely beneficial and adverse effects. In short, this study will provide information that people can use to make decisions about "balance".

As a result of this effort, the reconnaissance study produced an initial set of planning objectives and constraints. As a part of this feasibility study, the reconnaissance study problem identification was refined further.

5.2 ECOLOGICAL PROBLEMS AND OPPORTUNITIES

Natural resource specialists agree that the remaining ecosystems in south Florida no longer maintain the functions and richness that defined the pre-drainage system, and that these measures of ecological health will continue to decline without preventative actions. Not only is it certain that these natural systems will not recover their defining attributes under current conditions, it is unlikely that even the current, unacceptable ecological conditions can be sustained into the future. For example, wading birds, key indicators of broad, regional patterns of aquatic production, continue to show declines in the total number of birds initiating breeding in south Florida colonies. Other examples are the declines in population levels of commercially and recreationally important fish species in the St. Lucie and Caloosahatchee Estuaries, and Biscayne and Florida Bays. High water levels in recent years in Lake Okeechobee have resulted in widespread losses of the emergent and submerged plant communities that provide habitat for economically important fish. If this trend continues, there may be substantial declines in the lake's fisheries. Regulatory releases to the Caloosahatchee and St. Lucie Estuaries can have damaging effects on the plants and animals inhabiting these areas. Prolonged high volume releases from Lake Okeechobee are believed responsible for the defoliation of seagrasses, fish kills, and deformed fishes within the St. Lucie Estuary during 1998, for example.

Many of the defining characteristics of the pre-drainage ecosystem (spatial extent, habitat heterogeneity, and dynamic storage) have either been lost or substantially altered as a result of land use and water management practices during the past 100 years in south Florida. Loss in spatial extent of natural areas has been most severe in the past 50 years with the construction of the C&SF Project, including the construction of Herbert Hoover Dike around Lake Okeechobee. Nearly half of the original Everglades ecosystem has been converted to agricultural and urban uses. The ecological effects of this loss in spatial extent include:

- a substantial reduction in habitat options for fish and wildlife,
- reduction in the system-wide levels of primary and secondary production, changes in the proportions of community types within the remaining system, and
- increasing concentrations of pollutants in remaining natural system surface waters, sediments, and wetlands and degradation of water quality.

The hydrology of the remaining Everglades has become altered by the operation of the C&SF Project, which has generally:

- reduced average annual flows and surface water stages,
- lowered regional ground water,
- either increased or decreased annual hydroperiods, depending on location,
- geographically relocated long and short hydroperiod wetlands,
- reduced the extent of long hydroperiod refugia,
- altered the frequency, duration and magnitude of interannual wet and dry cycles, and
- altered salinity levels in estuaries.

Overall, the construction and operation of the C&SF Project and its subsequent modification of the natural system have:

- contributed to the substantial reduction in spatial extent and system resiliency,
- provided a network of canals and levees which have accelerated the spread of polluted water, sediments, and exotic species,
- greatly reduced the water storage capacity within the remaining natural system, and
- created an unnatural mosaic of impounded, fragmented, and both over-inundated and over-drained marshes throughout the natural system.

Some level of ecological improvement is expected to occur as a result of the implementation of a number of projects such as: changes in the Lake Okeechobee regulation schedule, the addition of the stormwater treatment areas as part of the

Everglades Construction Project, rainfall-based schedules for Water Conservation Areas 2 and 3, implementation of Minimum Flows and Levels for the Everglades and Lake Okeechobee, and the completion of the C-111 and Modified Water Deliveries projects. The effects of these projects on the regional system were modeled and analyzed. The magnitude of the cumulative, regional benefits from these improvements, relative to the level of ecological improvements required to recover a functional, Everglades-type system, is uncertain. The best professional opinion is that these projects will contribute less than 25 percent of the overall, improvement in hydrological patterns required for the recovery of a regionally integrated ecosystem, or to achieve the ecological targets that were contained in the performance measures used to define the restoration objectives. In general, these projects are expected to produce a higher level of improvement in the quality of water in the remnant natural system. Further discussion of water quality follows this section.

Translating these levels of improvement in hydrological patterns and water quality conditions into predictions of regional ecological health is risky business. A large question in this evaluation is concerned with ecological thresholds, and whether modest improvements in hydrological patterns are sufficient to shift production and animal behavior patterns towards more Everglades-like patterns. The prevailing technical opinion is that these modest hydrological improvements are not expected to produce major, and in some cases, measurable, improvements in regional ecological conditions or in habitats critical to several species of endangered species. As mentioned above, relatively greater levels of improvement are expected for water quality conditions. Reduced inputs of excessive nutrients should slow the spread of cattails and other plants with high nutrient tolerances, and should produce a slow recovery of natural vegetation patterns in some nutrient-stressed parts of the system.

5.3 WATER QUALITY PROBLEMS AND OPPORTUNITIES

5.3.1 Regional Overview

Many of the regulatory and environmental restoration programs, which are assumed to be in place in 2050 (see Section 4.8) are projected to result in a net improvement in water quality in south Florida. In addition to those assumptions, water quality improvement actions undertaken to comply with the requirements of the Federal Clean Water Act (P.L. 92-500) as implemented by the U. S. Environmental Protection Agency, the Florida Department of Environmental Protection, the South Florida Water Management District, the Seminole and Miccosukee Tribes, and local governments are expected to result in improvements in regional water quality necessary to comply with state, tribal, and local water quality standards. Examples of these programs include: Municipal Separate Storm

Sewer Systems (MS4) and other National Pollutant Discharge Elimination System (NPDES) point and non-point source pollution reduction permitting requirements, Total Maximum Daily Loads established under Section 303(d) of the Clean Water Act., and Pollutant Load Reduction Goals (PLRGs) established pursuant to the State of Florida's Surface Water Improvement and Management (SWIM) Act for designated priority waterbodies.

From a regional perspective, the most comprehensive of these programs is the TMDL program implemented by the Florida Department of Environmental Protection and the Seminole and Miccosukee Tribes. Under Section 303(d) of the Clean Water Act, states and tribes are required to identify water bodies within their jurisdictions not meeting water quality standards and rank those water bodies in terms of the severity of the pollution and designated and actual uses of the water bodies. The 303(d)-listed water bodies are to be reported to the U.S. Environmental Protection Agency in accordance with Section 305(b) of the Clean Water Act. TMDLs are to be developed for 303(d)-listed water bodies consistent with the priority ranking and are to be established "at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." However, the TMDL program, for the most part, has not been implemented in the study area.

In its 1998 report to the U.S. Environmental Protection Agency, the Florida Department of Environmental Protection identified approximately 160 impaired water bodies in the study area in accordance with the requirements of Section 303(d) of the Federal Clean Water Act. The Florida Department of Environmental Protection has developed a strategy for assessing watersheds (basins) and developing TMDLs and remediation plans for pollutants causing impairment of 303(d)-listed water bodies (FDEP, 1996a and FDEP, 1996b). (It should be noted that excessive nutrient loads were typically identified as the most common pollutant causing impairment.) The Florida Department of Environmental Protection's statewide strategy for implementing TMDLs involves five-year cycles for basin assessment, monitoring, data analysis and TMDL development, development of basin management plans, and implementation of basin management plans. However, it should be noted that this strategy has not yet been approved by the U.S. Environmental Protection Agency, and would take up to 15 years to complete (statewide) once approved. It should be further noted that the Florida Department of Environmental Protection's strategy for TMDLs does not give regional priority to south Florida; rather, the strategy was developed from a statewide perspective. Nevertheless, several key water bodies in south Florida will receive priority for TMDL development, including Lake Okeechobee and the Indian River Lagoon.

Development and implementation of TMDLs is an essential step for achieving overall ecosystem restoration in south Florida. Water quality restoration targets are necessary for detailed design of Restudy recommended plan components to achieve water quality restoration performance objectives. Further, implementation of basin management plans developed under the TMDL program is necessary to achieve ecological restoration in watersheds "downstream" of recommended plan components.

The triennial review of state and tribal water quality standards performed under Section 303(c) of the Clean Water Act is another essential step for achieving ecosystem restoration in south Florida. States and tribes are required to periodically review their water quality standards to ensure that standards are adequate to protect designated uses of waters. Within the study area, there are no specific numeric water quality criteria for many pollutants (e.g., nutrients and several pesticides) detected in ongoing water quality monitoring activities. The extent of the contribution of such pollutants to overall "impairment" levels in 303(d)-listed water bodies is also unknown. As part of the triennial review process, Florida Department of Environmental Protection and the Seminole and Miccosukee Tribes may propose modifications to existing water quality criteria and propose additional water quality criteria (as appropriate) to protect water resources. Modified and additional water quality criteria should be integrated with future detailed planning and design activities to assure that recommended plan components are operated consistent with water quality restoration targets.

The South Florida Water Management District is also developing pollution load reduction goals (PLRGs) for SWIM-listed water bodies. In south Florida, SWIM-listed water bodies include Lake Okeechobee, the Indian River Lagoon, and Biscayne Bay. PLRGs are similar to TMDLs in that numeric water quality targets are promulgated and remediation programs are developed. TMDLs and PLRGs are essential water quality restoration targets to be integrated into future detailed planning and design activities for recommended plan components during the implementation period.

Several larger municipalities within the study area are required to apply to the U.S. Environmental Protection Agency for "Municipal Separate Storm Sewer System" (MS4) permits to address non-point source pollution sources within their jurisdictional boundaries. MS4 permit requirements apply to master drainage systems of local governments with populations greater than 100,000. The U.S. Environmental Protection Agency has generally implemented the MS4 permitting program on a countywide basis, incorporating cities, Ch. 298 drainage districts, and the Florida Department of Transportation (FDOT) where appropriate. Cities with populations greater than 100,000 are permitted separately. The following municipal governments in the study area are currently subject to MS4 permitting: Reedy Creek Improvement District, Broward County (25 co-permittees), City of Ft.

Lauderdale, City of Hollywood, Palm Beach County (39 co-permittees), City of Hialeah, Dade County (20 co-permittees), City of Miami, and Lee County (12 co-permittees). Local government regulatory programs to control smaller point and non-point sources of pollution will compliment state and tribal water quality regulatory and remediation programs.

The following Sections 5.3.2 through 5.3.11 summarize projected water quality problems and opportunities in study area sub-regions. Accurately projecting future water quality conditions in the Restudy area is difficult, due to the vast scope of the study area, uncertainty in future growth and land use changes, and in part to the lack of comprehensive water quality data indicative of statistically reliable trends (FDEP, 1996a). The following sub-sections predict water quality changes expected to occur within each of the C&SF Project sub-regions based on current water quality data and descriptions of existing conditions, available trend data, future population growth projections and the assumed implementation of certain specific regulatory and environmental restoration and water supply projects. Actual improvements in water quality conditions, where projected to occur, depend in large degree upon the successful implementation of the programs and projects included in the future without plan assumptions. For mercury (***Section 5.3.12***), conditions are projected for the regional system as a whole.

5.3.2 Kissimmee River Region

By 2050, water quality conditions in the Kissimmee River watershed south of urbanized Orange County are expected to be improved overall compared to existing conditions due to ongoing and planned ecological restoration programs in the drainage basin. In its 1998 303(d) list, the Florida Department of Environmental Protection identified approximately 25 waterbodies or segments of waterbodies within the Kissimmee River watershed where water quality was not adequate to sustain designated uses. Several of the 303(d) listed waterbodies are actually reaches of the Kissimmee River. Most of the watershed is classified as Class III ("fishable–swimmable") waters; several waterbodies within the watershed are designated Outstanding Florida Waters by the State of Florida. Pollutants and/or water quality criteria identified contributing to impairment of designated use include: low levels of dissolved oxygen, excessive nutrients, coliform bactieria, high biochemical oxygen demand, several trace metals including mercury (based on fish-consumption advisories), turbidity, and un-ionized ammonia.

Kissimmee River restoration projects are expected to reduce net pollution loading to the Kissimmee River and in downstream Lake Okeechobee through the restoration of remnant wetlands presently used as agricultural lands currently contributing pollutants to wetlands. Restored wetlands will also have a pollutant assimilation function, resulting in improved water quality in downstream water bodies (tributaries and oxbows). Additional ongoing land acquisition activities by the South Florida Water Management District will supplement ongoing environmental restoration projects (SFWMD, 1997a).

The extent of urbanization in the vicinity of the cities of Orlando and Kissimmee, north of the Kissimmee River Chain of Lakes is expected to increase. While new developments must comply with water quality treatment requirements for stormwater runoff, the net load of pollutants, particularly those typically associated with urban stormwater runoff contributed to the watershed north of the Kissimmee Chain of Lakes is expected to increase. Most of this increased pollution load would be expected to be retained in the Kissimmee Chain of Lakes and not enter the Kissimmee River – Lake Okeechobee system. Urbanization and attendant pollution loads in the region are not expected to increase significantly south of Lake Kissimmee.

5.3.3 Lake Okeechobee

Lake Okeechobee is a Class I waterbody (potable water supply) according to Florida Administrative Code rule. Class I waterbodies generally have the most stringent surface water quality and pollution control criteria in Florida. However, water quality data for Lake Okeechobee indicate that the lake is in a eutrophic condition, primarily due to excessive nutrient loads from agricultural sources both north and south of the lake.

The main tributary to Lake Okeechobee is the Kissimmee River. As stated above, several waterbodies within the Kissimmee River watershed, including segments of the river itself, are impaired to various levels. Degradation of water quality in the Kissimmee River watershed contributes to downstream degradation in Lake Okeechobee. Lower reaches of the Kissimmee River contribute high levels of nutrient loading to Lake Okeechobee.

Another important tributary to the lake is the Taylor Creek/Nubbin Slough basin. The Taylor Creek/Nubbin Slough basin contributes high levels of nutrient loading, low levels of dissolved oxygen, and elevated coliform bacteria and turbidity levels to the lake. The Taylor Creek/Nubbin Slough basin contributes only 4 percent of the total volume of inflows to Lake Okeechobee, but accounts for approximately 29 percent of the total phosphorus inflow loads.

Eight segments of Lake Okeechobee are also included on the Section 303(d) list. Water quality parameters/criteria causing impairment at eight different monitoring locations in Lake Okeechobee include: excessive nutrients, low levels of dissolved oxygen, and high concentrations of unionized ammonia, iron, chlorides, and coliform bacteria. The Fisheating Creek and C-41 basins on the northwest side of the lake also contributes pollutants causing impairment in Lake Okeechobee.

Water quality in Lake Okeechobee is expected to slowly improve between 1999 and 2050. Field and laboratory studies of phosphorus stored in lake sediments indicate that sediment bound phosphorus is a dominant pollutant affecting lake water quality (Reddy et al., 1995). Currently, the average cumulative phosphorus load to the lake exceeds the Surface Water Improvement and Management Plan target by approximately 100 tons per year (SFWMD, 1997f). Phosphorus loads to the lake eventually become sequestered in lake sediments. The phosphorus in these sediments, which has accumulated over time from excessive external loads, is frequently resuspended (primarily by wind-aided mixing: Havens, 1997) and will tend to maintain a high phosphorus concentration in the water column, even if all sources of phosphorus in the contributing watershed are controlled consistent with regulatory and watershed management programs. Although short-term water quality conditions in Lake Okeechobee are not expected to improve, in place pollutant reduction programs in the lower Kissimmee River and Taylor Creek/Nubbin Slough basins are expected to result in long-term reduction in Lake Okeechobee water column nutrient concentrations

Urban development in the Lake Okeechobee watershed and non-point source pollution loading associated with urban stormwater runoff is not expected to increase significantly by 2050.

5.3.4 Upper East Coast and Indian River Lagoon

The Upper East Coast region includes Martin and St. Lucie Counties and a small portion of Okeechobee County. The principal water body is the Indian River Lagoon, which includes the St. Lucie River. The Upper East Coast is hydrologically connected to the Everglades and Florida Bay ecosystems through the C-44 (St. Lucie) Canal. The Indian River Lagoon is a SWIM priority water body. Most of the Upper East Coast watershed consists of Class III waters; however, there are small areas of Class II waters (shellfish propagation or harvesting) within the watershed. Class II waters are generally afforded greater protection than Class III waters. Currently, nine locations in the St. Lucie (C-44) Canal, the North and South Forks of the St. Lucie River, and several sub-basins draining to the Indian River Lagoon are listed by the Florida Department of Environmental Protection on the 1998 303(d) list of impaired waterbodies. Pollutants/constituents causing impairment include: low levels of dissolved oxygen, excessive nutrients, high levels of total suspended solids (TSS), high biochemical oxygen demand, coliform bacteria, and mercury (based on fish consumption advisories). There are an additional eight monitoring locations in the southern Indian River Lagoon area also included on the 1998 303(d) list. In addition to the above-listed constituents, copper and turbidity were identified to be causing use impairment at some of the monitoring sites.

Overall, water quality conditions in the Upper East Coast and the Indian River Lagoon are expected to be somewhat improved by 2050, compared to existing conditions. Lake Okeechobee freshwater discharges via the St. Lucie Canal (C-44) alter ambient salinity levels and deliver nutrients and other pollutants contained in Lake Okeechobee water and runoff from localized sources (agricultural and urban) to the estuary. The C-23/C-24/C-25 Canal system in St. Lucie County facilitates drainage to sustain agricultural (primarily citrus groves) and urban development in the vicinity of those canals. Implementation of a different regulation schedule for Lake Okeechobee is also expected to improve water quality conditions in the Indian River Lagoon Estuary by reducing the frequency and volume of fresh water delivered to the estuary. It is also expected that agricultural non-point source pollution loads delivered to the estuary via secondary and tertiary canals connected to C&SF Project canals will be reduced compared to existing conditions through the implementation of agricultural Best Management Practices and the conversion of some agricultural lands to other uses (e.g., conservation, urban/suburban development).

The extent of urbanization in the watershed is expected to increase by 2050. New growth and development in the watershed will be regulated to comply with water quality regulations governing point and non-point source discharges; however, the net pollution load contributed to the St. Lucie River and the Indian River Lagoon system from these sources is expected to increase compared to existing conditions. Ongoing and planned pollutant load reduction activities in the Upper East Coast region should help offset additional pollutant loads expected to occur from future urbanization.

5.3.5 Everglades Agricultural Area

According to the Florida Department of Environmental Protection's 1998 303(d) list of use-impaired water bodies, there are approximately 10 canal segments within the Everglades Agricultural Area not meeting designated uses for Class III waters. For the most part, these include canal segments affected by operation of the primary pump stations and canals discharging water from the Everglades Agricultural Area to downstream areas (e.g., S-7, and S-8 pump stations; North New River, Hillsboro, and West Palm Beach Canals). In addition to excessive nutrient loads, low dissolved oxygen levels and high levels of mercury (based on fish consumption advisories), coliform bacteria, total suspended solids, turbidity, and unionized ammonia contributed to use impairment in Class III waters within the Everglades Agricultural Area. It should be noted that within the Everglades Agricultural Area, there are many agricultural canals or ditches in agricultural water management systems controlled by water control structures permitted by the South Florida Water Management District. Such water bodies are classified as Class IV waters (agricultural water supply) pursuant to Rule 62-302.600(3)(a), Florida Administrative Code. Generally, the water quality criteria for Class IV waters are less stringent than those for Class III waters. None of the 303(d)-listed segments within the Everglades Agricultural Area are in Class IV waters.

Water quality conditions within the Everglades Agricultural Area are expected to improve in 2050 compared to existing conditions. It is important to note that the existing conditions for the Everglades Agricultural Area demonstrate significant water quality improvements compared with recent past conditions. Recent water quality improvements in the area have occurred as a result of the implementation of the Everglades Agricultural Area regulatory program (Florida Administrative Code Rule 40E-63) beginning in 1993. The regulatory program requires Best Management Practices and monitoring to achieve a 25 percent reduction in phosphorus loading from the Everglades Agricultural Area to the Everglades Protection Area. Recent monitoring results indicate that phosphorus loads in area runoff have declined approximately 51 percent (three year average, SFWMD, 1997b). The current average concentration of total phosphorus contained in Everglades Agricultural Area runoff is approximately 100 parts per billion (Havens, 1997). Best Management Practices are also expected to have resulted in a net reduction of other pollutants contained in agricultural runoff, although the extent of load reduction for other pollutants has not been fully quantified since the implementation of the program; nor is it a specific objective of that program.

5.3.6 Natural Areas

Approximately 18 waterbody segments within Loxahatchee National Wildlife Refuge (Water Conservation Area 1), and Water Conservation Areas 2 and 3 were listed as use-impaired on the Florida Department of Environmental Protection's 1998 303(d) list. Pollutants/water quality parameters contributing to use-impaired conditions include: excessive nutrient loads, low dissolved oxygen levels, high levels of mercury (based on fish consumption advisories), un-ionized ammonia, coliform bacteria, total suspended solids and certain trace metals. There are also four waterbody segments in Everglades National Park on the 303(d) list. Those water body segments include: ENP Shark Slough, ENP L67 Culvert @ US 41, Taylor Slough, and the Tamiami Canal. Problem constituents in Everglades National Park waters include low levels of dissolved oxygen, and high levels of nutrients, mercury (based on fish consumption advisories), iron, other trace metals. Many of the water body segments in the Water Conservation Areas and Everglades National Park may eventually be removed from subsequent 303(d) lists because the Everglades Forever Act includes schedules and strategies for achieving compliance with water quality standards, consistent with the requirements of the Clean Water Act.

Water quality conditions in the Rotenberger and Holey Land Wildlife Management Areas, Loxahatchee National Wildlife Refuge, the Water Conservation Areas and in downstream Everglades National Park are expected to be significantly improved in 2050 compared to current (without the Everglades Construction Project) conditions.

In the southern Everglades, implementation of the C-111 and Modified Water Deliveries Projects may also involve developing water quality treatment features necessary to assure that regulatory requirements are met. Minimally, implementation of the C-111 Project involves acquisition of the Frog Pond agricultural area adjacent to the C-111/L-31W levee/borrow canal system, which will result in a net reduction of pollution loading (nutrients, pesticides) into Everglades National Park via the existing canal system from non-point source agricultural runoff.

5.3.7 Lower East Coast and Biscayne Bay

For Restudy planning purposes, the Lower East Coast consists of Palm Beach, Broward, and Miami-Dade Counties, including Biscayne Bay and Lake Worth Lagoon. According to the Florida Department of Environmental Protection's 1998 303(d) list, approximately 42 waterbody segments (both fresh and marine waterbodies) within the Lower East Coast are use-impaired. Pollutants/water quality constituents causing impairment include low levels of dissolved oxygen, high levels of mercury (based on fish consumption advisories) and other trace metals, and high levels of coliform bacteria, total suspended solids, bio-chemical oxygen demand, and un-ionized ammonia.

Four of the main C&SF Project canals delivering flows from Lake Okeechobee and the Water Conservation Areas (the West Palm Beach, Hillsboro, New River, and Miami Canals) traverse the Lower East Coast. In addition to conveying Lake Okeechobee and Water Conservation Area flows, the C&SF Project canals and a network of connecting secondary and tertiary canals provide drainage in the Lower East Coast, which conveys stormwater runoff and attendant pollution loads to estuarine waters. Management of stormwater runoff and flooding via the existing canal system has been implicated as the chief cause of water quality degradation in the region, particularly in the northern portion of Biscayne Bay.

Improving water quality in the Lower East Coast to meet water quality standards in all impaired water bodies will likely be difficult, considering the extent of urban development, minimal or non-existent water quality treatment for non-point source runoff, and other direct (point source) and indirect discharges adversely affecting water quality in the Lower East Coast. Water quality conditions are expected to worsen in the Lower East Coast (central and southern Palm Beach, Broward, and Miami-Dade Counties) by 2050 compared to current conditions. Florida Department of Environmental Protection's 1996 Section 305(b) report to the U.S. Environmental Protection Agency describing water quality conditions in the region indicates that most of the region exhibits "fair" or "good" water quality. The report goes on to state that "most pollution (in the region) comes from stormwater", although bacteriological contamination from wastewater discharges and septic tanks is also a significant problem, particularly in the Miami River, downstream in Biscayne Bay, and urban areas west of the intracoastal waterway in Broward

County and north of the New River. Water quality conditions in receiving water bodies in 2050 are expected to be further degraded, due to the developed condition of the watershed and the continued accumulation of pollutants in sediments in receiving water bodies.

Nearly all of this heavily urbanized watershed drains to estuarine waters. Net pollution loads, especially from non-point sources, to receiving waters in the Lower East Coast are expected to increase as a result of projected population increases. The expected increase in net pollution loads may not be directly proportional to population growth. New growth and urban/suburban development in the Lower East Coast must comply with water quality treatment requirements for non-point source runoff, whereas much of the existing development in the Lower East Coast does not include facilities for treatment of non-point pollution sources. Nevertheless, the projected addition of approximately 2.7 million people to the region is expected to cause water quality conditions to be further degraded, especially in those basins which are already stressed by existing pollution loads.

In Palm Beach County, the Lake Worth Lagoon Estuary is the receiving water body for most of that urban watershed. There are approximately eight use-impaired waterbodies in Palm Beach County on the Florida Department of Environmental Protection's 1998 303(d) list. Listed waterbody segments include coastal canals and freshwater areas further inland. Water quality conditions are expected to improve (in terms of estuarine salinity targets) as a result the C-51 (Stormwater Treatment Area 1 East) Project, which will divert fresh water discharges to Lake Worth Lagoon to a treatment area prior to discharge to Water Conservation Area 1. However, net non-point source pollution loads to Lake Worth Lagoon may increase commensurate with increases in population and development.

Although there are no extensive estuarine water bodies in Broward County, remaining mangroves in southern Broward County canals and along the Intracoastal Waterway provide similar habitat. There are approximately 21 303(d)-listed use-impaired water body segments in Broward County. These waterbody segements are primarily coastal canals providing drainage. Due to the extent of existing urban development in the watersheds of those canals, it is not likely that there will be a significant increase in future non-point source pollution loads into these water bodies. However, it is also unlikely that basin-wide stormwater best management practices (e.g., retention/detention facilities, filtration, etc.) can be implemented effectively in heavily urbanized watersheds, due to the lack of available land for such facilities. Future basin planning efforts during TMDL development and implementation may result in more effective controls of other direct (point source) and indirect discharges of pollutants (e.g. car washes and other industrial facilities). At best, the long-term prognosis for improving all use-impaired water bodies in coastal areas of Broward County is uncertain.

In Miami-Dade County, approximately 13 waterbody segments were identified as use-impaired on the Florida Department of Environmental Protection's 1998 303(d) list. Most are coastal canals providing drainage of runoff to Biscayne Bay. Biscayne Bay is the largest estuarine water body in the Lower East Coast, and is the receiving water body for most of the developed area of Miami-Dade County. Most of Biscayne National Park is located within the central and southern portion of the Biscayne Bay Estuary. As with some of the Broward County canals, controlling non-point sources of runoff in heavily urbanized areas in Miami will be difficult, due to the lack of available land for basin-wide best management practices. Some incremental improvement of non-point source pollution loads may be realized through the basin management plans to be developed by the Florida Department of Environmental Protection. Point sources and other direct discharges of pollutants to Biscayne Bay and tributary canals should be significantly improved if basin management plans are fully implemented. However, overall, it is not expected that water quality in coastal canals draining to Biscayne Bay will be improved to the point that all surface water quality standards will be achieved. Furthermore, any water quality benefits achieved as a result of the Biscayne Bay Surface Water Improvement and Management Plan may be offset by increases in non-point source pollution loads associated with projected population increases.

5.3.8 Florida Bay

Barnes Sound is the only segment of Florida Bay included on the Florida Department of Environmental Protection's 1998 303(d) list. Excessive nutrients, chlorides, and low dissolved oxygen were identified as constituents of concern in ambient water quality monitoring. Other areas of the bay also experience periodic water quality problems. Salinity is the primary water quality parameter of concern in the bay. Bay waters are periodically hypersaline or too low in salinity, depending upon the frequency of hurricanes and other significant storm events and flood release discharges from Central and Southern Florida Project features. Advective conditions in the bay have also contributed to extensive algal blooms. Water temperature levels are also periodically elevated above prescribed temperature limitations. Seatrout collected from Florida Bay also exhibit elevated mercury levels.

Water quality conditions in northeastern Florida Bay should improve in 2050 compared to existing (1995) conditions. Full implementation of the Biscayne Bay SWIM Plan elements should benefit water quality conditions in Florida Bay also. When fully completed, it is anticipated that the C-111 Project would improve water quality conditions in the vicinity of Taylor Slough through the implementation of structural and operational changes necessary to achieve preferred hydrologic conditions. It is expected that the net load of agricultural non-point source pollution entering the C-111 Canal and south into Florida Bay will be reduced in 2050 compared to existing conditions. The Modified Water Deliveries to Everglades

National Park Project is also expected to result in water quality improvements in Florida Bay through the delivery of increased volumes of fresh water to the bay via Northeast Shark River Slough.

5.3.9 Florida Keys

The Florida Keys as a whole were identified as having use-impaired water quality on the Florida Department of Environmental Protection's 1998 303(d) list; however, water quality problems are generally restricted to canals, marina basins, and nearshore waters as opposed to adjacent open waters. The principal pollutants of concern are excessive nutrient loading and fecal coliform bacteria from inadequate wastewater treatment and disposal facilities, although low dissolved oxygen levels are also common in Keys canals.

Due to recently imposed growth management regulations and limitations on expanded urban development, the population of the Keys is not expected to greatly increase by 2050. In addition, the Florida Keys National Marine Sanctuary Plan (National Oceanic and Atmospheric Administration, 1996) contains a Water Quality Protection Program developed by the U.S. Environmental Protection Agency (USEPA, 1996) in cooperation with the Administration and the Florida Department of Environmental Protection. The Water Quality Protection Program Document, approved in 1996, contains a set of initial recommendations for corrective actions, monitoring, research, and education/outreach. These recommendations have been included in a Water Quality Action Plan focusing on wastewater, stormwater, marinas and live-aboard vessels, landfills, hazardous materials, mosquito spraying, canals and research and monitoring. If the recommended wstewater and stormwater corrective actions are implemented, water quality conditions in the Florida Keys region are expected to be improved in 2050 compared to existing conditions.

The U.S. Environmental Protection Agency, other federal, state and local agencies and citizen stakeholders have identified wastewater infrastructure as the single most important investment to improve nearshore and canal water quality. The cost of wastewater improvements necessary to improve nearshore and canal water quality in the Florida Keys has been estimated at between $184 to $418 million, depending on the percentage reduction in wastewater nutrient loadings to be achieved and which treatment system or systems are ultimately selected. Improvements of stormwater management in the area of the Florida Keys is also needed. The cost of stormwater management and treatment necessary to reduce pollutant loadings in the Florida Keys is estimated at between $370 to $680 million, depending on the percentage reduction in stormwater pollutant loadings targeted to be achieved and which areas are selected to be retrofitted. Water quality improvements in Florida Keys canals and nearshore areas are expected to result from improved wastewater collection, treatment, and disposal implemented through the Monroe County Wastewater Master Plan and through implementation of the Monroe County Stormwater Master Plan, both of which are major components of the Water Quality Protection Program.

5.3.10 Big Cypress Basin

The Big Cypress Basin (the watershed of Big Cypress National Preserve) includes agricultural areas west of the Everglades Agricultural Area, the Seminole Tribe's Big Cypress Reservation, most of the Miccosukee Tribe of Indians' reservation lands, and developed areas of the west coast including Naples and Marco Island. Five waterbody segments within the Big Cypress Basin were included on the Florida Department of Environmental Protection's 1998 303(d) list. Pollutants/constituents of concern include excessive nutrients, coliform bacteria, biochemical oxygen demand, mercury (based on fish consumption advisories), and low levels of dissolved oxygen. It should be noted that none of the 303(d) list sites are within the Big Cypress National Preserve. However, the L-28 Interceptor Canal, on the east side of the Big Cypress Basin was listed as use-impaired due to elevated nutrient levels and low levels of dissolved oxygen. It should be further noted that due to the scarcity of ambient monitoring sites in coastal waters of the basin, actual water quality problems are likely to be more severe in coastal waters than as described in the Florida Department of Environmental Protection's 1996 305(b) Report due to development pressure and point and non-point source pollution loading in developing areas.

Water quality in interior areas of the Big Cypress Basin (the watershed of Big Cypress National Preserve) is not expected to be significantly changed in 2050 compared to existing conditions. However, the rapidly expanding extent of agricultural (citrus) development in the north-central area of the region (Immokalee, southwestern Hendry County) could create an increase in non-point source pollution associated with agricultural activities in Mullet Slough and East Hinson Marsh. Water quality in coastal areas is expected to decline consistent with projected population growth.

Excessive drainage and the introduction of water of poor quality into Big Cypress National Preserve via the existing canal system constitutes the most significant existing and future water quality problem for Big Cypress National Preserve. It should be noted that the canals contributing pollutants into Big Cypress National Preserve are not part of the C&SF Project. Existing pollution loads entering the Big Cypress National Preserve from northwestern areas of the watershed (Big Cypress Seminole Indian Reservation, C-139 Basin and C-139 Annex agricultural areas) are expected to be reduced in 2050 through the implementation of planned and ongoing water quality improvement projects.

5.3.11 Caloosahatchee River Region

The Florida Department of Environmental Protection listed approximately 14 water body segments in the Caloosahatchee River basin and in downstream coastal waters on its 1998 303(d) list. Water quality parameters of concern include excessive nutrients, coliform bacteria, biochemical oxygen demand, and depressed levels of dissolved oxygen. As with the Big Cypress Basin, the number of monitoring locations in coastal waters of the region used to prepare the 305(b) Report is probably inadequate to accurately characterize the extent of water quality degradation in coastal areas. Extensive urban development (Ft. Myers and vicinity, Cape Coral) at the mouth of the Caloosahatchee River contributes significant point and non-point source pollution loads into coastal canals and downstream into the Caloosahatchee estuarine system.

In 2050, water quality conditions in the upper (eastern) and central portions of the watershed are expected to be unchanged compared to existing conditions. Water quality in downstream coastal areas is expected to decline as a result of increased population growth and urban and agricultural development. Water quality impacts from increased agricultural development are expected to be most readily observed in downstream areas of the watershed. The projected increase in population growth in urban areas of the Caloosahatchee River region's watershed is expected to exacerbate existing water quality problems in coastal waters, particularly those associated with wastewater discharges. Offsetting the coastal development and inland agricultural development water quality impacts is the implementation of a different regulatory schedule for Lake Okeechobee, which is expected to improve water quality conditions in the Caloosahatchee River and estuary by reducing the frequency and volume of large quantities of nutrient/sediment laden Lake Okeechobee flood regulation waters.

5.3.12 Mercury

There is much uncertainty about the sources of mercury in south Florida and the Everglades marsh mercury cycling processes that control mercury bioaccumulation. Controlling mercury contamination of the Everglades ecosystem depends on actions that are beyond the scope of the Restudy. The major external source of mercury for the Everglades ecosystem is atmospheric deposition. Some estimate that a high percentage of the mercury deposited into the Everglades could be contributed from local atmospheric emission sources in the urban area (Dvonch, 1998). Others estimate that most of the mercury deposited on the Everglades originates from outside Florida. Research indicates that mercury deposition rates in portions of North America have greatly increased since the turn of the century (Swain, et al, 1992). Some of this historically accumulated mercury is being recycled by the ecosystem; however, this historical mercury could also be buried beneath the recycling zone by accumulating peat if new sources are shut off.

The effect of this burial process hypothesis has been estimated with a mercury cycling model (Ambrose et. al., in press). The model predicts that as little as a 50 percent reduction in atmospheric mercury deposition over the next 50 years (2050) will decrease methylmercury concentrations in Everglades water and fish. Recent and potential future regulatory emission controls may be needed to reduce the atmospheric loading to the system from local sources; however, the significant global atmospheric mercury component is much more difficult to control and will require international agreements.

If control of atmospheric mercury deposition can be affected by decreasing local emission sources in concert with the implementation of the 44,000 acres of Stormwater Treatment Areas constructed as part of the Everglades Construction Project, additional benefits may accrue. However, the complex interactive modeling predictions have not yet been done. The long-term efficiency of the Stormwater Treatment Areas in removing phosphorus and other water quality constituents is presently uncertain, as is the effect of these water quality changes on mercury cycling downstream. Among the key factors that are thought to influence mercury cycling within the Everglades are complex inter-relationships involving phosphorus, sulfur, oxygen, carbon, periphyton, peat accretion and sediment redox conditions. There is no scientific consensus as to which of these factors will dominate, and whether the driving factors will be the same throughout all portions of the 4,000 square mile Everglades ecosystem. Given the 80 percent reduction in total phosphorus obtained in the Everglades Nutrient Removal Project during the early years of operation, it is possible that a decrease in the methylation of mercury could occur downstream due to the declining nutrient concentrations to the marsh and the reduced stimulation of both producers and decomposers. However, it is unclear what effect changes in sulfur forms will have on mercury methylation, and which influence will dominate.

5.4 ECONOMIC AND SOCIAL WELL-BEING PROBLEMS AND OPPORTUNITIES

The C&SF Project, by providing flood protection and water supply, has enabled the population of south Florida to grow from approximately 900,000 persons in 1950 to over 5.5 million in 1995. By 2050, population is projected to grow to 11.6 million. Increases in population growth intensify the competition for and stress upon regional water resources.

With the current C&SF Project, the availability of water from regional surface and ground water sources remains relatively constant. The growing demand for inexpensive, high quality water for agriculture, industry, and an increasing population could exceed the limits of readily available sources. When factoring in the needs of the natural system, upon which a good part of the region's economy depends, conflicts among water users may become even more severe. In addition, the human community is fundamentally dependent on the project for public health, safety, and welfare.

In the south Florida region in general and the Lower East Coast in particular, per capita income levels are higher than in the rest of the state. There is a strong per capita income difference between the urbanized Lower East Coast and the agricultural areas surrounding Lake Okeechobee. Employment and income opportunities in the important industries of agriculture and tourism are heavily reliant on the benefits provided by the C&SF Project.

Agriculture and tourism were identified as "critical industries" by the Governor's Commission for a Sustainable South Florida. Agriculture depends upon the system for vital water supply and flood protection. The tourism industry is dependent upon the project in a myriad of ways. For example, a healthy ecosystem and its attendant tourism are the mainstays of the Monroe County economy, as reflected by the relative domination of economic activity there in the services, retail trade, and fisheries industries. The ability to sustain the region's economy and quality of life depend, to a great extent, on the success of the efforts to protect and better manage the region's water resources.

Predictions of water shortages in the future indicate serious – and probably unacceptable – levels of water supply cutbacks. Modeling shows that for the Lake Okeechobee Service Area, 24 percent of water supply demands could not be met over a 30-year period. This translates into 16 years (out of 30) in which the area was in water supply cutbacks. In the Lower East Coast, water supply cutbacks were predicted to occur in a range from 15 years in northern Palm Beach County and Miami-Dade County to 29 years in Broward County. The monetary losses incurred by these shortages are quantified in ***Appendix E*** of this report.

5.5 PLANNING GOALS AND OBJECTIVES

The purpose of the Restudy is to review how well the C&SF Project is functioning and determine what modifications may be needed. The precursor to the feasibility phase of the study - the reconnaissance study – was completed in 1994 and identified a set of regional-scale planning objectives. The Governor's Commission for a Sustainable South Florida also developed a set of regional-scale objectives for the Restudy as part of their effort to develop the *Conceptual Plan for the Restudy*. A synthesis of these has resulted in an inclusive set of objectives to achieve two general goals for the south Florida ecosystem: enhance ecologic values, and enhance economic values and social well being. These goals, and the study objectives associated with them, are shown in ***Table 5-1***.

TABLE 5-1
GOALS AND OBJECTIVES FOR THE C&SF RESTUDY

Goal: Enhance Ecologic Values
• Increase the total spatial extent of natural areas • Improve habitat and functional quality • Improve native plant and animal species abundance and diversity
Goal: Enhance Economic Values And Social Well Being
• Increase availability of fresh water (agricultural/municipal & industrial) • Reduce flood damages (agricultural/urban) • Provide recreational and navigation opportunities • Protect cultural and archeological resources and values

5.5.1 Enhance Ecologic Values

Healthy natural systems are integral to the sustainability of south Florida. These systems provide numerous functions such as:

- habitat for numerous plant and animal species,
- recreation and educational opportunities (photography, fishing, hunting, bird watching, etc.),
- water quality filtration including removal of nutrients and silt,
- ground water recharge,
- soil formation,
- hydrologic linkages,
- ground water quality protection,
- interception of airborne pollutants,
- shoreline stabilization, and
- protection against erosion.

Each natural area is uniquely important. Wetlands and lakes, in particular, retard floodwater and provide surface water storage. Mangroves and estuaries provide important feeding areas for manatees and breeding habitat for numerous finfish and shellfish, including several of commercial interest. Upland natural systems function as noise buffers, urban green space, habitat for plants and animals (such as tree snails, deer, hundreds of species of birds, and the endangered panther and indigo snake), and travel corridors for these same animals. Thus, plant and animal habitat, although perhaps the most obvious benefit or function, is just one of many functions that natural systems provide. Collectively, these systems benefit the natural ecology and support agricultural, urban, and other human interests as well. The ecological health and hydrologic characteristics of Lake Okeechobee and south Florida's freshwater wetlands directly affect the quality of the receiving water bodies, including the St. Lucie and Caloosahatchee Estuaries, and Biscayne and Florida Bays.

Two documents are particularly important in framing the Restudy's goal for enhancing *ecological* values. These documents, which were prepared by many of the leading experts on Everglades ecology, are *The Science Sub-Group Report, Federal Objectives for the South Florida Restoration* (Science Sub-Group, 1993), and *Everglades, the Ecosystem and Its Restoration* (Davis and Ogden, 1994). Another earlier publication, *Ecosystems of Florida* (Myers and Ewel, 1990) also contributed substantial input into the Restudy.

5.5.1.1 Spatial Extent

Scientists have identified the large spatial extent of the south Florida wetlands as one of the defining physical characteristics of the pre-drainage ecosystem. The size of the south Florida wetlands, in combination with the complex mosaic of habitats, enabled multiple populations of plants and animals to persist over time. The size of the pre-drainage area made it possible for the natural ecosystem to: 1) support genetically viable numbers and sub-populations of species with large feeding ranges and/or narrow habitat requirements, 2) provide the aquatic production to support large numbers of higher vertebrate animals in a naturally nutrient-poor environment, and 3) sustain habitat diversity despite natural disturbances. The ability of animal populations to recover from disturbances decreases as the available habitat area decreases since habitat diversity, the amount of seasonal refugia, and the number of dispersal options also decrease.

Roughly 50 percent of the pre-drainage wetland area and 90 percent of pinelands have been lost to development. Lake Okeechobee was much larger then it is at present with an extensive littoral/marsh system extending to the north, west, and south. The resulting loss of these natural areas has caused wading bird, snail kite, and panther populations, for example, to be stressed. Assuring adequate spatial extent for natural systems, necessary to support the mosaic of habitats characteristic of the pre-drainage ecosystem, will provide for genetically viable numbers and populations of native species and habitat diversity.

5.5.1.2 Habitat and Functional Quality

Adverse changes in natural habitats, including sawgrass, mangroves, seagrass beds, and other native wetland habitats, as well as in many native fish and wildlife species, such as wading birds, alligators, shrimp, and lobsters, that depend on healthy habitats for survival have occurred in the south Florida ecosystems. The specific functions that wetlands or uplands perform are closely associated with their condition or quality. A reduction in the quality of these areas results in the loss of many or all of the functions that these areas historically performed. Improving the functional quality of the remaining natural areas is important to system-wide restoration given the loss of spatial extent and, thus, function of the historic wetlands and uplands.

South Florida natural habitats have been physically and hydrologically altered and manipulated. Consequently, these Florida ecosystems are now substantially less productive and diverse than the historic system. For example, although many of the historic short hydroperiod wetlands no longer exist, wetlands that were historically much wetter now have short hydroperiods. Another example is the alteration of wetlands in the Water Conservation Areas. These areas are managed as separate entities and are hydrologically different from historic conditions resulting in changed hydropatterns and quality of the wetlands and tree islands. Aquatic productivity has been reduced or highly altered throughout the marshes of the central Everglades and the estuaries. Reductions in aquatic productivity have affected the abundance of birds as well as fish. Changes in habitat, construction of deep canals, and abnormally extreme water levels impact the foraging ability of birds. Additionally, changes within interior and coastal wetlands have adversely influenced downstream commercial fish and other species in coastal ecosystems such as Florida Bay.

Invasive plant and animal species have also impacted the quality of the south Florida landscape. Invasive species include both native (i.e. cattails) and non-native species (e.g. Melaleuca, Brazilian pepper, and Australian pine). The increasing dominance of any community by a single species ultimately reduces the habitat variability necessary to sustain a healthy community of both plants and animals. Water management has encouraged the spread of these invasive species by creating conditions under which they can out-compete the native habitat that existed under pre-drainage conditions. For example, high phosphorus loads and increased hydroperiods have contributed to cattails out-competing sawgrass; altered hydrologic regimes have increased the spread of Melaleuca and Brazilian pepper; and the construction of levees has contributed to the spread of Australian pine and Brazilian pepper. Eliminating the invasive and exotic species and the conditions that favor these species will contribute to restoration of native plants and animal species and a more natural ecosystem hydrology and function.

5.5.1.3 Species Abundance and Diversity

The changes that have taken place in the natural system have led to decreases in native animal and plant populations. One of the most obvious indicators that the south Florida ecosystems have experienced ecologically significant reductions in productivity is the decline in wading bird populations. Several species are now so reduced in numbers that their long-term existence is jeopardized unless measures are taken to ensure their sustainability. Other species have a naturally restricted range; these species are also vulnerable to extinction if their specialized habitats are altered. In addition to considering these species, it is important to recognize that maintaining balanced communities of the more abundant species is also essential to a sustainable ecosystem. It is also important to recognize that a balanced community is dynamic; population levels fluctuate widely from year to year as natural conditions fluctuate. Unnaturally small, isolated populations can be quickly extinguished by natural conditions.

Increasing spatial extent and improving habitat quality can provide a basis for improving species abundance and diversity. However, compartmentalization caused by construction of physical barriers such as dikes, canals, levees, and roads, or even hydrologic barriers (such as the Water Conservation Areas) has fragmented the system by creating a series of poorly connected natural areas. These barriers have restricted the movement of many fish and consequently reduced their range. Fragmented communities are more likely to lose species because the number of individuals in each fragment may be too small to persist. The smaller the fragment, the higher is the likelihood of losing species or favoring an imbalance in the species that do inhabit the areas. Moreover, fragmentation itself alters the landscape by breaking connections between the various habitat types that were distributed historically across the landscape. Therefore, improving the connectivity of habitats will improve the range of many animals and their prey-base and provide for a more natural balance of species within the system. The physical barriers that created the fragmented environment themselves affect species abundance. The introduction of deep canals which act to drain surrounding areas, affect the ability of wading birds to forage over large areas.

5.5.2 Enhance Economic Values and Social Well Being

The C&SF Project provides economic benefits through regional water supply, flood damage reduction, navigation, and recreation. While most people recognize the need for a healthy ecosystem to support the region's economy and jobs, many people are concerned that restoration projects will displace farms and other businesses, limit development, reduce available water supply, and reduce job opportunities. By contrast, continued degradation of the south Florida ecosystem will adversely affect the tourism and recreational industry that are important to the regional economy.

5.5.2.1 Water Supply

Drainage, water supply, and flood protection afforded by the C&SF Project have provided for the growth of south Florida's population, which by 1990 was 5.2 million. Local governments in south Florida are predicting that total population will reach 8 million by 2010 and will range from 12-15 million people by 2050. Approximately 88 percent of the region's current population are concentrated in the coastal urban counties of Miami-Dade, Broward, Palm Beach, Lee, and Collier; this distribution pattern is projected to continue. Urban water supply demands could increase from approximately one billion gallons of water per day today to two billion gallons of water per day by 2050. Lake Okeechobee is an important source of water to both natural and developed areas, particularly during low rainfall years. The growing demand for dependable water for agriculture, industry, and a burgeoning population at a reasonable cost could rapidly exceed the limits of readily accessible sources. If the needs of the region's natural systems are factored in, conflicts for water among users will become even more severe.

In the study area, surficial aquifers supply the majority of water for urban use. These aquifers are vulnerable to salt water intrusion. In the Lower East Coast area, salinity intrusion has resulted from two major events. The first is the lowering of the ground water table in the area due to drainage and reduced recharge as well as the increased withdrawal of water by pumping. The second reason is the construction of numerous drainage and navigation canals from inland areas to the coastal waters.

In order to prevent saltwater from entering the local surficial aquifer and contaminating nearby well fields, the water table in coastal areas should be maintained at the level needed to stabilize the fresh water - saltwater interface. Existing criteria to protect against saltwater intrusion requires maintenance of a one-foot mound of fresh water between the withdrawal point and the saline interface. This is accomplished by maintaining canal levels high enough so that the hydraulic interconnection of the canals and the aquifer maintains a fresh water gradient that is adequate to prevent intrusion of saltwater into the fresh surficial aquifer.

5.5.2.2 Flood Protection

The C&SF Project was conceived and authorized to provide regional flood protection for south Florida. The system of canals, levees, water control structures and pump stations conveys and confines flood waters to regional storage facilities such as Lake Okeechobee and the Water Conservation Areas, or to tidal receiving waters. Further, additional protection is afforded by the local systems operated by special taxing districts, private property owners, and local governments.

Throughout the C&SF Project area, there are varying levels of flood protection. This is primarily due to variations in the original design goals and changes in land use that have occurred. Many areas that were expected to remain in agriculture have been developed, thereby changing the level of flood protection offered by the project. However, the existing investment in flood protection infrastructure was never intended to totally eliminate flooding in developed areas and flooding does occur periodically. In addition, natural areas have also suffered damage as a result of operating the flood control system to benefit the developed areas. For example, damaging releases to estuaries, unnaturally high water levels in the Water Conservation Areas, and backpumping to the Water Conservation Areas have occurred as a consequence of flood control.

Flood protection needs have increased since the original flood control project was constructed. As agricultural and urban development continues, the volume, duration, and frequency of floodwaters may increase; the actual level of flood protection may have declined in some areas. There is an opportunity to further reduce the extent of damages from flooding through operational and structural changes to the C&SF Project and local drainage systems.

5.5.2.3 Recreation and Navigation

Public use has been an important consideration of the C&SF Project since it was first developed. The C&SF Project provides opportunities for a wide range of outdoor activities, including: fresh water and estuarine fishing, boating, hunting, camping, picnicking, nature watching, and photography. It also provides the public with access to areas where they can simply "get away from it all." The opportunity to pursue these activities is very important to the economy of south Florida and to the people who make use of these opportunities, including residents, visitors, eco-tourists, and the Native American Tribes. Restoration and protection of the remaining Everglades system, the Keys, south Florida estuaries (including Florida Bay), and reef tracts are essential to the economic base provided by these recreational and traditional uses.

5.5.2.4 Social and Cultural

Societal sustainability requires the preservation of the rich cultural diversity of the region, such as the Native American communities and the multi-generational culture of the agricultural communities. The rapidly growing population of south Florida is decreasingly dependent directly on the environment for its sustenance, with the exception of water needs. Yet that population is increasingly dependent indirectly on a restored and sustainable environment, such as for support for the economic base of tourism as well as the heightened awareness of the environmental ethic to preserve and sustain this unique natural environment for the future generations to experience and value.

5.6 ECOSYSTEM RESTORATION

Following the development of the planning objectives, there were a number of principles and issues which were developed to guide the overall ecosystem restoration effort. This section defines and discusses these principles and issues.

5.6.1 Why Restore the South Florida Ecosystems?

South Florida ecosystems are highly valued at local, national, and international levels. Locally, people value these areas as places to go to interact with nature, to escape from the pressures of "city life," or as a means of making a living. In response to national recognition and concern for its future, a portion of the historic Everglades was designated as the Everglades National Park in 1947. Internationally, the Park is recognized as an International Biosphere Preserve and a World Heritage Site. Additional recognition of the region's wetlands occurred with the establishment of the Big Cypress National Preserve in 1974, and the Biscayne National Park in 1980.

Lake Okeechobee is one of the largest natural lakes in the United States. Lake Okeechobee is commonly referred to as the “liquid heart” of Florida. It is a vital component of the interconnected Kissimmee River, Lake Okeechobee, Everglades, St. Lucie and Caloosahatchee Estuaries, and Florida and Biscayne Bays ecosystems. This lake is important not only to its resident fish and wildlife species but also to wide-ranging animals, particularly wading and migratory birds. Thus the health of Lake Okeechobee affects not only its own resources but resources throughout south Florida, including the estuaries and bays.

At the ecosystem level, the south Florida lakes and wetlands are not only beautiful to see but help reduce the damage of floods, droughts, and contaminants. Inland freshwater lakes and marshes reduce the danger of floods by collecting runoff, storing it, and releasing it over longer periods of time. The effects of droughts are often offset by the vast quantities of water which are stored as groundwater or in shallow marshes during normal wet seasons. Wetlands clean water by removing organic and inorganic nutrients and toxic materials from water that flows across them. Freshwater wetlands are closely associated with groundwater recharge, and the hydraulic pressure of wetlands along the coast keeps saltwater at bay.

A number of plant and animal species which live in south Florida are in danger of becoming extinct. If these species are removed from the gene pool, the functions and other benefits they provide (known or unknown at this time) will be lost. Without top predators, for example, populations of prey species such as raccoons, rabbits, and rats could explode. The crucial roles of many species in the natural community are only now being determined -- sometimes only as the consequences of their absence are felt. Loss of a species represents an irreplaceable loss of genetic material. The benefits such lost species would have provided will never be known.

Estuaries and bays are also important ecosystems in south Florida. Commercially harvested fish and shellfish depend on estuaries for nursery areas. Estuaries and bays are habitat to numerous fish and wildlife species. The estuaries and bays depend on the health of the freshwater wetlands upstream which are their source of water. These areas are dependent on appropriate volumes of water, which affects salinity; timing of flows, which effect breeding animals; and quality of flows, which effects species composition and abundance. Consequently, estuaries and bays have been impacted by detrimental conditions within the south Florida freshwater ecosystems. Likewise, the health of the south Florida economy is closely linked to the health of all of these interconnected/interdependent ecosystems.

5.6.2 Certainties and Uncertainties

The restored wetlands of south Florida will be smaller in area than the historical ecosystems, and will have different landscape components and proportions. Within this framework of change in spatial scales, it is impossible to predict with certainty how animal populations will respond to restored or improved hydrological conditions. More needs to be known about animals in the south Florida wetlands than the basic biological characteristics of the species, and relationships with abiotic features of the environment, in order to predict responses (DeAngelis and White, 1994). Changes in the spatial scale and landscape patterns of the system create *"... a multitude of complicating factors that are difficult to anticipate, including the importance of population histories, biological feedback on abiotic driving forces, species interactions, and species invasions"* (DeAngelis and White 1994).

The result of these changing conditions is that fundamental relationships between species of animals and the environment may change. For example, Ogden (1994) has shown that the hydrological conditions that stimulate the creation of large nesting colonies of wading birds have changed several times during the past 60 years. At different periods during the evolution of water management practices in the Everglades, nesting wading birds have responded in different ways to any given hydrological pattern, due to shifting patterns of production, distribution and survival of the bird's prey related to management practices. For American alligators, Craighead (1968) suggested that the population centers in the southern Everglades have changed from the marl prairies and interior, mainland estuaries to the central Shark River Slough, as a result of changes in regional hydrological patterns. Although a restoration objective might be to "shift" the centers of high alligator density from the central and northern Shark River Slough to the marl prairies east of Shark River Slough, it remains to be known where, in a restored system, these centers will be.

Our ability to predict animal responses is further complicated by the fact that we *"...rarely have full understanding of the nature of driving forces in an ecosystem..."* *(White 1994). "Although our collective knowledge of the Everglades ecosystem may be much stronger...",* today than 10 years ago, *"...this baseline of information still contains many gaps"* (Davis and Ogden, 1994). The South Florida Ecosystem Restoration Working Group's Science Subgroup (1993), Davis and Ogden (1994) and Hoffman (1994) agree that a regional hydrological restoration program is an essential prerequisite for ecological restoration, but precise answers to questions of how various natural components will respond, in such a physically altered system, do not exist with certainty.

It also should be recognized that the wetland ecosystems of south Florida are undergoing continual change independent of management and restoration programs (Davis and Ogden, 1994). Gleason and Stone (1994) have documented the continuing evolution of environmental conditions in this geologically young system. Alternating bands of peat and marl soils below Everglades marshes reveal an ecosystem that is passing through longer wet and dry cycles than are normally recognized in more contemporaneous discussions of the dynamics of these wetlands. And Wanless et al. (1994) has proposed that an increasing rate of sea level rise in southern Florida can produce profound changes in environmental conditions in the lagoon and estuarine regions, and on the extent of freshwater wetlands, throughout the Everglades and Big Cypress Basins.

Uncertainties in defining optimum hydrological targets for restoration also are created by uncertainties in the accuracy of the Natural System Model output. Because the Natural System Model has played such an important role in defining restoration targets, it is appropriate to summarize what is known regarding the accuracy of this model. Although a technical review of the Natural System Model (Bales et al., 1997) endorsed the value of the model for *"...estimating pre-drainage hydrologic responses in south Florida."*, the review also offered a number of cautionary comments. The review demonstrated that uncertainty in the model is due to a number of factors, including input data (e.g., topography), model assumptions (e.g., rainfall & evapotransporation distributions), parameters (e.g., Manning's *n* and evapotransporation coefficients), and model discretization. The review suggested that the model's *"...total uncertainty cannot be quantified. However...it seems appropriate to interpret the Natural System Model simulated water levels and ponding depths with about a plus or minus 1 foot uncertainty."* The review added that, *because "...the model should not be used to simulate discharges in pre-drainage south Florida... the maintenance of acceptable water levels and hydroperiods, rather than flows, is probably the key to restoration..."* A final conclusion of the review was that, *"The Natural System Model is a regional-scale model (Fennema and others, 1994), and results need to be interpreted at a regional scale rather than cell by cell... restoration success likely will be judged on ecological criteria, rather than on the ability of the water-management system to meet certain hydrologic targets. Much stronger linkages between hydrologic conditions and biological responses are needed."*

5.6.3 Different Views

The vision of the future wetlands in south Florida is influenced by different views of how restoration goals for the system are determined (Hoffman, 1994). The future Kissimmee River, Lake Okeechobee, Everglades, Big Cypress, and Florida Bay ecosystems can be, to some extent, what society wants them to be, based on value systems, and decisions about what conditions and components constitute a restored ecosystem. The different perspectives on a restored ecosystem are represented by one view that says that these wetlands will have been restored once certain population levels have been reached, for wading birds, alligators, endangered species, etc. In contrast, a different view is that restoration will have been achieved when certain defining ecological conditions (functions and relationships) that characterized the pre-drainage ecosystems have been recovered, without setting specific population levels as goals. It may be true that these different restoration targets are nothing more than different ways of characterizing recovered ecosystems, and that achieving one will achieve the other. There is agreement by proponents of both perspectives that a set of performance measures will be required to show whether the restoration programs are carrying these ecosystems in the correct direction. These measures should include the trends in numbers and distribution patterns of characteristic wetland species of wildlife, and the patterns of habitat mosaics, for comparisons with what is known about these species and habitats in both the current and pre-drainage systems. Selection of a set of ecological and hydrological performance measures assumes that a vigorous monitoring program will be maintained, to determine if the restoration program is properly directed, and to serve as a basis for mid-course corrections (adaptive assessment) if problems are detected.

5.6.4 The Recovered Ecosystems

Although there are different views of what these south Florida ecosystems should look like in the future, most of these differences seem to be ones of degree, or different focuses on the elements of the system that need to be measured in order to show that goals have been reached. What is broadly recognized is that there were specific ecological and physical characteristics of these pre-drainage wetlands, which defined “The Everglades”, “The Big Cypress”, and “Florida Bay” as uniquely distinct ecosystems. It must be assumed that these defining characteristics must be recovered before these ecosystems can be recovered and sustained over time, and before the restoration program can be considered to have been successful.

The ecological and physical features that specifically defined these ecosystems have been reviewed and discussed by the Science Sub-Group (1993), Davis and Ogden (1994), Hoffman (1994) and Ogden et al. (1994). These authors identified three ecological and two physical features of the pre-drainage wetlands of south Florida that defined these systems. The process used for selecting these defining ecosystem features was to identify features that best describe the dynamics of animal and plant communities at system-wide scales, and which were present in the pre-drainage systems.

5.6.4.1 Ecologic Features

The ecological features that defined the pre-drainage, south Florida wetland ecosystems are defined below:

(1) Large populations of wetland species of vertebrates were able to maintain long-term stability only by operating over large spatial scales, across community and landscape boundaries, within the system. Populations of several hundred thousand wading birds (herons, egrets, ibis, storks), along with large numbers of snail kites, limpkins, mottled ducks, and other waterbirds, depended on a spatially broad mosaic of feeding and nesting site options, which differed in importance along temporal scales, depending on seasonal and interannual variations in rainfall and surface water patterns.

(2) A second defining ecological feature was that heterogeneous habitat patterns were created and maintained within and across community boundaries due to the dynamic interplay among such factors as micro-topographic features, local climatic variation, fires, freezes, storms, and animal impacts (alligator holes and trails, for example), acting across the large spatial extent of the pre-drainage wetlands. The resulting mosaic of upland and lowland habitat types provided the spatial and temporal network for the production and survival of animals under a wide seasonal and annual range of hydrological conditions. DeAngelis and White (1994) have described how environmental heterogeneity at a variety of scales, in combination with large ecosystem size, functions to enable persistence and resilience of populations of plants and animals.

(3) The third defining ecological characteristic was that the pre-drainage freshwater wetlands evolved as an oligotrophic system, with the very limited input of nutrients coming primarily as phosphorus in rainfall. The low-nutrient environment was essential for the support of green algae/diatom periphyton communities, which were a major food base for the production of aquatic invertebrates and fishes in relatively long hydroperiod, freshwater marshes of the Everglades. The large spatial scale of the historic Everglades and the organizing affects of seasonal and multi-year patterns of flooding and drying, created the pulses of secondary production and the prey densities that were necessary for the support of large populations of the larger species of vertebrates.

5.6.4.2 Physical Features

The physical features that defined the pre-drainage south Florida wetlands are defined below:

(1) Clearly, one defining physical feature was the large spatial scale of the network of pre-drainage wetland ecosystems. The large spatial extent was essential for supporting the regional levels of production necessary for maintaining robust populations of animals with large spatial requirements, and for supporting the range of physical features and the ecological and climatological processes that created and maintained the habitat mosaics of the region.

(2) The second defining physical feature of the pre-drainage wetlands was the region's dynamic patterns of water storage and sheet flow. It was these dynamic hydrological patterns, *"...operating over an extensive region, that made the Everglades a much wetter system than it is today, that organized and concentrated the primary and secondary production of the wetlands, established the salinity gradients in the estuaries, and created the substantial network of dry season refugia that were essential habitats for all freshwater animals"* (Ogden et al., 1994).

5.6.5 Role of Adaptive Assessment

Adaptive assessment is an approach which can be utilized during the implementation and evaluation of large, complex, long-range projects. In a discussion of a national restoration strategy, the National Research Council states that adaptive planning and assessment involve a decision-making process based on trial, monitoring, and feedback. Rather than developing a fixed goal and an inflexible plan to achieve the goal, adaptive assessment recognizes that there always will be gaps in knowledge regarding the relationships within and among natural and social systems, and that these information gaps require that plans be modified as technical knowledge improves and social preferences change. For adaptive assessment to succeed, the new knowledge gained (through monitoring) should be translated into restoration policy and program redesign over time and be shared across restoration programs at all levels of government (National Research Council, 1992). Adaptive assessment is a process which involves the iterative use of models, research, and monitoring in conjunction with on-going planning, in order to revise, improve, and fine tune management procedures (Science Sub-Group, 1993). It involves an iterative process of developing management tactics, and provides a process for breaking impasses where agencies are unwilling to proceed because of an inadequate knowledge base (Hoffman, 1994).

Lack of an adaptive assessment approach during the implementation and evaluation of large and complex projects can result in unintended and unexpected adverse environmental impacts. The initial C&SF Project is an example of what happens when plans are carried out in the absence of clearly defined long-term ecological goals and without provisions for adequate monitoring of project effects. Lack of a strategy resulted in several unanticipated changes being made to the C&SF Project beginning relatively soon after its construction was initiated in 1948. Water Conservation Areas 3A and 3B and a southern extension of Levee 67 were completed in the 1960s. As a result, natural flows to the Everglades National Park were eliminated and water was provided according to a regulation schedule. Sporadic and insufficient flows resulted in ecological decline in the Park. Consequently, in 1971 a minimum monthly schedule of water deliveries was established. Under this water delivery system, unseasonable regulatory releases often occurred during dry season months. During the period of the minimum delivery schedule, the ecological values of the southern Everglades declined at an accelerated pace. The Everglades National Park again requested modifications to the project and the Experimental Program of Water Deliveries to Everglades National Park was initiated in April 1984. Additional projects designed to modify the areas existing hydrologic regime to restore more natural flow and hydropatterns are the Modified Water Deliveries to Everglades National Park, and the Canal 111 (C-111) Project.

A barrier to viewing these projects as part of a larger scale, long-term restoration program has been that much of the information needed to develop the larger plan did not exist. The impact that this barrier has on restoration planning can be substantially reduced through an adaptive assessment process, which recognizes these inadequacies and provides a planning strategy for collecting the necessary information. Shabman (1993) has suggested that adaptive assessment assumes that no knowledge base is adequate for defining and implementing the socially correct and technically feasible long-term plan of action. Instead, decision making should proceed as sequential adjustments in response to new insights about social and economic priorities, and in response to new understandings of the ecological system. Consequently, an adaptive assessment strategy would require that plans be formulated which are designed to create new information. This planning approach maximizes the collection of new information by viewing each iteration as one “experiment” within a series of experiments. Each experiment should be designed from one or more technically-based hypotheses regarding the expected results, which in turn are measured by a monitoring program based on the same set of hypotheses.

For the C&SF Restudy, the conceptual ecological models of south Florida wetland landscapes identify the major hypotheses used to set planning priorities and restoration performance measures. The regional ecological monitoring program will evaluate how well the restoration projects correct the stresses shown in the conceptual models, and at the same time, allow for refinement of the hypotheses which were used as a basis for planning the major components of these projects.

5.6.5.1 Monitoring

The restoration of the wetland ecosystems of south Florida requires that a comprehensive monitoring program be in place to provide information that is essential to the planning and evaluation processes. It is assumed in this report that the south Florida ecosystem restoration program will most likely be successful in achieving its goals if implementation of the program is conducted by means of an adaptive assessment strategy. This strategy calls for the incremental implementation of the components of the plan, with each increment treated as one experiment within a stair-step evolution of experiments, each planned and designed to carry the program one step closer to the ultimate goal of systems restoration. An incremental process is required for the south Florida ecosystem restoration program, because of the large and complex nature of the ecosystem and its problems, and because of the uncertainties regarding the ecological responses that will occur as more natural hydrological conditions are established. These uncertainties are inherent where major alterations in the region's spatial scale and landscape components have in some cases substantially changed ecological relationships among species, habitats, and communities throughout the region. A regional monitoring program becomes the framework for designing the sequence of incremental steps, by providing information on how the ecosystem responds at each step as a basis for designing the next steps.

A fundamental requirement of a successful monitoring program is that it be focused on the biological and physical elements in the system which are most likely to reveal how the system responds to project actions. There should be broad agreement on restoration targets, and on the ecological changes that constitute improvements, as a prerequisite for determining which parameters in the system must be monitored. Because of the uncertainties inherent in any effort to restore such a complex and altered ecosystem, specific restoration targets and measures of success can only be provisionally identified. Nevertheless, these targets and measures need to be identified in order to design a monitoring program that is well focused and efficient, to assure that it provides the kind of information that is required for the implementation of an adaptive assessment strategy.

5.6.5.2 Conceptual Ecological Models

Conceptual ecological models have been developed at landscape and physiographic scales for the natural regions of south Florida. These models have performed an essential role in the Restudy, in that they provide a comprehensive framework for organizing existing scientific knowledge about the natural systems in south Florida into formats that are directly applicable to the planning, implementation and evaluation of restoration projects. The conceptual models are simple, non-quantitative tools which illustrate the collective opinion of a group of natural resource specialists for how existing, empirically and intuitively derived understandings of wetlands in south Florida should be organized to show the important ecological relationships in these systems.

The models were developed by teams of resource specialists during a series of workshops between October 1996 and July 1997. Conceptual models have been developed for Lake Okeechobee, the Caloosahatchee and St. Lucie Estuaries, the ridge and slough portions of the central and southern Everglades, the Big Cypress, the southern Everglades marl prairies, the southwestern Gulf Coast Estuaries, Florida Bay, and Biscayne Bay. Each model consists of a schematic representation of the major elements in the system, and a narrative interpretation of the model. An example of a completed conceptual model and narrative statement, for Lake

Okeechobee, is attached to ***Appendix D***. A technical report describing all of the models is in preparation (Ogden and Davis, in prep).

The conceptual models for south Florida show the major cause and effect relationships in stressed natural systems. Each model identifies the principal sources of human influences on the natural systems (societal drivers), the ecological stressors originating from these drivers, and the ecological effects from these stressors. The models also suggest the best set of ecological attributes (endpoints, indicators) and measures, which, collectively, characterize the overall "health" of the system relative to the effects from the stressors.

The broad purposes for creating the conceptual models have been to (1) create a set of measurable indicators of success as a basis for evaluating how well the projects meet the broad, policy-level goals that have been established for the regional restoration programs, and (2) develop a suite of causal hypotheses linking the most important hydrological stressors with the major ecological effects, as a basis for predicting responses to the restoration projects.

For the Restudy, the conceptual models have been used more specifically (1) to help set priorities among the hydrological issues to be resolved by the study, based on links between water management practices and the major ecological problems in the natural systems, (2) as a basis for creating performance measures for evaluating alternative plans for resolving the major ecological problems, and (3) to recommend a priority set of ecological indicators (attributes) to be monitored as a basis for evaluating how well the restoration projects correct the hydrological stressors in the natural systems. The recommended approach for accomplishing (3) will be to design performance measures and the components in a regional monitoring program so that they relate to the hydrological stressors and the ecological attributes shown in each model. The assumption from the conceptual models is that the restoration projects should focus on improving performance among the hydrological stressors, and that the success of the projects in meeting these objectives can best be measured by monitoring the behavior effect on the key ecological attributes in each natural system.

5.7 SOUTH FLORIDA ECOSYSTEM RESTORATION VISION

While a primary goal of the Restudy is the ecological restoration of the Everglades and other natural wetlands in south Florida, the Restudy Team, as well as the broad scientific community, recognizes that complete ecological restoration in this region is not possible. Traditionally, restoration has been defined as the full recovery of a natural system to a condition that existed during some pre-altered period. For the Everglades, this goal would require the creation of a system that mimicked the natural conditions that was here prior to the construction of the first drainage canals and levees, in the 1880s.

For at least two overwhelming reasons this goal is not possible. First, there have been substantial and irreversible reductions in the spatial extent of the wetland systems in south Florida (including an approximately 50 percent reduction in the extent of the true Everglades), and in the total water storage, timing, and flow capacities of these systems. These changes, coupled with the altering affects of sea level rise, infestations of exotic plants and animals, subsidence, and losses of organic soils, are among the factors which preclude any serious consideration of achieving true restoration. The second major hurdle to complete restoration is that few of the quantitative, ecological characteristics of the pre-drainage wetlands of south Florida are known. Simply stated, the pre-drainage Everglades is as much a vision created by opinion as by fact. For these reasons, and because complete restoration is not possible, the natural resource specialists in south Florida lack a strong consensus as to the restoration “endpoint”; i.e., there is a range of legitimate answers to the question, “what constitutes restoration?”

Because the pre-drainage Everglades cannot be recreated in its original form, the restoration goal for the Restudy is to create a “new” Everglades, one which will be different from any system that existed in the past, and one which will be substantially healthier than the current system. For this restoration project to be successful, it must recover important ecological components and patterns which are thought to have characterized the pre-drainage system, and it must be able to sustain these recovered ecological attributes over long time scales. The Restudy Team has attempted to understand the pre-drainage system, using such tools as the Natural System Model, and by creating conceptual ecological models of the major landscape features of Florida. These conceptual models have been developed from a series of hypotheses about the ecological relationships and biological components of the pre-drainage system, which have been derived from studies of the current system. The “new” Everglades must include key features that characterized the earlier natural system, if it is to again become an Everglades-type ecosystem. It also must acquire other natural attributes which are important to people who share an interest in the natural systems in south Florida, and the roles that these systems have in our lives. For example, modifications to the Everglades should recover certain wading bird and alligator patterns of behavior that were characteristic of an earlier, more natural system. It also should recover certain traits that are important to our society, such as clear water and good fishing in Lake Okeechobee, improved salinity ranges in the Caloosahatchee and St. Lucie Estuaries, and an enhanced role for the remaining natural system as a refugia for endangered species in a shrinking natural world.

It is too early in the south Florida ecosystem restoration process to state with certainty exactly what the “endpoint” for the restored Everglades should become. It is likely that the length of time required to implement the restoration projects, and the varying time lags in ecological responses, will mean that the current, managed system will evolve into a “new” Everglades over long time scales. During these transitional years, understandings of ecological patterns and relationships will continue to improve (almost certainly causing a change in the hypotheses currently being used to predict ecological responses to the restoration projects), unexpected responses to the initial restoration projects will occur, and the remaining wetland systems will continue to evolve in response to a wide range of continuing human and natural influences (e.g., sea level rise, hurricanes, long-term rainfall and temperature patterns). Thus, the point at which restoration is achieved, and the precise characteristics of that “restored” system, represent questions that are not completely answerable at present.

At the same time, it is important to not overstate or to be overly concerned about the uncertainties that are a part of the restoration planning process. For example, there is considerable professional agreement that recovery of the regional hydrological patterns depicted by the recent versions of the Natural System Model will result in substantial improvements in the ecological health of the wetland systems. An overall much wetter system, characterized by such features as multi-year hydroperiods in the sloughs, higher, dry season groundwater levels on the marl prairies, and increased flows of freshwater into Florida and Biscayne Bays, will produce dramatic improvements in the ecological health of these systems.

Because of these considerations and uncertainties, the Restudy Team, as well as most resource specialists in south Florida, view ecosystem restoration in south Florida much more as an open-ended process than as a specific set of targets (endpoints). Restoration planning has become a balancing act between the need to agree on desirable directions of change and the general features that should be present in a restored system, and the need to encourage flexibility in thinking about how and when certain objectives are achieved, and what the restored system should look like. For example, is it possible, in order to recover the fundamental ecological patterns that are an essential part of an Everglades-type system, that some features or components may need to be recovered at different scales or locations than were found in the pre-drainage system? This view of the restoration process is in part a response to the point made above, that current opinions still vary among resource specialists on how to set quantitative, ecological targets for a restored system.

More importantly, the realistic perspective at present is that it is premature to force the debate over the question of, “what constitutes restoration?” At this point, it is sufficient that there is broad agreement, demonstrated in the conceptual ecological models, over the identity of the water management and development practices that have caused much of the ecological damage in the south Florida ecosystem. Restoration projects geared to correcting these hydrological stresses should produce strong improvements in the health of these ecosystems. Consensus over the question of what a restored south Florida ecosystem should be, especially over the specific spatial, temporal and numerical targets for restoration, should emerge over time, as system responses from initial restoration projects begin to provide focus for the debate, and new modeling results and empirical data become available.

SECTION 6
GOVERNOR'S COMMISSION CONCEPTUAL PLAN FOR THE RESTUDY

This section describes the development of the *Conceptual Plan for the Restudy*, which was developed by the Governor's Commission for a Sustainable South Florida. The Water Resources Development Act of 1996 directs that the conceptual framework provided in the *Conceptual Plan for the Restudy* (GCSSF, 1996b) be considered in the development of the Comprehensive Plan. The acknowledgement of the Commission that hydrologic restoration is the key and a prerequisite to ecosystem restoration led to the development of the Conceptual Plan: the vehicle to specifically address water resource issues and natural system restoration. That document provided a framework for the formulation and evaluation of alternative plans for the Restudy. Most of the information in this section was taken directly from the *Conceptual Plan for the Restudy* published by the Commission.

6.1. GOVERNOR'S COMMISSION FOR A SUSTAINABLE SOUTH FLORIDA

On March 3, 1994, Governor Lawton Chiles created the Governor's Commission for a Sustainable South Florida through the Governor's Executive Order 94-54. The Commission's charge was to make recommendations that will move south Florida toward a healthy ecosystem that can coexist with, and be mutually supportive of, a sustainable south Florida economy and quality communities. This Commission consists of business, agriculture, government, public interest, and environmental organization representatives. A number of Federal agencies are represented on the Commission as non-voting members. Toward this end, the Commission unanimously adopted two successive documents: the *Initial Report,* (GCSSF, 1995) containing overall recommendations for a sustainable South Florida; and, *A Conceptual Plan for the C&SF Project Restudy*, (GCSSF, 1996b), which provided initial recommendations for the Restudy.

6.2. INITIAL REPORT

The Commission's *Initial Report* (GCSSF, 1995) contained 110 recommendations with a central theme of sustainability – meeting the needs of the present without endangering the ability of future generations to meet their needs – revolving around the management of water. In that report, the south Florida ecosystem was defined as a community of organisms, including humans, interacting with one another and the environment in which they live. The Commission recognized that *"Our quality of life is inextricably linked to the health and viability of natural systems"* and *"that a healthy Everglades system is vital to natural plant, animal and human population alike."* The Commission also unanimously agreed that the south Florida ecosystem is not sustainable on its present course.

Many of the recommendations in the *Initial Report* addressed the need to integrate all elements of water resource management including: water supply, flood protection, water quality, and natural resources restoration, protection and management. In addition the *Initial Report* also addressed a number of Restudy-related recommendations (see ***Table 6-1***).

TABLE 6-1
INITIAL REPORT: RESTUDY RECOMMENDATIONS

- The Corps and the District should "assure that the Restudy addresses the need to achieve a sustainable south Florida economy by ... proposing reliable, cost-effective measures to provide the necessary water supply." (Recommendation 11)
- "The Commission should provide a mechanism to enable input and integration of the state's concerns and interests with the U.S. Army Corps of Engineers and the south Florida Ecosystem Restoration Task Force in the Restudy and other Federal activities." (Recommendation 12)
- The Corps and the District should: "(1) address water supply needs for urban and agricultural users; (2) address natural water level fluctuations within the natural system and restoration of natural water quality, timing, volumes, and distribution to the Everglades; and (3) expedite the Restudy schedule without sacrificing thoroughness or quality of the final product." (Recommendation 13)
- "The Restudy should integrate all elements of water management (water supply, flood protection, water quality protection, and natural systems management). Redesign should provide for sustainability for human and natural system requirements." (Recommendation 15)
- "All plans, and especially the Restudy, should assure that new demands do not adversely affect the sustainability of human and natural systems." (Recommendation 16)
- "In the Restudy, the South Florida Water Management District and the Corps should ensure that the redesign of the system allows for resilience for a healthy natural system." (Recommendation 17)
- The agencies and interested parties should "redesign and develop new operations for the south Florida water management system at all levels to conserve and sustain the natural system, to maximize the capture of stormwater, and to conserve water for the benefit of all users." (Recommendation 23)
- The Corps and the District "should reduce the extent of damage from flooding to human and natural systems." (Recommendation 27)

6.3. DEVELOPMENT OF THE CONCEPTUAL PLAN

The Commission's *Conceptual Plan for the Restudy* consists of a strategy for coordinating and implementing a number of the water resource projects in south Florida into a cohesive whole, ensuring that they are consistent with the Commission's goals for a sustainable south Florida. While some projects are in various phases of implementation, these projects, by themselves, do not result in restoration. The Commission identified the need for additional and integrated efforts. The on-going projects form a foundation from which they developed the *Conceptual Plan for the Restudy*. Because the entire C&SF Project is hydrologically linked, all water management activities impact one another. Therefore, the Commission believes that implementation of the ongoing projects and programs must be closely coordinated by sharing information as they proceed from planning and design through implementation and operation. These on-going efforts, while not intended to be all-inclusive, are included as elements of the thematic concepts.

6.3.1. Commission's Planning Objectives

In developing the Conceptual Plan, the Commission first formulated a number of planning objectives ranging from restoring fish and wildlife, to increasing water supply for urban, agricultural and natural areas, to improving coastal and marine conditions. The Commission's objectives fall into three general categories: ecologic, hydrologic, and socio-economic. The Commission believes that if these objectives can be achieved, the goals of restoring the ecological health of the natural areas (including adjacent watersheds and tributaries) and enhancing the region's economy and quality of life can be achieved. The 23 planning objectives are listed in ***Table 6-2***.

The ecologic planning objectives focus on restoring environmental quality to a system that has experienced a massive loss of natural resources. They aim to expand habitat through reclamation and to improve habitat quality and heterogeneity consistent with the characteristic mosaic habitat of the pre-drained Everglades and the coastal and associated marine ecosystems.

The hydrologic objectives focus on ensuring adequate water quality; water supply; timing of flows; flood control for urban, natural, and agricultural needs; restoring more natural hydropatterns, including sheetflow; regaining lost storage capacity; reducing per capita consumption; and encouraging water reuse to achieve the ecologic objectives stated earlier.

TABLE 6-2
GOVERNOR'S COMMISSION
GENERAL PLANNING OBJECTIVES FOR THE RESTUDY

ECOLOGIC
• Improve habitat quality and heterogeneity. • Improve connectivity and reduce fragmentation of habitats. • Provide the spatial extent of natural areas required to support the mosaic habitat characteristic of the pre-drained Everglades ecosystem. • Improve and protect habitat quality, heterogeneity, and biodiversity in coastal and associated marine ecosystems. • Provide for sustainable populations of native plant and animal species with special attention to threatened, endangered, or species of special concern. • Restore and, where appropriate, improve functional quality of natural systems (including both wetlands and uplands). • Reduce the spatial extent of invasive nonnative species to the extent that they do not affect the natural system. • Halt and/or reverse the conditions causing the spread of native species that are threatening (and perhaps dominating) areas as a result of disturbances such as nutrient enrichment.
HYDROLOGIC
• Restore more natural hydropatterns, including associated sheetflow. • Provide more natural quality and quantity, timing and distribution of freshwater flow to and through the natural Everglades. • Provide more natural quality and quantity, timing, and distribution of freshwater flow to estuaries and coral reef ecosystems. • Ensure adequate water supply and flood protection for urban, natural, and agricultural needs. • Regain lost storage capacity. • Restore more natural organic and marl soil formation processes and arrest soil subsidence. • Improve water quality, including reduction of toxins, and ensure appropriate water quality consistent with designated uses including restoration and protection of the natural systems. • Control saltwater intrusion into freshwater aquifers. • Integrate the Project with local stormwater, wastewater, and other water management functions.
SOCIO-ECONOMIC
• Establish levels of provided flood protection in terms of frequency, depth, and duration. • Reduce damages from flooding to public and private property. • Provide water management that supports economic diversity and sustainability derived from the natural and developed systems. • Enhance economic opportunities consistent with sustainable marine ecosystems. • Protect and preserve cultural and archeological resources and values. • Increase recreational opportunities consistent with sustainable natural systems.

Finally, the economic and social objectives provide for water management that supports economic diversity and sustainability for natural, agricultural and developed systems. The Commission believes the need to integrate regional water management systems with local stormwater, wastewater, and other water management functions must be considered when developing alternatives.

6.3.2. Preferred Alternatives

As a first step toward identifying the additional actions needed to develop the Conceptual Plan for the Restudy, the Commission considered 66 options/ideas formulated from a myriad of Federal, state, and local agencies; interest groups; and other members of the public. Many of these options had been evaluated to varying degrees during the reconnaissance phase of the Restudy and the South Florida Water Management District's Lower East Coast Regional Water Supply Planning effort. The ideas ranged from non-structural options to ones that require major structural modifications or additions to the existing C&SF Project. Five additional options were generated by members of the Commission.

Through a series of three workshops, the Commission considered and grouped the options together to form alternative plans. This process helped the Commission gain an understanding of the interrelationships among the various options and set the framework for determining which options had common support and which ones did not. Facilitated discussion allowed for a systematic review and screening of each option.

The result of this process was a list of 40 preferred options, to be evaluated as modifications to the C&SF Project. The Commission agreed to support these options for technical evaluation in the Restudy, although conditions or limits were placed on certain ones. The conditions were intended to clarify important issues and to provide specific recommendations describing the Commission's alternatives for consideration in the Restudy in more detailed study of these options. ***Table 6-3*** includes the list of the 40 preferred options and the conditions (in italics) placed on those options.

Fundamental general concepts pertaining to the 40 preferred options were:

- The burden and responsibility for water storage should be shared across the system.
- Water quality and treatment should be addressed and optimized throughout the system.
- The Commission supports projects in general that salvage, clean up, and reuse water.

TABLE 6-3
40 PREFERRED OPTIONS (With Conditions)

Kissimmee River Area including Native American Tribal Lands
- Kissimmee River Pool A Restoration
- Paradise Run Restoration
- Kissimmee Region - Water Treatment Areas – *Project design must address water quality concerns. Holding areas should be multi-purpose.*

Lake Okeechobee Area
- Maximize Lake Storage Without Environmental Harm - *No significant impacts to the littoral zone or water quality should be allowed. Damage to the east and west coast estuaries by the current regulation schedule must be addressed.*
- Restore More Natural Fluctuations of Lake Levels - *No significant impacts to the littoral zone or water quality should be allowed. Other state agencies (e.g., FGFWFC) should be involved.*
- Restoration of Kreamer, Torry, and Ritta Islands
- Lake Okeechobee - Aquifer Storage and Recovery (Aquifer Storage and Recovery) - *The maximum additional storage and cost effectiveness should be evaluated. Impacts to the littoral zone should be minimized.*

Everglades Agricultural Area (Everglades Agricultural Area)
- Everglades Agricultural Area - Water Storage Areas (Reservoirs) – *Sufficiency of land to accomplish storage should be based on need, science, and appropriate cost-benefit analysis. Up to the entire Talisman property should be considered as a target of opportunity for increased storage with any portions not needed returned to agriculture; additional areas may be considered as necessary. Land acquisitions should be made with willing sellers and in consultation with local landowners. The burden of water storage should be shared across the system.*
- Increase Groundwater Levels to Control Soil Subsidence

Lower West Coast including Caloosahatchee River
- Caloosahatchee - Water Storage Areas (Regional Attenuation/Reservoir Facilities) – *Locations of potential storage areas should be chosen in consultation with local landowners.*
- Caloosahatchee – Water Treatment Areas - *Project design must address water quality concerns. Holding areas should be multi-purpose and located in consultation with local land owners.*
- Restoration of Golden Gate Estates - *Consistent with the South Florida Water Management District's restoration plan.*
- Caloosahatchee - Aquifer Storage and Recovery - *The maximum additional storage and cost effectiveness should be evaluated. Impacts to the littoral zone should be minimized.*
- Remove Organic Sediment Deposits from Caloosahatchee Estuary - *Any such removal should be evaluated as to cost effectiveness; pollution impacts from removal process; sediment disposal; and how to prevent resiltation.*

TABLE 6-3 (continued)
40 PREFERRED OPTIONS (With Conditions)

Western Basin including Native American Tribal Lands

- Water Treatment Area for L-28 (Interceptor)

Upper East Coast Area (UEC)

- UEC - Water Storage Areas (Regional Attenuation Facilities) - *Locations of potential storage areas should be chosen in consultation with local landowners.*
- Stabilize St. Lucie Canal Banks
- Remove Organic Sediment Deposits from St. Lucie Estuary - *Any such removal should be evaluated as to: cost effectiveness; pollution impacts from removal process; sediment disposal; and how prevent resiltation.*

Water Conservation Areas (Water Conservation Areas) including Holey Land and Rotenberger Wildlife Management Areas

- Modify Water Conservation Areas to Create Contiguous Natural Area – *Restore the connectivity of the Water Conservation Areas to the maximum feasible extent consistent with the ability to maintain flood protection and habitat quality, and to replace, through storage in the overall system, any existing urban water supply that may be lost.*
- Modify each Water Conservation Areas to Enhance Wetland Habitat – *Habitat should be enhanced to the maximum extent feasible. Public water supply may be addressed through storage in the overall system, and flood protection should be maintained.*
- Remove Invasive Non-Native Plants

Lower East Coast Area

- Water Preserve Areas
- Seepage Control - *All methods should be considered and evaluated.*
- Saltwater Treatment (Reverse Osmosis, Blending) – *Employ only as a last resort. Cost effectiveness should be evaluated. The technology does not stand alone.*
- LEC - Aquifer Storage and Recovery - *Use in conjunction with storage in buffer areas. Cost effectiveness, technical feasibility, and water quality should be addressed.*
- Wastewater Reuse
- Raise Coastal Canal Stages Coupled with Increased Discharge Capacity
- Water Treatment Area for S-9
- Inter-connect Local Water Management Systems – *There should be shared costs and a clear delineation of responsibilities. The responsibility to solve regional concerns should be included.*
- Implement Southern L-8 Basin / Loxahatchee Slough - *There should be no negative environmental impacts. This option is an example of a project that could salvage, clean-up, and reuse water. It would require local governmental consultation and review in concert with the Restudy.*
- Lake Belt/Seepage Barrier - *All methods of seepage control should be considered and evaluated.*
- Remove Invasive Non-Native Plants (LEC)
- 8 ½ Square Mile Area - *The progress of the East Everglades 8 ½ Square Mile Area Study should be monitored. The western 1/3 to ½ should be bought by the public and included in the buffer.*
- Control Structure in C-4 Canal

TABLE 6-3 (continued)
40 PREFERRED OPTIONS (With Conditions)

Big Cypress National Preserve

- Modify L-28 and L-28 Tieback Levees to Restore More Natural Flows Through Big Cypress National Preserve – *Increased conveyance through Tamiami Trail from CR 951 to 40 Mile Bend and Loop Road should be included.*

Everglades National Park

- Degrade L-29 Levee and Raise Portions of Tamiami Trail
- Add More Culverts Under Tamiami Trail – *Includes the entire reach of Tamiami Trail.*
- Flamingo Road Improvements to Improve Hydrologic Flow
- Incorporate Water Quality and Supply into C-111 and Modified Water Deliveries Projects

Florida Bay/Biscayne Bay/Florida Keys

- Hydrologic Improvements in the Model Lands Basin in Dade County
- Hydrologic Improvements in North, Central, and South Biscayne Bay Basins in Dade County

6.4. CONCEPTUAL PLAN ELEMENTS

After reaching consensus on the 40 preferred options, the Commission asked for additional analysis and information in order to refine the preferred options for possible inclusion into the Conceptual Plan for the Restudy. As part of the Restudy, the Commission's preferred options were screened and a process for analyzing them further was developed. Due to the similarities in function, the 40 preferred options were grouped into 13 thematic concepts to form a broad-based Conceptual Plan for the Restudy. These concepts include the spectrum of the preferred options identified by the Commission but are less specific. By generalizing the concepts, the Commission hoped to provide the Restudy with sufficient information to evaluate the broad spectrum of options and the trade-offs among them without restricting development of new options. Together with the potential modifications to the C&SF Project contained in the 40 preferred options, these concepts must be viewed holistically, not individually, since they come together to form an overall vision for the Restudy. In addition, many of the concepts will serve multiple purposes. For example, storage areas can help supplement natural system needs as well as provide water supply for agricultural and urban areas. The Commission recognized the need for detailed analyses conducted as part of the Restudy to develop specific projects. However, the concepts that comprise the *Conceptual Plan for the Restudy* provide a basis for the formulation and evaluation of specific plans.

Table 6-4 identifies the various thematic concepts and illustrates how the 40 preferred options fit within these concepts. Table 6-4 also identifies ongoing projects and the Federal Agriculture Improvement Act of 1996 (P. L. 104-127, known as the "Farm Bill") priority projects that fit under these thematic concepts. In addition, Figure 6-1 schematically portrays many of the concepts in relative geographic locales.

TABLE 6-4
THEMATIC CONCEPTS
Includes Projects Underway and 40 Preferred Options (in *Italics)*

Concept 1 – Regional Storage Within the Everglades Headwaters and Adjacent Areas
Kissimmee River Restoration Project*
Upper Chain of Lakes – Operational Changes*
Caloosahatchee – Water Storage Areas
Upper East Coast – Water Storage Areas

Concept 2 – Lake Okeechobee Operational Plan
Lake Okeechobee SWIM Plan.*
Interim Lake Okeechobee Regulation Schedule Study*
Maximize Lake Storage Without Environmental Harm
Restore More Natural Fluctuations of Lake Levels

Concept 3 – Everglades Agricultural Area Storage
Everglades Construction Project – STAs*,**
Bolles And Cross Canal Project*
*Everglades Agricultural Area Water Storage Areas***

Concept 4 – Water Preserve Areas
East Everglades 8 ½ Square Mile Area*
*Water Preserve Areas***
Seepage Control
Lake Belt/Seepage Barrier
Control Structure in C-4

Concept 5 –Natural Areas Continuity
Experimental Program of Modified Water Deliveries to Everglades National Park (Shark River and Taylor Sloughs)*
C-111 Project*
Modified Water Deliveries to Everglades National Park*
Florida Bay Emergency Interim Plan (Taylor Slough Demonstration Project)*
Modify Water Conservation Areas to Create Contiguous Natural Area
Modify Each Water Conservation Areas to Enhance Wetland Habitat
Modify L-28 and L-28 Tieback Levees to Restore More Natural Flows through Big Cypress National Preserve to Everglades National Park
Incorporate Water Quality and Supply into C-111 and Modified Water Deliveries Projects
Degrade L-29 Levee and Raise Portions of Tamiami Trail
Add More Culverts Under Tamiami Trail
Seepage Control
Flamingo Road Improvements to Improve Hydrologic Flow.
Hydrologic Improvements in the Model Lands Basin in South Dade County **
8 ½ Square Mile Area**
Seminole Water Conservation Project*,**
Rotenberger/Holey Lands**

Concept 6 - Water Supply and Flood Protection for Urban and Agricultural Areas
South Florida Water Management District Water Supply Planning*
Saltwater Treatment (Reverse Osmosis, Blending)
Wastewater Reuse
Raise Coastal Canal Stages Coupled with Increased Discharge Capacity
Interconnect Local Water Management Systems
Implement Southern L-8 Basin / Loxahatchee Slough

Concept 7 – Adequate Water Quality for Ecosystem Functioning
Everglades Construction Project - STAs*,**
Advanced Water Quality Treatment Technologies - Research*
Seminole Water Conservation Project*,**
Miccosukee Water Management Area*,**
SWIM Plans*
Mercury Program*
State Water Quality Efforts*
Florida Keys National Marine Sanctuary Water Quality Protection Program*
Kissimmee Region – Water Treatment Areas
Caloosahatchee - Water Treatment Areas
Water Treatment Area for L-28 (Interceptor)
Water Treatment Area for S-9
Best Management Practices for Agriculture **
Lower Western Basin STA**

Note: Projects Underway noted by *; Governor's Commission for a Sustainable South Florida's Farm Bill Priority Projects noted by **

TABLE 6-4-(continued)
THEMATIC CONCEPTS
Includes Projects Underway and 40 Preferred Options (in *Italics*)

Concept 8 – Increase Spatial Extent and Quality of Wetlands Beyond the Everglades Kissimmee River Restoration* Lake Kissimmee Drawdown* Save Our Rivers Program* *Kissimmee River Pool A Restoration* *Paradise Run Restoration* *Restoration of Kreamer, Torry, and Ritta Islands* *Restoration of Golden Gate Estates*** South Dade Wetlands Addition** Fakahatchee Strand** Belle Meade** South Glades** **Concept 9 – Invasive Plant Control** *Remove Invasive Nonnative Plants from Water Conservation Areas* *Remove Invasive Nonnative Plants from Urban Areas* **Concept 10 – Aquifer Storage and Recovery** *Lake Okeechobee – Aquifer Storage and Recovery* *Caloosahatchee – Aquifer Storage and Recovery* *LEC – Aquifer Storage and Recovery*	**Concept 11 - Protection and Restoration of Coastal, Estuarine, and Marine Ecosystems** SWIM Plans* C-111 Project* Modified Water Deliveries to Everglades National Park* Florida Keys Carrying Capacity Study*,** Florida Bay Emergency Interim Plan (Taylor Slough Demonstration Project)* Florida Bay Hydrodynamic Model* Biscayne Bay Hydrodynamic Model* Florida Keys National Marine Sanctuary Water Quality Protection Program* *Remove Organic Sediment Deposits from Caloosahatchee Estuary* *Stabilize St. Lucie Canal Banks* *Remove Organic Sediment Deposits from St. Lucie Estuary* **Concept 12 - Conservation of Soil** *Increase Groundwater Levels in the Everglades Agricultural Area* **Concept 13 – Operation, Management, and Implementation of the C&SF Project Modifications and Related Lands**

Note: Projects Underway noted by *; Governor's Commission for a Sustainable South Florida's Farm Bill Priority Projects noted by **

The following sections provide a description of each of the concepts which include those projects currently underway or programmed and additional features the Commission determined important to meet its objectives for the Restudy. The description of the concepts is taken directly from the Commission's report. The thirteen concepts broadly covered four major themes: regional storage for natural systems, water supply and flood protection; natural areas enhancement and restoration; improved water quality; and improved operation, management and implementation practices.

6.4.1. Concept 1: Regional Storage Within The Everglades Headwaters And Adjacent Areas

Sufficient water to meet competing demands can only be provided by maximizing storage. Water storage should be provided throughout the entire system and in such a way that no single area is environmentally damaged by excessive storage requirements or bears a disproportionate share of the storage burden. This storage must be achieved in all areas of the south Florida system using every practical option. As part of this concept, regional storage would be evaluated for the northern reaches of the Everglades system (Caloosahatchee, St.

Lucie, and Kissimmee River Basins). The additional storage in these basins should increase the water supply capabilities of the system and could ultimately reduce demands on Lake Okeechobee, thereby providing additional water during the dry season and reducing damaging high water conditions and harmful discharges to the east-west estuaries during the wet season.

6.4.1.1. Kissimmee River Basin

The Kissimmee Chain of Lakes forms the headwaters of the Everglades system and provides a critical source of water for Lake Okeechobee. The Kissimmee River Restoration Project, as currently planned, includes operational changes of lake levels in Lakes Kissimmee, Hatchineha, and Cypress to increase storage capacity necessary for the restoration of the Kissimmee River. Additional efforts that should be considered under this concept include examination of the operational plans for the remainder of the Upper Chain of Lakes to discern if they could provide additional storage capabilities to benefit the health of Lake Okeechobee and potentially reduce the volume of water shortages in the system.

Additional storage within the Kissimmee River Basin could reduce the amount of runoff entering Lake Okeechobee during the wet season when the lake typically approaches high levels. This could shorten the duration of high water levels within the lake that damage its littoral zone and could reduce the frequency of high volume discharges to the east and west coast estuaries. The increase in water levels within the Upper Chain of Lakes could be restricted to avoid natural system impacts of high water levels and the need to maintain flood protection to lakeside residential development throughout the area. In support of the Commission's sociological and economic goals, this concept must be designed to balance the need for storage with the need to maintain flood protection to lakeside developments and should not result in the relocation of communities and agricultural areas.

6.4.1.2. St. Lucie Canal and Caloosahatchee River Basins

Creating additional storage or enhancing the storage capacity on existing private or public facilities and open areas within the St. Lucie Canal and Caloosahatchee River Basins may reduce water supply demands on Lake Okeechobee by providing a supplemental source of water for irrigation and environmental base flow for the estuaries. The water conserved in Lake Okeechobee could be available for sustaining the health of the lake and downstream natural areas and other uses. Storage facilities could also attenuate local basin runoff that presently upsets the salinity balance in estuaries and adversely impacts seagrasses, invertebrates, and fisheries.

Pumping local basin urban and agricultural runoff into storage areas could attenuate flows during the wet season and provide storage into the dry season.

Restoring hydropatterns in large natural areas and storing excess water in wet pastures could attenuate flows and help restore cleaner and more natural inputs to the estuaries. Restoration of natural areas can also help meet the goal of expanding and enhancing the spatial extent of short hydroperiod wetlands. Dry period releases from these storage areas could be used for agricultural irrigation and for meeting minimum flow requirements of the estuaries. During those periods when supplemental irrigation requirements could not be met by the storage areas, water supply releases from Lake Okeechobee could still be provided. Attenuating stormwater runoff will provide some water quality benefits, although additional treatment may be required depending on the use of the discharged water. Water clarity is very important to aquatic vegetation, particularly grasses. For example, storing stormwater may allow suspended solids to settle out, consequently improving the transparency of the water.

The storage areas and their associated water treatment facilities should be sized and designed to be ecologically consistent with the location. The total storage volume, coupled with the size and depth of the storage areas, need to be optimized as a part of detailed design during the Restudy. The storage areas could require perimeter levees, pump stations, and conveyance canals to move water from the canal system into the storage areas and to control water supply and environmental releases from the storage areas. Ideally, individual upland storage areas would be divided among the various sub-basins and would be interconnected to provide for maximum flexibility of water management options among basins. The siting of these facilities should, to the maximum extent practicable, avoid primary or secondary impacts to existing wetlands and adjacent uplands, both of which contribute to a viable ecosystem and economy. The Indian River Lagoon Feasibility Study is examining the option of on-site retention for large dischargers within the St. Lucie Basin not presently providing such facilities; this concept should be examined for other areas as part of the Restudy effort.

6.4.2. Concept 2: Lake Okeechobee Operational Plan

Lake Okeechobee provides a critical source of water for the Everglades Agricultural Area (EAA), the urbanized areas of the Lower East Coast, portions of the Lower West Coast, the remaining portions of the historic Everglades system, and other wetland components of the south Florida ecosystem. Prior to manmade alterations, lake levels rose in response to rainfall and served as a valuable source of freshwater spilling into the Everglades during a relatively small number of high rainfall years. Today a lake regulation schedule triggers different management activities according to different lake levels. The current regulation schedule, known as Run 25, was developed for multiple purposes including water supply, flood control, navigation, and environmental protection. Since some of these goals conflict, achieving all of them under current conditions is impossible. Past efforts to meet all of these conflicting goals have resulted in damage to the lake's littoral zone and to the east and west coast estuaries. The Commission believes a new operational plan for the lake is needed that maximizes storage opportunities, protects the east and west coast estuaries, restores the ecological health of the lake, and enhances wildlife populations. The ability to accomplish these goals greatly depends on additional storage throughout the system and on other improvements to the overall C&SF Project.

Within the constraints imposed by these conflicts, the operational guidelines for Lake Okeechobee are currently being reviewed to attempt to optimize the natural resources within the lake, water discharges for the purpose of restoring the natural hydropattern of the Everglades, and flows to the estuaries without adversely impacting flood control or urban and agricultural water supply. Avoiding environmental harm to the St. Lucie and Caloosahatchee Estuaries caused by massive lake releases is an important goal. Equally important is protection of the lake littoral zone from prolonged high water. Maximizing storage for environmental, agricultural and urban needs while protecting the lake and estuaries will require creative new operational schedules. This interim study of operational guidelines for the lake is being conducted in conjunction with South Florida Water Management District's Lower East Coast Regional Water Supply Plan. In addition, the South Florida Water Management District's Surface Water Improvement and Management Plan requires specific regulatory and non-regulatory activities to address water quality conditions, including ongoing development and testing of agricultural Best Management Practices to reduce pollutants and assure water quality compliance for discharges into the lake. Additional actions may be necessary since current nutrient loads to the lake remain above the established target. Nutrient levels contained in lake water would need to be lowered before it could be discharged into the Everglades. These ongoing efforts should serve to benefit the health of the lake through improved water quality and operational changes which are more desirable for the lake's littoral zone without compromising other project purposes such as flood control and water supply. To fully resolve these conflicting demands on the lake, additional storage areas throughout the system and methods to improve water quality are required.

Until additional storage options are available elsewhere in the system, temporary storage capacity in the lake could help meet projected demands for urban and agricultural water supply and natural system needs. Revisions to the operational plan for Lake Okeechobee may allow additional water to be stored in the lake during wet periods and may help meet the projected demands during dry periods while maintaining ecologically desirable water fluctuations and lake levels. This could be accomplished by allowing periodic lower levels during droughts and higher water levels during wet periods, providing there is no significant adverse impact to the lake's littoral zone, or the east and west coast estuaries. A new operational plan needs to be identified that triggers management activities for high lake levels and "supply-side" management actions for low lake levels. Modified lake operations could increase the storage capacity of the lake, while reducing impacts to other parts of the regional system. All operational options that seek to increase lake storage capacity, while protecting the littoral zone and the east and west coast estuaries, must be carefully examined.

Lake Okeechobee's littoral zone provides important nursery grounds and habitat for fish and other aquatic organisms. It also supports large populations of wading birds and migratory waterfowl. The current location of the littoral zone is the result of the construction of the existing dike system, and the lowering of the lake level by drainage. Colonization by aquatic plants creates a littoral zone where fluctuating water levels are sufficient to support emergent vegetation. A diverse littoral zone cannot survive under periods of prolonged inundation. Timing of varying water levels and light penetration in the shallows are key factors in maintaining a viable littoral zone. The existing littoral zone was established when lake regulation levels fluctuated between 13.0 and 15.5 feet NVGD. In 1978, the regulation schedule was set at 15.5 to 17.5 feet to increase lake water storage. Assuring the continued health of the existing littoral zone is an important goal. All available information should be used to design a lake regulation schedule that preserves a healthy littoral zone, maximizes lake storage, and allows attenuation of floodwaters to protect the east and west coast estuaries. If it is determined to be feasible, raising the regulation schedule above the current limits may require costly structural changes such as raising existing levees, modifying or adding water control structures, constructing new pump stations, canals, and tie back levees. Also, State Road 78 may need to be raised and additional flood easements acquired. Recent high lake levels and the resulting dike seepage problems indicate levee repairs and improvements may be required even if the current regulation schedule is not raised. In addition, the Seminole Tribe's Brighton Reservation is located on the northwest side of Lake Okeechobee. As Federal Trust Property, this reservation should be considered in any decision regarding modifications to the water levels of the lake. The Restudy must consider all of these aspects when evaluating the role that Lake Okeechobee will play in the future.

6.4.3. Concept 3: Everglades Agricultural Area Storage

Much of the supplemental water supply for the Everglades Agricultural Area in the dry season is currently met by deliveries from Lake Okeechobee. Additional water storage in the Everglades Agricultural Area will lessen its dependency on Lake Okeechobee for irrigation water and potentially reduce the ecologically damaging high water conditions in the Water Conservation Areas and backpumping into Lake Okeechobee during the wet season. Regional above-ground impoundments or storage areas within the Everglades Agricultural Area could capture and store Everglades Agricultural Area runoff or excess water from Lake Okeechobee during the wet season. During the dry season, reservoir releases could be made to the primary canals for agricultural irrigation and for restoration of the downstream Everglades ecosystem. Lake Okeechobee would then no longer serve as the only supplemental source for meeting Everglades Agricultural Area irrigation demands. During the periods when supplemental irrigation requirements could not be met by the storage areas, water supply releases from Lake Okeechobee could still be provided.

The Commission recommends that the determination of sufficient land to accomplish storage in the Everglades Agricultural Area be based on need, science, and appropriate cost-benefit analyses. The Talisman property is currently being considered for acquisition by the State for use as a water storage area. The Commission supports the acquisition of up to the equivalent of the Talisman property as a target of opportunity for increased storage. Additional areas may be considered. Until the total storage volume, size, and depth of storage areas are designed and optimized during the Restudy, based on analyses of costs, benefits, needs, and impacts, all land acquisition should be made with willing sellers and in consultation with local landowners. Acquired lands could be returned to agricultural use if not needed for restoration activities.

Properly sized and designed storage areas have the potential of improving the quality of water being delivered to the natural system by reducing Everglades Agricultural Area runoff entering the stormwater treatment areas, thereby reducing the nutrient loading coming from the Everglades Agricultural Area and aiding the stormwater treatment areas in meeting target phosphorus levels entering the Water Conservation Areas. Further, detention of stormwater for attenuation purposes will improve water quality. However, additional water treatment may be required if the water within these storage areas is to be used to meet natural system demands.

Ongoing efforts to improve flood control capacity within the Everglades Agricultural Area and water quality of downstream flood control discharges, include the Everglades Construction Project and the reevaluation of the Bolles and Cross Canals. Presently, the design of the major canals of the Everglades Agricultural Area is constrained in moving water internally within the Everglades Agricultural Area or from Lake Okeechobee to the south. By incorporating expanded or modified Everglades Agricultural Area canals with stormwater treatment areas and new water storage areas, the increased operational flexibility could provide additional flood protection to the Everglades Agricultural Area while protecting the Water Conservation Areas and the coastal estuaries from damaging high water levels and untimely discharges. When Lake Okeechobee exceeds its regulation schedule, water that currently impacts the lake's littoral zone or disrupts the east and west coastal estuaries could be moved southward into new storage areas or, water quality permitting, to the Water Conservation Areas.

6.4.4. Concept 4: Water Preserve Areas

The purpose of the Water Preserve Areas concept is to: (1) increase storage and hold more water in the system by controlling seepage from natural areas; (2) capture and store excess stormwater currently discharged to coastal waters, thus retaining an important water supply source for both urban and natural systems; (3) provide a buffer between the natural and developed areas; (4) preserve and protect wetlands outside the publicly owned Everglades; and (5) provide important transitional land uses between the natural and developed areas. The Water Preserve Areas concept may also enhance flood control in areas to the east of the Water Preserve Areas. Attempts to meet these various goals should be coordinated and developed in a consistent manner.

Hydrologic modeling of the regional system has demonstrated seepage control is a critical component for achieving restoration targets in the southern Everglades and Florida Bay. Much of the water that seeps out of the Everglades is collected in the secondary canal network and discharged into the regional canal system, resulting in excessive releases to coastal waters. The Water Preserve Areas concept must include a cost-effective implementation of one or all of these alternatives to achieve the multi-purpose functions and operational flexibility needed to meet the Commission's objectives. Water Preserve Areas should enhance regional capabilities for meeting environmental, urban, and agricultural water demands, while simultaneously providing protection of certain designated wetlands outside the Water Conservation Areas and Everglades National Park. The Water Preserve Areas concept consists of a series of surface water impoundments, interconnected and managed as a system of marshlands, storage areas, and/or aquifer recharge basins. These areas provide the potential to backpump stormwater currently discharged to coastal waters and serve to control urban sprawl into remaining peripheral wetlands. Some examples of seepage control alternatives which should be evaluated for inclusion in the Water Preserve Areas are creating areas to store excess urban runoff, creating a step down of water levels toward the east, building collection and backpumping facilities, and installing subterranean barriers.

Water quality becomes an important consideration where enhancement of existing wetlands or backpumping into the Water Conservation Areas or wellfield recharge areas is desired. Untreated stormwater should be diverted to a treatment facility or should undergo other treatment options necessary to achieve water quality standards prior to discharge to a wetland area, wellfield recharge area, or surface water supply source areas. In particular, the S-9 pump station must also be considered. The S-9 pump station is the only major C&SF Project facility that currently discharges untreated urban stormwater into the Everglades. Other urban stormwater discharge into the Everglades by local drainage districts must also be addressed. Structures that discharge into Water Conservation Areas should have appropriate permits to discharge effluent, should be monitored, and should meet all applicable state and Federal water quality standards and laws. A water treatment facility could remove phosphorus and other constituents from stormwater prior to discharge into the Water Conservation Areas.

The Water Preserve Areas concept includes the remaining natural areas and open spaces along the eastern boundaries of Everglades National Park and the Water Conservation Areas and extends north into the Upper East Coast area. This concept is considerably more extensive than the existing South Florida Water Management District East Coast Buffer Project boundaries, that is a land acquisition initiative that preserves, where possible, design flexibility for future water preserve elements. For example, Palm Beach County has proposed that the Water Preserve Areas concept be extended east and northeast into the Loxahatchee Basin.

In June 1995, the Martin and St. Lucie County Commissions established a Water Preserve Areas Task Force to facilitate selection of suitable sites for Water Preserve Areas in those counties. In Martin and St. Lucie Counties, Water Preserve Areas could provide for the diversion of surplus runoff from the C-23, C-24, and C-25 drainage basins to storage areas where the water could be used for agricultural purposes or, with treatment, could be discharged into the estuary to enhance needed baseflow. The Task Force has completed a draft report that evaluated a number of potential Water Preserve Areas sites and conducted a design charette for a potential site at Allapattah Ranch. Water Preserve Areas in these two counties could help alleviate the problems caused by excessive inflows of freshwater to the St. Lucie Estuary and Indian River Lagoon.

The area of northwestern Miami-Dade County proposed as a future "Lake Belt" by the South Florida Limestone Mining Coalition lies east of Water Conservation Areas-3B and comprises a large portion of land being considered for the Water Preserve Areas. The Florida Legislature recognized that one of the few remaining high-quality, construction grade limestone deposits suitable for the production of aggregates, cements and road base materials in the state is located in this area. Therefore, the legislature established the Northwest Dade County Freshwater Lake Plan Implementation Committee and further defined the proposed lake plan boundaries. The objective of the legislation is to develop a plan that:

> *"(a) enhances the water supply for Dade County and the Everglades; (b) maximizes efficient recovery of limestone while promoting the social and economic welfare of the community and protecting the environment; and (c) educates various groups and the general public of the benefits of the plan."*

A public/private partnership may offset the cost or reduce the need for acquiring portions of the Water Preserve Areas (including but not limited to land donations, land swaps, and less than fee simple acquisitions). However Lake Belt Plan development is proceeding in advance of the Water Preserve Areas design component of the Restudy. Coordination between these two planning efforts is necessary to avoid difficulties associated with Everglades restoration. It is important that the future lake plan be consistent with economic and environmental sustainability and flexible enough to ensure compatibility with south Florida natural system restoration and other objectives set forth by the Governor's Commission.

The Water Preserve Areas concept should extend seepage control south of Tamiami Trail to the eastern panhandle of Everglades National Park including the 8 1/2 Square Mile Area and the C-111 Basin. The stretch of the L-31N from Tamiami Trail to the 8 1/2 Square Mile Area is of significant concern because of the extreme rates of seepage along the eastern border of Northeast Shark River Slough. Raising water levels in the L-31N Canal is a critical element in restoring hydropatterns in Everglades National Park. This cannot be achieved without seepage control due to the flooding threat to the 8 1/2 Square Mile Area and areas to the east of the L-31N Canal. One suggestion in support of the Water Preserve Areas concept is to install a divide structure in the C-4 Canal. This would increase the potential volumes of stormwater that could be captured by various backpumping configurations as well as help recharge wellfields and improve flood protection for urban areas.

Because the 8 1/2 Square Mile Area is located adjacent to the Everglades National Park boundary, flood control could affect restoration of natural hydropatterns, flows and water quality within the Park. The currently authorized flood mitigation for the 8 1/2 Square Mile Area does not provide adequate protection for the community. The 8 1/2 Square Mile Area deserves consideration by the Restudy, consistent with the recommendations of the Governor's Committee on the 8 1/2 Square Mile Area.

The exact extent, design, and operation of the Water Preserve Areas should be evaluated and determined as part of the Restudy. However, time is of the essence as lands in some of the proposed Water Preserve Areas are rapidly being converted to uses that are incompatible with their potential use as Water Preserve Areas. Therefore, The Commission believes that accelerated acquisition of critical lands is needed to ensure that this concept remains viable.

6.4.5. Concept 5: Natural Areas Continuity

Historic freshwater wetland habitats in south Florida have been reduced spatially, compartmentalized, and hydrologically altered as a result of the C&SF Project. Further, habitats have been unnaturally fragmented. Reestablishing the hydrologic and ecologic continuity of the remaining natural areas is expected to benefit the entire Everglades ecosystem by recovering the pre-drainage functions and habitat values of historic freshwater wetlands, reducing the fragmentation, and restoring more natural hydropatterns including associated sheetflow. These actions may also help restore the ecological processes and relationships, and the diversity and numerical abundance of animals that can only come by reestablishing the central and southern Everglades and Big Cypress into a single, fully integrated ecosystem. This concept proposes to restore ecological continuity to areas that are currently treated as geographically and hydrologically distinct. These areas include the three Water Conservation Areas, the Rotenberger/Holey Land Wildlife Management Areas, the Big Cypress National Preserve, Ten Thousand Islands, Fakahatchee Strand, Mullet Slough, Corkscrew Swamp, Caloosahatchee Slough, Rookery Bay, Everglades National Park, the Model Lands, Florida Bay, the Florida Keys, and associated estuarine and marine waters. This concept involves structural and/or operational changes within the remaining natural areas for the benefit of the entire ecosystem. These structural changes should also include examining the effects and/or proposing changes to U.S. 27, which bisects the Water Conservation Areas, to enhance natural conditions.

Water quantity and water quality are important aspects of this concept, however, features to achieve these goals will generally come from outside the boundaries of the remaining natural areas. This concept assumes that appropriate quantity and quality of water needed to meet ecosystem goals in the natural areas will be available and that the Water Conservation Areas will be managed to the maximum extent feasible for natural values. Existing legislation by the State of Florida, the Everglades Forever Act, addresses non-point source pollution from agricultural activities in the Everglades Agricultural Area. Best Management Practices and treatment of runoff from the Everglades Agricultural Area through stormwater treatment areas are designed to reduce phosphorus levels in water released to the Everglades to 50 parts per billion, an interim goal for the discharges. Additional water quality treatment may be necessary if more stringent water quality standards are applied and additional water for restoration is required. Where possible, the Everglades Forever Act implementation schedule should also be accelerated.

Several efforts are currently underway that will help achieve the goals of restoring the hydrological function and reestablishing ecological connections between natural areas and wildlife communities. These ongoing projects include the Experimental Program of Modified Water Deliveries to Everglades National Park, the C-111 Project, and the Florida Bay Emergency Interim Plan (Taylor Slough Demonstration Project). The Commission believes implementation of these projects will help achieve these goals while maintaining and, where possible, improving levels of water supply and flood protection to the adjacent agricultural areas.

The Experimental Program of Modified Deliveries to Everglades National Park was initiated in 1984 to test alternative operational plans and to provide more natural hydrologic conditions in the Everglades during the testing process. Initial tests addressed water deliveries to Shark River Slough and have since incorporated tests of water deliveries to Taylor Slough. The program will continue through the design and construction of the Modified Deliveries to Everglades National Park and the C-111 Projects. The Modified Water Deliveries to Everglades National Park Project is aimed at restoring the original deep water portion of Shark River Slough and reducing the impacts of large flood releases in western Shark River Slough. The C-111 Project will create a buffer area along the eastern boundary of the Park to allow increased water levels in Taylor Slough and gradually lessen water levels from west to east. C-111 Project design modifications should also ensure natural water deliveries to the panhandle area of Everglades National Park and the Model Lands area east of U.S. 1. In addition, the Florida Bay Emergency Interim Plan, required by the Everglades Forever Act, should increase the amount of freshwater reaching Florida Bay by acquiring the Frog Pond and raising canal stages to promote more freshwater to flow through Taylor Slough into Florida Bay. Flood protection will be maintained and, where possible, improved for adjacent, existing urban and agricultural lands as these projects are implemented. Results should be monitored to evaluate effectiveness or identify needed modifications. The goal is to replicate flows, more natural hydropatterns, and flows in natural areas to maintain and restore native wetland, upland plant communities, and wildlife communities.

In the development of this Conceptual Plan for the Restudy, the Commission identified additional efforts needed in the region to fully meet its objectives for hydrologically and ecologically reconnecting natural areas. These are described as follows:

6.4.5.1. Water Conservation Areas

Historically, the three Water Conservation Areas were an expansive mosaic of habitats including uplands, hammocks, sawgrass plains, wet prairies, sloughs, lakes, and marl-forming marshes that constituted the central and northeastern portions of the historic Everglades. Construction of the three Water Conservation Areas has resulted in the management of each of the areas according to a regulation schedule based on inflow and outflow of water through water control structures and system demands.

As part of this concept, structural modifications to the levees and structures currently compartmentalizing the Water Conservation Areas and changes in operational plans will be investigated for the purpose of restoring more natural hydrologic and ecologic continuity within all of the Water Conservation Areas. Preliminary hydrologic modeling conducted during the reconnaissance phase of the Restudy indicated some levees and structures may still be necessary to create desirable hydrologic and ecologic conditions throughout the area. Further, the current Water Conservation Areas regulation schedules need to be modified to schedules based on more natural conditions. The goal is to replicate more natural hydropatterns within the Water Conservation Areas and to maintain and restore native wetland and upland plant communities. It is important to note that the movement of water through these areas has been altered by soil subsidence. Current flow patterns are much different than historic flow patterns. For these and other reasons, more detailed hydrologic modeling is necessary to determine changes in hydrologic patterns that result from modifications to the amount, timing, and distribution of water flowing into and through the Water Conservation Areas. As part of the Restudy, restoring the connectivity of the Water Conservation Areas with the other portions of the Everglades should be consistent with the ability to maintain flood protection and existing water supply for agricultural and urban areas.

6.4.5.2. Big Cypress National Preserve

The Big Cypress National Preserve area is a mosaic of evolving habitat types resulting from both natural and manmade forces. Historically, long hydroperiods limited the invasion of shrubs and pines into cypress forests and frequent fires prevented hardwoods from dominating cypress and pine forests. Infrequent hot fires burned holes into peat soils that created new pools. The result of these conditions was a balance of shifting successional communities. Construction of the L-28 levee, Tamiami Trail, and Loop Road altered flows and changed the habitat cycles of floods and fires.

As part of this concept, hydrological and ecological conditions will be improved by providing more historic-like flows along the eastern border of Big Cypress National Preserve. This will provide for more natural inter-annual and seasonal variations of flow that will, in turn, result in a more natural cycle of floods and fires in the area. As more natural patterns of fires and floods are restored, overall habitat heterogeneity will increase and a more natural interspersion of uplands and wetlands will return. Additional benefits of this concept may include improvements in water table elevations in the coastal mangrove forests in the Ten Thousand Islands area of Everglades National Park. Impacts to threatened and endangered species such as the Cape Sable Seaside Sparrow and the West Indian manatee will need to be considered and addressed.

The L-28 Levee presently separates Water Conservation Area 3A and the Big Cypress National Preserve. To restore hydropatterns within Big Cypress National Preserve, this levee, Tamiami Trail, and Loop Road may need to be modified. Further upstream, the L-28 Interceptor Canal (L-28I) collects water from the Seminole Reservation and upstream basins and discharges it into Water Conservation Area 3A. Allowing this canal to discharge further upstream in the northeast corner of Big Cypress National Preserve could rehydrate Mullet Slough and the headwaters of Big Cypress Natural Preserve, while still providing flood protection to the Seminole and Miccosukee Reservations. Facilities for water treatment will be necessary to improve water quality entering natural areas from the C-139 and the L-28I canals that presently flow directly into Water Conservation Area 3A. The Seminole Tribe's Water Conservation Plan provides a greater opportunity to restore more natural hydropatterns in the Big Cypress National Preserve by creating flows further north and west. Bypass structures will be placed under the West Feeder Canal on the Big Cypress Reservation that will sheetflow clean water south along the length of the west Feeder Canal into the Big Cypress Preserve Addition.

6.4.5.3. Everglades National Park

Tamiami Trail (U.S. 41) and L-29 form an ecological and hydrological barrier between Water Conservation Area 3 and Everglades National Park. Two on-going projects have identified ways to improve hydrologic and ecologic conditions within Everglades National Park; the Modified Water Deliveries to Everglades National Park and C-111 Projects. These projects will help improve conveyance into Everglades National Park and provide some seepage control south of Tamiami Trail. While these projects will improve conditions in Everglades National Park in the interim, additional measures may be needed to further control seepage and restore conveyance to historical levels. These issues need to be addressed through the Restudy and evaluated collectively. Structural modifications to the L-29 levee and improving conveyance through Tamiami Trail (bridge structure) from CR 951 to 40 Mile Bend and Loop Road need to be evaluated by the Restudy from the perspective of restoring the hydrologic and ecologic continuity of Water Conservation Area 3, Everglades National Park, the Big Cypress, and Ten Thousand Islands.

Groundwater seepage loss is the main impediment to any kind of restoration within Everglades National Park. Its impact is far reaching, affecting every water management decision along Tamiami Trail. To address this problem, the Water Preserve Areas concept has been extended south of Tamiami Trail to control the extreme seepage losses that occur on the east side of the Park. At a minimum, the areas of concern include the 8 ½ Square Mile Area, Bird Drive Basin, and the Pennsucco Wetlands.

Flamingo Road, which is the main road through Everglades National Park, is the only road providing access to the Flamingo visitor center. This roadway acts as a levee during high flow conditions and impedes sheetflow through portions of Everglades National Park. This concept addresses improving conveyance through this road. Adding culverts, bridges, or other improvements to Flamingo Road will remove a hydrological barrier and restore more natural flows within the area, resulting in improved hydrologic and ecologic continuity.

6.4.5.4. Biscayne National Park

Large public works projects in South Miami-Dade County (e.g. U.S. 1, the C&SF Project, etc.) have interrupted natural freshwater flows into Biscayne Bay. The pending transfer of Homestead Air Force Base to Miami-Dade County, and the public acquisition of the Model Lands provide important opportunities to improve these hydropatterns. The Commission supports the sustainable conversion of the air base and redevelopment of appropriate areas in southeast Miami-Dade County as critical economic development projects. Water management changes that result from these activities must be made in ways that protect Biscayne National Park and other vital environmental resources in southeast Miami-Dade County, reconnect drained wetlands east and west of U.S. 1, and reinforce the sustainable agricultural goals of this Commission. The reconnection of Biscayne Bay to more natural freshwater flows from the mainland will complete the "natural area continuity" at the southeastern end of the natural system.

6.4.6. Concept 6: Water Supply and Flood Protection for Urban and Agricultural Areas

The flood protection and water supply provided by the C&SF Project have facilitated the development of urban and agricultural areas in south Florida. Population growth and the intense development in south Florida are expected to continue resulting in significant increases in the demand for water and pressure to maintain and enhance flood protection. The Commission recognizes that flood protection and water supply for all users are critical components of sustainability of the region. The Commission also recognizes the continued importance of the C&SF Project to meet these needs. It is the goal of the Commission to maintain existing levels of water supply and flood protection and, where consistent with restoration goals, to balance future flood protection and water supply.

C&SF Project facilities allow the Water Conservation Areas and Lake Okeechobee to serve as a critical source of water for meeting urban needs during periods of low rainfall. This includes providing recharge to the surficial aquifer along the Lower East Coast and maintaining surface water supplies to the Caloosahatchee Basin and the West Palm Beach Water Catchment Area. In addition, the lake serves as a direct source of water for lakeside communities.

The South Florida Water Management District is currently developing four water supply plans that, together, cover the entire boundaries of the South Florida Water Management District. Each regional plan analyzes the available water supply and makes projections of future demand through the year 2010. Working with public advisory committees, the South Florida Water Management District is determining the likelihood of future water supply problems, and is developing potential solutions to these problems. The majority of the C&SF Project facilities fall within the boundaries of the Lower East Coast Regional Water Supply Plan. An interim plan was completed in early 1998. The Lower West Coast Water Supply Plan was completed in 1994. The Upper East Coast Water Supply Plan was completed in 1998 and the Kissimmee Water Supply Plan is underway. The plans will make recommendations to address immediate water supply issues and will also make long term recommendations to the Restudy.

One important option under consideration in both the Lower East Coast Regional Water Supply Plan and the Restudy is the Water Preserve Areas concept, which will benefit regional water supply. Capturing and storing excess stormwater runoff in the Water Preserve Areas could serve as additional storage areas for urban water supply and enhance recharge of the Biscayne Aquifer. Other regional concepts, such as modification of the regional and secondary canal systems to improve water management and recharge capability are possible methods of increasing recharge to the surficial aquifer. Options that have been identified for this purpose include raising coastal canal stages (with appropriate means to maintain flood control) and interconnecting local surface water management systems and the southern L-8 Project in northern Palm Beach County.

Other alternatives, while less regional in nature, include new inland wellfields, public water supply aquifer storage and recovery, wastewater reuse, the reduction of per capita water usage, and the use of brackish or saltwater sources of water. Utility or local government programs for plumbing retrofit and landscape water conservation programs may also be useful in slowing the increase in urban demands. It is anticipated that the implementation of a combination of alternatives will be necessary, depending on the type of user and the circumstances that the user encounters. It is critical that the Restudy effort work closely with local water utility departments to further develop these alternatives. The Commission believes the Restudy must take a regional view toward water supply. Further, the Commission recognizes that regional water supply deliveries from the C&SF Project are critical to achieving sustainability. The Restudy must develop plans to mitigate and replace any water supply lost through system modifications for environmental restoration.

The C&SF Project has provided regional flood protection throughout the entire system. Flood protection provided to existing agriculture and development should be maintained. In a number of areas, some features of the Project have never been constructed and development and agriculture have occurred in areas not previously anticipated to be converted. Of particular concern is the south Miami-Dade area where projects such as the Modified Water Deliveries to Everglades National Park and the C-111 Project are underway. These south Miami-Dade projects must incorporate appropriate flood protection into their design. The Commission has identified a number of water storage options throughout the C&SF Project system that will provide increased flood protection. These options, including the Water Preserve Areas and storage areas, should also include flood protection as their purpose.

6.4.7. Concept 7: Adequate Water Quality for Natural System Functioning

A fundamental requirement for maintenance and restoration of the Everglades ecosystem, Florida Bay and the coastal estuaries is the delivery of adequate amounts of clean water. Just as restoration of water quantity in proper volumes and timing to the Everglades is the cornerstone of Everglades restoration, the Commission believes that the natural system can only be restored through the supply of clean rainwater and surface water from upstream marshes, rivers, sloughs, and Lake Okeechobee.

Drainage from the extensive agricultural development in the Everglades Agricultural Area delivered to the Everglades marsh via the C&SF Project structures resulted in the degradation of Everglades marsh surface waters. Stormwater runoff from extensive urban development on both coasts has degraded water quality in the coastal estuaries and certain portions of the Everglades where urban stormwater/drainage water is backpumped (i.e., the C-11 Basin) via the C&SF Project structures. Since the natural Everglades ecosystem is oligotrophic, with high plant biomass and very low nutrient concentrations in marsh surface waters, it is acutely vulnerable to eutrophication by elevated nutrient levels. The estuaries, notably Florida Bay, Biscayne Bay, and the St. Lucie Estuary, have been damaged by degraded water quality or unnaturally high volumes of water facilitated by the C&SF Project canals.

Large scale Everglades restoration planning and implementation must include the delivery of clean water to the Everglades marsh. Ecological restoration cannot be accomplished if water flowing to the Everglades contains high nutrients and ecologically damaging levels of pesticides, heavy metals, and other constituents. If, in the future, the Everglades marsh consists of large expanses of cattail monoculture, the ecologic integrity of the Everglades will not be equivalent to restoration of a diverse, heterogeneous system of sawgrass marsh intermingled with spikerush flats, deep water sloughs, tree islands and upland hardwood hammocks.

A number of activities are currently underway or programmed by various agencies to address the issue of water quality entering Lake Okeechobee, the Everglades, Florida Bay and the region's estuaries. These activities serve to improve the quality of water currently being discharged into lake, wetland, and estuarine ecosystems from existing water management infrastructure and are a critical and integral component of the Commission's Conceptual Plan for the Restudy. Evaluations of these water quality improvement activities must occur to insure their adequacy in meeting the goal of restoration.

The Florida Department of Environmental Protection's water quality standards program develops designated uses and classifications of State waters. Narrative and numeric water criteria are set for various water quality parameters to protect the designated use of the water body. The Everglades Forever Act mandates that the Florida Department of Environmental Protection, in conjunction with the South Florida Water Management District, develop numeric water quality criteria for phosphorus in the Everglades Protection Area by the year 2001. The development of numeric water quality criteria, particularly for phosphorus in the Everglades marsh, is a critical step in developing ecosystem-wide water quality and ecological restoration strategies. The Seminole and Miccosukee Tribes have also been delegated the authority to set water quality standards. These standards will address protection of wetlands with cypress and sawgrass communities.

Because enforcement of state narrative and numerical water quality standards is critical to protecting the ecological health of the Everglades ecosystem, the Commission recommends that structures discharging into the Everglades Protection Area be appropriately permitted, as provided by law, and that discharge effluents be monitored to ensure all applicable state and Federal water quality standards and laws are met.

Non-point source pollution associated with urban or agricultural land uses adversely impacts both groundwater and surface water resources and must be controlled in basins draining to both the Everglades Protection Area and the coastal estuaries. Specifically, non-point source pollution associated with the backpumping of untreated water into Water Conservation Area 3-A at pump structure S-9, in the C-11 drainage basin in western Broward County, must be adequately addressed and controlled by local, state and Federal water pollution control agencies.

In addition, high levels of methyl mercury have been found in fish and wildlife in Everglades marshes and canals. In Florida, the highest concentrations of mercury in fish have been found in Water Conservation Area 3A. Human consumption advisories have been issued by the State banning consumption of several fish species in Water Conservation Areas 2A, 3A and the Park, and limiting consumption in Loxahatchee National Wildlife Refuge (Water Conservation Area 1). Possible sources of mercury include atmospheric deposition, effects of drainage, soil disturbance, hydroperiod alteration and historic storage of mercury in the Everglades. An extensive interagency state-Federal mercury research program is underway to identify and quantify mercury sources and transport systems to the Everglades. The Environmental Protection Agency (EPA), DEP and the United States Geological Society (USGS) are developing models to evaluate the effect of various mercury source control and water management strategies on the Everglades mercury problem. The South Florida Water Management District and the Florida Game and Fresh Water Fish Commission (FGFWFC) are also working as part of the multi-agency effort to better understand this ecological problem and develop appropriate responses.

Florida Department of Environmental Protection and the South Florida Water Management District are also involved with numerous water quality improvement efforts throughout south Florida aimed at establishing appropriate criteria for discharges and streamlining the permitting process. These efforts are consistent with the Commission's objectives for sustainability in that they support integration of human activities with the needs of south Florida's natural resources and allow for an ecosystem management perspective.

About 700 million gallons of wastewater are treated and discharged in south Florida daily, much of it to tide. Some urban areas in south Florida have experienced problems with sewage overflow and lack of capacity. The tripling of population anticipated in south Florida in the next few decades may result in three times as much wastewater. There must be adequate capacity to treat this wastewater to a quality that does not adversely impact groundwater or receiving surface waters such as canals, estuarine areas or near-coastal waters. In addition, if properly treated, reuse of this wastewater for appropriate purposes would help meet regional water supply needs.

In addition to areas that generate large quantities of wastewater, there are also numerous communities in south Florida that utilize on-site sewage disposal systems, such as septic tanks and cesspits, for wastewater treatment. Throughout the region, concentrations of such systems pose significant water quality problems. Replacement of these systems with centralized wastewater disposal systems or other technologies which significantly reduce nutrient impacts may be expensive, but necessary, and is often beyond the means of many of the region's small communities, particularly around Lake Okeechobee and the Florida Keys.

The Seminole Tribe's Water Conservation System Conceptual Project provides for sustainable development of their Big Cypress Reservation and balances the needs of the environment with the Tribe's needs for economic sustainability on its homeland. It provides for a network of surface water management structures and the implementation of a comprehensive system of best management practices. This effort helps the Tribe meet the numerical standard for phosphorus concentration in waters discharged from the Reservation, thereby supporting sustainable agriculture while contributing to restoration of the western Everglades ecosystem. The Seminole Tribe is also contributing to the improvement of water quality in the Western Basins through the Landowners Agreements and an Agreement with the South Florida Water Management District. The Everglades Forever Act only covers flows from the C-139 Basin and the C-139 Annex. These waters currently flow through the L-28 into Water Conservation Area 3A. Water from these basins will be diverted and treated through STA 5 and STA 6 of the Everglades Construction Project. In order to address high phosphorus inflows to the Reservation, the Seminole Tribe has entered into these agreements and will be embarking on an enhanced water quality monitoring program.

Of the 23 planning objectives developed by the Commission for the Restudy, 12 are either directly or indirectly dependent on attainment of adequate water quality conditions (see Table 6-1). Many of the concepts considered for inclusion into the Restudy require further water quality evaluation and could have either a positive or a negative influence on the Everglades. As the Restudy progresses, the water quality aspects of individual alternatives must be assessed. In particular, certain concepts give rise to opportunities to address water quality issues including: the Everglades Agricultural Area water storage concept, Water Preserve Areas, and the regional storage within the Everglades headwaters concept. The Commission also proposes specific water quality improvement projects to be considered under this concept including water treatment facilities for the Kissimmee River, Caloosahatchee River, S-9, C-111, and L-28 Interceptor Canal.

6.4.8. Concept 8: Increased Spatial Extent and Quality of Wetlands Beyond the Everglades

Roughly 50 percent of the Everglades have been destroyed by land conversion to agricultural, urban, and industrial development. They continue to be lost through wetland permitting programs. Wetland loss has reduced landscape heterogeneity, eliminated habitat of wetland dependent species, and threatened the long-term viability of vertebrate species that require extensive territory (e.g., wading birds and panthers). The protection and restoration of wetlands outside the publicly owned lands, not just the Everglades, could substantially increase success in reestablishing many native communities. This concept focuses on the protection and restoration of existing wetlands including smaller, isolated wetlands not contained in the remnant Everglades. It includes ongoing restoration efforts, such as the wetland conservation strategies and multi-species recovery planning, as well as additional efforts that address the Commission's objective for increasing the spatial extent and quality of wetlands. A regulatory permitting strategy coupled with a land acquisition program for the remaining wetlands is needed immediately to ensure their values are protected and restoration opportunities are not precluded.

The State of Florida's Conservation and Recreation Lands and Save Our Rivers Programs use bond proceeds, supported by the general revenue portion of the State's Documentary Stamp Tax, to acquire lands for the purposes of water management, water supply, and the conservation and protection of the State's water resources. Manageability, surface and groundwater systems, and the formation of corridors for the critical interaction of wildlife populations are major considerations in this land acquisition process. Prime requisites in managing these public lands continue to ensure water resources, fish and wildlife populations, and native plant communities are maintained in an environmentally acceptable manner, and that they are made available for appropriate outdoor recreational activities consistent with their environmental sensitivity.

The Kissimmee River, once a meandering river with associated marshlands that provided water storage for the Everglades system and habitat for birds, fish, and wildlife, was channelized into a 56-mile ditch (the C-38 Canal) as part of the C&SF Project. Channelization drained approximately 20,000 acres of wetlands. The Corps and the South Florida Water Management District are currently restoring portions of the Kissimmee River's floodplain.

Two areas of the Kissimmee River not presently under consideration for restoration, but supported by the Commission, are Pool A and Paradise Run. Pool A is situated south of Lake Kissimmee. The existing C-38 flood control channel there will remain in place to ensure flood protection in the Upper Chain of Lakes. Flow-through marshes, encompassing approximately 3,000 acres, could be created to improve the quality of water delivered southward and to restore additional high quality floodplain wetland habitat. Paradise Run, 8.5 miles in length, lies immediately north of Lake Okeechobee and west of the old Kissimmee River channel. It now consists of 1,200 acres of wetlands. The restoration of Paradise Run would result in more natural hydrologic conditions and improved habitat for fish and wildlife resources, and would add an additional 2,200 acres of high quality floodplain wetlands.

The Herbert Hoover Dike was built around portions of Lake Okeechobee in the 1930s, largely as a consequence of the 1926 and 1928 hurricanes. The C&SF Project completed the impoundment of the lake in the 1950s and 1960s. This impoundment separated large natural areas located adjacent to the northern, western, and, to a more limited extent, the southern portion of the lake from their connection to the lake. These areas, once upper elevation marshlands, are drier than they were historically and no longer function as they once did. Wetland enhancement to areas that once formed the littoral system would contribute to the quality of fish and wildlife habitat. Any activities related to this restoration need to consider impacts to the Seminole Tribe's Brighton Reservation on the northwest side of Lake Okeechobee.

Kreamer, Torry, and Ritta Islands, located in the southern end of Lake Okeechobee, were formerly used for agricultural purposes. The restoration of these islands would involve degrading selected levees to allow more natural water levels and transplanting native vegetation. These actions would not affect existing private properties. They could result in additional habitat for water birds, fish, and other wildlife. Contaminant studies need to be completed prior to restoration design.

The Big Cypress Basin provides freshwater to the coastal marsh and mangrove communities of the southwestern Everglades. Construction activities associated with the defunct Golden Gate Estates development has altered the basin's natural drainage patterns through over-drainage and has affected biologic habitat and natural hydropatterns. Restoration of the southern portion of the Golden Gate Estates (between I-75 and Tamiami Trail) would restore sheetflow over an area of 113 square miles. This, in turn, would improve habitat quality and heterogeneity, notably for the endangered Florida panther, reduce the incidence of destructive wildfires, and improve the quality and timing of freshwater discharges to Faka Union Bay, Pumpkin Bay, Rookery Bay, Ten Thousand Islands, and Naples Bay.

The areas along the Lower East Coast are generally included in the Water Preserve Areas concept and should be carefully examined to ensure remaining areas are preserved or restored, where feasible. The Model Lands Basin that is located in southern Miami-Dade County is one such area. It is predominately east of U.S. 1 and encompasses approximately 79,000 acres. U.S. 1 and Card Sound Road have impeded the flow of water to the basin, impacting wetland habitat and necessitating discharges to downstream bays. Restoring hydrologic connections and functions to the Model Lands, including improving the hydrologic connections under U.S. 1, would not only improve the functional quality of these wetlands, but would also help restore Barnes

Sound, Card Sound, and Biscayne Bay. Additionally, it would complete a contiguous wildlife corridor stretching from the basin southward to the Florida Keys National Marine Sanctuary. Similarly, the Pennsucco wetlands, west of the Dade-Broward levee in northwestern Miami-Dade County, are peripheral wetlands used by foraging wading birds, including endangered species. Management of the Pennsucco wetlands, the final footprint of which is being considered by the Northwest Dade County Freshwater Lake Implementation Committee, should include maintaining and enhancing the habitat and foraging benefits of this area for wildlife.

The South Florida Ecosystem Restoration Working Group, the Chair of the Governor's Commission, and the Miami-Dade County Commissioners have supported the need to protect open spaces and wetlands that serve vital hydrologic functions for Biscayne Bay. This refers to lands between Biscayne National Park and Miami-Dade County's present Urban Development Boundary. These lands are all that remain of once vast coastal uplands, prairies, and wetlands in the Biscayne Bay Basin that filtered, conditioned, and dispersed freshwater flowing east into Biscayne Bay. These lands have been drastically reduced in area and in hydrologic integrity. The protection and hydrologic improvement of these areas is needed to sustain agriculture and the marine systems of Biscayne National Park.

6.4.9. Concept 9: Invasive Plant Control

Non-native ("exotic") plant species, such as melaleuca, Australian pine, Brazilian pepper, torpedo grass, and hydrilla have invaded large portions of the south Florida ecosystem. This occupation resulted in the displacement of native species and/or the degradation of habitat essential to native plants and animals. Melaleuca is especially damaging because of its high rate of evapotranspiration compared to native grasses that may contribute to lowering water levels in the Everglades and Lake Okeechobee. Aerial and other types of surveys reveal the proliferation of exotic plants has resulted in the formation of melaleuca monocultures in some areas of the Water Conservation Areas. Surveys also show their occurrence throughout most areas east of the Water Conservation Areas, particularly those that may be included as Water Preserve Areas. Even when these plants do not occur in natural areas, they act as seed sources and pose a threat to natural areas. Control or eradication of invasive exotic plants is necessary to improve and protect habitat quality and heterogeneity.

This concept includes the development and evaluation of methods to control invasive (exotic) plants throughout south Florida, the application of these methods to control exotics within the C&SF Project area, and the establishment of success criteria combined with appropriate biological monitoring. Successful control of exotic pest plants depends on the formation of cooperative intergovernmental and public/private partnerships.

Existing methods to remove invasive exotics are being used throughout south Florida. These methods include mechanical harvesting, application of herbicides, and use of biological agents. Because extensive use of herbicides is contrary to water quality improvement, alternative methods, such as biological controls, need further investigation or testing on a trial basis.

While past and present invasive exotic eradication activities have been limited, it appears that future activities may be further reduced because of Federal budgeting priorities. The Commission believes that a comprehensive invasive exotic plant control program that includes monitoring activities designed to map the distribution and abundance of exotics throughout south Florida must be developed and implemented to control and eventually remove invasive exotics from natural habitats. Additionally, melaleuca should be added to the Corps' list of invasive aquatic plants so that funds can be allocated for its control. The use of volunteers, analogous to the University of Florida's Institute for Food and Agricultural Science's Lake Watch program, should also be considered as part of a sustained eradication strategy.

The Science Subgroup of the South Florida Ecosystem Restoration Working Group, in their November 15, 1993, report, recommended that short hydroperiod wetlands should be reestablished. The Restudy process should investigate the role of short hydroperiod wetlands in south Florida natural system restoration and, if additional short hydroperiod wetlands are determined to be necessary, their location and spatial extent must be determined.

6.4.10. Concept 10: Aquifer Storage and Recovery

This concept addresses the potential use of Aquifer Storage and Recovery technology as a means of storing water in aquifers for future use. Water is injected into an aquifer during periods of surplus for later recovery during dry periods. Storing water in an aquifer, such as the upper Floridan, using Aquifer Storage and Recovery technology may provide greater storage efficiency when compared to the land requirements and high seepage and evapotranspiration rates associated with above ground reservoir storage. Areas that could potentially benefit from Aquifer Storage and Recovery include the Everglades Agricultural Area, the Caloosahatchee Basin, St. Lucie Basin, Lake Okeechobee and the urbanized lower east coast. Aquifer Storage and Recovery technology should be investigated to determine its feasibility at a regional scale, as well as its environmental impacts.

Water quality concerns, particularly regarding untreated surface water, currently limit the ability to use Aquifer Storage and Recovery. Aquifer Storage and Recovery should be tested to evaluate technical uncertainties with high capacity applications (GCSSF, 1996a). In planning a pilot study for large-scale Aquifer Storage and Recovery, several issues need to be addressed. These include environmental and health concerns regarding water quality, current regulatory constraints, costs of the project, and potential benefits of having additional clean water at the chosen site.

Potential locations for Aquifer Storage and Recovery pilot projects include sites on the fringe of Lake Okeechobee, to store excess lake water that would either be lost through discharge to tide or create harmful, prolonged high water conditions in the lake's 100,000 acre marsh. Since the higher lake regulation schedule was fully implemented in 1979, discharges to the estuaries have exceeded 400,000-acre feet in 10 of the following 17 years. During six of those years, discharges exceeded 1,000,000-acre feet; during two years discharges exceeded 2,000,000-acre feet; and during one year discharges exceeded 3,000,000-acre feet. Damaging prolonged high water levels also covered the lake's marsh for a number of those years. When the rain comes, we cannot refuse to accept it. When the lake rises to damaging or dangerous levels, our current choices are limited to accepting damage to lake's marsh, or the estuaries, or both. If the goals of protecting the estuaries and the lake's marsh, while improving the quality, heterogeneity, and expanding the spatial extent of Everglades system natural habitats are to be achieved, development of alternative water storage methods for the massive amounts of water entering Lake Okeechobee is vital.

Current water supply demands are projected to increase to meet environmental goals and expanding water supply needs. There is also a need to both protect the lake's marsh and to establish minimum levels for natural waterbodies. Storage of excess water during years of surplus for use during drought years will become increasingly important. Acquiring sufficient lands to hold all of an average year's estuarine discharge is cost prohibitive. Using Aquifer Storage and Recovery in combination with Everglades Agricultural Area storage has the potential to store large amounts of water at its source and close to the demand while protecting the ecological health of the estuaries and the lake. A proposed Aquifer Storage and Recovery project utilizing Lake Okeechobee water is currently under review by the U.S. Environmental Protection Agency and Florida Department of Environmental Protection. The Commission supports this pilot project.

The possibility of conducting pilot projects at other sites, using other aquifers, should also be considered. Sites within the Lower East Coast which could store, in the upper Floridan aquifer, water taken from the Water Preserve Areas should also be considered. If large-scale Aquifer Storage and Recovery is shown to be feasible, more extensive regional scale facilities utilizing untreated surface water runoff and Lake Okeechobee discharges could be beneficial in meeting additional demands within the region. Detention facilities or canals that intercept and hold excess water for injection into the aquifer may be required at some sites. The quality of untreated stormwater runoff may preclude its injection for Aquifer Storage and Recovery purposes under current regulations

Regional scale Aquifer Storage and Recovery facilities could be beneficial in meeting demands in the Caloosahatchee River and St. Lucie River Basins, or other basins. Water quality concerns would also be present in these areas. Regional scale Aquifer Storage and Recovery in association with the Water Preserve Areas has also been proposed for western Miami-Dade, Broward, and Palm Beach Counties. The source of water would be surface water backpumped into the Water Preserve Areas or canal flow. Utilization of Aquifer Storage and Recovery in these areas may increase the storage capability of the Water Preserve Areas and provide more urban water supply benefits for these areas. The feasibility of Aquifer Storage and Recovery in association with the Water Preserve Areas may be limited due to many of the same water quality concerns that face projects using untreated surface water in other areas. The Commission recognizes that water injected into the aquifer may not meet appropriate water quality standards. Water recovered from the Aquifer Storage and Recovery system may not have the appropriate quality for its intended use. A final consideration is that Aquifer Storage and Recovery facilities are most useful at the site of water treatment plants, where clean treated water can be injected, plant operation economies can be realized, and conveyance losses can be eliminated.

6.4.11. Concept 11: Protection and Restoration of Coastal, Estuarine, and Marine Ecosystems

Florida's estuaries and bays have been harmed by human alterations to the ecosystem within the last 50 years. Without drainage canals to divert storm and surface waters, development in low-lying coastal areas would never have been possible. Unfortunately, too much water is diverted too efficiently. Untreated stormwater is rapidly funneled out to sea through the estuaries instead of being stored in wetlands. What remains of the inland marshes seldom receive their full share of water. Estuaries suffer from a glut of freshwater following heavy storms and a lack of freshwater when not enough water is stored in the system to make it through Florida's dry winters and periodic droughts.

These alterations have radically changed the volume, timing, and quality of freshwater flow to south Florida's estuaries. From the Indian River and St. Lucie estuaries to the Biscayne and Florida Bays, the Ten Thousand Islands to the Caloosahatchee tidal river estuary, the quality of estuarine habitat for fish and other marine resources has been affected by freshwater flow changes associated with the C&SF Project and other water control efforts (e.g., the Golden Gate Estates canal system). In general, channelization decreases the time lag between rainfall and runoff. This increases the rate of flow to certain downstream estuaries during the wet season and decreases the flow during the dry season. Estuarine life is negatively impacted both by the wet season excesses and the extended dry season deficiencies. Surface water also permeates the soil and becomes groundwater, whose quantity, quality, and distribution is equally important to coastal systems, such as Biscayne and Florida Bays. An extreme example of this problem is in the upper Ten Thousand Islands, where 200 square miles of the Big Cypress wetlands is channelized into Faka Union

Bay. Freshwater flow has been diverted away from Florida Bay and the mangrove estuaries of the Lower Southwest Coast (e.g., Whitewater Bay), possibly resulting in both wet season and dry season deficits. In the St. Lucie and Caloosahatchee Estuaries, regulatory releases from Lake Okeechobee have exacerbated the problems of excess flows.

Water quality in the Keys and on the reef tract is declining due to macro-scale regional development in south Florida, the diversion of water away from Florida Bay, and detrimental water quality activities locally and regionally. Over the years, the cumulative effect of these changes is catastrophic. Murky water and algal blooms have replaced the clear waters of Florida Bay. Similar degradation is occurring in northern Biscayne Bay. The highly productive seagrass beds and fisheries of the St. Lucie and Caloosahatchee Estuaries, as well as Florida Bay, are now in decline as a result of dramatic fluctuations of freshwater input into estuarine and marine waters. Diseases and eutrophication threaten the coral reef systems of the Florida Keys. The Commission places a high priority on protecting and restoring south Florida's coastal and marine ecosystems, not only for their intrinsic value, but for protecting the fisheries, the fishing and tourist industries, and the characteristic south Florida lifestyles that depend on nature's bounty. Understanding the linkage between the lower watersheds, the Ten Thousand Islands, and Florida Bay is critical to developing solutions that provide for sustainability of the Keys.

The Florida Keys, including Florida Bay and the offshore coral reefs and sea grasses, are a threatened resource of international significance. In response to the Governor's Executive Order directing public agencies to take action to improve environmental conditions in the Keys, a carrying capacity study of the Florida Keys has been initiated by the Corps with funding provided by the Florida Department of Community Affairs. The study will result in an information base upon which informed development and infrastructure investment decisions can be made to achieve a balance between the economic and environmental needs of the area. Research activities in Florida Bay are being coordinated by the Florida Bay Program Management Committee. The Program Management Committee has developed the Florida Bay Research Plan and is utilizing adaptive management in the implementation of that plan. Although numerous research and monitoring activities are currently underway in Florida Bay by a variety of governmental agencies and private organizations, a process to collectively evaluate the information and develop a comprehensive plan of action is not currently planned or programmed. A program is needed to ensure effective coordination of all efforts in Florida Bay, identify all the problems and their sources, and develop a plan of action and implementation process. A comprehensive literature search and data analysis will serve to ensure that all activities influencing the bay are identified and that adequate monitoring activities are implemented. The program should also include analyses that give sufficient consideration to any improvements of current state and Federal water quality standards that may be needed to achieve the Commission's goal of sustainability.

The programmed and proposed projects that form previously described concepts of the Commission's Conceptual Plan for the Restudy involve restoring appropriate freshwater flows to bays and estuaries to protect natural salinity gradients, restore water clarity and quality, and improve water supply through management changes within the south Florida Region. The Florida Bay Emergency Interim Plan (Taylor Slough Demonstration Project), the C-111 Project, Modified Water Deliveries to Everglades National Park Project, the Lake Okeechobee Operational Plan, and the creation of water storage areas in the Water Preserve Areas, Caloosahatchee Basin, and the Upper East Coast area will help protect the region's coastal estuaries from the detrimental effects of excessive stormwater runoff and will improve essential baseflow of freshwater during dry seasons. Projects identified as part of the regional Surface Water Improvement and Management plans will serve to improve the quality of water delivered to the coastal areas through development and implementation of best management practices for agricultural and development activities, retrofitting of existing stormwater management facilities to reduce pollutant loads, and elimination of sewage effluent discharges and septic tank impacts. The various regional Surface Water Improvement and Management plans need to be integrated and coordinated with other adjacent local restoration efforts such as those for the Miami River and the New River.

Other major projects underway to achieve the Commission's goals for sustainability include the development of hydrodynamic circulation models for Biscayne Bay and Florida Bay. A hydrodynamic model of Florida Bay is under development for use in simulating water movement patterns in the Bay. Among other things, the model will enable salinity predictions from varying temporal and spatial freshwater inflows. The Florida Bay model will accept output from the hydrologic models used to predict overland flows to determine the impacts that the modifications and operational changes to the C&SF Project will have on Florida Bay. (Often, the hydrologic models can predict the volume and location of flows across the mangrove zone.) The model will be multi-dimensional, allowing two dimensional vertically averaged calculations at a minimum, and perhaps some three dimensional calculations where stratification is evident. The hydrodynamic model will be linked with a water quality model. Development of a mathematical computer simulation model system for Biscayne Bay is currently underway as a first step to investigate the effects of the C&SF Project on water circulation and salinity patterns. This effort must be further developed to assess impacts to biological communities and water quality in the Bay. The South Florida Water Management District developed a one-dimensional hydrodynamic model that predicts salinity throughout the St. Lucie Estuary under various inflow conditions from the watershed. This model was used to identify a salinity range that is favorable to the development and maintenance of a healthy estuarine ecosystem. This effort must be further developed and expanded to assess the C&SF Project freshwater discharge impacts on the Indian River Lagoon. These model efforts are essential to the identification of existing conditions and the evaluation of the effects of any proposed modifications to the C&SF Project on these important coastal resources.

6.4.11.1. Sediment Removal and Control in Estuaries

Accumulated organic sediments have been deposited in the Caloosahatchee and St. Lucie Estuaries. Organic sediments settle out in the estuaries as a result of sediment runoff and the interaction between fresh and estuarine water. These organic sediments deplete the dissolved oxygen and degrade water quality through resuspension during periods of physical disturbance. Removal of these sediments could improve water quality and possibly expose coarse-grained substrate suitable for aquatic plant growth along the littoral shelf of the estuaries. Small scale pilot projects should be implemented to determine the feasibility and environmental effects of muck removal or stabilization from the St. Lucie Estuary.

A report on a potential muck removal demonstration project for the St. Lucie Estuary was previously completed. The report recommended that further studies be conducted prior to proceeding with a demonstration project. The report concluded that large scale sediment removal may improve water quality by reducing re-suspension of fine sediments and would reduce oxygen demands in the water column, assuming upstream sediment sources were eliminated.

The St. Lucie Canal was constructed in the 1920s by the Everglades Drainage District. The canal banks are unstable in a number of areas along the length of the canal and material from the banks that sloughs off is transported and deposited as shoals in the St. Lucie Estuary. Stabilizing the canal banks with rip-rap, or reshaping and restoring vegetation on the canal banks could reduce the sediment loading to the estuary. The Restudy should include an analysis of the bank erosion and its impacts to the estuary. It may be possible to acquire additional rights-of-way and reshape the canal banks to create a functional littoral zone. Such projects could reduce erosion and produce other benefits such as water quality and habitat improvements. Additional study will be necessary to evaluate and quantify the benefits to the estuary from environmentally sensitive bank stabilization measures.

6.4.12. Concept 12: Conservation of Soil

Conservation of soils in the agricultural areas bordering the Everglades increases the opportunity for long-term sustainability of agriculture and natural areas. In particular, organic soil subsidence, caused by man's drainage facilities including the C&SF Project, is adversely impacting natural areas and agriculture in south Florida. Subsidence is created by a number of factors, including the oxidation of organic soils resulting from lowered water tables for extended periods of time, fires, wind erosion, and peat shrinkage.

In the Everglades Agricultural Area, soil loss has diminished the higher ground elevations that maintain the hydraulic head which drives water south. In some areas more than eight feet of organic soil was lost by 1984. Soils continue to oxidize; however, Best Management Practices should slow down the rate of oxidation. Some areas in the southern Everglades Agricultural Area, where shallow soils overlie bedrock, already have less than two feet of soil remaining. As soils subside, the movement of stormwater out of the area requires increased pumping. Soil conservation is also important in southern Miami-Dade County, where agriculture still forms a vital part of the local economy as well as a buffer between urban development and the natural system. In this area, soil conservation and sustainable agriculture programs will enhance the long-term viability of the ecosystem.

Research has shown that if soil moisture content of the organic soils is maintained for longer periods of time throughout the year, soil subsidence can be significantly reduced. Limited research is now underway to develop sugar cane varieties that can tolerate higher water levels, yet maintain an acceptable yield. These types of crops, some conversion to traditional wet-pasture beef cattle production, aquaculture, rice production, best management practices, and improved water management may significantly increase the long-term sustainability of agricultural activities in the Everglades Agricultural Area.

Increasing groundwater levels in the Everglades Agricultural Area will reduce the overdrainage that has caused the oxidation of organic soils. Under this concept, rainfall during the wet season will reduce the need for water from Lake Okeechobee to be used in maintaining these higher water tables. This should result in benefits to the natural system, including increased water storage in the Everglades Agricultural Area, decreased vulnerability to floods, and decreased necessity to send large pulses through the east coast and west coast estuaries. Further, water quality should be improved by reducing phosphorus inputs from oxidation and erosion of the soil through application of best management practices and maintenance of higher water tables.

Soil subsidence has also impacted portions of the natural system. Restriction and diversion of natural sheet flow has overdrained portions of the Water Conservation Areas, the Holey Land and Rotenberger Wildlife Management Areas resulting in areas of major subsidence. Overdrainage has also caused additional soil loss as a result of severe muck fires. In addition, tree islands have been destroyed through such soil loss. As soil elevations are altered, water levels change and the associated biological community is altered. Restoration of more natural flows and hydropatterns in the Everglades, Holey Land and Rotenberger Wildlife Management Areas and other natural areas should control the subsidence and potentially reverse the trend by creating conditions favorable to the accretion of peat soils.

The goal of current public and private research efforts is for modified water management to provide conditions enabling soil accretion rather than soil oxidation. This soil conservation activity, in both natural and agricultural areas, can serve as a measure of both the environmental and economic sustainability of restoration efforts. Opportunities exist to expand on these research efforts through public/private partnerships.

6.4.13. Concept 13: Operation, Management, and Implementation of the C&SF Project Modifications and Related Lands

The south Florida ecosystem is a water-driven system encompassing a massive, unique, and fragile natural system that is also home to five million human inhabitants. The C&SF Project provides a physical and operational framework around the south Florida ecosystem that offers options for managing the natural functions of the Everglades and other natural areas. The C&SF Project also provides other benefits, including flood control and water supply for the human population of south Florida. The interconnection of the C&SF Project, both within and without its boundaries, cannot be ignored for its contributions and complexity. This Project is a multi-purpose public works system that has inherent conflicts among the competing priorities of water management.

The Commission seeks to maximize the benefits of the C&SF Project while reducing the problems it has caused. In addition to the structural changes to the C&SF Project as expressed in the 40 options, and the other 13 thematic concepts, new operational and management measures for the system will be required. How the system is managed hydrologically affects virtually every aspect of the south Florida ecosystem. This suggests that the operational changes throughout the system are critical and thus require specific attention during the Restudy. The Restudy must incorporate the best available research and modeling to ensure the multi-purpose objectives are balanced and maximized. Effective monitoring programs must be developed that allow for the implementation of adaptive management strategies to ensure that the Commission's objectives are met.

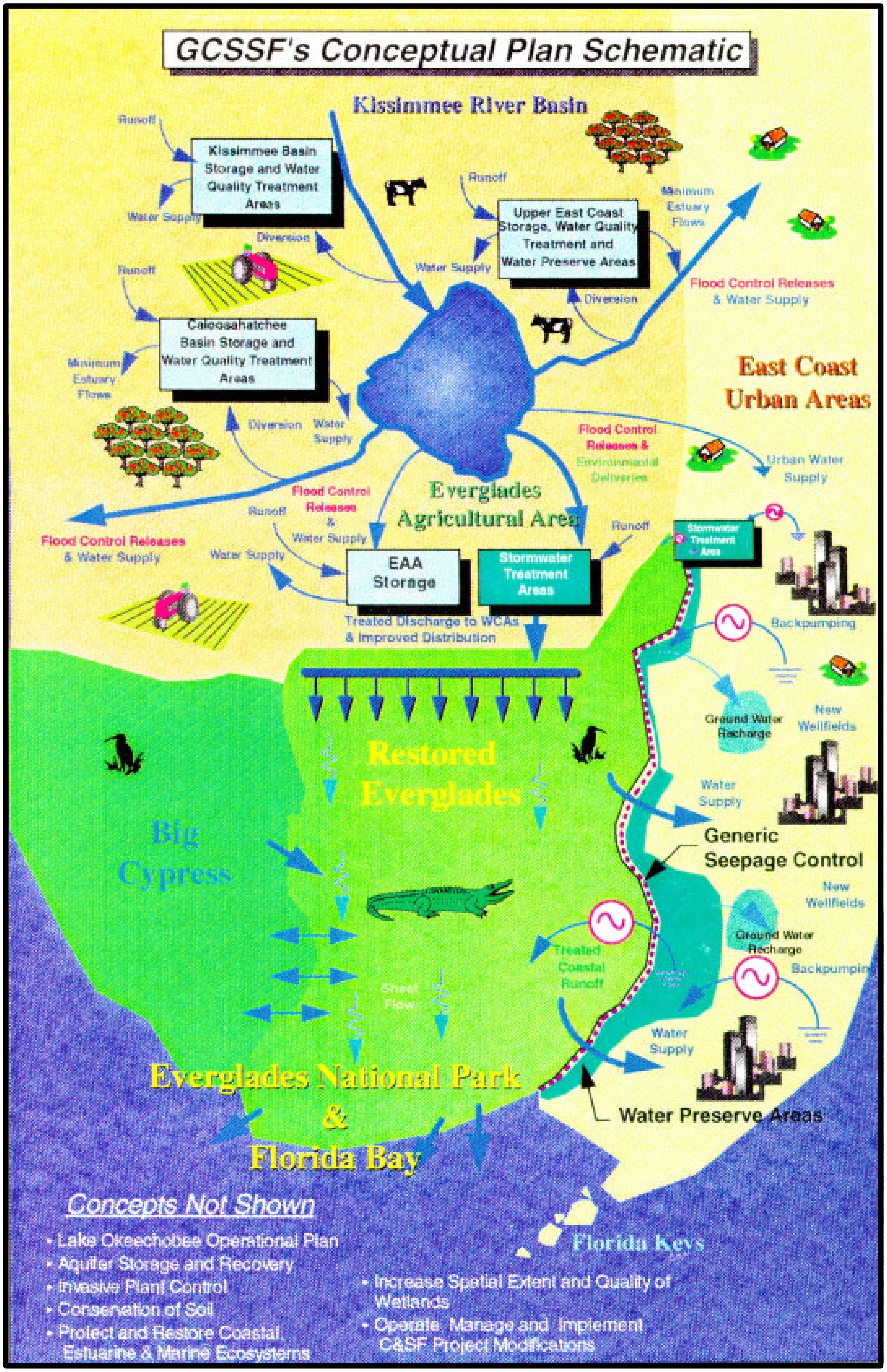
Where project operations are expected to affect lands (and their associated communities) being protected and restored as natural wetlands, operational planning needs to be consistent with sound biological science. Adequate provision is needed for monitoring biological impacts, especially where these operational changes may affect recovery efforts for endangered species and the protection of sensitive habitats.

As a first attempt to restore hydrology in Everglades National Park, a rainfall-based plan for water deliveries has been developed and implemented. A rainfall-based plan is a delivery formula that delivers water to natural areas based on antecedent climatic conditions. The Restudy should investigate the potential use of rainfall-based delivery formulas to determine if natural areas, including the Water Conservation Areas, and estuaries, can benefit from such operational changes to water deliveries.

Further, the Restudy and other efforts to provide for the sustainability of the south Florida ecosystem will ultimately determine both the extent of lands needed for the Project and the management of these lands. Rapid development of some areas of south Florida is limiting the ability to fully implement these modifications to the C&SF Project, which are needed for sustainability. As a result, the Commission has recognized the need to expedite certain land acquisitions prior to final planning and design of the modifications to the C&SF Project. Because lands are such a critical component to all restoration efforts in south Florida, recent Federal funding was provided to expedite implementation of potential project features. This has required the Commission and other decision makers to prejudge certain land acquisition projects without having all the scientific and engineering analyses completed. Acquisition of these identified priority lands should be limited to voluntary/willing sellers. Careful consideration must be given to determine the potential uses of the lands and, to the extent possible, the justification for acquisition of these lands should be based on available science.

Once acquired, these lands must be managed to meet the environmental and economic needs of the region. Meeting these needs will require the inclusion of advanced planning and land management strategies as part of the acquisition process. Such planning will ensure that the lands are properly utilized and managed consistent with the intended objectives. For example, one mechanism to help promote economic sustainability of the region would be to return agricultural lands back to agriculture, so long as such use does not conflict with long-term land use/management objectives, until a final project design utilizing these lands is completed. Therefore, these lands could be secured at an overall lower cost with less disruption to the south Florida economy.

FIGURE 6-1


GCSSF's Conceptual Plan Schematic
Kissimmee River Basin
Runoff
Kissimmee Basin Storage and Water Quality Treatment Areas
Water Supply
Diversion
Upper East Coast Storage, Water Quality Treatment and Water Preserve Areas
Minimum Estuary Flows
Flood Control Releases & Water Supply
Caloosahatchee Basin Storage and Water Quality Treatment Areas
East Coast Urban Areas
Flood Control Releases & Environmental Deliveries
Urban Water Supply
Everglades Agricultural Area
Flood Control Releases & Water Supply
EAA Storage
Stormwater Treatment Areas
Stormwater Treatment Area
Treated Discharge to WCAs & Improved Distribution
Backpumping
Ground Water Recharge
New Wellfields
Restored Everglades
Big Cypress
Generic Seepage Control
Treated Coastal Runoff
Sheet Flow
Everglades National Park & Florida Bay
Water Preserve Areas
Florida Keys
Concepts Not Shown
• Lake Okeechobee Operational Plan
• Aquifer Storage and Recovery
• Invasive Plant Control
• Conservation of Soil
• Project and Restore Coastal, Estuarine & Marine Ecosystems
• Increase Spatial Extent and Quality of Wetlands
• Operate, Manage and Implement C&SF Project Modifications

SECTION 7
PLAN FORMULATION AND EVALUATION

The purpose of this Section is to explain the process, called plan formulation, used in the Restudy to develop and evaluate alternative plans. This process involved the development of potential solutions to the water resource problems and the evaluations used to select the Comprehensive Plan. The iterative planning process followed during the Restudy is fully presented in this Section. In being so transparent and thorough, this Section presents information about planning iterations that is not typically found in a Corps feasibility report. While the process of following several progressive and comparative iterations is not unusual in water resources planning, it may be unusual to find it so rigorously documented. It would be more likely to find a simple presentation of the final array of alternatives (see ***Section 7.5***), with only a brief overview of the iterations that led to that array. In presenting all of the iterations, the Restudy has fully disclosed the decision making process that led to the recommended plan. Such full disclosure may carry the price of some confusion when it so clearly shows that the basis for making decisions continue to change with each iteration.

7.1 PLAN FORMULATION AND EVALUATION METHODOLOGY

Plan formulation is a repetitive, or iterative, process of identifying alternative plans that achieve a set of planning objectives and allows those plans to be modified as more information becomes available. Each subsequent iteration of this process provides an opportunity to refine and sharpen the planning focus. Key steps in formulating the alternative plans are shown in ***Figure 7-1***.

This plan formulation process evolved over three years, ultimately resulting in selection of a recommended plan. During this time frame, the Restudy team used an iterative process to identify and evaluate the merits of individual components and the effect of combining these components into “comprehensive plans.” This process involved separate sequential steps that allowed plans to be modified, as more information became available, allowing the opportunity to refine and sharpen the planning focus. This process resulted in discreet steps of formulation results that are displayed, as such, in this section. These discreet plan formulation steps are displayed in ***Table 7-1***.

FIGURE 7-1
ALTERNATIVE PLAN
FORMULATION & EVALUATION PROCESS

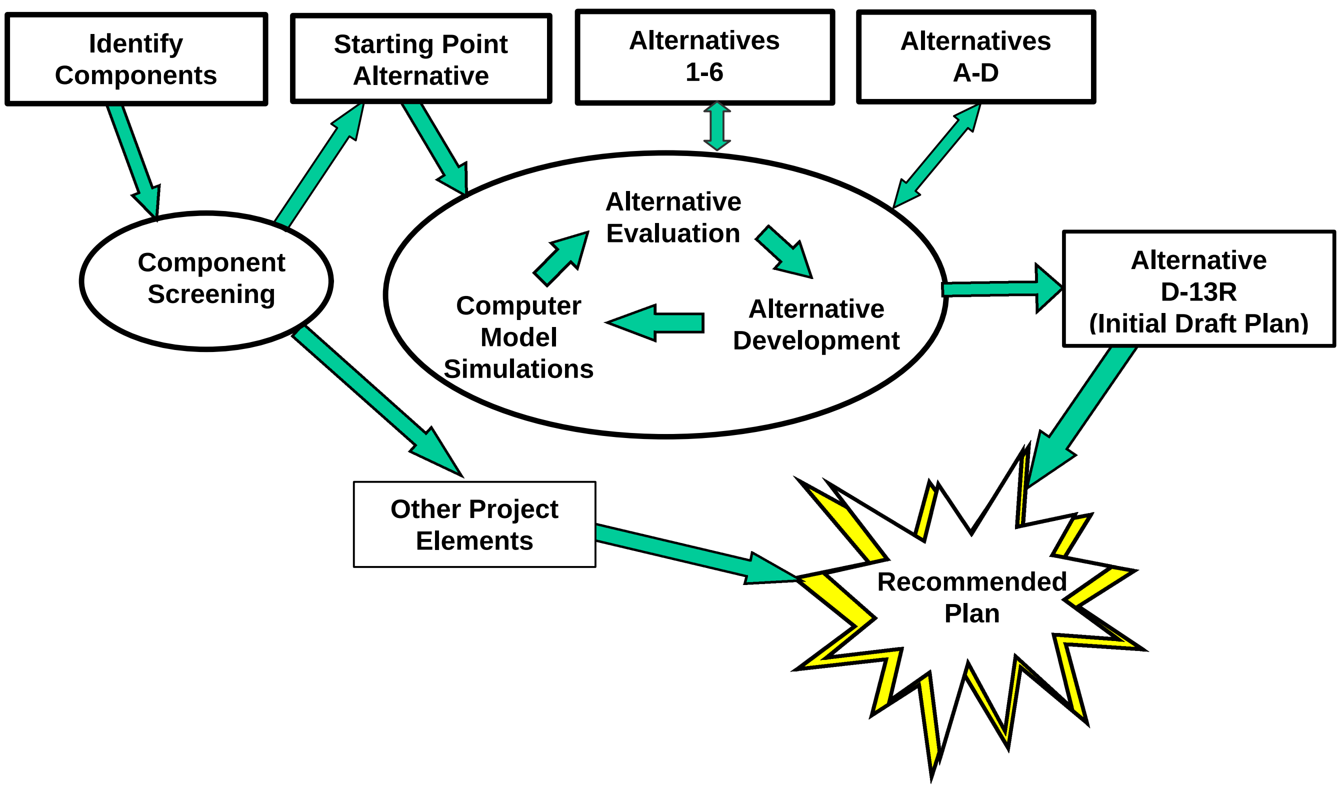


TABLE 7-1
PLAN FORMULATION STEPS

Formulation Process (Steps) →	Resulting Recommendation
Component Screening	Formulation of Alternatives 1-6
Alternatives 1-6	Additional Formulation of Alternatives 3-6 (A-D)
Alternatives A-D	Further formulation of Alternative D
Alternative D-13R	Selected as Initial Draft Plan
Other Project Elements (Separable Elements)	Added to Initial Draft Plan to form Recommended Plan

7.2 IDENTIFICATION AND SCREENING OF PLAN COMPONENTS

Plan formulation began by developing a list of the many different ideas to achieve the planning goals and objectives. These different ideas are called “components”. Components are the individual building blocks that can be combined in various ways to form alternative plans. They include both structural measures, such as reservoirs, pump stations, and canals, and nonstructural measures, such as reservoir operating schedules.

7.2.1 Identification of Plan Components

The Restudy was not the first effort to develop a list of components for water management in south Florida. Rather, it was able to take advantage of a vast array of previous studies and plans with similar planning goals and objectives. The Restudy's first list of components was developed in January 1996 and included components identified in the Reconnaissance Study (U.S. Army Corps of Engineers, 1994), the South Florida Water Management District's Draft Lower East Coast Regional Water Supply Plan (SFWMD, 1994a), and other sources. These sources were reviewed and discussed by the Restudy Team, and a first group of components were subsequently listed, described and linked to the planning goals and objectives.

This first list of components was considered and refined by the Governor's Commission for a Sustainable South Florida in its development of the *Conceptual Plan for the Restudy* (GCSSF, 1996b). The Conceptual Plan contained 40 components ("preferred options"), assembled into 13 thematic concepts, and served as the Restudy's initial framework for organizing components and developing a Comprehensive Plan (see ***Section 6*** of this report).

The Restudy Team met again in November 1996 to design a formulation and evaluation strategy for developing comprehensive plans. This meeting resulted in the development of the document entitled *Restudy Plan Formulation* (see ***Appendix A*** of this report) which outlined the Restudy goals and objectives, and listed and briefly described the components to be considered in developing alternative comprehensive plans.

The *Restudy Plan Formulation* document was subsequently used at 20 stakeholder focus group meetings throughout south Florida between January 1997 and May 1997 (see ***Section 11*** of this report). These meetings helped to ensure that most stakeholders were satisfied with the range of components to be considered and the strategy for formulating and evaluating alternative plans.

7.2.2 Screening of Plan Components

By the end of 1996, these efforts had produced an extensive inventory of potential components. Even after an initial screening of these ideas, the list of components numbered 112 (see ***Appendix A, Section 1*** of this report). The approach adopted by the Restudy Team to use these components in formulating a Comprehensive Plan was to begin with the formulation of a single plan. This plan, which the Restudy Team called the "Starting Point", would combine many of the listed components and could progressively be refined and shaped into the best possible Comprehensive Plan. In order to determine which components to include in the Starting Point plan, as well as in subsequent refinements, the list of components were evaluated to:

(1) optimize the general size, location, and configuration of certain components based on hydrologic criteria;

(2) rank order similar components in terms of their dollar costs and the magnitude of their non-dollar outputs; and

(3) reduce the number of components to a more manageable number for consideration in subsequent steps.

This evaluation process was called screening, and involved developing information bases from the Lower East Coast Regional Water Supply planning process and the Water Preserve Areas Land Suitability Analysis; hydrologic modeling primarily using the Everglades Screening Model; and a cost effectiveness analysis. The conclusions of the screening analysis are in ***Appendix A, Section 1*** of this report.

7.2.2.1 Screening Using the Lower East Coast Regional Water Supply Planning Process

The South Florida Water Management District's Lower East Coast Regional Water Supply planning process modeled and evaluated a series of five alternatives. Of the 112 Restudy components, 35 were previously modeled and evaluated in the Lower East Coast Regional Water Supply planning process.

Preliminary results from these alternatives provided information about the relative storage capabilities of components. In addition, it also provided insight into the system-wide affects and interactions among components. For example, the plan revealed the combined effects of modifications of the Lake Okeechobee operation schedule and storage facilities outside the Lake. This information was useful in establishing the best range of storage volumes. In addition, the benefits of rainfall driven delivery schedules for the Everglades were also evaluated.

7.2.2.2 Screening Using the Water Preserve Areas Land Suitability Analysis

The Water Preserve Areas concept was initially proposed by the National Audubon Society (1994) as a way to capture and store excess surface waters that are normally discharged into the coastal waters through the C&SF Project canals. This area would also serve as a buffer between the Everglades and the urban areas to the east. This concept has evolved from a number of studies including the South Florida Water Management District's East Coast Buffer Feasibility Study (CH2M-Hill, 1994) as part of the Lower East Coast Regional Water Supply planning process.

In 1995, a feasibility study for the Water Preserve Areas was initiated by the Corps and the South Florida Water Management District to accelerate the formulation and evaluation of Water Preserve Areas components. This study's land suitability analysis provided information about land cover, hydroperiod regime, and soils that was useful in determining the best places to: (1) store water, (2) recharge the aquifer, and (3) restore degraded wetlands.

This information provided considerable insight to determine the best locations for the Water Preserve Areas components. For example, the land suitability analysis identified sensitive wetlands that should be restored and less sensitive wetlands that could be used for water management purposes.

7.2.2.3 Screening Using the Hydrologic Screening Models

The Everglades Screening Model was the primary hydrologic computer model used for screening. This model simulates how water moves through south Florida and how operational and structural modifications to the C&SF Project may affect water movement. A complete discussion of the hydrologic modeling is in ***Appendix B***.

The Everglades Screening model was used to quickly evaluate and narrow the range of water storage concepts in the Everglades Agricultural Area, the Kissimmee River Basin, the Caloosahatchee Basin, and the St. Lucie Basin. It was also used to identify the range of storage options for: alternative Lake Okeechobee operation schedules; Lake Okeechobee aquifer storage and recovery systems; and Water Preserve Areas reservoirs and wetlands. It also provided information about how much water could be retained in the Water Conservation Areas using seepage barrier components.

7.2.2.4 Screening Using Cost Effectiveness Analysis

Cost effectiveness analysis was used to help identify the least expensive options to achieve a desired effect. Cost effectiveness analysis is typically done near the end of a study to compare complete alternative plans. However, the analysis can also be used earlier to compare similar components to assist in the formulation of cost effective alternative plans. A summary of how the analysis was used in the Restudy Plan Formulation is included in ***Appendix A, Section 2*** of this report.

Of the 112 Restudy components, 47 were analyzed using the cost effectiveness analysis. These components were grouped into seven different functional categories of output including, for example: reducing phosphorus loading to Lake Okeechobee, increasing water storage capacity in the Lower East Coast, and increasing acres of wetlands throughout the study area.

The cost effectiveness analysis provided information about the least costly way to achieve each level of output. For example, the analysis revealed that storage reservoirs in the Caloosahatchee Basin were more cost effective than Aquifer Storage and Recovery around Lake Okeechobee. Therefore, the reservoirs would be a better initial financial investment. This type of information was useful in selecting the best size of a component as well as a priority for selecting components based on the cost for the level of output achieved. However, the analysis was limited in scope such that only a single output was measured for each component. For example, a storage reservoir in the St. Lucie Basin not only increases water supply but it also reduces damaging flows to the St. Lucie Estuary. In this case, the one-dimensional approach used for the analysis resulted in under-estimating the effectiveness of the component. However, in other cases there were negative effects that were not measured. For example, backpumping to Lake Okeechobee results in increased water supplies but it could impact the Lake's littoral zone and this impact was not measured during this analysis.

Further, without a target, the screening conclusion was limited to identification of the most efficient component. That is, the component with the lowest cost per unit of output desired. If an output target was available, and the most efficient component failed to meet its target, the analysis was used to identify the next most efficient component or group of components.

7.2.2.5 Screening Using Other Analyses and Best Professional Judgement

In addition to the other screening techniques, the Restudy Team used information from a variety of sources including previous C&SF Project studies, and South Florida Water Management District Surface Water Improvement and Management (SWIM) Plans. The Restudy Team also took advantage of the extensive knowledge and experience of the team members and others that have lived and worked in south Florida and had a day-to-day familiarity with the water resources issues being addressed in this feasibility study.

7.2.3 Screening Conclusions

A summary of the major findings from the screening analysis is shown in ***Table 7-2***. For more detailed screening conclusions about each of the 112 components, see ***Table 5*** in ***Appendix A, Section1***.

TABLE 7-2
SCREENING CONCLUSIONS SUMMARY

KISSIMMEE RIVER REGION
• Storage reservoirs effective for Lake level management
• Water quality treatment very cost effective for improving Lake Okeechobee
• Paradise Run most cost effective way to increase spatial extent of wetlands in this basin
UPPER EAST COAST REGION
• Storage reservoirs for C-44 Basin effective to improve estuary conditions
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, adverse impacts to Lake's littoral zone were not evaluated
• Adding Aquifer Storage & Recovery to storage reservoirs should be considered
• Opportunities to increase spatial extent of wetlands in this basin
• C-23, C-24, and C-25 Basins being considered in detail as part of Indian River Lagoon Study
CALOOSAHATCHEE RIVER REGION
• Storage reservoirs effective.
• Lake Hicpochee should be considered as first increment for storage
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, adverse impacts to Lake's littoral zone were not evaluated
• Adding Aquifer Storage & Recovery to storage reservoirs should be considered
LAKE OKEECHOBEE REGION
• Increases to Lake levels cost effective; however, adverse impacts to Lake's littoral zone were not evaluated
• Regional Aquifer Storage & Recovery not cost effective in this area for Lake level management (however, later screening analyses showed that this component was effective at reducing flows to the St. Lucie and Caloosahatchee Estuaries)
EVERGLADES AGRICULTURAL AREA REGION
• Storage reservoirs effective
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, potential adverse impacts to Lake's littoral zone were not evaluated
WATER CONSERVATION AREAS REGION
• Detailed modeling required to evaluate components to reconnect habitats
• Rainfall driven delivery schedules are needed to achieve hydropattern restoration
BIG CYPRESS REGION
• Restoration of southern Golden Gate Estates very cost effective to increase spatial extent of wetlands
LOWER EAST COAST REGION
• Southern L-8 project effective in delivering water to North Palm Beach County and Loxahatchee Slough
• Urban Water Supply: (depending on location) wellfield relocation/expansion, utility Aquifer Storage & Recovery, and secondary canal operations are effective
• Regional Aquifer Storage & Recovery is very effective on C-51 and Hillsboro Canals
• Opportunities to increase spatial extent of wetlands in Northern Palm Beach County, Model Lands, and Biscayne Bay coastal areas
WATER PRESERVE AREAS
• Storage reservoirs adjacent to Water Conservation Areas effective in a number of basins
• Aquifer Storage & Recovery should be considered to reduce size of storage reservoirs
• Seepage collection and backpumping generally most cost effective seepage management component
• Water quality treatment needed if drainage water is backpumped to natural areas
• Opportunities to increase spatial extent of wetlands

7.3 FORMULATION AND EVALUATION OF ALTERNATIVE PLANS

The next phase of plan formulation involved assembling components into alternative plans to meet the planning goals and objectives. These plans came from an iterative process that began with the formulation of a Starting Point plan based on the screening conclusions. Subsequent iterations methodically created new plans based on how well they performed relative to the objectives and associated performance measures and targets.

7.3.1 Methodology for Formulation and Evaluation of the Alternative Plans

Alternative plans were formulated and evaluated by two teams, the Alternative Development Team (ADT) and the Alternative Evaluation Team (AET). Each of these teams had a specific planning purpose. The Alternative Development Team was responsible for designing each alternative plan in response to the Alternative Evaluation Team's evaluations of the previous plan iteration. The designs of these alternative plans were built into the South Florida Water Management Model, a regional-scale hydrologic model (see ***Appendix B*** of this report), to identify plan effects. The Alternative Evaluation Team was responsible for evaluating each plan's strengths and weaknesses, and describing plan shortfalls to the Alternative Development Team. This repetitive formulation and evaluation process progressively refined and improved the performance of subsequent alternative plans.

Communication between these teams and among team members was facilitated by several mechanisms. First, a small cadre of interdisciplinary experts participated on both the Alternative Evaluation Team and the Alternative Development Team to assure timely and consistent communication between the teams. Second, the over 100 members of the overall Restudy Team met seven times during this process and had the opportunity to participate in both the formulation and evaluation processes.

Finally, because of the large and geographically dispersed number of people involved and interested in the Restudy, the Internet was used to communicate formulation and evaluation results. This allowed the Restudy Team to solicit comments from a broad base of the public and permitted people to participate as team decisions were being made. The Restudy Internet address is ***http://www.restudy.org***.

7.3.1.1 Alternative Development Team

The Alternative Development Team was a multi-agency team of about 30 planners, engineers and scientists. The team identified and designed specific components to be simulated in the South Florida Water Management Model with the intent to improve the performance of each alternative plan and to test different strategies for component modification identified by the Alternative Evaluation Team.

7.3.1.2 South Florida Water Management Model

The South Florida Water Management Model (see ***Appendix B***) is a regional-scale computer model of the water resources system from Lake Okeechobee to Florida Bay. This is an integrated surface water – groundwater model based on historical climatic data for the 31-year period between 1965 and 1995. This period includes a range of drought and wet periods that are believed to encompass a number of extreme hydrologic events for simulation purposes.

The model simulates the major elements of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and groundwater pumping. As the water management control structures and operational rules are changed, the model simulates the effects on these hydrologic conditions.

The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region. Technical experts have extensively reviewed and accepted this model as the best available tool for analyzing regional-scale structural and operational changes to the complex water management system in south Florida.

The model was used to estimate hydrologic responses to proposed structural and operational modifications to the water management system in south Florida. The large scale and spatial extent of the model allows it to perform system-wide evaluations. For example, the model can estimate hydrologic conditions, such as the depth of water, in the Water Conservation Areas and Everglades National Park, if changes are made in Lake Okeechobee's operations.

7.3.1.3 Alternative Evaluation Team

The Alternative Evaluation Team was also a multi-agency team of about 50 biological and physical resource specialists, planners, and engineers. The team was responsible for plan evaluation, including:

(1) developing quantitative indicators of plans' performance (called performance measures) and targets for each indicator,

(2) comparing model results against performance targets to identify the most significant strengths and shortfalls of each alternative plan,

(3) providing the "top 10" shortfalls of each plan to the Alternative

Development Team,

(4) performing the evaluation and comparison of the final array of comprehensive alternative plans, and

(5) collating and considering comments from the public and Restudy Team regarding each alternative plan.

The Alternative Evaluation Team used multiple analytical tools to accomplish the alternative plan evaluations: performance measures from the South Florida Water Management Model computer simulations, the Across-Trophic-Level System Simulation (ATLSS) model, and water quality models.

7.3.1.3.1 Performance Measures

The Alternative Evaluation Team developed a set of performance measures as the basis of its evaluations for all areas of concern. Each performance measure was implicitly linked to one or more of the planning objectives, and consisted of a measurable indicator and target. The performance measures were largely indicators of hydrologic characteristics. The performance measures were used to judge how well each alternative met the objectives.

Many of the performance measures used to measure progress toward the ecological objectives were based on hydrologic patterns revealed by the Natural System Model. This model was developed from the South Florida Water Management Model by removing the complex network of canals, structures and levees in the current system and replacing them with the pre-drainage rivers, creeks, and transverse glades. The topography of subsided areas are adjusted in the Natural System Model to estimated pre-drainage levels. The output from the Natural System Model represents the best available approximation of the pre-drainage condition and is the basis for many of the restoration targets. Refer to ***Appendix B*** of this report for a more detailed description of the Natural System Model.

The hydrologic patterns shown by the Natural System Model are generally consistent with what is known or hypothesized about the optimum hydrologic patterns for a number of characteristic plant and animal communities in the historic Everglades. The Alternative Evaluation Team agreed that it was appropriate to use the model as a basis for setting targets if appropriate scales were used. For example, it would be appropriate to use the model to get targets for the duration of inundation, depth and distribution patterns over a broad area; but it would not be appropriate for development of depth targets at scales less than plus/minus 0.5 feet, or to be used for estimates of flow volumes.

Performance measures were also developed to evaluate the degree to which the alternative plans are likely to meet water supply objectives. These considered the frequency, duration and severity of water supply restrictions for both urban and agricultural areas. Flood protection performance measures were also developed. However, due to the coarse spatial resolution of the South Florida Water Management Model, these performance measures were simply used to identify areas of concern.

For each alternative plan, the South Florida Water Management Model produced information about the performance measures in the form of tables, graphs and maps. This information was useful for two reasons. First, the results could be compared against the performance measure targets to evaluate plan success at achieving the objectives. Second, the information was used to compare different conditions including: the Existing Condition (1995 Base), the Future "Without Plan" Condition (2050 Base), and any of the previously simulated alternative plans. For example, a graph may compare Alternative 1 with the Natural System Model (Historic Condition), the Existing Condition, and the Future without Plan Condition.

7.3.1.3.2 Across Trophic Level System Simulation Model

The Across Trophic Level System Simulation (ATLSS) model ***(Appendix D)*** is a set of computer models that integrates several approaches for different levels of the ecologic hierarchy. The model uses hydrologic information from the South Florida Water Management Model simulations of the alternative plans and predicts biological responses of several species and species groups. The basic models of ATLSS model included:

- Cape Sable Seaside Sparrow Breeding Potential Index
- Wading Bird Foraging Condition Index
- White-tailed Deer Breeding Potential Index
- Landscape Fish Model
- Cape Sable Seaside Sparrow Individual Based Model
- Snail Kite Breeding Potential Index

The nature and extent of ATLSS model results depended on the progress of each model's development and therefore varied among species and species groups. For example, detailed results were available for the Cape Sable seaside sparrow's western population and for fish abundance because development of these models was nearly complete at the time the alternative plans were evaluated. Less detailed results were available for foraging and breeding condition indices for the snail kite, wading birds, and others because these models were in earlier stages of development.

ATLSS model results for each alternative were compared with results for other alternatives, the 2050 Base, and in most cases, with 1995 Base. When results indicated that an alternative would improve species' biological responses as compared to the other conditions, the Restudy Team concluded that there was evidence to suggest that the alternative was beneficial for those species as compared to the other conditions.

7.3.1.3.3 Water Quality Models

The effects of alternative plans on water quality were evaluated using three analytical tools. The Lake Okeechobee Water Quality Model (James *et al.*, 1997) simulated lake eutrophication processes. The Everglades Water Quality Model (SFWMD, 1997h) simulated phosphorus transport in the Everglades Protection Area. In addition to these two models, an analysis (Walker, 1998) of the performance of the Everglades Construction Project and proposed reservoirs in reducing phosphorus was utilized.

7.3.1.4 Basis for Formulation and Tradeoffs for the Alternative Plans

In formulation for ecological restoration, the team agreed that it was important to make progress toward all the targets and that achieving a target in one area should not cause damage to another area. Recovery of an Everglades-like system is more likely to occur through recovery of a strong balance of all of the hydrological features that characterized the pre-drainage system. These features include spatial extent, duration of hydroperiods, sheet flow, flow volumes into estuaries and depth patterns.

Fundamentally different strategies for achieving Everglades restoration have been characterized as the "cookie cutter" and "Xerox reduction" approaches. Should the goal be "point-for-point" matches with pre-drainage characteristics in the remaining portions of the Everglades ("cookie cutter"), or should the goal be to recreate all the original community and landscape proportions in an Everglades that is now one-half its pre-drainage size ("Xerox reduction")? While this question prompted a healthy debate, most recent views have been (a) we should do neither, or (b) we should do some combination of the two.

Plan formulation for the Restudy was based on a variety of approaches. Alternative plans were formulated in an attempt to achieve pre-drainage targets, that is, a "cookie cutter" approach was followed. Additionally, a "Xerox reduction" approach was also achieved because the proportion of long-hydroperiod sloughs to short-hydroperiod prairies in the current Everglades is similar to the proportion between these two landscapes in the pre-drainage system.

The Restudy Team began formulation with the expectation that it would be possible to design a plan that would meet all of the performance measure targets. The team assumed that the targets could be met by increasing the amount of stored water, minimizing the amount of excess water to tide and re-distributing it.

As the process proceeded, it became increasingly apparent that, given the physical, operational, legal, and societal constraints in south Florida, it would not be possible to fully achieve every performance measure target. The constraints created situations where alternative plans could not meet all targets in all areas at all times resulting in the need to make tradeoffs among competing objectives. Tradeoff situations included cases where the volume of water was insufficient, or management options for local or sub-regional water supplies were sufficiently limited. Since it was not possible to reach all targets, the Restudy Team established the following guidelines for setting priorities among competing performance measure targets:

(1) The pre-drainage hydrological patterns shown by the Natural System Model are most likely to lead to the recovery of natural systems, and should be a priority for the natural wetlands of south Florida over other targets.

(2) Where not all pre-drainage hydrological parameters can be recovered, or where meeting these targets reduces the ability of a plan to meet pre-drainage targets in a different part of the system, the Conceptual Ecological Models (see ***Section 5*** of this report) set the priority for hydrological targets. Each Conceptual Ecological Model identifies critical ecological pathways which show the critical hydrological parameters related to ecological changes, and which should be given priority.

(3) Restoration should not cause additional, long-term ecological damage. However, the Restudy Team, recognizing that substantial changes in community structure and natural system boundaries have occurred over the past 100 years, is willing to see additional local community shifts (short-term "damage") occur if these would allow the realization of larger scale restoration targets. This view is consistent with the recognition by most Everglades ecologists that a successful Everglades restoration program will be one that recovers those ecological characteristics that defined the original system to a sufficient degree so that a "new" Everglades-type ecosystem is created (Davis and Ogden, 1994).

(4) Priorities for ecological targets may be based on criteria other than those shown by the pre-drainage model where there is a compelling technical basis for doing so. However, such targets may not have priority if, in meeting these targets, it becomes substantially more difficult to reach ecological targets in other regions.

7.3.2 Formulation and Evaluation Iterations

The formulation of alternative plans was generally an iterative process in which each plan was developed as a result of the evaluation of the previous alternative. Through the first three iterations, each alternative plan was developed in an attempt to improve upon the previous plan's performance. The iterative nature of this process allowed the team to learn more about particular components of the plans including how the components perform under a range of conditions. Through the last few alternative plans, a different approach to Everglades ecosystem restoration was explored, namely restoration through removal of the canals and levees within the remaining Everglades to restore connectivity and unrestricted sheetflow.

Each iteration began with an alternative plan. The components of that plan were built into the South Florida Water Management Model to simulate the plan's hydrologic effects. The model results were then posted on the Internet, and the Alternative Evaluation Team and others reviewed the results. These results were used as input into other models as described above to evaluate the plan's performance. Comments were provided to the Alternative Development Team, which in turn modified the alternative plan to improve performance shortfalls, thus creating the next alternative.

The iterative process to formulate and evaluate alternative plans began in September 1997 and was completed in June 1998.

7.3.2.1 Starting Point

The Starting Point was the first alternative plan formulated. It combined many of the features that were considered to solve system-wide problems. It was formulated by a Restudy sub-team with extensive experience in the C&SF Project and related studies such as the Lower East Coast Regional Water Supply Plan process and the Restudy Reconnaissance study.

The screening analysis provided the information needed to assemble the components into the Starting Point plan. Screening identified solutions for specific problems and the Starting Point integrated the individual solutions into a whole system-wide response. The components of the Starting Point are listed in ***Table 7-3***. The general philosophy of the Starting Point, and the first few alternatives, was to start small and build components with the intent to provide a clear justification as to why additional components were added in subsequent iterations.

The evaluation of the Starting Point showed the need for increased water storage throughout the system to meet ecological restoration and water supply objectives. In addition, the Starting Point included extensive seepage control components to keep more water in the natural system. However, the reduced seepage led to increased saltwater intrusion into the Biscayne Aquifer and urban wellfields. Therefore, formulation of Alternative 1 proceeded by increasing the storage capacity of the components proposed in the Starting Point and scaling back the rate of seepage management. It also included additional storage components and additional, more passive, seepage management components. The theme of adding additional storage continued throughout the plan formulation process.

TABLE 7-3
MAJOR COMPONENTS OF THE "STARTING POINT"

EAA Storage Reservoir
Caloosahatchee/C-43 Basin Storage Reservoir
St. Lucie/C-44 Basin Storage Reservoir
North of Lake Okeechobee Storage Reservoir
Everglades Rainfall-Driven Operations
Water Preserve Areas Components:
Site 1 Impoundment
Water Conservation Area-2B Seepage Management
C-11 Impoundment
Western C-9 Recharge Area
Central Lakebelt In-Ground Storage Reservoir
Bird Drive Impoundment
L-31N Seepage Management

7.3.2.2 Alternatives 1-6

Alternative 1 was formulated to overcome the water storage shortfalls identified in the Starting Point plan and to reduce the negative impacts of aggressive seepage management. ***Table 7-4*** lists the major features and design criteria used in Alternative 1 as well as the Starting Point and Alternatives 2-6. The evaluations of Alternative 1 and subsequently Alternative 2 continued to show the need for improved seepage management and greater storage throughout the system. However, it became evident that the remaining options to store additional water in surface reservoirs were more costly and other non-traditional storage options, such as aquifer storage and recovery (ASR, see ***Appendix C***), would have to be considered.

Alternative 3 substantially increased water storage capacity by including a series of aquifer storage and recovery components. However, the plan needed improvement in the timing and distribution of the water deliveries. Further, none of the plans had attempted to reestablish unrestricted sheetflow (connectivity) through the remaining Everglades.

Alternative 4 included partially decompartmentalizing the remaining natural system by removing physical barriers to flows. The alternative evolved from analyses of a series of South Florida Water Management Model computer simulations, called scenarios, that combined components of Alternative 3 with different amounts of levee and canal removal within the remaining Everglades. At a Restudy Team meeting on December 15, 1997 various approaches for modeling levee and canal removal within the natural areas of the Everglades were discussed. Three scenarios were formulated as a result of that discussion. Each scenario progressively removed more of the internal compartments between the Water Conservation Areas. The Alternative Evaluation Team evaluation of these scenarios showed that as levee and canal removal increased from south to north flows to Shark River Slough increased and some benefit was seen in the southern portion of Water Conservation Area 3A where extreme high water was greatly reduced -- because of removal of the L-29. However, removal of the levees and canals also resulted in extreme high water conditions in Water Conservation Area 3B and eastern Water Conservation Area-3A. With complete removal of the levees and canals from within the Water Conservation Areas, high water in Water Conservation Area 3B was the most extreme of any scenario or alternative considered by the Restudy Team. Further, drying conditions in Loxahatchee National Wildlife Refuge (WCA 1), Water Conservation Area 2A, and Northeast Shark River Slough were exacerbated, increasing the burden on Lake Okeechobee and impacting the littoral zone. Lower East Coast Region's dependence on the Lake for water supply increased as well.

Because one of the basic tenets of the Restudy is to do no harm to one part of the natural system in order to restore another, the team recommended taking a more moderate approach to levee and canal removal, understanding that if ways to mitigate the problems could be found, levee and canal removal of the upper part of the system could be reexamined at a later date.

Therefore, for Alternative 4 and each subsequent alternative, the barriers in the northern part of the system were retained. Specifically, the barriers between Loxahatchee National Wildlife Refuge and Water Conservation Area-2A and between Water Conservation Area-2A and Water Conservation Area-3A were kept to prevent excessive dry-downs in the Refuge and Water Conservation Area-2A and to protect Lake Okeechobee's littoral zone. The barrier between Water Conservation Area-2A and Water Conservation Area-2B was retained to prevent the excessive depths in Water Conservation Area-2B seen in the more extensive levee and canal removal scenarios.

The resulting alternative, Alternative 4, removed levees and canals within Water Conservation Area 3 and eliminated barriers between this Water Conservation Area and Everglades National Park. However, this alternative still produced unintended adverse consequences to Lake Okeechobee, water supply, and parts of the Water Conservation Areas.

Alternative 5 attempted to address problems created in Alternative 4. Many areas were substantially improved, but at this point it was clear that it would not be possible to precisely meet all targets. In addition, the timing and distribution of water in the Water Conservation Areas remained problematic.

Another plan, Alternative 6, was formulated to address the continuing problems identified from Alternative 5. This plan added additional high cost features including wastewater reuse. However, this plan was not evaluated in the same manner as the previous plans because the team recognized that the plans were no longer comparable. The formulation of the previous alternatives allowed the team to learn more about the individual plan components with each iteration. This led to component modifications and improvements in the later alternatives that were not included in the earlier alternatives. For example: excess flows in the Caloosahatchee Basin were identified and, as such, were available to store in the Caloosahatchee Basin or to backpump to Lake Okeechobee; and Biscayne Bay water demands were identified, resulting in degradation to the ecology of the Bay. Further, engineering designs of the components were improved upon with each iteration. For example, a stormwater treatment area was reduced in size from earlier plans because the land initially assumed to be available was not. An unintended consequence of these modifications and improvements was that the alternatives could not be fairly compared to each other. Therefore, the team decided to reformulate and redesign the alternative plans to place them on an equal footing for comparison.

TABLE 7-4
MAJOR FEATURES OF STARTING POINT – ALTERNATIVE 6

Major Features	Alternatives						
	Starting Point	1	2	3	4	5	6
North L.O. Storage	100K ac-ft	200K ac-ft	200K ac-ft	200Kac-ft	200K ac-ft	200K ac-ft	200K ac-ft
C-44 Basin Storage	20K ac-ft	20K ac-ft	40K ac-ft	40K ac-ft	40K ac-ft	40K ac-ft	40K ac-ft
C-43 Basin Storage	80K ac-ft	160K ac-ft	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR	160K ac-ft 220 mgd ASR
EAA Storage Area	240K ac-ft	240K ac-ft	240K ac-ft	360K ac-ft	360K ac-ft	360K ac-ft	360K ac-ft
Additional L-8 Improvements					25 mgd ASR	25 mgd ASR	50 mgd ASR 48K ac-ft
Site 1 Impoundment	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft 25 mgd ASR	10K ac-ft 75 mgd ASR	10K ac-ft 75 mgd ASR	14.8K ac-ft 150 mgd ASR
Western C-11 & North New River Diversion	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft	6.4K ac-ft
C-9 Impoundment and Diversion	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft	10K ac-ft
Central Lake Belt Storage	80K ac-ft	80K ac-ft	80K ac-ft	100K ac-ft	135.2K ac-ft	135.2K ac-ft	187.2K ac-ft
Bird Drive Basin Impoundment	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft	11.5K ac-ft
L-31N Seepage Management	100% Levee 100% Groundwater	100%Levee	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater	100% Levee 100% Wet Season Groundwater
Taylor Creek/Nubbin Slough Storage and Treatment			50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA	50K ac-ft Reservoir 20K ac-ft STA
Lake Okeechobee ASR				1K mgd ASR	1K mgd ASR	1K mgd ASR	1K mgd ASR
C-51 Regional Ground Water ASR				340 mgd ASR	540 mgd ASR	540 mgd ASR	340 mgd ASR
C-23/24/Northfork and Southfork Storage Reservoirs					165K ac-ft	190K ac-ft	192K ac-ft
North New River Regional Ground Water ASR				250 mgd ASR			
Hillsboro Canal Basin Regional Groundwater ASR				370 mgd ASR	220 mgd ASR	220 mgd ASR	
WCA-3 and ENP (Remove Canals and Levees)				9 miles of Canal	146 mi of Canal 82 mi of Levee	127 mi of Canal 54 mi of Levee	127 mi of Canal 56 mi of Levee
Palm Beach County Agriculture Reserve Reservoir					10K ac-ft	10K ac-ft 75 mgd ASR	19.9K ac-ft 75 mgd ASR
North Lake Belt Storage					70K ac-ft	70K ac-ft	90K ac-ft
Lower East Coast Water Conservation						6% Reduction in 2050 Utility Demands	6% Reduction in 2050 Utility Demands
South Dade County Reuse						131 mgd Capacity	131 mgd Capacity
C-51/Southern L-8 Reservoir							120K ac-ft Capacity
West Dade Reuse							100 mgd Capacity

Ac-ft - Acre-Feet, K- unit of 1,000's, STA - Stormwater Treatment Area, mi – miles, mgd - million Gallons per Day

7.3.2.3 Alternatives A-D

The next phase of plan formulation focused on developing a comparable array of alternative comprehensive plans. The team recognized that neither the Starting Point nor Alternatives 1 or 2 would achieve the planning objectives at levels that would be acceptable. Alternative 3, which had evolved from these first three plans, was clearly superior to its predecessors. Therefore, the Starting Point and Alternatives 1 and 2 were not considered further.

Next, the remaining alternatives were modified to reflect more current design assumptions that would make them comparable, and improve their performance. These changes fell into the following categories:

(1) Operational changes that would allow better performance of the alternatives (for example, climate forecasting for Lake Okeechobee operations and related reservoirs) or operational changes required due to a change to another component.

(2) Changes to the South Florida Water Management Model input data to account for better information (for example, runoff estimates from basins contributing inflow to the St. Lucie Estuary).

(3) Modifications to correct design deficiencies identified during formulation of Alternatives 1-5 (for example, canal design and location for backpumping water from C-17 to the West Palm Beach Water Catchment Area) or; design modifications to improve performance without an increase in cost (for example, relocating aquifer storage and recovery facilities from Hillsboro Canal to Site 1 Reservoir).

(4) Exclusion of components that were consistently poor performers (for example, North New River Regional Groundwater Aquifer Storage and Recovery).

(5) Inclusion of components that proved to be extremely good performers, but were omitted from earlier alternatives due to insufficient data (for example, Caloosahatchee Backpumping to Lake Okeechobee).

(6) Inclusion or exclusion of components as a result of changes to the base conditions (for example, inclusion of the C-4 Divide Structure that was previously believed to be implemented by the non-Federal sponsor but was subsequently proposed as an element of the Critical Projects Program).

In view of these changes, the team elected to rename the reformulated and redesigned alternative plans to clearly differentiate them from their earlier iterations. The final array of plans included:

- Alternative A, which was a reformulated and redesigned Alternative 3.
- Alternative B, which was a reformulated and redesigned Alternative 4.
- Alternative C, which was a reformulated and redesigned Alternative 5.
- Alternative D, which was Alternative 6.

Alternative A had the greatest number of changes from its original form, followed by Alternative B then C. ***Tables 7-5*** and ***7-6*** list the components in each alternative. Further, ***Figures 7-2, 7-3, 7-4, and 7-5*** display select features of Alternatives A – D, respectively. For a more complete description of the components included in Alternatives A – D, see ***Appendix A, Section 3***.

The reformulation provided an opportunity to make other modifications in the modeling including using the most recent version of the Natural Systems Model (NSM v4.5). Previous alternatives (Starting Point – Alternative 5) had been evaluated and compared to a provisional version of this model. This newer version of the Natural System Model became available in December 1997, so the team agreed to use this newer version for the evaluation of Alternatives A through D.

With the reformulation of the alternative plans, the final set of Alternatives A through D underwent a rigorous evaluation using a variety of analytical tools and processes. These included: River of Grass Evaluation Methodology, Summary Evaluation Criteria, Keystone and Endangered Species analysis, and Water Quality analysis. The results of these analyses were arrayed and compared to identify significant differences among plans.

TABLE 7-5
COMPONENTS COMMON TO ALTERNATIVES A – D

Component Title		Alternatives			
		A (Alt 3 Rev)	B (Alt 4 Rev)	C (Alt 5 Rev)	D (Alt 6)
A	North L.O. Storage	✓	✓	✓	✓
B	C-44 Basin Storage	✓	✓	✓	✓
C	Environmental Water Supplies to St. Lucie Estuary	✓	✓	✓	✓
D	C-43 Basin Storage	✓	✓	✓	✓
E	Environmental Water Supplies to Caloosahatchee Estuary	✓	✓	✓	✓
F	Lake Okeechobee Regulation Schedule	✓	✓	✓	✓
G	EAA Storage Area	✓	✓	✓	✓
H	Everglades Rain-Driven Operations	✓	✓	✓	✓
K	Additional L-8 Improvements	✓	✓	✓	✓
L	Relocate Wellfield Operations	✓	✓	✓	✓
M	Site 1 Impoundment	✓	✓	✓	✓
O	Water Conservation Area 3A and 3B Levee Seepage Management	✓	✓	✓	✓
Q	Western C-11 Diversion	✓	✓	✓	✓
R	C-9 Impoundment and Diversion	✓	✓	✓	✓
S	Central Lake Belt Storage	✓	✓	✓	✓
T	C-4 Divide Structures	✓	✓	✓	✓
U	Bird Drive Basin Impoundment	✓	✓	✓	✓
V	L-31N Levee Seepage Management	✓	✓	✓	✓
W	Taylor Creek/Nubbin Slough Storage and Treatment	✓	✓	✓	✓
X	C-17 Backpumping to Water Catchment Area	✓	✓	✓	✓
Y	C-51 East Backpump to Water Catchment Area	✓	✓	✓	✓
BB	Dade Broward Levee Improvement	✓	✓	✓	✓
CC	Improve Broward County Secondary Canals	✓	✓	✓	✓
DD	New Regulation Schedule for Holey Land	✓	✓	✓	✓
EE	Modify Reg Schedule for Rotenberger	✓	✓	✓	✓
FF	Construction of S-356 A and B Structures	✓	✓	✓	✓
GG	Lake Okeechobee ASR	✓	✓	✓	✓
II	Modify G-404 Structure (ECP)	✓	✓	✓	✓
KK	LNWR Internal Canal Structures	✓	✓	✓	✓
LL	C-51 Regional Ground Water ASR	✓	✓	✓	✓
OO	Modifications to South Dade in southern portion of L-31N and C-111	✓	✓	✓	✓
UU	C-23/24/Northfork and Southfork Storage Reservoirs	✓	✓	✓	✓
DDD	Caloosahatchee Backpumping w/STA	✓	✓	✓	✓

✓ - indicates that the component is included in the respective alternative

TABLE 7-6
COMPONENTS DIFFERENT IN ALTERNATIVES A - D

Component		Alternatives			
Title		A (Alt 3 Rev)	B (Alt 4 Rev)	C (Alt 5 Rev)	D (Alt 6)
I	Improve Conveyance between Water Conservation Area-3B and ENP	✓	Merged with QQ		
N	Water Conservation Area-2 B Levee Seepage Management	✓	Merged with YY		
P	North New River Diversion and Treatment	✓	Merged with YY		
AA	Additional S-345 Structures	✓		✓	✓
HH	Modify S-343 A&B Operations	✓		✓	✓
MM	Hillsboro Canal Basin Regional Groundwater ASR	✓	✓	✓	
PP	Backpumping of the C-7 Basin to the Central Lake Belt Storage System via the C-6 Canal	✓			
QQ	Decompartmentalize Water Conservation Area-3		✓	✓	✓
RR	Flow to Central Water Conservation Area 3A		✓	✓	✓
SS	Relocate Miami Canal Water Supply Deliveries to NNR		✓	✓	✓
VV	Palm Beach County Agriculture Reserve Reservoir		✓	✓	✓
WW	C-111N Spreader Canal		✓	✓	✓
XX	North Lake Belt Storage		✓	✓	✓
YY	Divert Water Conservation Area-2 flows to Central Lake Belt Storage		✓	✓	✓
ZZ	Divert Water Conservation Area-3A/3B flow to Central Lake Belt or South Dade			✓	✓
AAA	Lower East Coast Water Conservation			✓	✓
BBB	South Dade County Reuse			✓	✓
CCC	Big Cypress L-28I Modifications			✓	✓
EEE	Flow to eastern Water Conservation Area-3B			✓	✓
FFF	Biscayne Bay Coastal Canals			✓	✓
GGG	C-51/Southern L-8 Reservoir				✓
HHH	West Dade Reuse				✓

✓ - indicates that the component is included in the respective alternative
Components J, Z, JJ, NN and TT are not included in alternatives A-D

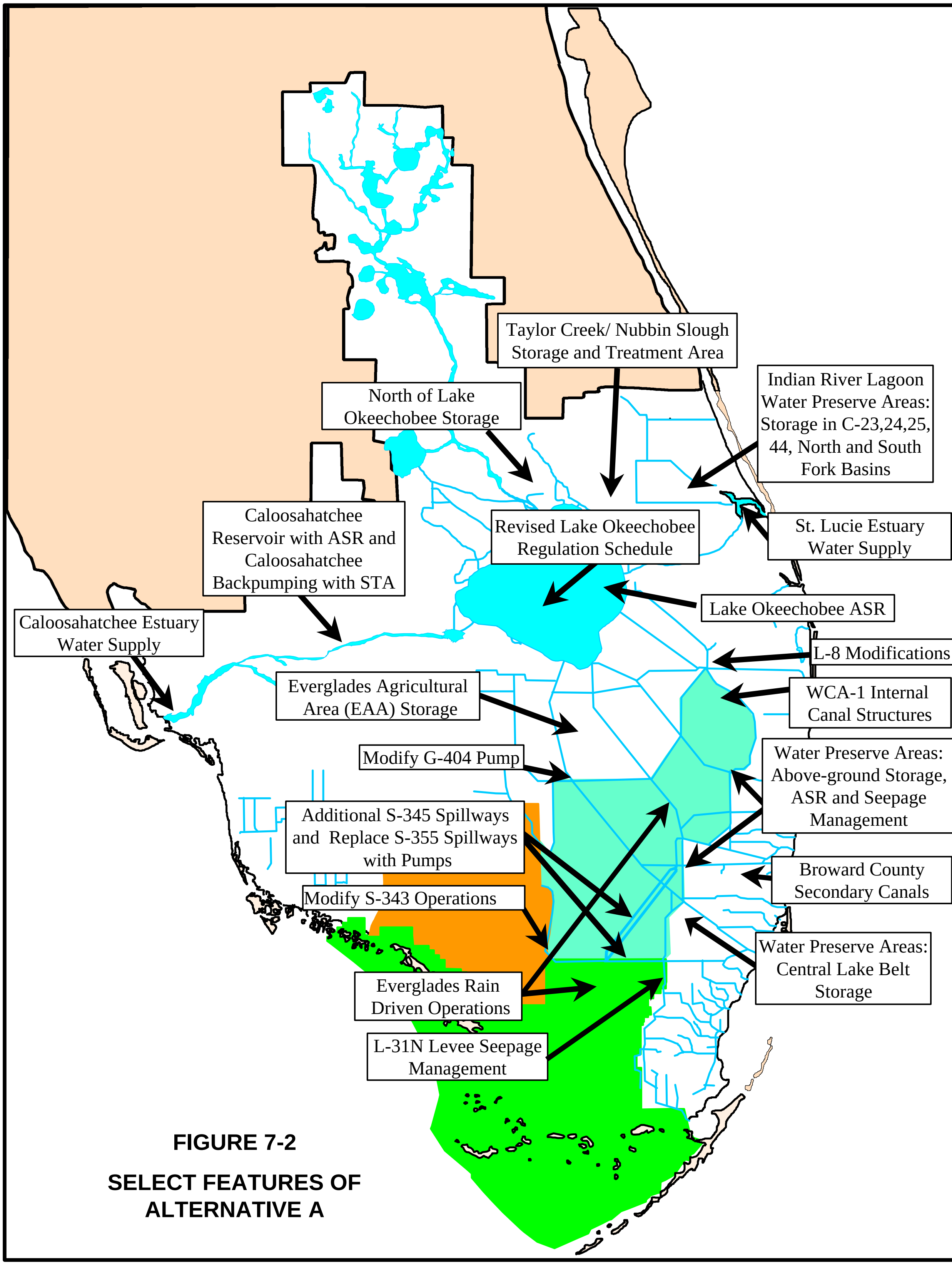


FIGURE 7-2

SELECT FEATURES OF ALTERNATIVE A

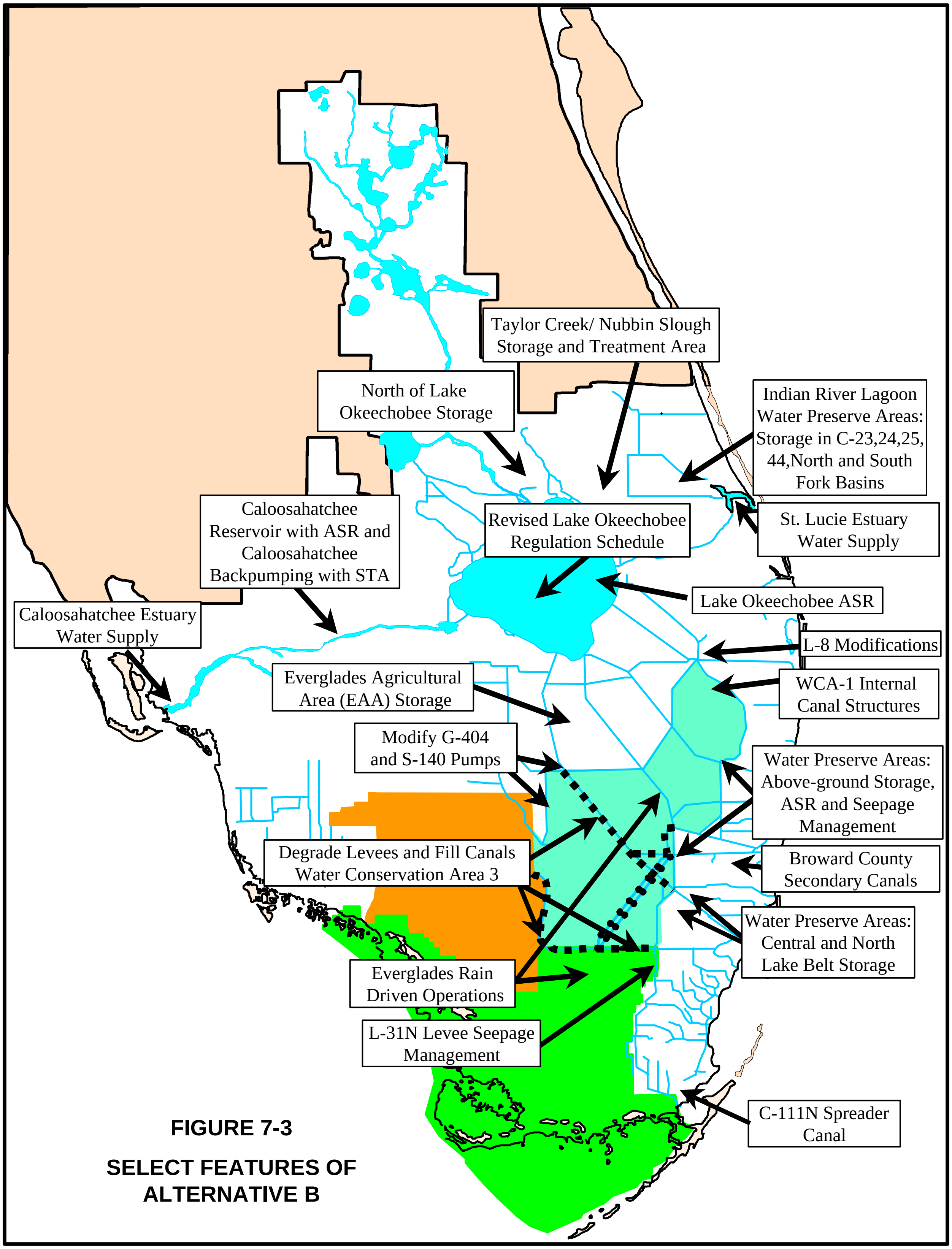


FIGURE 7-3

SELECT FEATURES OF ALTERNATIVE B

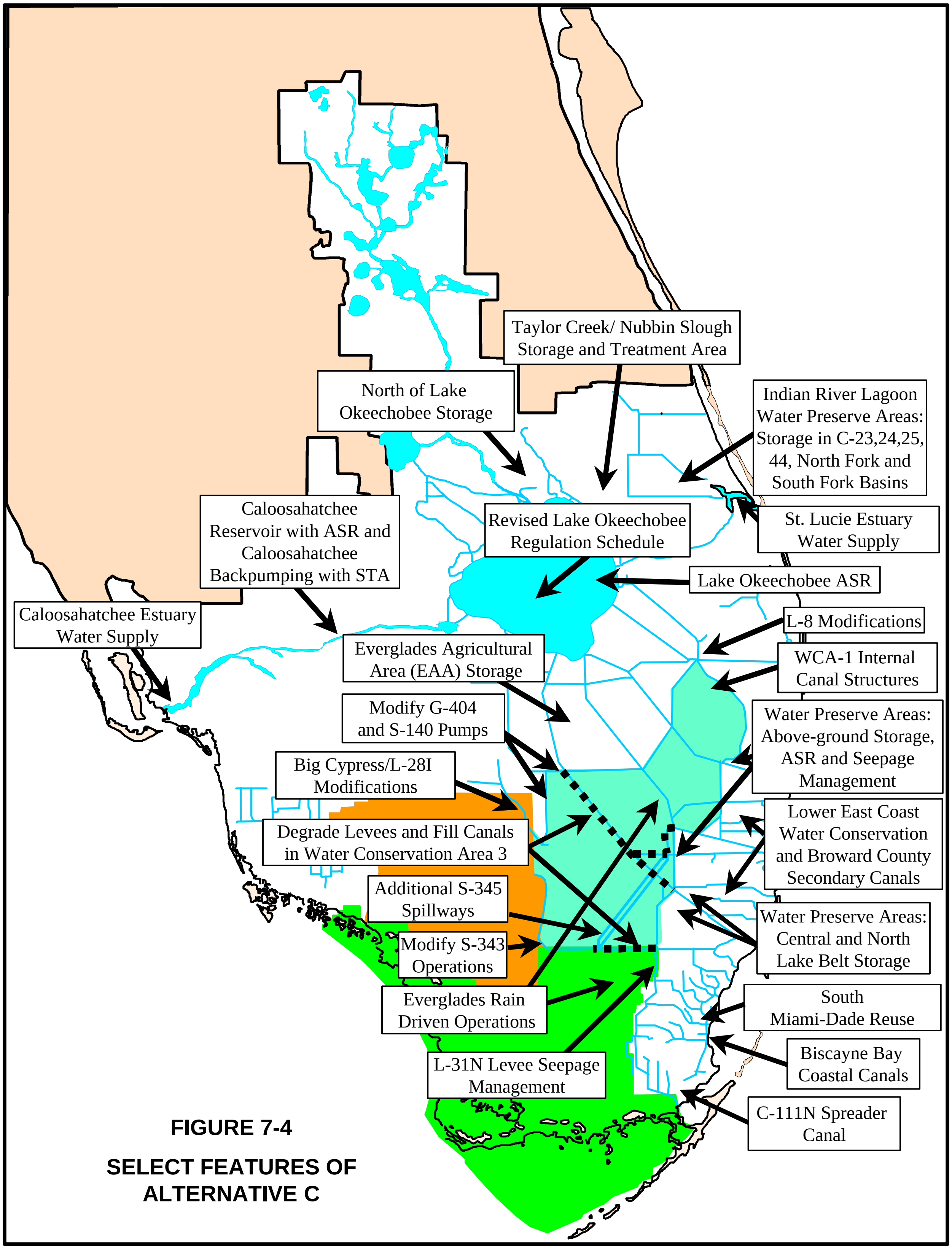


FIGURE 7-4

SELECT FEATURES OF ALTERNATIVE C

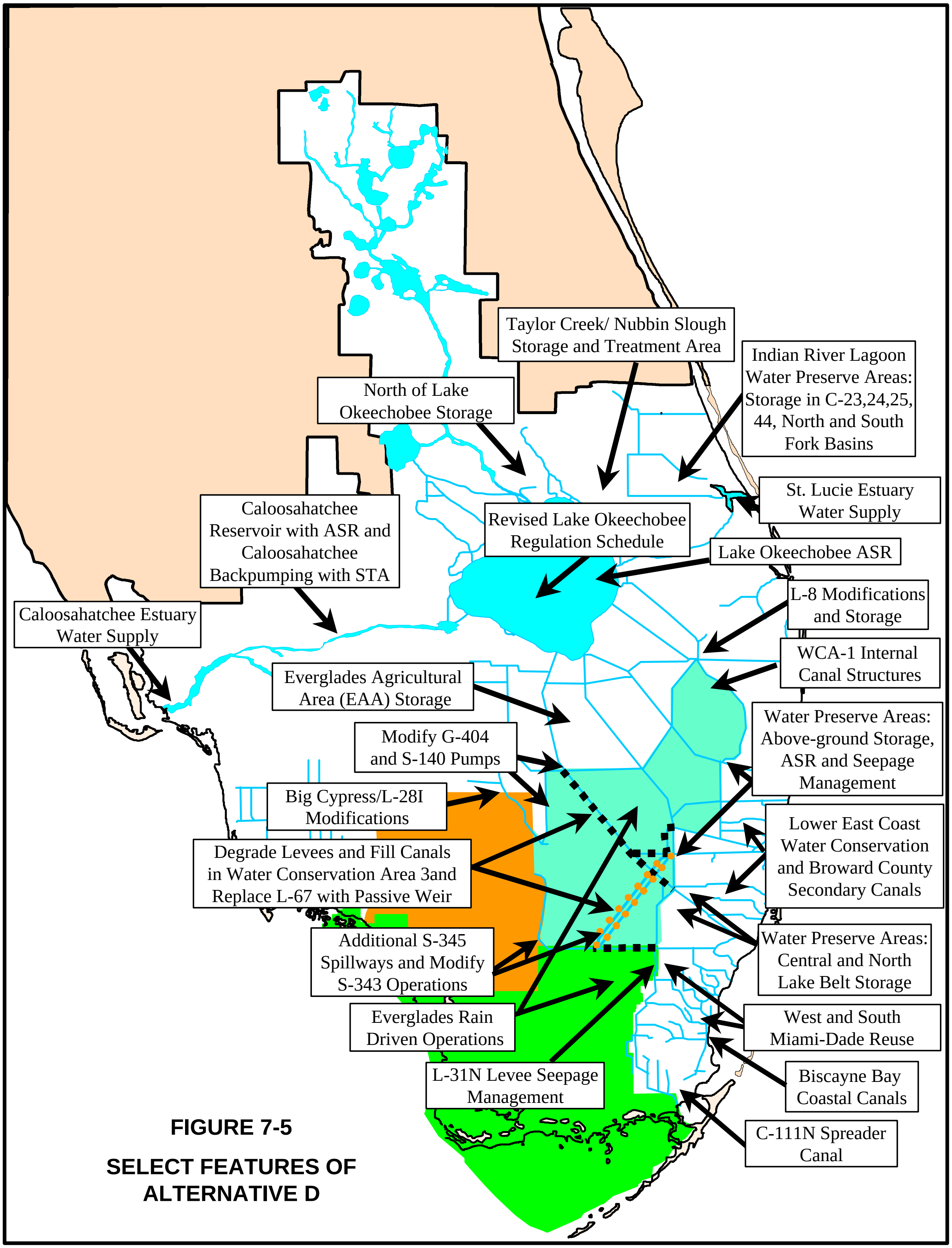


FIGURE 7-5

SELECT FEATURES OF ALTERNATIVE D

7.3.2.4 River of Grass Evaluation Methodology, Alternatives A - D

The River of Grass Evaluation Methodology ***(Appendix D)*** was a tool used to determine the habitat quality of the alternative plans based on a subset of the performance measures. The methodology provided a process to select key performance measures, by sub-region, that are critical to achieving the ecologic objectives. Through mathematical equations and best professional judgement, each set of performance measures was normalized to generate a numeric score between 0 and 1.0. The result is a value that represents the habitat quality based on the relationship between hydrologic characteristics and habitat restoration targets. For water supply, a similar method of developing numerical output was followed to allow comparison of the plans relative to the water supply objectives.

The output from this analysis was used to compare the relative differences in habitat quality between alternative plans for each sub-region. It was not used to compare the habitat quality of one sub-region with the habitat quality of another sub-region. For example, it is appropriate to compare results for Shark River Slough to determine how well each alternative plan performed for that region. However, because different equations were used for each sub-region, it is not appropriate to make a comparison between Shark River Slough and Lake Okeechobee. The numeric scores are presented in ***Table 7-7*** and are explained in Appendix D, which includes a detailed interpretation of the effect of the alternative plans on the sub-regions. Alternative Plan D-13R which is included in this table is discussed in ***Section 7.3.3***.

7.3.2.4.1 Summary Evaluation Criteria, Alternatives A-D

The Alternative Evaluation Team made its final comparisons of the alternative plans by using three summary evaluation criteria:

- plan ranking
- plan grade
- plan color

These criteria were designed to convert the numerical scores from the River of Grass Evaluation Methodology into more qualitative descriptions of plan performance. Plan rankings compared relative performance among the plans, based on a tally of the ordinal scores created from the numerical scores. Plan grades were created by combining numerical scores, and converting these groupings of scores into letter grades, equivalent to the grading system in academic schools. Color schemes (green for successful, yellow for uncertain; red for unsuccessful) were used to express the team's best professional opinion of how likely each plan will result in the attainment of the long-term ecological or water supply objectives. A range of numerical scores could be given the same color evaluation, if the sub-team felt that the objectives could be realized within a range of hydrological conditions.

TABLE 7-7
RIVER OF GRASS EVALUATION METHODOLOGY
NUMERICAL SCORES
(0=lowest, 1=highest)

Sub-Regions	Affected Acres	Alternatives						
		1995	Without Plan	A	B	C	D	D-13R
Lake Okeechobee	467,000	0.6	0.6	0.8	0.8	0.9	0.9	0.9
Caloosahatchee Estuary	9,000	0	0.1	1.0	1.0	1.0	1.0	1.0
St. Lucie Estuary	5,000	0	0.1	0.8	0.8	0.8	0.8	0.9
Loxahatchee National Wildlife Refuge	143,000	1.0	0.6	1.0	1.0	1.0	1.0	1.0
Water Conservation Area-2A	105,000	0.4	0.4	0.4	0.4	0.4	0.4	0.6
Water Conservation Area-2B	28,000	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Northwest Water Conservation Area-3A	118,000	0.1	0.4	0.8	0.8	0.8	0.8	0.8
Holey Land and Rotenberger WMAs	61,000	0.4	0.6	0.8	0.8	0.8	0.8	0.8
Northeast Water Conservation Area-3A	54,000	0.1	0.4	0.8	0.6	0.1	0.1	0.4
Eastern Water Conservation Area-3A	74,000	0.1	0.4	0.1	0.1	0.1	0.1	0.4
Central and Southern Water Conservation Area-3A	276,000	0.4	0.4	0.8	0.8	0.4	0.4	0.8
Water Conservation Area-3B	69,000	0.8	0.4	1.0	0.1	0.1	0.1	0.6
Pennsuco Wetlands	18,000	0.4	0.4	0.6	0.6	0.8	0.8	0.8
Shark River Slough	204,800	0.2	0.3	0.5	0.6	0.6	0.6	0.8
Rockland Marl Marsh	77,000	0.2	0.6	0.7	0.7	0.8	0.8	0.8
Model Lands	18,000	0.6	0.6	0.5	0.7	0.8	0.8	0.8
Florida Bay	448,000	0.2	0.3	0.8	0.9	0.8	0.8	0.8
Biscayne Bay	138,000	0.9	0.8	0.5	0.6	0.8	0.8	0.8
South and Southeast Big Cypress	364,000	0.9	0.9	1.0	0.9	1.0	1.0	1.0
Lake Okeechobee Service Area	N/A	0.6	0.3	0.8	0.7	0.8	0.9	0.9
Lower East Coast Service Area	N/A	0.8	0.7	0.9	0.9	1.0	1.0	1.0

Ranking of the Alternative Plans: For each sub-region, the alternative plans and the Without Plan Condition were ranked from one through five. The best plan for each sub-region was awarded a one (1) and the worst plan a five (5). Ties were dealt with by averaging. For example, if two plans were tied for first place, they each received a score of 1.5, the average of 1 and 2. If three plans tied for first place, they each received a score of 2, the average of 1, 2, and 3. This system ensured that fifteen points for each sub-region were allocated across the alternatives, equalizing the contribution of each sub-region to the final sum of rankings. The results of this evaluation are included in ***Table 7-8***. The plan with the lowest cumulative score received the highest rank. For example, Plan D, the highest ranked plan, scored 44 points compared to the Without Plan condition which received 98 points.

TABLE 7-8
PERFORMANCE OF THE WITHOUT PLAN CONDITION AND ALTERNATIVES
BASED ON RELATIVE RANKING
(1=best, 5=worse)

Subregion	Alternatives				
	Without Plan	A	B	C	D
Lake Okeechobee	5	3.5	3.5	1.5	1.5
Caloosahatchee Estuary	5	2.5	2.5	2.5	2.5
St Lucie Estuary	5	2.5	2.5	2.5	2.5
Lake Worth Lagoon	5	4	1	2.5	2.5
Holey Land & Rotenberger Wildlife Management Areas	3	3	3	3	3
Loxahatchee National Wildlife Refuge	5	4	2	2	2
Water Conservation Areas 2 & 3	5	1	3	3	3
Shark River Slough	5	4	1.5	3	1.5
Rockland Marl Marsh	5	3.5	3.5	2	1
Model Lands	4	5	2	2.5	1.5
Florida Bay	5	1.5	1.5	3.5	3.5
Biscayne Bay	2.7	4.3	4.3	2.2	1.5
Southern Big Cypress	4	4	4	2	1
Southeastern Big Cypress	5	2	4	2	2
Connectivity	5	4	1	2	3
Sheet Flow	5	4	1	2.5	2.5
Fragmentation	4.5	4.5	1	2.5	2.5
Water Quality	5	3.5	3.5	1.5	1.5
Dade Agricultural Area	5	2.5	2.5	2.5	2.5
Lake Okeechobee Service Area	5	3	4	2	1
Lower East Coast Service Area	5	3.5	3.5	1.5	1.5
Total Sum of Rankings	**98.2**	**69.8**	**54.8**	**48.7**	**44**

Grading the Alternative Plans: Plan grades were created based on the numerical output from the River of Grass Evaluation Methodology for most sub-regions. All sub-regions except the Northern and Central Everglades, which developed letter grades independently, assigned letter grades (A, B, C, D, or F) based on the numerical scores (refer to ***Table 7-7***). The results of this evaluation are included in ***Table 7-9***. Letter grade A was best, or excellent at meeting the performance measures; and letter grade F was worst, or failed to meet the performance measure targets, just like the letter grading system used in academia. The letter grades indicate how well each alternative plan and the Without Plan Condition performed at meeting the performance measure targets. If two or more of the plans performed similarly for the performance measures for the sub-region, then more than one plan could receive a similar grade for a sub-region. For example, Loxahatchee National Wildlife Refuge earned a letter grade A for alternative plans A-D.

TABLE 7-9
PERFORMANCE OF THE WITHOUT PLAN CONDITION AND ALTERNATIVES
RELATIVE TO PERFORMANCE MEASURES
LETTER GRADE

Sub-region	Alternatives				
	Without Plan	A	B	C	D
Lake Okeechobee	C	B	B	A	A
Caloosahatchee Estuary	F	A	A	A	A
St Lucie Estuary	F	C	C	C	B+
Lake Worth Lagoon	F	D	B	C	C
Holey Land & Rotenberger Wildlife Management Areas	C	B	B	B	B
Loxahatchee National Wildlife Refuge	C	A	A	A	A
Water Conservation Areas 2 & 3	D	C	D	D	D
Shark River Slough	F	F	D	D	D
Rockland Marl Marsh	D	C	C	B	B
Model Lands	F	F	C	B	B
Florida Bay	F	C	C	C	C
Biscayne Bay	C	F	F	C	B
Southern Big Cypress	B	B	B	B	A
Southeastern Big Cypress	B	A	B	A	A
Connectivity	D	D	A	B	B
Sheet Flow	F	B	B	B	B+
Fragmentation	F	F	A	B	B
Lake Okeechobee Service Area	F	B	C	B	A
Dade Agricultural Area	F	A	A	A	B
Lower East Coast Service Area	D	B	B	A	A
Water Quality	D	C	C	C	C

Color Assessment of the Alternative Plans: The alternative plans were also scored using colors (green, yellow, and red) by converting plan grades into a "best professional opinion" prediction of how likely each plan would achieve the long-term ecological or water supply objectives. The results are displayed in ***Table 7-10.*** Each color provides two kinds of information: (a) a prediction of how likely a plan will achieve the recovery and long-term sustainability objectives defined by the performance measure(s); and (b) a recommended priority for further improvement in the design and operation of the currently modeled plan. Green means that the current plan is likely to recover and sustain the ecological or water supply objective described by the performance measures. Yellow means that achievement of the long-term objectives is marginal or uncertain, and that improvement in the plan is a moderate priority. Red means that the recovery and long-term sustainability of the objectives are unlikely, and that the current plan requires improvement if these targets are met.

TABLE 7-10
PERFORMANCE OF THE ALTERNATIVE PLANS TO ACHIEVE LONG-TERM OBJECTIVES
COLOR RANKING
G = successful, Y = marginal or uncertain, R = unsuccessful

Sub-region	Alternatives				
	Without Plan	A	B	C	D
Lake Okeechobee	Y	G	G	G	G
Caloosahatchee Estuary	R	G	G	G	G
St Lucie Estuary	R	Y	Y	Y	Y
Lake Worth Lagoon	Y	R	R	Y	Y
Holey Land & Rotenberger Wildlife	Y	G	G	G	G
Loxahatchee National Wildlife Refuge	Y	G	G	G	G
Water Conservation Area 2 & 3	R	Y	R	R	R
Shark River Slough	R	R	R	R	R
Rockland Marl Marsh	R	Y	Y	G	G
Model Lands	R	R	Y	G	G
Florida Bay	R	Y	Y	Y	Y
Biscayne Bay	Y	R	R	Y	G
Southern Big Cypress	Y	Y	Y	Y	G
Southeastern Big Cypress	Y	G	Y	G	G
Connectivity	Y	Y	G	G	G
Sheet Flow	R	G	G	G	G
Fragmentation	R	R	G	G	G
Dade Agricultural Area	R	G	G	G	Y
Lake Okeechobee Service Area	R	G	Y	G	G
Lower East Coast Service Area	R	Y	Y	G	G
Water Quality	ne	ne	ne	ne	ne

ne – not evaluated using color ranking

7.3.2.4.2 Keystone and Endangered Species Evaluation of Alternatives A-D

Evaluation of alternative plans' performance with regard to threatened, endangered and keystone species was accomplished through a combination of several methods. The Across Trophic Levels System Simulation model results provided information on expected biological responses of several species and species groups. Other methods to predict species response to the alternative plans included: (1) the additional Crocodile Habitat Suitability and Wood Stork Nesting Patterns performance measures; (2) information on known hydrological responses of species gleaned from Volume I of the *Multispecies Recovery Plan* for the Threatened and Endangered Species of south Florida, Technical/Agency Draft (U.S. Fish and Wildlife Service, 1998b); and (3) discussions with research biologists widely recognized as experts on particular species. These additional sources of information were considered along with results from the Across Trophic Level System Simulation model to form a "weight of the evidence" or "consensus" conclusion among members of the Restudy Team and species experts. The relative ranking of the plans for the keystone and endangered species are included in ***Table 7-11***.

TABLE 7-11
KEYSTONE AND LISTED SPECIES
(1=best, 5=worse)

	Alternatives				
Species	**Without Plan**	**Alt A**	**Alt B**	**Alt C**	**Alt D**
CSS Sparrow	5	4	1	1	1
Snail Kite	5	3	3	1	1
Wood Stork	5	1	1	1	1
Panther	1	1	1	1	1
Crocodile	5	2	2	2	1
Deer	5	2	1	2	2
Wading Birds	5	3	3	1	1
Fish	5	3	3	1	1

7.3.2.4.3 Water Quality Evaluation of Alternatives A - D

Model output from the South Florida Water Management Model and the water quality models were evaluated in the context of performance measures developed by the Restudy Water Quality Team. The Water Quality Team's empirical evaluation was conducted on a slightly different sub-regional basis than the Alternative Evaluation Team. The Water Quality Team did not develop an empirical evaluation of alternative plans on water quality conditions in the Big Cypress Basin or the Holey Land and Rotenberger Wildlife Management Areas. For those areas, a qualitative assessment was made based upon the proposed operation of the components contained in the alternatives.

From this evaluation, the Water Quality Team ranked the base conditions and alternative plans on a scale of 1 to 6, with higher scores indicating a more preferred condition from a water quality perspective. It should be noted that this method of ranking is reverse from the previous ranking evaluations, meaning a lower score indicates a more preferred condition. The rankings are included in ***Table 7-12***.

TABLE 7-12
WATER QUALITY RANKINGS
1=worse, 6=best[1]

Sub-Region	1995 Base	Alternatives				
		Without Plan	A	B	C	D
Lake Okeechobee	1.5	4.5	1.5	4.5	4.5	4.5
Everglades Agricultural Area and the Everglades Construction Project	1	2	6	5	3.5	3.5
Water Conservation Areas 2 & 3	1	2.5	5	2.5	5	5
St. Lucie Watershed	1	2	3.5	3.5	5	6
Caloosahatchee Watershed	1.5	1.5	3	4	5	6
Loxahatchee National Wildlife Refuge	1	2	4.5	4.5	4.5	4.5
Everglades National Park	1.5	5	3.5	6	1.5	3.5
Lower East Coast Service Area	6	3.5	1.5	1.5	5	3.5
Cumulative Score	*14.5*	*23*	*28*	*31.5*	*34.0*	*36.5*

[1] Care should be taken when comparing the water quality rankings with other evaluation rankings due to the differences in scale.

7.3.2.4.4 Evaluation Conclusions for Alternatives A - D

Results presented in the previous tables show that Alternative D is generally the best plan at achieving the ecologic, water supply, and water quality objectives. For these same criteria, Alternative C is the second best plan. ***Table 7-11*** shows that for Listed Species, Alternative D ranks slightly higher than the other alternatives, with Alternative C ranking second. All tables show that for most sub-regions, the plans provide substantial benefits (i.e., improvements) over the Without Plan Condition.

The Alternative Evaluation Team selected Alternative D, with the provision that steps be taken to correct specific weaknesses in the alternative. Overall, Alternative D performed best for:

- Lake Okeechobee Service Area
- Caloosahatchee Estuary

- Lake Okeechobee Service Area
- Lower East Coast Service Areas
- Loxahatchee National Wildlife Refuge
- Holey Land and Rotenberger Wildlife Management Areas
- Southern and southeastern Big Cypress Basin
- Southern Everglades Rocky Glades

Alternative D, was inadequate (reds in ***Table 7-10***) at meeting performance targets for:

- Portions of Water Conservation Areas 2 and 3
- Shark River Slough

Alternative D was moderately adequate (yellows in ***Table 7-10***) at meeting performance targets for:

- St. Lucie Estuary
- Florida Bay
- Lake Worth Lagoon
- South Dade Agricultural Region

From a water quality perspective, Alternatives C and D were preferred over Alternatives A and B. The Without Plan Condition was considered not acceptable. Due to a lack of model results (particularly the Everglades Landscape Model results), the alternative plans could not be ranked based upon water quality impacts or benefits in Big Cypress National Preserve and the Holey Land and Rotenberger Wildlife Management Areas.

The Alternative Evaluation Team recommended that ad hoc teams of ecologists, hydrologists and modelers be created to determine both the immediate and long-term strategy for improving the performance of Alternative D in the red and yellow scored areas.

The Alternative Evaluation Team also highlighted three specific strengths of Alternative B, which, if incorporated into Alternative D, would bring the different ecological strengths of these two plans together to form a more robust restoration plan. These included:

- Higher volumes of flow into the Florida Bay Estuary compared to other plans.
- Greater success at reestablishing system connectivity.
- Improved levels of sheet flow, compared to other plans.

These three features were a consequence of the greater extent of system-wide decompartmentalization, by the removal of levees and canals that create barriers between natural areas, which characterized Alternative B. The Alternative Evaluation Team recommended that the same ad hoc team explore the feasibility of merging these features of Alternative B into D.

At a Restudy Team meeting in early June 1998, the full team agreed with the conclusions of the Alternative Evaluation Team and selected Alternative D as the preferred alternative. The full team also accepted the Alternative Evaluation Team's recommendation that Alternative D should be refined to improve performance in five key areas: Water Conservation Areas 2 and 3, Shark River Slough, Florida Bay, and the St. Lucie Estuary.

7.3.3 Initial Draft Plan

In June 1998, a team of engineers and ecologists conducted an intense iterative process to improve the hydrologic performance of Alternative D in the five key areas. During the first seven iterations, the team attempted to achieve the improved performance by making only operational changes. However, such changes proved inadequate to meet the desired performance, and structural changes to the plan were considered. The next six iterations included both operational changes and structural changes to achieve the desired performance. The thirteenth and final iteration included component modifications and improvements to Alternative D that rectified performance inadequacies in portions of the Water Conservation Area, Everglades National Park, Florida Bay, and the St. Lucie Estuary. The plan that resulted was called Alternative D-13R. Alternative D-13R was designated as the Initial Draft Plan by the Restudy Team.

7.3.3.1 Features of Alternative D-13R

The most significant change between Alternative D and D-13R was the removal of additional levees and canals between Water Conservation Area 3A and Everglades National Park and Big Cypress National Preserve. Unlike Alternative B, Alternative D-13R left a barrier between Water Conservation Areas 3A and 3B. This barrier, a levee known as L-67, was modified in Alternative D-13R to include a conveyance canal and a series of passive weirs to promote high flows between these areas, in addition to allowing for managed flows during the dry season. Alternative D-13R also included several new operating rules for triggering when surface water is allowed to enter the Water Conservation Areas and Everglades National Park. Furthermore, additional surface water storage capacity was included for the C-23, C-24, Northfork and Southfork Basins in the Upper East Coast to further reduce damaging local basin runoff to the St. Lucie Estuary. The major features of Alternative D-13R are displayed in ***Figure 7-6***. For a complete description of this plan, refer to ***Appendix A, Section 4***.

7.3.3.2 Evaluation of Alternative D-13R

The modifications to Alternative D resulted in substantial improvements in the Water Conservation Areas and Everglades National Park without compromising Lake Okeechobee water levels or water supply to Lake Okeechobee and Lower East Coast Service Areas. The modifications relieved adverse high and low water conditions in the Water Conservation Areas. Flow volumes to Shark River Slough were increased while maintaining seasonal distribution of flows indicated by Natural System Model. The number of dry-downs in Shark River Slough was reduced to three events over the period of record compared to two events under Natural System Model. Salinity in Florida Bay coastal basins was improved as well. These improvements were achieved through partial decompartmentalization of Water Conservation Area 3 and Everglades National Park, which makes Alternative D-13R more like Alternative B as desired by the Alternative Evaluation Team and the Restudy Team. Additional storage acreage in the Upper East Coast basins reduced high volume local basin runoff to the St. Lucie Estuary. This enabled Alternative D-13R to come closer to meeting the performance measure target described by the number of times high local basin runoff occurred to the estuary.

Table 7-13 is a summary table of letter grades for the Without Plan Condition, and Initial Draft Plans D and D13R. ***Table 7-14*** shows the same by color ranking. ***Table 7-7*** includes the River of Grass Evaluation Methodology results for Alternative D-13R. A separate water quality evaluation was also conducted for Alternative D-13R (***see Appendix D***). From a water quality perspective, the performance of Alternative D-13R was improved when compared to Alternative D.

7.3.3.3 Uncertainty Analysis of D-13R Components

In selecting the components that are in Alternative D-13R, the Restudy Team recognized the high level of technical and implementability (due to high cost) uncertainties associated with some of the components. These uncertainties can be viewed as a question of whether an uncertain component will achieve the desired effect. If the component fails to achieve the desired effect, the feasibility of implementing an alternative component along with or as a replacement to the uncertain component may need to be considered to assure that the Comprehensive Plan meets its stated objectives.

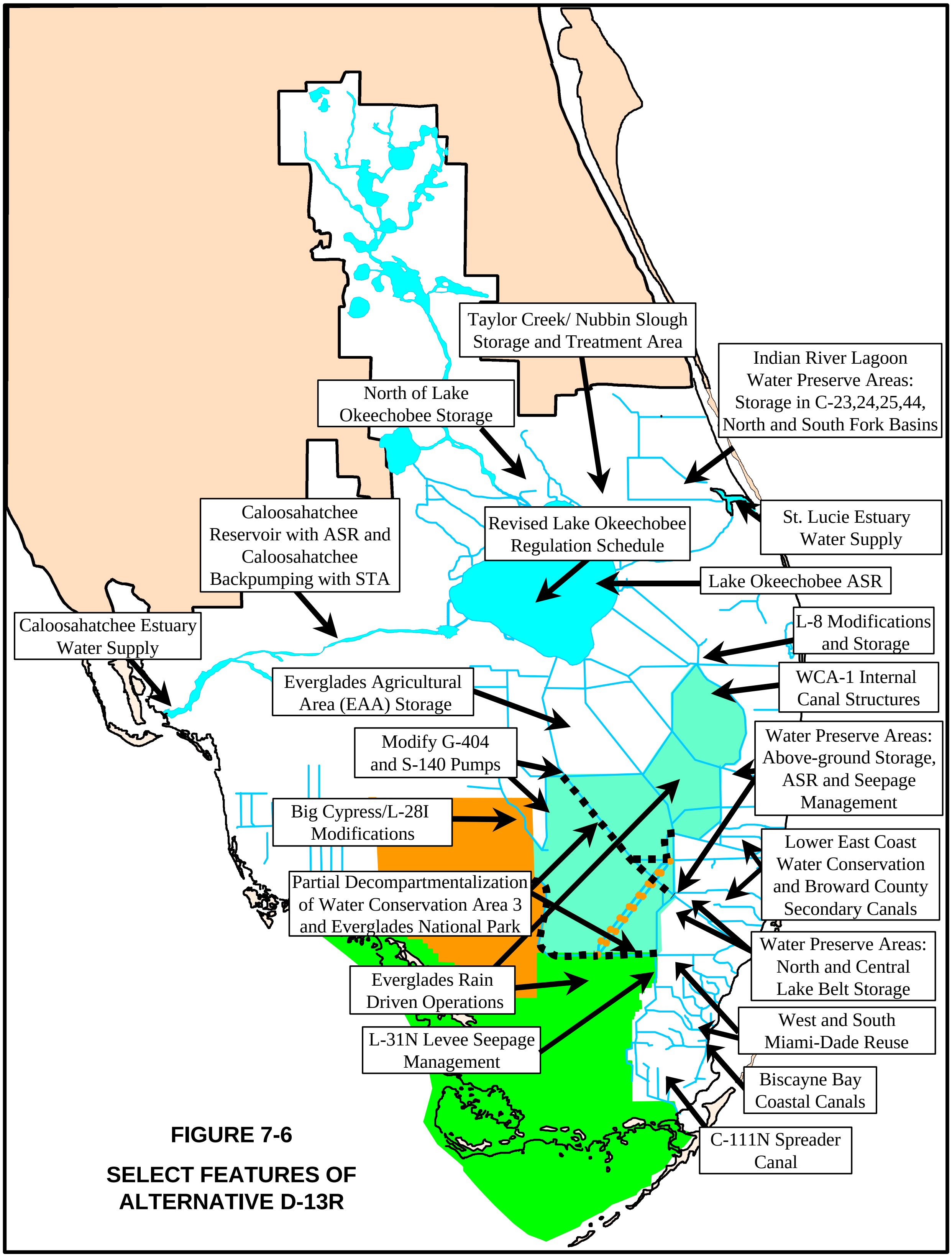


FIGURE 7-6

SELECT FEATURES OF ALTERNATIVE D-13R

TABLE 7-13
PERFORMANCE OF D & D13R
RELATIVE TO ECOLOGICAL PERFORMANCE MEASURES
LETTER GRADE

<table>
<tr><th>Sub-Region</th><th>Without Plan</th><th>Alt D</th><th>D-13R</th></tr>
<tr><td>Lake Okeechobee</td><td>C</td><td>A</td><td>A</td></tr>
<tr><td>Caloosahatchee Estuary</td><td>F</td><td>A</td><td>A</td></tr>
<tr><td>St Lucie Estuary</td><td>F</td><td>C</td><td>B+</td></tr>
<tr><td>Lake Worth Lagoon</td><td>F</td><td>C</td><td>C</td></tr>
<tr><td>Holey Land & Rotenberger WMA</td><td>C</td><td>B</td><td>B</td></tr>
<tr><td>Loxahatchee NWR</td><td>C</td><td>A</td><td>A</td></tr>
<tr><td>Water Conservation Area 2A</td><td rowspan="7">D</td><td>D</td><td>C</td></tr>
<tr><td>Water Conservation Area 2B</td><td>F</td><td>F</td></tr>
<tr><td>Northwestern Water Conservation Area 3A</td><td>B</td><td>B</td></tr>
<tr><td>Northeastern Water Conservation Area 3A</td><td>F</td><td>D</td></tr>
<tr><td>Eastern Water Conservation Area 3A</td><td>F</td><td>D</td></tr>
<tr><td>Central & Southern Water Conservation Area 3A</td><td>D</td><td>B</td></tr>
<tr><td>Water Conservation Area 3B</td><td>F</td><td>C</td></tr>
<tr><td>Pennsuco Wetlands</td><td>ne</td><td>B</td><td>B</td></tr>
<tr><td>Shark River Slough</td><td>F</td><td>D</td><td>B</td></tr>
<tr><td>Rockland Marl Marsh</td><td>D</td><td>B</td><td>B</td></tr>
<tr><td>Florida Bay</td><td>F</td><td>C</td><td>B</td></tr>
<tr><td>Biscayne Bay</td><td>C</td><td>B</td><td>B</td></tr>
<tr><td>Model Lands</td><td>F</td><td>B</td><td>B</td></tr>
<tr><td>Southern Big Cypress</td><td>B</td><td>A</td><td>A</td></tr>
<tr><td>SE Big Cypress</td><td>B</td><td>A</td><td>A</td></tr>
<tr><td>Connectivity</td><td>D</td><td>B</td><td>B+</td></tr>
<tr><td>Sheet Flow</td><td>F</td><td>B</td><td>B</td></tr>
<tr><td>Fragmentation</td><td>F</td><td>B</td><td>A</td></tr>
<tr><td>Water Quality</td><td>D</td><td>C</td><td>C</td></tr>
</table>

ne – not evaluated

TABLE 7-14
PERFORMANCE OF D AND D-13R
TO ACHIEVE LONG-TERM ECOLOGICAL OBJECTIVES
COLOR RANKING

<table>
<tr><th>Sub-Region</th><th>Without Plan</th><th>Alt D</th><th>D-13R</th></tr>
<tr><td>Lake Okeechobee</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Caloosahatchee Estuary</td><td>R</td><td>G</td><td>G</td></tr>
<tr><td>St Lucie Estuary</td><td>R</td><td>Y</td><td>G</td></tr>
<tr><td>Lake Worth Lagoon</td><td>Y</td><td>Y</td><td>Y</td></tr>
<tr><td>Holey Land & Rotenberger WMA</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Loxahatchee NWR</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Water Conservation Area 2A</td><td rowspan="7">R</td><td>R/Y</td><td>G/Y</td></tr>
<tr><td>Water Conservation Area 2B</td><td>R</td><td>R</td></tr>
<tr><td>Northwestern Water Conservation Area 3A</td><td>G</td><td>G</td></tr>
<tr><td>Northeastern Water Conservation Area 3A</td><td>R</td><td>Y</td></tr>
<tr><td>Eastern Water Conservation Area 3A</td><td>R</td><td>Y</td></tr>
<tr><td>Central & Southern Water Conservation Area 3A</td><td>R/Y</td><td>G/Y</td></tr>
<tr><td>Water Conservation Area 3B</td><td>R</td><td>Y</td></tr>
<tr><td>Pennsuco Wetlands</td><td>ne</td><td>G</td><td>G</td></tr>
<tr><td>Shark River Slough</td><td>R</td><td>R</td><td>G</td></tr>
<tr><td>Rockland Marl Marsh</td><td>R</td><td>G</td><td>Y</td></tr>
<tr><td>Florida Bay</td><td>R</td><td>Y</td><td>G</td></tr>
<tr><td>Biscayne Bay</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Model Lands</td><td>R</td><td>G</td><td>G</td></tr>
<tr><td>Southern Big Cypress</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>SE Big Cypress</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Connectivity</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Sheet Flow</td><td>R</td><td>G</td><td>G</td></tr>
<tr><td>Fragmentation</td><td>R</td><td>G</td><td>G</td></tr>
<tr><td>Water Quality</td><td>ne</td><td>ne</td><td>ne</td></tr>
</table>

ne – not evaluated

To understand the extent of these uncertainties, the team identified contingency plans to address potential performance deficiencies or cost-effectiveness problems related to these uncertain components. As a first step in identifying the scope of contingency plans, the Restudy Team identified the components with the highest degree of uncertainty and the most likely alternatives that could be implemented as partial or complete substitutes for the uncertain components. The team also identified the sources of the uncertainty as well as the contribution these components make to the overall system. The results of this investigation are included in ***Table 7-15.***

In addition, sensitivity analyses were conducted for the uncertain components using the South Florida Water Management Model. These computer simulations were evaluated to determine the extent of degraded performance. The results are documented in ***Section 7.3.3.4.***

7.3.3.4 Sensitivity Analysis of D-13R Components

Special investigations were undertaken to assess the sensitivity of Alternative D-13R (Appendix B). The analysis included removing components or reducing efficiency of components with the highest uncertainty from Alternative D-13R and then analyzing the simulated performance of D-13R under these conditions. These simulations were undertaken, in addition to other special investigations, at various stages in the alternative development process in order to assist in the design of alternatives or to investigate particular effects that could not be built into the alternatives. Although some of the sensitivity analyses indicate that the overall system performance does not change significantly when certain components are removed, this does not necessarily mean that the feature is not important or needed. No operational modifications or structural components were added to replace the function of the removed components. It was found that one or more of the remaining components was typically utilized more extensively to compensate for the removal of a component.

TABLE 7-15
COMPONENT UNCERTAINTY

Component	Key Performance Attributes of Component	Sources of Uncertainty	Potential Alternatives	Expected Downsides of Potential Alternatives
Lake Okeechobee ASR	A. Attenuates high Lake levels B. Keeps Lake levels up in dry periods C. Greatly reduces regulatory releases to Caloosahatchee and St. Lucie Estuaries D. Stores excess water for future use	1. High construction and O&M costs, especially potential treatment costs for water to be stored 2. Technical uncertainty, especially as regards how much water can ultimately be recovered	a) Increase storage by raising levels in Lake Okeechobee (B, C, D) (1, 2) b) Partition Lake into ecologically and water supply managed areas (A, B, C, D) (1, 2) c) Expand capacity of reservoirs in Alternative D13-R that can store Lake water, by making them larger and/or deeper (A, B, C, D) (2) d) New reservoir(s) (A, B, C, D) (2) Deep disposal wells (A, C) (1, 2)	• Increased evapotranspiration or loss of water to saline aquifers (c, d) • Negative ecological impact on Lake (a, b) • Higher Costs (c, d)
Lower East Coast ASR	A. Improves efficiency of reservoirs B. Reduces flows to tide (Lake Worth Lagoon) C. Stores water for future use	1. Technical uncertainty, especially as regards how much water can ultimately be recovered 2. High construction and O&M costs, especially potential treatment costs for water to be stored	a) Deepen surface storage reservoirs (B, C) (1) b) Construct new or expand reservoirs (include alternative location) (B, C) (1) c) Alternative water sources including reuse and Floridan aquifer water with membrane treatment (1)	• Higher costs (a, b, c) • Additional Land Required for Water Management (b)
Caloosahatchee ASR	A. Reduces excessive flows and helps meet minimum flows to Caloosahatchee Estuary B. Improves efficiency of reservoir C. Stores water for future use	1. Technical uncertainty, especially as regards how much water can ultimately be recovered	a) Deeper surface storage (A, C) (1) b) New expanded reservoirs (include alternative location) (A, C) (1) c) Deep disposal wells (A – excessive)	• Increased Evapo-transpiration or loss of water to saline aquifers (b) • Higher Costs (a, b) • Additional Land Required for Water Management (b)
North Lake Belt	A. Water supply to canal system B. Reduce deliveries from WCA/L C. Maintain canal stages (C-2, C-4, C-6, C-7, C-9) D. Flood protection	1. Ability to fluctuate levels in storage area may be limited by influx of poor quality water from deeper aquifers	a) Configure North Lake Belt Storage Reservoir with more above ground level storage capacity b) ASR if technical and cost uncertainties are successfully solved c) Alternative water supply/R.O./Reuse d) Store water in an alternative surface storage area which may be located locally or in the EAA	• Usable storage may still be reduced (a, c) • Costs per unit of storage capacity may be higher(b,d)

TABLE 7-15
COMPONENT UNCERTAINTY

Component	Key Performance Attributes of Component	Sources of Uncertainty	Potential Alternatives	Expected Downsides of Potential Alternatives
Central Lake Belt	A. Reduces high stages in WCAs and ENP B. Improves dry season flows to ENP	1. Ability to fluctuate levels in storage area may be limited by influx of poor quality water from deeper aquifers	a) Configure Central Lake Belt Storage Reservoir with more above ground level storage capacity b) Intercept water – store in EAA for later use c) Deepen above ground reservoirs in Alternative D13 such as C-9, C-11 and Bird Drive d) Increase delivery of water from west Dade to ENP	• Usable storage may still be reduced (a, c) • Costs per unit of storage capacity may be higher (a, b, c) • Coastal basin water shortages may be increased and flows to Biscayne Bay may be reduced (d)
Reuse – South Dade	A. Provides a base flow to Biscayne National Park B. Helps prevent saltwater intrusion by providing water to maintain canal and groundwater levels	1. Funding due to high costs related to treatment operations and maintenance 2. Treatment effectiveness and reliability	a) ASR if ASR technical and cost uncertainties are successfully solved (B) (1) b) In-ground storage (B) (1) c) Alternative water supply – R.O. Conservation (A, B) (1) d) Floridan Aquifer (A,B) e) Alternative surface water sources (A,B)	• Provides less water for Biscayne Bay when water is being placed into storage (a, b) • Quantity and quality of source water uncertainty(d,e)
Reuse – West Dade	A. Provides groundwater recharge for west wellfields B. Reduces deliveries from WCA/LO to Service Area 3 C. Provides flow to Biscayne National Park and to South Dade Conveyance system which helps recharge Taylor Slough D. Provides groundwater recharge to L-31N area from which water is withdrawn to deliver to ENP	1. Funding due to high costs related to treatment operations and maintenance 2. Treatment effectiveness and reliability	a) ASR if ASR technical and cost uncertainties are successfully solved (A, B, D) b) In-ground storage (A, B, D) (1) c) Alternative water supply – reverse osmosis and conservation (A, B, C, D) (1) d) Floridan Aquifer (C) e) Alternative surface water sources (C)	• Provides less water for uses when water is being placed into storage (a, b) • Quantity and quality of source water uncertainty(d,e)
L-31N Seepage Management	A. Provides ability to seasonally manage groundwater seepage out of ENP B. Protects water levels in ENP C. Protects necessary groundwater flows to coastal Miami-Dade County	1. Ability of pumping technology to seasonally manage groundwater seepage 2. Effectiveness and feasibility of the levee seepage barrier and resulting downstream impacts	a) Curtain wall with improved surface water deliveries to enhance coastal basin groundwater recharge b) Partial curtain wall with enhanced surface deliveries to ENP to mitigate for groundwater outflows. c) Seepage collection system	• Higher costs (a, b) • Reduced effectiveness (c)

(A, B, C, etc>) corresponds to key attributes of a component
(1, 2, 3, etc.) corresponds to the uncertainties related to a particular component
(a, b, c, etc.) corresponds to the potential alternative

Due to the high construction, operation and maintenance, and potential treatment costs for water stored in aquifers, and the technical uncertainty regarding the recovery efficiency of aquifer storage and recovery, two sensitivity modeling scenarios were run and evaluated. Modeling scenarios were run and evaluated for each of the aquifer storage and recovery components included in the Caloosahatchee Basin, the Lake Okeechobee area, and the Lower East Coast area. The two scenarios were evaluated against Alternative D-13R. The first scenario considered reduction in recovery efficiency of aquifer storage and recovery from 70 to 35 percent. The second scenario considered total removal of the aquifer storage and recovery component. These sensitivity analyses showed the following results. The scenarios with decreased aquifer storage and recovery efficiency at the Caloosahatchee and Lower East Coast Basins aquifer storage and recovery facilities required additional water from Lake Okeechobee and Water Conservation Area 1 to offset deficits. Scenarios with reduced efficiency for Lake Okeechobee and Lower East Coast Basins aquifer storage and recovery showed increased discharges to tide and more high flows to Lake Worth Lagoon. The scenario removing Lake Okeechobee aquifer storage and recovery more than tripled Lake Okeechobee Zone A regulatory discharges to the St. Lucie Estuary and doubled discharges to the Caloosahatchee Estuary. In addition, when Lake Okeechobee aquifer storage and recovery was removed southerly discharges from the lake to the Everglades Agricultural Storage Area and Water Conservation Areas increased.

In the North and Central Lake Belt Storage Areas, concern was expressed that the ability to fluctuate water levels within the storage areas may be limited due to the potential for introduction of poor quality water from deeper aquifers. Sensitivity analysis modeling scenarios were carried out to individually remove each of these storage components. The removal of the North Lake Belt Storage Area resulted in a significant increase in water deliveries from Lake Okeechobee and Water Conservation Area 3A to the Lower East Coast Service Area 3, to maintain water levels in the canals. As a result, lake stages were lower and there were increases in water restrictions in Lower East Coast Service Area 2 with the reduced ability to maintain coastal canals, and a redistribution of flows to Biscayne Bay. The removal of the Central Lake Belt Storage Area resulted in a significant increase in eastward diversions of excess water from Water Conservation Area 3A and 3B. This resulted in lowered stages in Water Conservation Area 3A and 3B and reduced flows south to Northeast Shark River Slough. Discharges to Biscayne Bay increased as a result of increased seepage from Water Conservation Area 3.

The wastewater reuse components were evaluated due to their high construction, operation and maintenance costs. Removal of the West Miami-Dade reuse component significantly lowered stages in the Bird Drive Recharge Area and in L-31N, decreased flows to Central Shark River Slough and Everglades National Park, lowered Lake Okeechobee stages during droughts, and increased Lake Okeechobee triggered water restrictions in the Lower East Coast Service Area.

Removal of the South Miami-Dade reuse component reduced discharges to Biscayne Bay and slightly increased locally triggered water restrictions in Lower East Coast Service Area 3. Water deliveries from Lake Okeechobee in particular increased to compensate for the removal of the reuse components.

Four Everglades Agricultural Area reservoir sensitivity scenarios were developed and resulting performance was compared to that of Alternative D13-R. Findings show that the 20,000 acre compartment dedicated to capturing Everglades Agricultural Area runoff and meeting Everglades Agricultural Area irrigation needs has a large region-wide benefit. The two-20,000 acre surge tank storage areas, dedicated to capturing excess Lake Okeechobee water and meeting Everglades water needs, are useful for reducing the dependence on Lake Okeechobee for meeting Everglades water needs. The analysis revealed that the adverse system-wide effects from removing the surge tanks were minimized by increased usage of the Lake Okeechobee aquifer storage and recovery component.

Component uncertainty for the L-31N Seepage Management results from concern regarding the effectiveness and feasibility of the levee seepage barrier and resulting downstream impacts and the ability of pumping technology to seasonally manage groundwater seepage. This sensitivity analysis was not modeled, however, the modeling results of the removal of the Central Lake Belt Storage Area and its perimeter seepage barrier could be extrapolated for general analysis. Wet season, groundwater seepage would be expected to raise the L-31N Borrow Canal levels, increase groundwater levels east of L-31N, flows to Biscayne Bay can be expected to increase due to seepage, and stages and hydroperiods in Everglades National Park west of L-31N can be expected to decrease.

7.3.4 Conclusions of Comprehensive Plan Formulation and Evaluation

The Restudy Team formulated and evaluated 10 alternative plans and in excess of 20 intermediate computer simulations (termed scenarios) that culminated in the selection of Alternative D-13R as the Initial Draft Plan. This plan was then further evaluated by identifying components that have a high degree of uncertainty and analyzing the sensitivity of these features. The results of these analyses suggest that Alternative D-13R, even with all of its uncertainties, is the plan that best achieves the planning objectives. However, a number of components had yet to be evaluated because they were outside the purview of the analytical tools being used to evaluate the alternative plans. Therefore, a subsequent analysis was initiated to evaluate these components, which the Restudy Team termed Other Project Elements.

7.4 OTHER PROJECT ELEMENTS

During the iterative plan formulation process, it became apparent that some components could not be evaluated using the South Florida Management Model because either they were outside the boundary of the model or they were too small to be simulated at the scale of the model. These components were termed Other Project Elements (OPEs) and underwent a separate evaluation (See ***Appendix A, Section 6***).

An initial list of Other Project Elements was developed by the Restudy Team from a number of sources including: the Critical Projects, the Restudy Plan Formulation document, and new proposals from Restudy Team members.

The Water Resources Development Act (WRDA) of 1996 authorizes the Secretary of the Army, subject to specific criteria, to proceed expeditiously with the implementation of restoration projects that are deemed critical to the restoration of the south Florida ecosystem (see ***Appendix A5***). These projects were termed "Critical Projects." This authority resulted in an expedited study to identify projects that would meet the criteria set forth in the authorizing legislation. A total of 35 projects were nominated as Critical Projects under this authority. However, the cumulative cost estimate for these projects exceeded the legislatively mandated limit. Therefore, it is anticipated that only a fraction of the projects will actually be implemented under the Critical Projects authority. Hence, to ensure that all of these projects received full consideration, the Restudy included the Critical Projects that had not yet been approved for construction in its planning process. Some of these Critical Projects are included in alternative plans such as the C-4 Divide Structure. The remainder of the Critical Projects were considered in this Other Project Element evaluation.

7.4.1 Evaluation of Other Project Elements

The first step in the evaluation of the Other Project Elements involved screening the initial list using the following criteria:

(1) The project element could not be evaluated using the South Florida Water Management Model.

(2) The project element must support and be consistent with the Restudy planning objectives.

(3) The project element must have a Federal interest.

(4) The project element should not be a stand alone research or data collection activity.

This screening resulted in 37 potential Other Project Elements. These were then evaluated by an interagency - interdisciplinary team in four benefit categories including: (1) ecological values based on hydrology, spatial extent, habitat quality, and improvement to native flora and fauna; (2) urban and agricultural water supply, (3) flood damage reduction; and (4) water quality. In addition, the team considered two other parameters including geographic extent and the significance to the Initial Draft Plan.

7.4.2 Conclusions of the Evaluation of the Other Project Elements

Of the 37 potential Other Project Elements, the team rated 26 of them (eleven of them were not rated due to lack of information). Of the 26 rated, 11 of them were recommended to be included with the Initial Draft Plan. Further, many of the other proposed Other Project Elements, including many of the lower-priority Critical Projects, were recommended for further study. However, in response to public and agency comments recommending the implementation of the Comprehensive Plan be accelerated to expedite ecologic restoration, many of these Critical Projects and additional Other Project Elements are now included in the final plan. Accordingly, 21 Other Project Elements are now recommended for inclusion in the Comprehensive Plan as displayed in ***Table 7-16***.

7.5 FINAL ARRAY OF ALTERNATIVE PLANS

Subsequent to the selection of Alternative D-13R as the Initial Draft Plan, an evaluation of the final array of alternative plans was conducted. This included an analysis of the economic benefits and impacts, an analysis of the environmental planning objectives, a cost effectiveness and incremental analysis, mitigation analysis, and an evaluation of the plans to meet various policy and regulatory requirements.

7.5.1 Economic Evaluation of the Alternative Plans

Many of the benefits afforded by the alternative plans are environmental in nature and were not converted to monetary units for evaluation. As a result, a major focus of the economic evaluation was on the cost effects of the alternatives. Such effects can result at both the national and regional levels.

TABLE 7-16
RECOMMENDED OTHER PROJECT ELEMENTS

Other Project Elements Title	CP[1] Rank
Melaleuca Eradication – Renovation of Existing Facility and Biological Agent Rearing components (CP)	3
Seminole Tribe Big Cypress Reservation Water Conservation Plan (CP)	6
Southern Golden Gate Estates Hydrologic Restoration (CP)	7
Southern CREW Project Addition/Imperial River Flowways (CP)	9
Lake Okeechobee Watershed Water Quality Treatment Facilities (includes Lake Okeechobee Water Retention/Phosphorus Removal (CP))	10
Lake Trafford Restoration (CP)	15
Biscayne Bay Coastal Wetlands (includes L-31E Flow Redistribution (CP*)*	16
Henderson Creek Belle and Meade Restoration (CP)	17
Lake Okeechobee Tributary Sediment Dredging (CP)	18
Florida Keys Tidal Restoration (CP)	22
Lake Worth Lagoon Restoration (CP)	23
Palm Beach County. Wetlands Based Water Reclamation Project (CP)	24
Miccosukee Water Management Plan (CP)	26
Lakes Park Restoration (CP)	31
Palm Beach County Winsberg Farms Constructed Wetlands Project (CP)	33
Restoration of Pineland & Tropical Hardwood Hammocks in C-111 Basin (CP)	35
Lake Istokpoga Regulation Schedule	N/A
Protect & Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including Strazzulla Tract	N/A
Pal Mar and Corbett Hydropattern Restoration	N/A
Acme Basin B Discharge	N/A

[1]CP – Critical Project

Evaluation of economic effects of the alternatives was concerned with various aspects of the relationships between the economy and water. For example, water is necessary for agricultural and manufacturing processes, and individual survival. It is important for recreation and tourism. It is necessary for navigation. It plays a significant and obvious role in commercial and recreational fishing. The costs of transporting and treating water before and after its use, as well other costs associated with water use, are imbedded in the network of relationships and transactions of the economy. These interrelationships between the economic system and the ecosystem from which water is either consumed, or used in a non-consumptive way, by the economic system are the focal point for measuring some of the costs and benefits of the alternative plans.

The water-economy linkages briefly discussed above are perhaps the more obvious ones. There are also important linkages between the health of south Florida's natural ecosystem, and adequate amounts and timing of water, discussed elsewhere in this and other documents. The more elusive, hard-to-measure linkages, are those between the economic system and the natural ecosystem. This set of relationships is harder to see on a case-by-case basis (some polluted runoff here, some wildlife habitat lost there). In the aggregate, however, it is clear that a healthy functioning ecosystem is part of the requisite infrastructure for a healthy functioning economy. For purposes of this study, economic benefits were not used to "justify" ecosystem restoration plans.

The economic evaluation considered the effects on: agricultural water use, municipal and industrial water use, potential changes in flooding damages, navigation, recreation, and commercial fishing. A summary of the findings of this evaluation are displayed in ***Table 7-17*** and for a complete description of the evaluation, refer to ***Appendix E***.

Agricultural Water Supply – Since all plans involve some change in the management of water, the potential exists for changes in the amount and timing of water available for irrigation of crops, as well as changes in the water table. Such changes could in turn affect agricultural productivity (different productivity for existing crops, different crops, changes in crop practices, etc.). For the Everglades Agricultural Area and the Lower East Coast, changes in water deliveries to agriculture were converted to changes in agricultural crop yields, and in turn, to changes in net farm income. The agricultural water supply effects in the St. Lucie and Caloosahatchee Basins were measured by estimating the difference between the amount of irrigation water provided for a particular alternative and the demands of that basin. The result is a “demands-not-met” measurement that was compared to the Without Plan Condition. This analysis revealed that the alternative plans should result in a positive effect.

Municipal and Industrial Water Supply – Projections of future water demand were made using the IWR-MAIN Water Demand Forecasting software, and were used as input to the South Florida Water Management Model. Changes in water deliveries to the urban users were converted to estimated willingness to pay values. There is expected to be a positive effect for each of the alternative plans compared to the Without Plan Condition.

TABLE 7-17
ECONOMIC EFFECTS OF THE ALTERNATIVE PLANS
($Millions)

Economic Category	How Measured	Alternatives					
		Without Plan	A	B	C	D	D-13R
Agricultural Water Supply: Everglades Agricultural Area and Lower East Coast	Average Annual value of unmet demands (lower is better)	$2.6	$.58	$.88	$.66	$.74	$.71
St Lucie Basin	Percentage of Demands Not Met (lower is better)	22.4%	4.1%	6.5%	4.1%	3.1%	3.1%
Caloosahatchee Basin		31.6%	9.2%	14.9%	9.0%	7.5%	7.5%
Municipal and Industrial Water Supply	Average Annual Value of Unmet demand (lower is better)	$31.8	$10.2	$10.3	$6.4	$4.6	$4.6
Commercial Navigation	Percent of time Lake Okeechobee falls below critical stage (12 feet) (lower is better)	30%	16%	20%	16%	11%	11%
Recreation	See Appendix E	NQ	NQ	NQ	NQ	NQ	NQ
Commercial and Recreational Fishing	See Appendix E	NQ	NQ	NQ	NQ	NQ	NQ
Flood Control	See Appendix E	NQ	NQ	NQ	NQ	NQ	NQ
Regional Economic:	Expressed as percent of regional economy* (higher is better)						
Earnings		NA	.08%	.08%	.10%	.13%	.14%
Employment		NA	.06%	.07%	.07%	.10%	.11%
Output		NA	.08%	.09%	.08%	.12%	.14%

NQ – effects were not quantified
% - percent
* - Regional Economic effects for the alternatives are the difference between with and without a plan.

Commercial Navigation – Low lake levels affect the ability of commercial navigation traffic to safely navigate the Lake Okeechobee Waterway, and can also result in lock operation restrictions. Prior to this study, it was felt that changes in Lake Okeechobee water levels associated with some of the plans could impact navigation in Lake Okeechobee. However, for the alternative plans, this is not an issue. Lake level fluctuations appear to be moderated in the plans being considered compared to the Without Plan Condition. High levels are not as high as, and low levels are not as low as in the Without Plan Condition. The navigation effects could have been translated into monetary units, but the data uncertainty is such that the effects were evaluated by identifying when Lake Okeechobee stages fall below 12 feet.

Recreation – Recreation is a major industry in south Florida, and the natural ecosystems play a potentially important contributing role. Besides opportunities for ecosystem-related tourism (visitor centers, educational programs, etc.), there are potentially major implications for that part of the economy linked to the health of Florida Bay (mainly Monroe County, which includes the Florida Keys). While there is the possibility of a significant positive effect associated with any of the alternative plans being examined, but there is so much uncertainty at this stage of the planning process, that such effects were not monetized. ***Appendix E*** includes a lengthy discussion about this topic and the context within which possible changes will take place. However, the kind of detailed information that is necessary to estimate recreation effects of the different alternative plan was not available during this study.

Commercial Fishing – It is possible that economic commercial and recreational fishing benefits could result from the alternative plans. If fish stocks were to increase as a result of positive Florida Bay responses to Everglades ecosystem restoration, and commercial fish catch were to increase, then the difference in the value of fish catch would be an economic benefit. Some studies reveal strong evidence suggesting that such could be the case, particularly for pink shrimp. The potential exists for similar positive effects in the other affected areas of St. Lucie Estuary, Caloosahatchee Estuary, and Biscayne Bay. These effects could extend to offshore fisheries as well, due to the relationship between conditions in the bays and estuaries, which provide nursery functions for the offshore fisheries. Again, details necessary to identify monetary effects of each alternative plan were not available during this study. Similar to the recreation analysis, a discussion of the role commercial fishing plays in the economy is provided in ***Appendix E*** to highlight the relative significance of potential impacts in this area.

Flood Damage Reduction – A major justification for much of the existing C&SF Project was to control flooding. Modifications to achieve ecosystem restoration have the potential to change flood control. For example, alternative plans that increase canal capacities or include additional water storage capacity enhance flood control provided by the system. For this study, neither additional benefits nor costs (increased damages) have been quantified. This was because the South Florida Water Management Model, which was the primary tool used to simulate the alternative plans, did not have the spatial resolution, nor was it sufficiently calibrated in the urban areas to definitively evaluate flood damage changes expected to result from any of the alternative plans. However, known (existing) problem areas were defined and cross-compared with some of the South Florida Water Management Model output that identifies gross changes in annual peak stage. Further, during the engineering design of the plan components, steps were taken to minimize potential flooding that could result from any of the components. Therefore, the flood damage reduction analysis, which can be found in ***Appendix E***, identified areas which have a strong potential for follow-on flood damage reduction or mitigation analysis that may be needed in the more detailed implementation analyses which will follow the Restudy.

Regional Economic Development Effects – Regional economic impact effects were estimated for the alternative plans. This included the “multiplier” effects of project spending, as well as agricultural water supply changes, and the impact of agricultural land taken out of production due to project components (e.g., water storage facilities). In the context of the 12- county area of economic influence, the alternative plans would result in a relatively small positive effect on the regional earnings, sales, and employment. The analysis, which can be found in ***Appendix E***, showed that the positive effects associated with project spending and increased agricultural production due to fewer water restrictions would be greater than the negative effects of agricultural land removed from production for storage facilities.

7.5.2 Environmental Evaluation of the Alternative Plans

Two different methods were used to assess the ecological performance of the alternative plans. The color assessment scheme developed by the Alternative Evaluation Team was the first method of assessment. This provides information about the potential for achieving the long-term ecologic objectives. The team used "green" to indicate that an alternative plan will likely result in the recovery and long-term sustainablility of the ecologic and water supply objectives in the sub-region. The goal was to achieve a green assessment for all areas throughout the study area indicating potential system-wide restoration.

This assessment was used to quantify the spatial extent in meeting the planning objective by summing the acreage of each sub-region that was assessed as green. The result of this evaluation is displayed as "Green Acres" in ***Table 7-18.*** Alternative D-13R resulted in a substantially larger area of predicted sustainable ecosystems than any of the other plans evaluated. Had all sub-regions achieved this goal, approximately 2.7 million acres would be restored to levels capable of sustaining long term ecological objectives. The without plan condition has no areas assessed green; therefore, 0 acres.

A second evaluation was conducted to determine the success of alternative plans in meeting the planning objective for improving habitat quality of natural areas in south Florida. Habitat quality is critical to reestablishing sustainable populations of fish and wildlife resources in the central and south Florida ecosystem. To measure this objective, "Habitat Units" were calculated by multiplying the area of a sub-region (acres) by the numeric output from the River of Grass Evaluation Methodology. When summed, the habitat units provide an indication of the potential system-wide habitat quality. The result of this evaluation is displayed in ***Table 7-18***. If all sub-regions were restored, the result would be 2.7 million habitat units. Alternative D-13R resulted in 2.2 million habitat units, the most for any of the plans evaluated.

The Other Project Elements are not included within the domain of the South Florida Water Management Model; therefore, the environmental evaluations of these features were not included in the color assessment nor the River of Grass Evaluation Methodology. An estimate was prepared using principles similar to the River of Grass Methodology but at a more localized scale. The evaluation of the Other Project Elements included development of habitat units for the localized benefits produced within the “footprint” of the feature. No attempt was made to assess benefits that were expected to accrue offsite or benefits from Other Project Elements without a discrete footprint, such as the Biological Control for Melaleuca and Other Invasive Exotic Species project. The construction of this feature would have system-wide benefits but the assumptions necessary to make an estimate of habitat unit improvement would be overly gross and were not attempted. Accordingly, the estimate of Other Project Elements benefits is considered underestimated at 9,000 habitat units.

7.5.3 Cost Effectiveness and Incremental Cost Analyses

Cost effectiveness and incremental cost analyses reveal information about good financial investments given the dollar costs and non-dollar outputs (“benefits”) of alternative investment choices. The analyses are conducted in a series of steps that progressively identify alternatives that meet specified criteria and screen-out those that do not. Corps Engineer Regulation 1105-2-100 requires cost effectiveness and incremental cost analyses to support recommendations for ecosystem restoration.

Cost effectiveness analysis begins with a comparison of the costs and outputs of alternative plans to identify the least cost plan for every possible level of output. The resulting least cost alternative plans are then compared to identify those that will produce greater levels of output at the same cost, or at a lesser cost, as other alternative plans. Alternative plans identified through this comparison are the cost effective alternative plans. Next, the cost effective alternative plans are compared to identify the most economically efficient alternative plans, that is, the “best buy” alternative plans that will progressively produce the “biggest bang for the buck”. Finally, the additional costs for the additional amounts of output (“incremental cost”) produced by the best buy alternative plans are calculated. The results of all of the calculations and comparisons of costs and outputs provide a basis for addressing the decision question “Is it worth it?” In the case of the Restudy, the question is how much ecosystem restoration is worth the dollar cost? Additional information about the analyses is in *Evaluation of Environmental Investments Procedures Manual, Interim: Cost Effectiveness and Incremental Cost Analyses* by the U.S. Army Corps of Engineers, Institute for Water Resources (USACE, 1995).

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TABLE 7-18
ENVIRONMENTAL EVALUATION OF THE ALTERNATIVE PLANS

Sub-Region	Acres	Existing		Without Plan		A		B		C		D		D-13R	
		ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU	ROGEM	HU
Lake Okeechobee	467,000	0.6	280,200	0.6	280,200	0.8	373,600	0.8	373,600	0.9	420,300	0.9	420,300	0.9	420,300
Caloosahatchee Estuary	9,000	0.0	0.0	0.1	900	1.0	9,000	1.0	9,000	1.0	9,000	1.0	9,000	1.0	9,000
St. Lucie Estuary	5,000	0.0	0.0	0.1	500	0.8	4,000	0.8	4,000	0.8	4,000	0.8	4,000	0.9	4,500
Loxahatchee NWR	143,000	1.0	143,000	0.6	85,800	1.0	143,000	1.0	143,000	1.0	143,000	1.0	143,000	1.0	143,000
WCA-2A	105,000	0.4	42,000	0.4	42,000	0.4	42,000	0.4	42,000	0.4	42,000	0.4	42,000	0.6	63,000
WCA-2B	28,000	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800	0.1	2,800
Northwest WCA-3A	118,000	0.1	11,800	0.4	47,200	0.8	94,400	0.8	94,400	0.8	94,400	0.8	94,400	0.8	94,400
Holey Land and Rotenberger WMAs	61,000	0.4	24,400	0.6	36,600	0.8	48,800	0.8	48,800	0.8	48,800	0.8	48,800	0.8	48,800
Northeast WCA-3A	54,000	0.1	5,400	0.4	21,600	0.8	43,200	0.6	32,400	0.1	5,400	0.1	5,400	0.4	21,600
Eastern WCA-3A	74,000	0.1	7,400	0.4	29,600	0.1	7,400	0.1	7,400	0.1	7,400	0.1	7,400	0.4	29,600
Central and Southern WCA-3A	276,000	0.4	110,400	0.4	110,400	0.8	220,800	0.8	220,800	0.4	110,400	0.4	110,400	0.8	220,800
WCA-3B	69,000	0.8	55,200	0.4	27,600	1.0	69,000	0.1	6,900	0.1	6,900	0.1	6,900	0.6	41,400
Pennsuco Wetlands	18,000	0.4	7,200	0.4	7,200	0.6	10,800	0.6	10,800	0.8	14,400	0.8	14,400	0.8	14,400
Shark River Slough	204,800	0.2	40,960	0.3	61,440	0.5	102,400	0.6	122,880	0.6	122,880	0.6	122,880	0.8	163,840
Rockland Marl Marsh	77,000	0.2	15,400	0.6	46,200	0.7	53,900	0.7	53,900	0.8	61,600	0.8	61,600	0.8	61,600
Model Lands	18,000	0.6	10,800	0.6	10,800	0.5	9,000	0.7	12,600	0.8	14,400	0.8	14,400	0.8	14,400
Florida Bay	448,000	0.2	89,600	0.3	134,400	0.8	358,400	0.9	403,200	0.8	358,400	0.8	358,400	0.8	358,400
Biscayne Bay	138,000	0.9	124,200	0.8	110,400	0.5	69,000	0.6	82,800	0.8	110,400	0.8	110,400	0.8	110,400
South & Southeast Big Cypress	364,000	0.9	327,600	0.9	327,600	1.0	364,000	0.9	327,600	1.0	364,000	1.0	364,000	1.0	364,000
Total Habitat Units			**1,298,360**		**1,383,240**		**2,025,500**		**1,998,880**		**1,940,480**		**1,940,480**		**2,186,240**
Green Acres (Sustainable Ecosystem)	**2,712,800**	**NE**		**0**		**680,000**		**680,000**		**793,000**		**1,331,000**		**2,405,800**	

NE-- Not Evaluated HU – Habitat Unit

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In practice, Corps ecosystem restoration studies typically measure the ecosystem benefits of alternative plans in terms of physical dimensions (number of acres of wetlands, for example), or population counts (number of wading birds, for example), or various habitat-based scores ("habitat units" based on the U.S. Fish and Wildlife Service's *Habitat Evaluation Procedures*, or "HEP", for example). Any of these metrics may be used in conducting cost effectiveness and incremental cost analyses. For the purposes of the Restudy, the analyses were conducted using the "habitat unit" and "green acre (sustainable ecosystem)" measurements of plan outputs; see ***Section 7.5.2*** Environmental Evaluation of the Alternative Plans and ***Table 7-18*** for additional information about these metrics. Recognizing the cautions and limitations on using these metrics in a comparative manner and the uncertainties inherent in the metrics as well as the cost estimates, the habitat unit and green acre estimates were used in the analyses to illustrate the type of information they may reveal.

Cost effectiveness and incremental cost analyses were conducted for Alternatives A, B, C, D and D-13R. The analyses compared the alternative plans' average annual costs (over a 20-year construction period) against the habitat unit and green acre estimates. In preparation for the analyses, the effects of each alternative were calculated by subtracting the Without Plan Condition value from the with-alternative value ("with-and-without analysis") to determine the value of the alternative's change. ***Table 7-19*** displays the resulting scores for the habitat unit and green acre outputs, as well as costs, used in the cost effectiveness and incremental cost analyses.

The results of the cost effectiveness and incremental cost analyses for the final Restudy alternative plans are summarized in ***Table 7-20*** and ***Figure 7-7*** and provide the following information about the plans:

- In comparing costs against habitat units, Alternatives B, C and D would not be good choices because each would produce fewer habitat units at a greater cost compared to Alternative A. Therefore, if Alternatives B, C and D are set aside based on this reason, the remaining cost effective plans would be Alternatives A and D-13R. A subsequent analysis to identify the "best buy" plans indicated that Alternative A is the first best buy plan (with an incremental cost per habitat unit of $390), followed by Alternative D13R as the second and final best buy plan (with an incremental cost per habitat unit of $930).

- In comparing costs against green acres, Alternative B would not be a good choice because it would produce the same number of acres but at a greater cost compared to Alternative A. Therefore, if Alternative B is set aside based on this reason, the remaining cost effective plans would be Alternatives A, C, D and D-13R. A subsequent analysis to identify the "best buy" plans indicated that Alternative D-13R is the only best buy plan (with an incremental cost per green acre of $170).

TABLE 7-19
COSTS AND OUTPUTS USED
IN COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES
OF FINAL ALTERNATIVE PLANS

	Without Plan	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D-13r
Average Annual Cost ($1,000)	$0	$253,540	$286,305	$340,937	$382,831	$402,292
Habitat Units	0	642,260	615,640	557,240	557,240	803,000
Green Acres	0	680,000	680,000	793,000	1,331,000	2,405,800

TABLE 7-20
RESULTS OF THE
COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES
OF FINAL ALTERNATIVE PLANS

Output Indicators	**Alternative A**	**Alternative B**	**Alternative C**	**Alternative D**	**Alternative D-13r**
Habitat Units	Cost effective and best buy plan				Cost effective and best buy plan
Green Acres	Cost effective plan		Cost effective plan	Cost effective plan	Cost effective and best buy plan

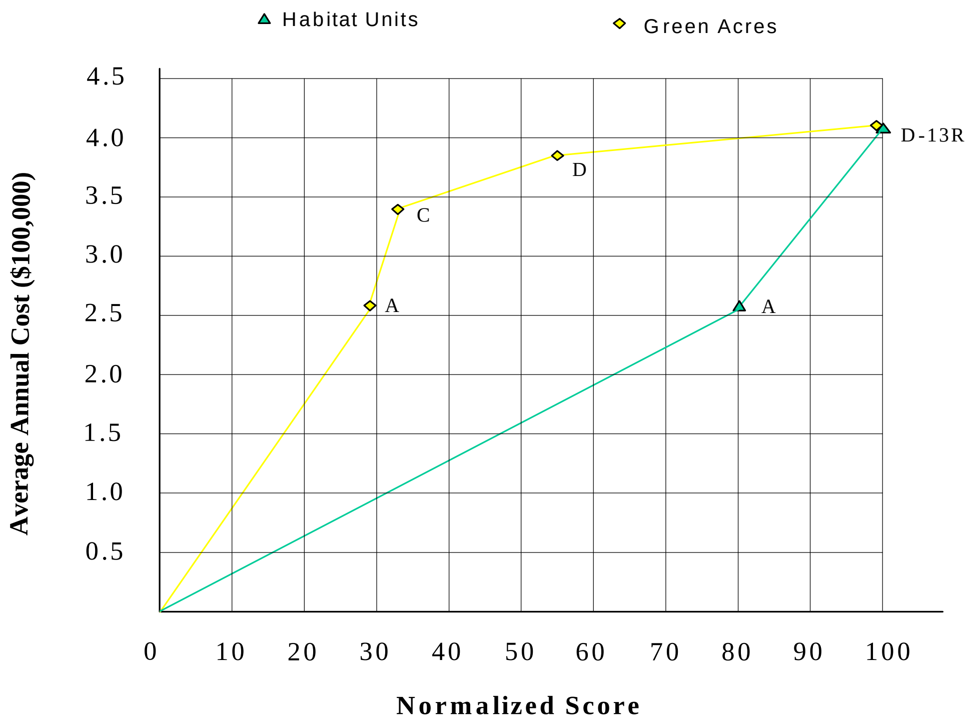
Table 7-21 presents the incremental cost information for the best buy alternative plans for both habitat units and green acres output indicators.

TABLE 7-21
INCREMENTAL COST INFORMATION
FOR THE BEST BUY ALTERNATIVE PLANS

HABITAT UNITS						
Best Buy Alternative plans	Average Annual Cost ($1,000)	Habitat Units	Additional Average Annual Cost	Additional Habitat Units	Incremental Cost per Habitat Unit	Average Cost per Habitat Unit
Without Plan Condition (No Action)	$ 0	0	$ 0	0	Not applicable	Not Applicable
Alternative A	$253,540	642,260	$253,540	642,260	$0.39	$0.39
Alternative D-13R	$402,292	803,000	$148,752	160,740	$0.93	$0.50

GREEN ACRES						
Best Buy Alternative plans	Average Annual Cost ($1,000)	Green Acres	Additional Average Annual Cost	Additional Green Acres	Incremental Cost per Green Acre	Average Cost per Green Acre
Without Plan Condition (No Action)	$ 0	0	$ 0	0	Not applicable	Not applicable
Alternative D-13R	$402,292	2,405,800	$402,292	2,405,800	$0.17	$0.17

FIGURE 7-7
COST EFFECTIVE ALTERNATIVE PLANS



7.5.4 Fish and Wildlife Mitigation Analysis

Some of the components in the alternative plans have the potential to cause localized adverse environmental impacts. For example, the construction of levees, canals, reservoirs and stormwater treatment areas, could adversely impact wetlands and other aquatic sites as well as native upland habitats. The locations of many features are known, while others are only conceptually proposed within a study region or basin. As site-specific details for the components are developed during the Project Implementation Process, land suitability analyses will be utilized as part of the site selection process. Sites with extensive wetland and/or aquatic habitats and native upland habitats will be avoided to the greatest extent practicable. For selected sites where impacts to these habitats are unavoidable, impacts will be minimized through project design. Notwithstanding the current uncertainty regarding component siting and design, an analysis was conducted to determine the approximate extent of these potential impacts.

For the features that involve large areal extent like reservoirs, estimates were made for the affected wetland acreage. For the known sites, the acreage estimates were based on available information, such as existing studies, aerial photography and other physiographic data. Due to the variety of native upland habitats that could be encountered and the inability to discern them at the level this estimate was made, potential impacts to uplands were not included in this analysis. Furthermore, it is anticipated that the land suitability analyses to be utilized during the Project Implementation Report processes will minimize the potential effects on native habitat types in favor of disturbed sites. For sites that were only conceptually located, conservative estimates were made of the percent of wetland area expected to be encountered. For linear features such as canals and levees, the worst case scenario was used and it was assumed these features would be located entirely within wetlands.

In addition to the estimates of wetland acreage that could be affected, habitat quality estimates were made for both the existing and with-plan conditions. These wetland habitat quality estimates were made using a scale of zero to one, with 0.0 representing very poor habitat quality and 1.0 representing optimum habitat quality. For the existing condition estimates, habitat quality was based on available data for project features with known locations and best professional judgement was used for project features with conceptual locations. To estimate the habitat quality for the with-plan condition, operational details of the feature are needed. For example, the hydrologic operation and vegetative management of the Water Preserve Areas will dictate the effect on habitat quality as either beneficial or detrimental. Again, a conservative approach was taken and all features were assumed to produce an adverse impact. The total estimate of the potential adverse impacts of Alternative D-13R and the Other Project Elements is a loss of approximately 10,000 “wetland habitat units”. These units were derived by multiplying the estimated area of affected wetlands by the difference between the existing and with-plan habitat quality estimates.

7.5.5 Uncertainty Analysis

The primary purpose of the uncertainty analysis (see ***Appendix O***) was to identify which of the remaining uncertainties are most significant. That is, which have the most potential to affect the effectiveness of the project that will eventually be implemented. A secondary purpose of the analysis was to identify broad strategies that can be used to address or reduce the remaining uncertainties.

Much of the uncertainty that attends this study effort is considered routine uncertainty. Planning is an iterative process. The iterations are distinguished by an increasing quantity and quality of information and a corresponding decrease in uncertainty. In any planning study there are things that are unknown at one point in time that must and will be known before the project can be implemented. That includes such things as specifically where project elements will be located, how much they will cost, and who will pay for them, among many other issues. While there is a great deal of routine uncertainty attending the current iteration of this planning study, processes have been developed to ensure that they are resolved in due time.

Although much of the uncertainty that remains in the Restudy is routine and will be addressed in time, there are some uncertainties that are too unique to ignore. For example, although the basic workings of Aquifer Storage and Recovery (ASR) technology are a perceived uncertainty, there are some unique uncertainties associated with their application on a magnitude of this scale. Four key uncertainties were identified in the analysis that are unique enough to warrant special attention in the future. They include:

- Uncertainties about major Restudy models;
- Uncertainties about the linkage between hydrologic change and ecosystem restoration;
- Uncertainties about new technologies; and,
- Uncertainties about the risks associated with the Comprehensive Plan.

Appendix O includes the commitments that the Restudy Team has made to address these key uncertainty issues in subsequent planning and design activities and recommendations for additional studies to help resolve outstanding uncertainty issues including a qualitative risk assessment.

7.5.6 Planning Criteria

Performance of the alternative plans with respect to the planning objectives including ecologic, economic, and hydrologic criteria, is displayed in ***Table 7-22***.

7.5.7 Evaluation Accounts

Planning by Federal agencies for water resource development and management is guided by the requirements of the U.S. Water Resources Council's Principles and Guidelines. The Principles and Guidelines establish the Federal Objective for water projects, set forth a six-step planning and decision making process, and prescribe four accounts of evaluation.

TABLE 7-22
PLANNING CRITERIA EVALUATION

PLANNING CRITERIA	WITHOUT PLAN	A	B	C	D	D-13 R and OPEs
ECOLOGIC Increase the total spatial extent of natural areas (Acres of Sustainable Ecosystem, Green ranking)	0 acres	680,000 acres	680,000 acres	793,000 acres	1,295,000 acres	2,370,000 acres
Improve habitat and functional quality (ROGEM Numeric Score x effected acres) HU = Habitat Units	1,383,000 HU	2,025,000 HU	1,000,000 HU	1,940,000 HU	1,940,000 HU	2,186,000 HU
Improve native plant and animal species abundance and diversity (Number of Ecologic Landscape Types that are Sustainable, Green Ranking)	NA	58	58	58	56	58
ECONOMIC Increase availability of fresh water (volume of water restriction cutback for agricultural / urban, Acre-feet)	6,665,000	1,798,000	2,325,000	1,767,000	1,395,000	1,333,000
Reduce flood damages	Evaluation did not result in quantification of benefits and impacts since SFWMM is not designed for flood studies. Refer to Appendix E for description of the analysis.					
Provide recreational and navigation opportunities: Lake Okeechobee (percent time Lake Okeechobee falls below 12 feet)	30%	16%	20%	16%	11%	11%
Other recreational opportunities	Problematic to quantify effects of alternative plans; current expenditures $404 million (parks and preserves), $598 million (region); current consumer surplus $290 million (parks and preserves), $764 million (region)					
HYDROLOGIC Regain lost storage capacity (Additional Storage – total for 31 year period of record) (Coastal Discharges – water wasted to tide)	NA 1,774,000 ac-ft	44,016,000 ac-ft 67,000 ac-ft	48,315,000 ac-ft 138,000 ac-ft	48,369,000 ac-ft 383,000 ac-ft	52,469,000 ac-ft 311,000 ac-ft	52,005,000 ac-ft 311,000 ac-ft
Restore more natural hydropatterns (acres with improved ROGEM scores)	NA	2,725,358	2,656,188	2,344,142	1,669,263	2,777,045
Improve timing and quantities of fresh water deliveries to estuaries (Flood Discharge Volumes from Lake Okeechobee)	9,114,000 ac-ft	1,116,000 ac-ft	682,000 ac-ft	868,000 ac-ft	930,000 ac-ft	868,000 ac-ft
Restore water quality conditions (Cumulative Score from combined ranking matrix, higher = better)	27.0	32.5	35.5	30.5	40.5	45.5

The four accounts facilitate the evaluation, display, and comparison of the effects of alternative plans. These accounts are national economic development (NED), environmental quality (EQ), regional economic development (RED) and other social effects (OSE). The EQ account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be measured in monetary terms. The OSE account shows urban and community impacts and effects on life, health and safety. The NED account shows effects on the national economy. The RED account shows the regional incidence of NED effects, income transfers, and employment effects.

These four accounts encompass all significant effects of plan implementation, including economic, socioeconomic and environmental effects that must be considered in water resources planning as prescribed in the following Federal laws:

- The 1969 National Environmental Policy Act (Public Law 91-190);
- Section 122 of the 1970 Rivers and Harbors Act (Public Law 91-611);
- Sections 904 and 905 of the 1986 Water Resources Development Act (Public Law 99-662).

The 1969 National Environmental Policy Act (NEPA). Public Law 91-190 (42 USC 4321) requires assessment of alternative plan impacts on the human environment. NEPA also requires documentation of the planning process, alternative plan comparison and plan selection.

Section 122 of the Rivers and Harbors Act of 1970 (Public Law 91-611, 84 STAT. 1823) requires that consideration be given to possible adverse economic, social and environmental effects. It also requires that final decisions on the project be made in the best overall public interest, taking into consideration the need for flood control, navigation and associated purposes; and the associated costs of eliminating or minimizing the following adverse affects:

- Air, water and noise pollution;
- Destruction or disruption of man-made and natural resources, esthetic values, community cohesion, and availability of public facilities and services;
- Adverse employment effects;
- Tax and property value losses;
- Injurious displacement of people, businesses and farms;
- Disruption of desirable community and regional growth.

Section 904 of the 1986 Water Resources Development Act (Public Law 99-662, 100 STAT. 4185, 33 USC 2281)) describes additional requirements that must be addressed in the formulation and evaluation process for Federal water resources projects. These requirements are listed below. The formulation and evaluation process must consider the associated benefits and costs of these items, both quantifiable and unquantifiable, and must be displayed in the benefits and costs of such projects.

- Enhancing national economic development;
- Quality of the total environment;
- The well-being of the people;
- Prevention of loss of life;
- Preservation of cultural and historical values.

Section 905 of the 1986 Water Resources Development Act (Public Law 99-662 (100 STAT. 4185, 33 USC 2282) describes the requirements for feasibility reports for any water resources project or related study authorized to be undertaken by the Secretary. The feasibility report will describe, with reasonable certainty, the economic, environmental and social benefits and detriments of the recommended plan and alternative plans considered by the Secretary.

Effects of the alternative plans in the four evaluation accounts are displayed in ***Tables 7-23*** and ***Table 7-24.***

TABLE 7-23
EVALUATION ACCOUNTS LISTED IN THE "PRINCIPLES AND GUIDELINES"
(all dollar values in $ millions)

Evaluation Accounts	WITH- AND WITHOUT-PROJECT CONDITIONS					
	2050 Base Condition	Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
National Economic Development Account						
Agricultural Water Supply: Avg. annual value of unmet demand*	$2.6	$0.6 (+$2.0)	$0.9 (+$1.7)	$0.7 (+$1.9)	$0.8 (+$1.8)	$0.7 (+$1.9)
M&I Water Supply: Avg. annual value of unmet demand*	$31.8	$10.2 (+$21.7)	$10.3 (+$21.5)	$6.4 (+$25.4)	$4.6 (+$27.2)	$4.6 (+$27.2)
Flood Control	• Limited evaluation of impacts, since SFWMM not designed for flood studies.					
Commercial Navigation	• No significant difference expected between with- and without-project conditions.					
Recreation	• Problematic to quantify effects of alternative plans. • Current Expenditures: $404 million (parks/preserves); $598 million (region). • Current Consumer Surplus: $290 million (parks/preserves); $764 million (region).					
Commercial/Recreational Fishing	• Annual revenues estimated for commercial and guided & recreational sportfishing in five areas: Lake Okeechobee, St. Lucie & Caloosahatchee estuaries, and Biscayne & Florida bays. • Significant positive economic impacts are expected to result from hydrologic modifications and consequent ecological impacts to all five areas with the exception of Biscayne Bay.					
Project Costs						
Total Construction & Real Estate Costs		$5,229	$6,023	$6,725	$7,335	$7,789
Annual Operations & Maintenance Costs		$70	$72	$126	$162	$165
Annual Monitoring Costs		$10	$10	$10	$10	$10
Annualized Costs		$254	$286	$341	$383	$402
Regional Economic Development Account						
Average annual effects (% of regional economy)						
Output		$173 (.08%)	$195 (.09%)	$192 (.09%)	$277 (.12%)	$307 (.14%)
Employment (jobs)		1,707 (.06%)	1,934 (.07%)	2,057 (.07%)	2,903 (.10%)	3,165 (.11%)
Earnings		$59 (.08%)	$65 (.08%)	$78 (.10%)	$103 (.13%)	$108 (.14%)
Environmental Quality Account	• Refer to Table 7-22 and 7-24 for a display of ecologic, cultural, and aesthetics attributes.					
Other Social Effects Account	• Potential community disruption from conversion of agricultural land to reservoirs.					

Note, A "+" indicates a reduction in unmet water demand.

TABLE 7-24
SUMMARY OF EFFECTS

CATEGORIES OF EFFECTS	EXISTING CONDITION	WITHOUT PLAN	A	B	C	D	Selected Plan
Air Quality	H	H	0	0	0	0	0
Noise Pollution	L	L	-**	-**	-**	-**	-**
Water Quality	L-M	M	-**/+	-**/+	-**/+	-*/+	-**/+
Natural Resources	M	M	+/+	+/+	+/+	+/+	+/+
Wetlands	M	L	+	+	+	+	++
Endangered and Threatened Species	4 Critical Habitats	0	+	+	+	++	++
Fish and Wildlife	M	L	+	+	+	++	++
Wild and Scenic Rivers	8 miles	8 miles	+	+	+	+	+
Coastal Zone	--	--	+	+	+	+	++
Flood Plains	M	M	0	0	0	0	0
Aesthetic Values	M	M	0	0	0	0	0
Man-made Resources	M	M	+/-	+/-	+/-	+/-	+/-
Community Cohesion	M	M	N/A	N/A	N/A	N/A	N/A
Historic and Cultural Properties	L	L	0	0	0	0	0
Public Facilities and Services	M	M	+	+	+	+	+
Employment	M	M	+	+	+	+	+
Tax Values	M	M	+	+	+	+	+
Property Values	M	M	+	+	+	+	+
Displacement of People	L-M	L-M	-	-	-	-	-
Displacement of Businesses	L-M	M-H	-	-	-	-	-
Prime and Unique Farmlands	L	M	-***	-***	-***	-***	-***
Displacement of Farms	M	M-H	--	--	--	--	--
Desirable Community Growth	M	M	+	+	+	+	+
Desirable Regional Growth	M	M	+	+	+	+	+

Existing and Without Plan Conditions display estimates of each resources relative values: H = high, M = moderate, L = low.
Plans' effects are estimates of net overall changes from the Without Plan Condition:

++ = very beneficial change
+ = beneficial change
0 = no change
- = adverse change
-- = very adverse change
N/A = not applicable

** During construction, localized
*** Unique Farmland will be taken out of production however no Prime Farmland will be impacted

7.6 PLAN FORMULATION PROCESS SUMMARY

The planning process used by the Restudy Team evolved over three years, ultimately resulting in selection of a recommended Comprehensive Plan. The team used an iterative decision making process to identify and evaluate the merits of individual components and the effects of combining these components into different comprehensive plans. The Restudy's major iterations are illustrated in **Figure 7.1**. ***Table 7-25*** highlights the purpose, decision criteria and results of the major iterations.

TABLE 7-25
PLAN FORMULATION MAJOR ITERATIONS

ITERATION We started with:	**PURPOSE Our intent was to:**	**CRITERIA We made decisions based on:**	**RESULT The iteration ended with:**
Goals and Objectives	Progressively identify components to meet the goals and objectives	Ideas from technical experts and the public	Components
Components	Comparatively array and screen components	• Lower East Coast Regional Water Supply Plan • Water Preserve Areas Land Suitability Analysis • Everglades Screening Model • Cost Effectiveness Analysis	Starting Point Alternative
Starting Point Alternative	Progressively formulate plans	Performance measures	Alternatives 1-6, which were screened to Alternatives A-D (3-6)
Alternatives A-D	Comparatively array and screen plans	• River of Grass Evaluation Methodology • Ranking Score • Grade Score • Color Score • Keystone and Endangered Species Evaluation • Water Quality	Alternative D
Alternative D	Progressively reformulate plans	Performance measures	Alternative D-13R
Alternatives A-D and D-13R (Final array)	Comparatively array and screen plans	• Economic Evaluation • Environmental Evaluation • Cost Effectiveness and Incremental Cost Analyses • Mitigation Analysis • Planning Criteria • Evaluation Accounts	D-13R plus Other Project Elements

As the Restudy planning iterations evolved, the criteria that were the basis for deciding the fate of solutions were refined and modified, but the planning objectives remained the same throughout. During the early iteration of screening components, it was possible to make such decisions using more qualitative information that was readily available from a limited number of analyses. This is in stark contrast to the final iteration in which new and more quantitative analyses were required to make more sophisticated judgments across a more extensive set of criteria. During each iteration, the decision criteria reflected the best available information that could be used to support decisions for dropping or retaining the solutions at hand.

This iterative planning process progressively eliminated inferior plans and carried superior plans forward for reformulation into even better plans. Subsequent iterations to improve the plans were based on criteria (and their related metrics) that had been refined and improved from criteria used in the previous iterations. Each iteration flowed from and built upon the decisions reached in the previous iterations. As such, the team did not carry along plans eliminated in previous iterations so that all plans are continually evaluated on an ever-evolving comparable basis. An iteration was not an opportunity to revisit previous decisions (although, on occasion, some iterations were indeed just that). Rather, each iteration sought to move decision making closer to a final recommendation.

7.7 SUBSEQUENT ITERATIONS OF THE RECOMMENDED PLAN

The U. S Department of Interior, and the Florida Game and Fresh Water Fish Commission listed a number of concerns about the draft Comprehensive Plan in the draft Fish and Wildlife Coordination Act Reports presented to the Corps of Engineers in August, 1998 (see ***Annex A***). Some of these issues were considered critical to acceptance of the Comprehensive Plan. While it was considered unreasonable to expect these issues could be completely resolved before completion of this report, the South Florida Ecosystem Restoration Working Group agreed they warranted additional attention and additional modeling, if possible.

The Alternative Evaluation Team agreed to develop a short-term issue identification and resolution process for addressing the outstanding issues associated with the Comprehensive Plan. Task teams were formed. The Everglades Basin task team combined the former Total Systems, Northern and Central Everglades, Southern Everglades and Florida Bay, and Big Cypress subteams. The Southeastern Estuaries task team combined the Biscayne Bay and Model Lands/C-111 Basin subteams. The Water Quality subteam was already in existence and a small Northern Estuaries team was formed.

The four teams identified all outstanding issues including, but not limited to, those coming from the two Coordination Act Reports. Some of the issues were plan formulation, evaluation, and modeling issues occurring in each Alternative Evaluation Team sub-region. These issues were considered to be within the scope of the Alternative Evaluation Team. Other agency concerns, such as policy issues, were listed, but because they were beyond the scope of the Alternative Evaluation Team, they were not pursued further during this process. The issue teams then agreed that six issues were exceptionally important and deserved additional attention prior to completion of the final report.

Team members drafted issue papers on each of the five most important issues following an agreed-upon outline developed by the Everglades Basin team and ratified by the others. The purpose of each issue paper was to better define the issues, propose a process for resolving the issue by creating a common understanding of the specific tasks that will be required and the information needed to resolve each issue either for the final report or during the future planning and implementation of the recommended Comprehensive Plan. Each paper was to propose a time line for reaching closure on each issue.

The six issues can be paraphrased as follows:

1. The plan needs to increase total overland flow to Florida Bay, Northeast Shark River Slough and Taylor Slough to fully meet Natural System Model depth and duration targets.

2. The plan needs to improve ecological performance in the Water Conservation Areas by eliminating damaging high and low water conditions.

3. The plan should improve ecological conditions in Biscayne Bay by restoring more natural freshwater inflows.

4. The risks and uncertainties associated with using wastewater reuse as a water source for Biscayne Bay should be closely examined.

5. Restoration targets in the St. Lucie Estuary should be more closely met.

6. The plan needs to improve ecological performance in the Model Lands and C-111 Basins by providing adequate freshwater to maintain target hydropatterns.

The Alternative Evaluation Team also undertook to draft a white paper to refine the team's working definition of restoration.

The Alternative Evaluation Team and its issue resolution task teams had an array of both short-term and long-term opportunities for addressing the remaining issues. Possible avenues included: optimization modeling, model refinements, technical peer review for questions of science, additional field studies and measures, refinement and creation of new performance measures, the development of review papers (white papers) on key issues, recommending operational and structural improvements during the detailed design phases, the use of an adaptive assessment strategy, and the design of a comprehensive ecological monitoring program.

The short-term strategy outlined above was an interim strategy intended to feed into and support the implementation and adaptive assessment strategies currently being developed for this report and to satisfy the recommendations of the U.S Fish and Wildlife Service and the Florida Game and Fresh Water Fish Commission Final Coordination Act Reports.

Four papers have been completed, reviewed by the Alternative Evaluation Team and accepted: the St. Lucie issue paper, the two Biscayne Bay issue papers, and the "defining restoration" white paper. The two Everglades basin teams combined and completed a draft issue paper. The issue papers can be found in the U.S. Fish and Wildlife Coordination Act Report (***Annex A***).

Understanding that two of the issues (numbers 1 and 3) would be resolved if the plan provided more water for Biscayne Bay and Shark River Slough, an initiative was begun to investigate the capture of additional water discharged to tide beyond the quantity captured in Alternative D-13R. This investigation included additional model runs of the SFWMM hydrologic model. These model runs were referred to as D-13R_x scenarios, with the $_x$ representing each of the additional scenarios. For example, the first scenario developed was called D-13R_1. The purpose of these scenarios was to increase the water supply to Northeast Shark River Slough and Biscayne Bay by capturing and directing water currently discharged to tide in previous alternative plans. An intense effort by the interagency Alternative Evaluation Team subteam chairs and hydrologic modelers involved daily meetings to view model outputs, evaluate them, and quickly suggest improvements for model runs to be made that night for review the following day. A total of four scenarios were developed during this process with scenario D-13R_4 producing the greatest additional water flow. Therefore, only alternative D-13R_4 is described further in this report. The description of the other scenarios can be found on the Restudy web site (*www.restudy.org*).

7.7.1 Scenario D-13R_4 Description

The components of D-13R_4 scenario were designed to provide peak flood attenuation, reduction of freshwater discharges to tide and increase flows to Northeast Shark River Slough, Water Conservation Area 2A and Biscayne Bay while recharging Miami-Dade County's coastal canals. This was accomplished by backpumping excess runoff from the C-51 Canal through the Lake Worth Drainage District's canal system (which will require conveyance improvements) and pumped into the Palm Beach County Agricultural Reserve Reservoir. From the Agricultural Reserve Reservoir, runoff will be discharged south into the Lake Worth Drainage District E-1W canal and routed into the Site 1 Impoundment. Further, the Site 1 Impoundment (Component M) had to be modified to accept the runoff routed south from the C-51 Canal. In addition, more runoff from the Hillsboro Canal was captured by increasing the inflow pump capacity. The Site 1 reservoir would be modified from the D13-R design (6 feet deep, 2,460-acre reservoir) to a 12 feet deep 300-acre reservoir and a 2,160-acre stormwater treatment area. This component modification also assumes that urban runoff that is pumped into the 300-acre reservoir provides recharge for the 30-5 MGD ASR wells proposed in D-13R. Further, water from the reservoir will gravity flow to the stormwater treatment area for treatment prior to discharging into the northeast corner of Water Conservation Area 2A. It is assumed that flood protection in all affected areas will be maintained.

Further, urban runoff from the C-14, C-13, North New River Canals and Water Conservation Area 2B levee seepage will be backpumped to the US 27 west borrow canal via C-42 and North New River Canals. This runoff will be directed south to the North Lake Belt Storage Area if storage is available in that facility. Discharges from the North Lake Belt Storage Area are described in Component XX. If storage is not available in North Lake Belt Storage Area, the backpumped water will be routed either to the Bird Drive Recharge Area or Biscayne Bay via the US 27 west borrow canal, the North Lake Belt Storage Area conveyance system improvements, and the C-1, C-2, C-4 and C-6 Canals. Deliveries will not be made during storm peaks to avoid impacting flood protection. If storage is not available in North Lake Belt Storage Area and conveyance capacities are also not available (without impact to flood protection), backpumping will not occur. Water quality of deliveries to Northeast Shark River Slough must be of acceptable quality for restoration or water will not be delivered. Additional types of water quality treatment may be required and it is assumed that flood protection in all affected areas will be maintained. Backpumping will not occur if the conveyance systems can not adequately pass flows to storage and/or treatment areas.

Finally, while the Everglades Construction Project is designed to backpump runoff from urban areas to the Water Conservation Areas after treatment within Stormwater Treatment Areas, this scenario denotes the first time the Restudy included a proposal to direct urban runoff into the Everglades Protection Area. These scenarios propose to direct water from C-51 into Water Conservation Area 2A after treatment and from North Lake Belt Storage Area, which receives runoff from C-6, C-9, C-11 and in this scenario C-14, C-13 and North New River to Northeast Shark River Slough after treatment. There are concerns about the level and practicality of treatment needed to provide water of appropriate quality to the

Everglades. Without completion of a pilot project, the quality of the water coming out of in-ground storage areas remains an unknown.

7.7.2 Evaluation of D-13R_4

The Alternative Evaluation Team conducted a preliminary evaluation of the D-13R_{1-4} scenarios during a meeting of the full Alternative Evaluation Team on 20 January 1999. The objective of these additional scenarios was to determine the feasibility of improving D-13R, by capturing additional surplus water from the amount discharged to tide each year, and conveying that "new" water (plus redistributing excessive water in the Water Conservation Areas) to better meet performance targets in the natural system. These scenarios were designed to convey urban runoff water into the natural system, an alternative water management scheme that had not been included in any previous comprehensive plan alternative due to the high cost and the risk associated with contamination of the Everglades from urban runoff. The D-13R_4 scenario was clearly the most successful of the four scenarios that were developed during this intensive, multi-agency planning and modeling process, which began in November 1998.

The Alternative Evaluation Team found that the overall performance of Scenario D-13R_4, as modeled included both gains and losses when measured against the existing and the future without plan conditions, and D-13R. D-13R_4 captured an average of 245,000 acre-feet/year of new water for the natural system from Palm Beach and Broward counties. This new water, when combined with excessive water from the Water Conservation Areas, provided an average of 271,000 acre-feet of new water each year to Everglades National Park and an average of 77,000 acre feet of new water to Biscayne Bay each year. The increased annual mean flows to the park and Biscayne Bay are expected to produce substantial improvements towards meeting the hydrological performance targets for these two areas. Although D-13R_4 also provided modest improvements in northeast Water Conservation Area 3A and northeast 2B, by reducing the number of undesirable high water events in these two subregions, this scenario increased the number of undesirable high water events in Water Conservation Areas 2A and 3B to a level greater than that predicted for the two base conditions and D-13R. Further, D-13R_4 created undesirable increases in the depth and duration of flooding in the Pennsuco wetlands. By delivering urban water to the natural system, this scenario raises a number of new water quality questions.

The Alternative Evaluation Team recognizes that much new information regarding the potential performance of D-13R was gained during the modeling of the four scenarios. The hydrological responses during the modeling of these four scenarios convincingly demonstrated the operational flexibility of D-13R, and offers encouraging documentation that additional improvements can be achieved during the detailed planning phases of the restoration program. The Alternative Evaluation Team recommended that the specific features of D-13R_4 that allowed for the capture and conveyance of substantial amounts of new water for the natural system be incorporated into the Recommended Plan, D-13R, contingent upon:

(1) Finding a way to reduce the number of damaging high water events in Water Conservation Area 2A and 3B and the Pennsuco Wetlands to a level at or below the level predicted for D-13R.

(2) Adequately treating the stormwater runoff from the C-51 east and C-13/14 basins directed into the Everglades Protection Area to meet all state and federal water quality standards to enable ecological restoration to be achieved.

It was agreed that these concerns can best be resolved during the finer scale modeling and planning, which will occur as a part of detail design work. The addition of these features should allow greater operational flexibility during future efforts to improve the overall performance of D-13R. Further, an issue paper is required from the Restudy's Water Quality Team, to more fully explore the questions being raised by the use of urban water to meet natural system targets in the Everglades.

Following the Alternative Evaluation Team's evaluation of D-13R_{1-4}, comments were received from Lake Worth Drainage District concerning the possible detrimental affects on flood protection that could be experienced within their system if the proposed modifications to their secondary canals are made. Lake Worth Drainage District recommended that the specific features of D-13R_4 not be incorporated into the recommended Comprehensive Plan until it can be demonstrated that the existing level of flood protection will not be compromised.

Finally, it should be noted that the Natural System Model topography in Northeast Shark River Slough is assumed to be the same as current topography, although recent data collected by the U.S. Environmental Protection Agency scientists indicate that substantial soil subsidence has occurred since the 1940's. This discrepancy in the topographic data in the model very likely affects the depth targets for Northeast Shark River Slough. Hence, if consistent topographic data assumptions were used for both Northeast Shark River Slough and Water Conservation Area 3B, target depths in Northeast Shark River Slough would be shallower, excess depths in Water Conservation Area 3B reduced and less water would be needed to meet Northeast Shark River Slough performance measure targets.

7.8 PLAN FORMULATION CONCLUSIONS

The initial screening effort identified the pressing need to capture more water in south Florida to restore the Everglades, protect the estuaries, and to provide for adequate water supply for urban and agriculture needs in the future. During the screening phase, the Restudy Team used modeling combined with an economic "best buy" approach to reduce to a workable number the vast array of components available for capturing and storing water and for conveying that water to the right parts of the system at the right time. Detailed plan formulation followed. In a nine-month period, representatives from every concerned agency - federal, state and local - worked closely together with other stakeholders to decide which features would be included in each alternative plan. Each alternative plan was modeled, the results reviewed by the team, and new alternative plans were formulated based on the improvements the team believed were needed. After looking at 10 alternative plans and over 25 modeling scenarios including D-13R$_4$, Alternative D-13R is by far the best of the alternative plans. This alternative, coupled with the 21 Other Project Elements, contains the array of components that has the most potential to achieve the Restudy's planning goals and objectives. Implementation of this plan will make restoration of healthy, sustainable south Florida ecosystems possible. Hence, Alternative D-13R, in combination with the Other Project Elements makes up the recommended Comprehensive Plan.

Economic and environmental evaluations of the plan show that the recommended plan is strongly justified. The environmental benefits are great and despite the scale of the project, it is extremely cost effective. The recommended plan appears to do what the varied participants in the study asked for it to do. More water has been captured and conveyed to areas where it is needed. Extreme events like regulatory releases to the estuaries, excessive flooding in the Water Conservation Areas and severe damaging dryouts in the marshes will be significantly reduced. Urban and agriculture areas will benefit from the extra water storage and be less dependent on the natural areas to meet their needs. Substantially more water makes its way into the large sloughs of Everglades National Park and the seasonal timing of flows throughout Everglades is more natural. In short, by balancing the needs of the natural system with the needs of urban areas and agriculture, a plan was developed which results in considerable benefits throughout the system. South Florida has clearly outgrown its old water management infrastructure and this plan provides sustainable solutions.

In response to comments made by the public and in the draft Fish and Wildlife Coordination Act reports the Alternative Evaluation Team produced a series of issue papers and developed additional modeling scenarios from D-13R. A major impetus for developing these scenarios was to determine if additional water could be captured in the Lower East Coast urban areas and used to better meet performance measure targets in the Water Conservation Areas and Everglades

National Park as well as for investigating alternative sources of water for Biscayne Bay. Preliminary evaluation by the Alternative Evaluation Team of scenarios $D13R_{1-4}$ indicate that additional captured water helps to meet hydrologic targets for Everglades National Park, Biscayne Bay and some areas within the Water Conservation Areas. However, in other areas of the Water Conservation Areas and the Pennsuco Wetlands, performance declines markedly relative to D-13R. In addition, issues relative to treating urban runoff prior to discharge into the Water Conservation Areas and the Everglades, and potential flooding impacts to secondary canals have not been resolved. These remaining areas of concern and the ultimate amount of additional water recaptured and its distribution will be determined in the subsequent more detailed design phase of individual components.

In summary, the recommended Comprehensive Plan contains the array of components that has the most potential to achieve the Restudy's planning goals and objectives. The subsequent detailed design phase of individual components will address the outstanding performance issues associated with the recommended Comprehensive Plan including:

1. The plan needs to increase total overland flow to Florida Bay, northeast Shark River Slough and Taylor Slough to fully meet Natural System Model depth and duration targets.

2. The plan needs to improve ecological performance in the Water Conservation Areas by eliminating damaging high and low water conditions.

3. The plan should improve ecological conditions in Biscayne Bay by restoring more natural freshwater inflows.

4. The risks and uncertainties associated with using wastewater reuse as a water source for Biscayne Bay should be closely examined.

5. Restoration targets in the St. Lucie Estuary should be more closely met.

6. The plan needs to improve ecological performance in the Model Lands and C-111 Basins by providing adequate freshwater to maintain target hydropatterns.

SECTION 8
ENVIRONMENTAL EFFECTS

This section includes a brief summary of the expected beneficial and adverse physical, ecological, and socio-economic effects on resources of regional concern within the study area. It does not attempt to provide comprehensive coverage of all effects or all resources; rather its purpose is to provide a summary account of effects on a "big picture" scale. In all instances the assessment of effects is based on a comparison between the recommended Comprehensive Plan and the Without Plan Condition (2050 Base).

Further information on effects on the regional system and the ten study regions is available in ***Appendix K***. Detailed analyses of effects on water quality are available in ***Appendix H,*** air quality in ***Appendix I,*** and to socio-economics in ***Appendix E***. Supporting information, including Fish and Wildlife Coordination Act Reports supplied by the Department of Interior and the Florida Game and Fresh Water Fish Commission, and a Programmatic Biological Opinion on effects on threatened and endangered species, supplied by the U.S. Fish and Wildlife Service, are provided in ***Annexes A*** and ***B***, respectively.

8.1. SOILS

Peat soils in the central Everglades marshes are expected to be positively affected by the Comprehensive Plan. With the recovery of multi-year hydroperiods, especially in many overdrained slough regions, peat accretion is likely. Any measurable affects to soils would probably occur over a medium to long-term time scale. The Restudy should include plans for close monitoring of soil accretion and possible loss, with a view to providing a more accurate, detailed assessment in the future.

For peat soils, an increase in hydroperiod will result in retardation of subsidence. A decrease in hydroperiod will accelerate soil oxidation, rate of subsidence and frequency of peat fires. Immediate effects of a shorter hydroperiod would be soil shrinkage, alteration of vegetation types, and reduction in productivity of current agriculture. On a regional scale, the Comprehensive Plan results in generally longer hydroperiods. Therefore, areas containing peat soils will experience reduced soil subsidence, and possibly reduced frequency of peat fires. Furthermore, retardation of soil subsidence in certain areas may result in conditions favorable for optimal productivity and maintenance of desired vegetation.

8.2. GEOLOGY

No significant effect is anticipated on the geology of the study area as a result of implementation of Comprehensive Plan. The only geologic resource exploited in the study area is limerock, and this activity will not be affected. The construction of a seepage barrier or curtain wall within the Central Lake Belt area may locally affect geology and groundwater flows.

8.3. CLIMATE

Overall, climate is not expected to be directly or indirectly affected by implementation of the Comprehensive Plan. Possible moderating effects on local micro-climates near large above ground storage reservoirs may occur due to the fairly extreme change in land use from some blend of terrestrial and wetland environment to an open water environment for up to several months or longer each year.

8.4. AIR QUALITY

Air quality is not expected to be permanently affected by implementation of the Comprehensive Plan. Small to moderate localized and temporal impacts are likely to occur due to the use of earth moving equipment for levee degradation, and other construction activities over the period of project construction. Detailed information on effects on air quality within the study area are in ***Appendix I.***

8.5. NOISE

Implementation, operation and maintenance of the proposed project will have little effect on ambient noise levels. Noise levels will be moderate in both scope and scale, and limited to construction areas. These localized impacts would likely occur for relatively brief periods at any one location. On a regional basis however, noise impacts due to construction activities may occur for an extended period of time, as the schedule for construction activities may last up to 20-30 years prior to project completion. Additional pumps associated with regional Aquifer Storage and Recovery facilities will introduce a new noise source into the region, but most will be located far from inhabited areas. Within the Lower East Coast region pump operations will likely represent a new noise source for inhabitants and visitors to areas near the ASR facilities.

8.6. VEGETATION

Implementation of the Comprehensive Plan is expected to have profound effects on native and exotic vegetation. More natural hydroperiods should assist in restoring natural plant communities. The reduction in persistent high water levels in some areas that are now “too wet”, and the provision of more and better-timed water to regions that are now “too dry”, should result in a more natural mosaic of plant communities. Restored hydroperiods, decompartmentalization of important interior areas of the Everglades Protection Area, restoration of more natural sheet flow, and the filling of several interior canals, it is believed, are all changes that will benefit native vegetation to the detriment of exotics. Native vegetation will further benefit through restored water quality conditions (see ***Appendix H***), and removal of interior canals such as the C-6 and the L-29 borrow canal, among others, which act as transportation corridors for nutrients, pesticides, and exotic plants and animals.

The Comprehensive Plan reduces dependence on water storage in Lake Okeechobee by increasing water storage in the regional system. In the past, this storage has resulted in extreme high lake water levels that damage the littoral zone. Restored, moderate lake levels will aid in maintaining a more healthy marsh and littoral vegetative community. Alternative storage areas, proposed under the Comprehensive Plan, also reduce and improve the timing of water releases to the Caloosahatchee River Estuary, and St. Lucie Estuary, and into the Everglades Protection Area. Regulatory flood releases, which in the past have negatively affected salinity and seagrass beds in the estuaries, will be substantially reduced. Extreme high and low water events in the central Everglades will no longer be as pervasive or as damaging to freshwater marsh vegetation. Although unnaturally long hydroperiods still remain a concern in portions of the central Everglades, their impact is less under the Comprehensive Plan than under either the existing condition or the Without Plan Condition. Further improvements should be addressed during detailed studies, by operational changes, monitoring, and adaptive management practices designed to address uncertain results for certain actions.

The northern and central Everglades constitute roughly 900,000 acres of Everglades landscape. The managed system caused widespread loss of peat soils from over-drainage, followed by microbial oxidation and muck fires. Tree island vegetation was destroyed by muck fires in over-drained regions and by prolonged high water in deeply ponded areas. The Comprehensive Plan appears to make major progress toward solving these two critical problems. Although all of the final alternatives developed by the Restudy Team helped relieve drought conditions and damage to peat soils, the Comprehensive Plan provides the best reduction in extreme high-water conditions that would flood tree island plant communities. Existing flows to the southern Everglades, Shark River Slough and estuaries of Florida Bay are believed to be a principal cause of seagrass die-off and expansion of woody vegetation into coastal marshes. The Comprehensive Plan produces greater overland flow and restored hydroperiods in the southern Everglades, which should result in restored conditions for seagrasses in Florida Bay and interstitial lakes, reduce the spread of mangroves into coastal marshes, and woody vegetation into marl prairies (J. Ogden, pers. comm.).

The Comprehensive Plan resulted in an overall decrease in surface water discharges to Biscayne Bay from Snake Creek. The projected discharges from Snake Creek would be expected to cause significant fluctuations in salinity, which may adversely affect existing vegetation. However, these impacts may be minimized through operational modifications to the Lake Belt reservoirs.

8.7. FISH AND WILDLIFE

Fish and wildlife and their habitat are expected to greatly benefit under conditions brought about under the Comprehensive Plan.

Lake Okeechobee will function more as a natural lake, rather than as a reservoir with prolonged high lake stages. This change should benefit fish reproduction and growth. Juvenile fish and other small aquatic species depend on a healthy, vegetated littoral zone for food and cover. Under the Comprehensive Plan, ecological conditions within the Lake marsh and littoral zone, valuable habitat for the fishery, would be enhanced. Heterogeneity of vegetation assemblages will be protected with less frequent prolonged flooding and extreme drydown events. There will be lower phosphorus loading to the littoral zone from the open water zone of the Lake.

In the northern and central Everglades, the Comprehensive Plan tends to reduce extreme high and low water events at the expense of increasing hydroperiod in several areas. Compared to the Without Plan Condition, the plan improves conditions in southern Water Conservation Area-3A by reducing high water and in northern Water Conservation Area-3A by reducing drydowns, but may affect conditions in northeastern Water Conservation Area-3A and Water Conservation Area 3B by increasing high water. Across Trophic Level Systems Simulation (ATLSS) model results predict higher average fish abundance under the Comprehensive Plan than the Without Plan Condition. Restoration of this important link in the food chain would enhance not only the fishery, but those animals such as wading birds, alligators *(Alligator mississippiensis*), otters (*Lutra canadensis*), minks (*Mustela vison evergladensis*), raccoons *(Procyon lotor*), and predatory fish, that prey upon them. Longer hydroperiods in sloughs also will improve habitats for limpkins (*Aramus guarauna*), mottled ducks (*Anas fulvigula*), pied-billed grebes (*Podilymbus podiceps*), pig frogs (*Rana grylio*), crayfish (*Procambarus alleni*), and other organisms.

The reduction of excessive high water conditions in many portions of the Water Conservation Areas should provide slightly better foraging conditions and reduce white-tailed deer mortality due to starvation and drowning. Conditions in Water Conservation Areas 2B and 3B are still wetter than optimal and do not result in improved foraging conditions as they do in Water Conservation Area 3A, particularly south of I-75. In Everglades National Park where deer habitat is already poor, the Natural System Model-like conditions in the plan would further reduce quality. For those few areas with high deer breeding potential (Long Pine Key, surrounding short hydroperiod marsh and northwest Big Cypress), there will be little impact.

In the southern Everglades and Florida Bay, the Comprehensive Plan approaches modeled natural hydropatterns. Improved timing and duration of freshwater flows to the Florida Bay estuaries and improved timing of fish-concentrating drydowns should lead to improved wading bird foraging and breeding conditions in the southern Everglades, when compared to existing conditions or the Without Plan Condition. Wetter conditions in marl prairies and greater flow into mainland estuaries (lower salinity) should substantially improve degraded alligator habitat. Improved freshwater flows are also expected to markedly improve conditions for pink shrimp (*Penaeus duorarum*), and a variety of fish and invertebrate species that inhabit the mangrove swamps and Florida Bay.

The rehydration of coastal wetlands and shifting of point source canal flow to distributed overland flow should provide more stable estuarine conditions along the western shoreline of southern Biscayne Bay. Stabilized estuarine conditions will result in enhanced nursery habitat for estuarine-dependent organisms.

Within those areas proposed for large-scale above-ground reservoirs, Stormwater Treatment Areas and regional scale Aquifer Storage and Recovery systems, a potentially large number of acres of uplands and wetlands may be permanently altered due to the need to site these facilities in the least sensitive areas. This would include existing uplands and wetlands around Lake Okeechobee, within the Everglades Agricultural Area, Water Preserve Area, and Caloosahatchee River and St. Lucie River Basins. Even though upland resources are valuable in and of themselves, particularly within the study area where wetland resources are abundant, and uplands are relatively fewer, avoidance of wetlands over uplands generally receives priority in planning. Many of these uplands support wildlife habitat of some value and adverse impacts to sensitive, rare or particularly valuable habitat needs to be avoided or minimized whenever possible.

8.8. THREATENED AND ENDANGERED SPECIES

Within the regional system, improved habitat conditions are anticipated for the West Indian manatee (*Trichechus manatus latirostris*), American crocodile (*Crocodylus acutus*), snail kite (*Rostrhamus sociabilis*), wood stork (*Mycteria americana*), Cape Sable seaside sparrow (*Ammospiza maritima mirabilis*), and the Okeechobee gourd (*Cucurbita okeechobeensis*). In the case of the manatee and crocodile, this is due to substantially enhanced freshwater flows to Florida Bay, and decreased salinities in the Florida Bay and Shark River Slough estuarine habitats relative to the Without Plan Condition. For the snail kite, wood stork, and Cape Sable seaside sparrow, improvements in restoring more natural hydroperiods, with Natural System Model-like conditions throughout much of their habitat, leads to an overall regional improvement in their populations. In some instances there may be local, minor negative impacts to habitat, caused by vegetation shifts over time, or increased ponding depths in relatively small areas currently serving as functional foraging or breeding grounds.

The endangered Okeechobee gourd is also expected to benefit due to a reduced occurrence of high water events and flooding of its habitat on the south shore of Lake Okeechobee.

Locally, the Florida scrub jay (*Aphelocoma coerulescens*), bald eagle (*Haliaeetus leucocephalus*), caracara (*Polyborus plancus*), and eastern indigo snake (*Drymarchon corais couperi*) may be negatively impacted by the Comprehensive Plan, primarily by the construction and operation of new water storage and treatment areas, mostly within the Kissimmee River and Caloosahatchee River regions. Filling in of canals is also likely to negatively impact some eastern indigo snake habitat, and may cause direct mortality of snakes, as they are known to utilize crab holes as refugia. The impacts to these animals are not likely to jeopardize their continued existence.

The opinion of the Department of Interior regarding impacts to Federally listed threatened and endangered species resulting from implementation of the Comprehensive Plan, is stated in their preliminary programmatic biological opinion, dated August 7, 1998 and confirmed by letter dated March 1, 1999 as the final biological opinion (see ***Annex B***). The Opinion states that the Comprehensive Plan is not likely to jeopardize any of the listed species or adversely affect critical habitat.

8.9. WATER MANAGEMENT

For the Kissimmee Basin, water managers will use a climate based inflow forecasting model, in conjunction with operational rules, which will help them in deciding when to pump water to the storage facilities outside Lake Okeechobee. Under the Comprehensive Plan, most of the water previously stored in the lake at prolonged and even extreme lake stages and/or sent to tide via the estuaries, will be pumped to storage north of the lake (127,000 acre-feet on a mean annual basis) or to other storage facilities in the Everglades Agricultural Area, Caloosahatchee River (C-43) Basin or the St. Lucie (C-44) Basin.

Changes to the existing Lake Okeechobee operation schedule (Run-25) include operational changes only, except for the project features designed to enhance water storage outside of the lake. Water storage facilities are expected to reduce the frequency and duration of flood control releases to the St. Lucie and Caloosahatchee Estuaries. Water from Lake Okeechobee will be pumped into Aquifer Storage and Recovery wells when the climate-based inflow forecasting model projects that the lake water level will rise significantly above those levels that are desirable for the littoral zone. Water management of the lake will rely on existing structures that will not require modification. In order to meet capacity requirements for water conveyance to Aquifer Storage and Recovery facilities, and storage reservoirs, additional canals, resizing existing canals, pumps and conveyance structures will be constructed outside of the immediate lake area.

The Caloosahatchee Basin storage reservoir and Aquifer Storage and Recovery system will capture local basin runoff and releases from Lake Okeechobee. Water from the reservoir will be used to provide environmental deliveries to the Caloosahatchee Estuary, to meet demands in the Caloosahatchee Basin, and to inject water into the Aquifer Storage and Recovery wellfield for long-term (multi-seasonal) storage. Lake Okeechobee water will also be used to meet any remaining local basin demands subject to supply-side management. The operation of project components in the Caloosahatchee Basin will significantly improve regional water managers' abilities to meet local basin agricultural/urban demands as well as the environmental needs of the downstream estuary. Water will be pumped to the storage facilities in the Everglades Agricultural Area with increased conveyance from Lake Okeechobee to the reservoir. The purposes are to improve timing of environmental deliveries to the Water Conservation Areas (including damaging flood releases from the Everglades Agricultural Area to the Water Conservation Areas) reduce Lake Okeechobee regulatory releases to the estuaries, meet supplemental agricultural irrigation demands, and increase flood protection within the Everglades Agricultural Area.

The proposed storage areas under the Comprehensive Plan will significantly improve water management on the Upper East Coast relative to the Without Plan Condition. Water storage sites will allow localized rainfall runoff to be captured and used for flow augmentation to the St. Lucie Estuary when needed during the dry season. The greatest benefit will come from storage of peak rainfall inside the basins, and reduced loss of this turbid, nutrient-laden water to tide. The

Comprehensive Plan reduced the frequency of high-flow discharges to the estuary by nearly 80 percent.

The Comprehensive Plan introduced operational changes in Water Conservation Area 2A that improved inundation patterns in the north, but in so doing increased the frequency of extreme drought conditions in the south. It appears that water management in Water Conservation Area 2A imposes tradeoffs involving improved marsh conditions in some areas but worse conditions in others. If rainfall based operational rules are adopted for Water Conservation Area 1 in the future, such unnatural fluctuations in depth in Water Conservation Area 2A may be alleviated. Rather than combining high water in the south with over-drainage in the north, as is currently the case in all of the Water Conservation Areas, the Comprehensive Plan predicts longer hydroperiods near Stormwater Treatment Area-2 input in the north, increased drying in the south, and accumulation of water at the southern end of in Water Conservation Area 2B.

A number of components in the Comprehensive Plan lead to significant predicted changes in hydrologic conditions in Water Conservation Area 3A. The Comprehensive Plan succeeded in limiting the frequency of extreme high water events within the overall bounds defined for the natural system by the Natural System Model. This performance can clearly be credited to the barrier provided by the L-67 levee, which prevents excess build up of water within the northern and central sections of the Water Conservation Areas. The Comprehensive Plan predicts a lower frequency of extreme high water events, and reduced flooding in Water Conservation Area 3B relative to the Without Plan Condition. The Without Plan Condition however, still predicts drier conditions than the ideal restoration target in Northeast Shark River Slough.

The principal changes in water management will be an increase in the number of structures (levees, pumps, weirs, and canals) associated with the storage areas and their operation. A fairly complex operation schedule will have to be designed and implemented to maximize the benefits of these storage sites. Water will be pumped into and out of the storage areas, requiring fuel and causing additional noise to nearby areas.

The Water Preserve Areas located adjacent to the eastern protective levee will function to prevent seepage out of the Water Conservation Areas and Everglades National Park, increase Everglades spatial extent by restoring existing quality wetlands, capture and store excess water that is currently lost to tide, buffer the urban developed areas from the natural areas, and treat water prior to returning it to the natural system. They are a critical element of the Comprehensive Plan, particularly in terms of re-routing flows from Water Conservation Area 2 south to the Central Lake Belt and into Biscayne Bay and Everglades National Park. They will be highly effective at reducing undesirable discharges to Lake Worth Lagoon, as well as conserving water originating from the natural system, currently lost to tide through the east coast canals.

The proposed changes in water management associated with southern and central Biscayne Bay will be due to the shifting of point source canal flow to distributed overland flow and to the transport of recycled water to the Bay from wastewater reuse plants. The backpumping from canals to the Lake Belt reservoirs resulted in significant decreases in freshwater flows to Biscayne Bay from Snake Creek and the Miami River. The Comprehensive Plan may enhance saltwater intrusion protection for the surficial aquifer in the south Miami-Dade area due to increased canal stages in the dry season. The effects of above ground storage on flood protection will be positive. The western C-4, C-9, and Hillsboro basins are currently flood prone basins. Available above ground storage areas should greatly reduce flooding in those areas during storm events.

Overall, the remaining Everglades will be managed as a whole, not as individual subcomponents of the regional system. A number of hydrologic benefits could be gained by construction of the Everglades Construction Project and implementation of rainfall-driven hydropattern targets within the Everglades. Rainfall-based delivery plans for Water Conservation Areas 2A and 3A based on antecedent rainfall and natural system hydropatterns should be developed. In addition, modifications should be made to the Everglades National Park’s current rainfall-based delivery plans in a manner that replicates natural system-like conditions. Model results showed that using the rainfall-driven targets significantly improved the quantity, timing, and distribution of water delivered to Water Conservation Area 2A, Water Conservation Area 3A, and Everglades National Park to closely match natural pre-drainage conditions.

8.10. WATER QUALITY

The Comprehensive Plan is expected to improve water quality conditions in the study area; however, water quality improvement in south Florida must be viewed as an integrated effort with several interdependent parts. As outlined below, these include: several components and other project elements of the Comprehensive Plan, with emphasis on a proposed Comprehensive Integrated Water Quality Plan (see ***Section 9.7.3***); the State of Florida’s Everglades Forever Act; Surface Water Improvement and Management (SWIM) Act planning efforts, including the development of pollutant load reduction goals (PLRGs); development of total maximum daily loads (TMDLs) under Section 303(d) of the Federal Clean Water Act; and the Florida Keys Water Quality Protection Program.

Water quality was a consideration in every aspect of the Comprehensive Plan. Major features include creation of approximately 181,270 acres of surface water storage area, totaling approximately 1.5 million-acre feet of additional storage volume. Surface water storage areas will reduce pollution loading into downstream receiving water bodies through the attenuation of surface flows and settling of attendant pollution loads prior to discharge. The Comprehensive Plan also includes a feasibility study to develop a Comprehensive Integrated Water Quality Plan, which will ensure that Comprehensive Plan facilities will be designed and operated to achieve maximum water quality benefits. More detailed descriptions of the positive water quality benefits that will be provided to waterbodies across the Restudy project area from construction and operation of the water storage areas are provided in ***Appendix H*** and ***Attachment F*** (Water Quality, Environmental Effects).

Additionally, many components and other project elements of the Comprehensive Plan include treatment features to ensure that water quality conditions are improved. Specifically, the Comprehensive Plan includes over 19 Stormwater Treatment Areas totaling approximately 35,550 acres of treatment area. These Stormwater Treatment Areas represent additional storage and treatment volume beyond that provided by the storage areas. More detailed descriptions of the positive water quality benefits that will be provided to waterbodies across the Restudy project area from construction and operation of the Stormwater Treatment Areas is provided in ***Appendix H*** and ***Attachment F*** (Water Quality, Environmental Effects). Those components of the Comprehensive Plan involving Aquifer Storage and Recovery and wastewater reuse also include treatment facilities to meet applicable State of Florida water quality standards.

Furthermore, implementation of the Comprehensive Plan according to the Implementation Plan (see ***Section 10***) will lead to the optimization of water quality benefits, above and beyond merely increasing surface water storage. Significant benefits to water quality conditions in waterbodies in the following study regions are anticipated through construction and operation of the above-discussed water storage areas and Stormwater Treatment Areas: Lower Kissimmee River, Lake Okeechobee, St. Lucie River/estuary, southern Indian River Lagoon, Lake Worth Lagoon, Caloosahatchee River/estuary, the Everglades Protection Area, Biscayne Bay, and Florida Bay.

However, water quality restoration in all water bodies within the study area depends on actions outside the scope of the Restudy. To fully achieve ecological restoration in all regions of the study area, pollution loads must be identified and quantified within each of the study area regions, and load reduction and concentration targets for pollutants of concern must be established. Concurrent with or prior to the proposed operation of components of the Comprehensive Plan, water quality improvement programs for degraded and/or designated use-impaired water bodies must be implemented by the responsible agencies in order to fully achieve ecological restoration objectives.

In its 1998 report to the U. S. Environmental Protection Agency, the Florida Department of Environmental Protection identified approximately 160 use-impaired waterbodies in the study area in accordance with the requirements of Section 303(d) of the Federal Clean Water Act. Section 303(d) listing is based on designated and actual uses of waterbodies, ambient monitoring data, and water quality standards. The South Florida Water Management District, Florida Department of Environmental Protection, and other agencies have developed water quality improvement strategies for several of the impaired waterbodies within the Restudy area. The most notable example is the Everglades Forever Act, which focuses on achieving adequate water quality in the Everglades. Other examples include Surface Water Improvement and Management Act (SWIM) planning efforts for the Indian River Lagoon, Lake Okeechobee, and Biscayne Bay, and the Florida Keys National Marine Sanctuary Water Quality Protection Program. However, there is not, presently, a comprehensive water quality strategy for the entire Restudy area, and implementation of some of the existing water quality improvement plans has been limited by lack of funding to complete assessment and planning activities. Watershed assessments are necessary to develop pollutant source reduction programs and to design and construct water quality treatment facilities, if necessary.

To address the lack of a comprehensive water quality strategy for south Florida, the recommended plan includes a feasibility study to develop a Comprehensive Integrated Water Quality Plan (see ***Section 9.7.3***). Development of this plan will involve an interagency effort to ensure that recommended plan facilities are designed and operated to achieve maximum water quality benefits in watersheds where Restudy facilities are located. An essential element of the Comprehensive Integrated Water Quality Plan is the development of total maximum daily loads (TMDLs) of pollutants for specific use-impaired waterbodies, and subsequent implementation of management programs to achieve TMDL pollution reduction targets. It is anticipated that the Comprehensive Integrated Water Quality Plan will expedite the process of developing TMDL pollution reduction targets and management plans for water quality impaired waterbodies in the study area.

8.11. WATER SUPPLY

The Comprehensive Plan will substantially improve water supplies for the Lake Okeechobee and Lower East Coast Service Areas when compared to the future Without Plan Condition. The Comprehensive Plan meets public water demands, minimizes the duration of water supply cutbacks, and maintains saltwater intrusion stages in the primary coastal canals in this region. Compared to the Without Plan Condition, it greatly improves the ability to meet public water supply demands and prevent saltwater intrusion. All of the alternative plans reduce the dependence of users on Lake Okeechobee and the Water Conservation Areas by providing regional water from new storage facilities. In the Comprehensive Plan, 23 percent less water will be delivered from the Water Conservation Areas and Lake Okeechobee through the structures to the Lower East Coast than in the Without Plan Condition. The future for urban and agricultural water supply shows significant problems in the Without Plan Condition even if the health of the environment were not a consideration. The urban areas will benefit from a sustainable system that supports their future water supply demands and restores the Everglades ecosystem.

8.12. SOCIO-ECONOMICS

The economic impact evaluation of the alternative restoration plans includes the following:

- Agricultural water supply,
- Municipal and industrial (M&I) water supply,
- Flooding potential,
- Commercial navigation,
- Recreation (Everglades-related),
- Commercial and recreational fishing,
- Costs,
- Regional economic effects, and
- Other social effects.

Four of the above are translated into monetary terms. Positive effects of the different alternatives on agricultural water supply range from about $1.7 to $2.0 million on an average annual basis. The effect for the Comprehensive Plan is $1.9 million per year. Positive effects on municipal and industrial water supply range from $21.5 to $27.2 million annually, the latter being the estimated impact associated with the Comprehensive Plan. Costs of the plans, on a uniform annual equivalent basis, range from $254 to $402 million for the Comprehensive Plan. The initial costs for construction and real estate range from $5.2 to $7.8 billion for the Comprehensive Plan. Recurring annual costs for operation and maintenance, and monitoring, range from $70 to $165 million per year. Average annual regional effects on total sales range from +$173 to +$307 million. Employment effects range from about +1,700 to +3,165 jobs. Impacts on earnings range from $59 to $108 million per year. While these are large numbers, they are small taken in the context of total economic activity within the study area, accounting for about 1/10th of one percent of total economic activity within the study area.

Flooding impacts of the alternatives are inconclusive at this time, due to the limitations of the analytical tools available within the scope and time frame of this study. It is possible that some areas will benefit from reduced flooding, and some areas will require more detailed analysis. Such an analysis will be done as a part of any plan implementation.

Very small positive effects on commercial navigation in Lake Okeechobee are expected to result from any of the alternative plans. These effects are due to decreased occurrence of low stages.

Plan implementation may cause some significant impact on recreation. Recreation and tourism are significant economic activities in Florida, and small incremental changes to this large activity base have the potential to be significant. Potential negative impacts on recreation include, among others, the filling in of canals and closure of points of access to established fisheries, most notably along the L-29 and L-67A canals. It is anticipated that existing fishery resources impacted within the Everglades Protection Area, would be offset, in the long term, by reservoir construction proposed as a part of the Comprehensive Plan. These effects have not been quantified or translated into monetary values due to uncertainties regarding the actual timing and effects of alternatives on recreation, and regarding plans and policies for recreational facilities and marketing. Such details will become known during implementation planning expected to follow this study. Lacking a clear vision of these pertinent factors at this time, it would be speculating to quantify recreational effects of the Comprehensive Plan or any of the other alternatives.

The alternative plans have the potential to affect recreational and commercial fishing throughout south Florida by modifying the hydrologic regime in the region’s waterways and estuaries. The linkage between hydrologic changes and ecological changes is expected to be positive, which would possibly result in positive economic implications for fishing. Not enough is known about the linkages between fishing and hydrological changes, which would be brought about by plan implementation, nor is enough known about the timing of the linkages between these changes, the resulting ecological changes, and ultimately the changes in the value of fishing, to estimate the economic effects on fishing in this study. All of the plans are expected to positively impact fishing, with the exception of Biscayne Bay, whose fishery would likely benefit only under Alternative D and the Comprehensive Plan.

The most potentially significant “other social effects” consideration for the alternative plans concerns the development of new storage reservoirs in the rural areas surrounding Lake Okeechobee, and the consequences for urban and community impacts and displacement of people. These project features would convert farm land to reservoirs. Their development could eliminate the jobs of the individuals who are employed in the affected area and have adverse effects on local communities and economies. The potential locations of the new reservoirs are not known at this time. However, the resilience of local economies and the cohesion of local communities to agricultural land conversion depend on a variety of factors, including the age, ethnic, and racial composition of the community and income, unemployment, and poverty levels. A social vulnerability index was developed using county-scale socio-economic characteristics, and this type of analysis could be replicated in more detail when and if new reservoir sites are proposed.

8.13. LAND USE

The most significant effect on land use will be the proposed creation of approximately 181,270 acres of storage reservoirs within the Caloosahatchee River Basin, St Lucie River Basin, Kissimmee River Basin, the Everglades Agricultural Area, and the Lower East Coast. It is anticipated that the majority of the storage needs will be met with agricultural lands, undeveloped lands and lands adjacent to the east coast protective levees. Therefore, implementation of these features in the Comprehensive Plan will likely have an effect on existing agricultural land use.

Storage reservoirs designed to augment the regional water supply system will occupy 25,000 acres in the Kissimmee River region and 60,000 acres in the Everglades Agricultural Area. There is also proposed a 20,000 acre storage reservoir in the Caloosahatchee River basin, a 5,000 acre Stormwater Treatment Area in the Kissimmee River region and 10,000 acres of storage in the St. Lucie Canal Basin, on mostly existing agricultural or vacant lands. In the remaining Upper East Coast region, additional storage facilities are planned for the C-23, C-24, C-25, North Fork and South Fork Basins totaling 35,550 acres. The acreage proposed for these project features is subject to change depending on design depths, which will be determined during final design and specifications. Proposed Aquifer Storage and Recovery facilities include 200 5-Million Gallon per Day wells located near the landside of the Herbert Hoover Dike, which surrounds the Lake. These Aquifer Storage and Recovery wells will require some land for construction, operation, and maintenance. Agricultural production may be compatible with Aquifer Storage and Recovery wells, as the structures are expected to take up minimal land above ground. It appears likely; however, that more than 120,000 acres of land in the northern portion of the study area will be taken out of existing or future agricultural production. Conversion of 60,000 acres of agricultural land in the Everglades Agricultural Area to create storage reservoirs would be approximately a nine percent reduction of the area farmed in this region, which is designated as unique farmland. Implementation of the Comprehensive Plan should have no negative effect on future urban land use around Lake Okeechobee. Urban lands surrounding the lake should benefit through a greater, more consistent source of water for urban and industrial use, including continued flood protection, beyond that projected in the Without Plan Condition.

Several thousand acres of land will be needed for water management facilities in the Lower East Coast region. The lands proposed for the Water Preserve Areas in the Lower East Coast are generally vacant or are in agricultural production. It is assumed that the majority of these lands would eventually be designated urban land, especially low density residential. These urban land uses can in general be accommodated on other vacant lands or by increasing the density of development. The lake belt reservoirs, which are in-ground facilities, are not expected to diminish the land use of rock mining or impinge on productive agricultural land. Seepage management should not cause changes to existing land use, as minimal land is required for the wells and physical barrier methods. Seepage control components along eastern Water Conservation Areas 3A and 3B are located on wetlands. These components will lengthen the hydroperiods of the wetlands involved.

Land use within the Big Cypress Basin will not likely be significantly affected by implementation of the Comprehensive Plan. The urban areas along the Lower West Coast, including the municipalities of Naples, Everglades City, and Marco Island, are outside the area of hydrologic influence of the Comprehensive Plan and land use will be unaffected by the project.

The Comprehensive Plan does not include construction features in the Florida Keys, therefore it will not affect land use. However, improvements in freshwater flow, and lower salinities in upper Florida Bay, may enhance the pink shrimp fishery in the Keys.

8.14. RECREATION RESOURCES

Some limited impacts to recreation may be assumed under the Comprehensive Plan. In an effort to restore more natural sheet flow and reduce negative ecological and hydrologic effects wrought by interior canals, miles of canals would be filled and levees degraded. Some of these canals currently support regionally important sport fisheries. New opportunities for recreation resource growth would become available with the implementation of the Comprehensive Plan. These include the restoration of existing national and regionally significant fisheries, including Lake Okeechobee, Indian River Lagoon and others, and the creation of tens of thousands of acres of reservoirs, which could function, in part, as recreation resources. If properly sequenced, fishery resources could be established within new project features, prior to impacting existing canals scheduled for filling in through levee degradation.

Restoration of the Everglades, a unique and internationally recognized wetland resource with huge spatial extent, and proven recreation potential in and of itself, should provide vast benefits to recreation resources. Native wildlife game and non-game populations are expected to increase in a sustained manner under improved ecological conditions resulting from the Comprehensive Plan. It is reasonable to conclude that overall, there is greater regional recreation resource potential under the Comprehensive Plan than either the existing condition or the Without Plan Condition.

As stated previously, the Comprehensive Plan may result in an initial localized decline in the mileage of canals available to fishermen, some of these are of state-wide importance. According to Corps design and cost estimates for the Comprehensive Plan, approximately 72 miles of canals are scheduled to be filled, while 74 miles of new canals will be constructed, and 100 miles of existing canals will be widened. The planned construction of the Water Preserve Areas, in Palm Beach, Broward and Miami-Dade Counties offers an important potential for new water based recreational areas.

8.15. AESTHETIC RESOURCES

Restoration of the south Florida ecosystem is expected to result in a healthier environment that will support vigorous plant communities, larger fish and aquatic animal populations, large numbers of wading birds, alligators, and sustainable populations of wide-ranging mammals in a natural setting, in perpetuity. Viewing wildlife, wetlands and open, relatively pristine spaces are valued by people, as tourism statistics for south Florida would seem to support. Regardless, the anticipated increase in native animals and native plants alone will probably not appreciably impact aesthetics to the casual observer. To the casual observer, the Everglades may already meet those criteria, as it is already a wilderness of pristine character to the casual viewer. Implementation of the Comprehensive Plan will not so much change the aesthetic as ensure that a truly healthy and sustainable ecosystem exists into perpetuity.

There are undoubtedly some areas where degradation of the natural environment has reached the point where restoration benefits may be seen and appreciated. Improvements to water quality and clarity should benefit important parts of the environment currently being impacted, including the waters of Lake Okeechobee, the Everglades Protection Area, the estuaries, and Florida Bay. Reducing damaging freshwater releases into the Caloosahatchee and St. Lucie Estuaries will improve water quality and clarity, reduce seasonal fish kills, restore important seagrass beds, oyster beds, and improve estuarine fisheries and wading bird foraging. Improvements in inflow water quality, and an overall reduction in exotic vegetation, should enhance conditions for a more natural heterogeneous assemblage of native vegetation, providing the necessary conditions to support optimal wildlife populations.

8.16. CULTURAL RESOURCES

Component features at this stage of planning are conceptual and feature locations are not precisely determined. Under the tiering concept of NEPA, specific effects on culturally significant sites will be addressed and coordinated with the State Historic Preservation Officer under Section 106 of the National Historic Preservation Act. In the future, separate Environmental Assessments or supplemental Environmental Impact Statements will be prepared for each project feature, and cultural resources assessments will be conducted in support of those documents, when necessary. Specific effects on historic period and pre-Columbian period archeological sites and standing structures, engineering structures and architectural features will be evaluated after individual project feature sites are provided. Effects from the proposed project are anticipated to come from project feature construction, operational changes, erosion, human disturbance, and changes in the hydrologic regime of the flood plain.

The State Historic Preservation Officer, in a letter dated August 14, 1998, reaffirmed the archeological and historical potential of the C&SF Project area. They also acknowledged our commitment to adhere to the procedures outlined in 36 CFR Part 800, and concurred that at this stage of project planning, the Restudy will have no adverse effect on historic properties listed or eligible for listing on the National Register.

8.17. HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

A Phase I Hazardous, Toxic and Radioactive Waste (HTRW) site assessment was conducted in the general vicinity of proposed project features or existing features proposed for significant modification for the entire area of the Restudy. Several site visits were conducted over the past few years, with the most recent survey having been performed in August 1998. The HTRW database search was performed on the entire area and it indicated that overall, the majority of the proposed new construction areas are free of hazardous and toxic waste. Most of these general features are proposed for remote and rural areas, and were farms, vacant land, or wildlife management areas. The most common type of HTRW being hydrocarbons, was found along state highways where the majority of the gasoline stations had leaking underground storage tanks.

Perusal of relevant databases also revealed that several locations are National Priority Listed. Most of these National Priority Listed sites are due to past landfill operations. These sites are located in Palm Beach County, the Lower East Coast Lake Belt area in the vicinity of the S-9 Structure and in Broward County south of Alligator Alley. Contaminated sites located on the perimeter of any proposed water storage area may experience migration or expansion of leachate or other pollutants into the study area. Any such sites would require further survey and specific evaluation prior to detailed design. Another feature of concern is the numerous landfills and waste handling facilities in the Lower East Coast region. To the extent feasible, water storage areas should not be sited immediately adjacent to these known sites.

These findings and conclusions are of existing conditions at this time. The project conditions assume that any HTRW found during any phase of the project would be remediated in accordance with local, state and federal laws. Therefore, it can be assumed that conditions at future construction sites will be contamination free or of low levels, which would include de minimis conditions that generally do not present a material risk of harm to the public health or the environment.

8.18. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Land Use (Agriculture)

Cumulatively, a significant number of acres of agricultural lands will be permanently removed from production due to the construction of large above ground storage reservoirs and Stormwater Treatment Areas. Affected areas are north of Lake Okeechobee, in the Caloosahatchee River and St. Lucie River Basins, and Upper East Coast Basins, and within the Everglades Agricultural Area. Further agricultural land use will be permanently removed from Palm Beach, Broward and Miami-Dade Counties due to the construction of the Water Preserve Areas.

Wetlands

A limited number of acres of wetlands will be permanently altered within the boundaries of the large above-ground storage reservoirs and Stormwater Treatment Areas, and within the Water Preserve Areas.

Uplands

A potentially large number of acres of uplands may be permanently altered within the boundaries of the large above-ground storage reservoirs and Stormwater Treatment Areas, and within the Water Preserve Areas. Due to their relative value in a study area rich in wetland resources, upland resource impacts should also be studied carefully during detailed planning in order to avoid or minimize impacts to particularly valuable or sensitive upland areas.

Water quality

Temporary increases in turbidity of local waters are expected from the removal of canals and levees and by the construction of raised roadways and other structures.

Air quality

Fugitive dust from vehicular traffic and earth moving will be unavoidable but insignificant overall.

Soils

Temporary disruption of soils is expected from the removal of canals and levees and most construction activities.

Wildlife

Significant short-term disruption of wading bird colonies is expected from altering hydroperiods in the Water Conservation Areas. Localized disturbances to fish and wildlife are expected from removal of canals and levees and from the elevation of roadways and construction of other structures.

Recreation

Limited impacts to recreation resources (canal fisheries for example) are expected. However, project features proposed under the Comprehensive Plan, including restoration of existing natural resources, construction of new canals, deep water storage reservoirs and Stormwater Treatment Areas, all offer potentially important recreation benefits, which should offset existing resource loss.

Cultural Resources

An unknown number of historic and archeological sites may be affected. Studies will identify significant sites and necessary mitigation will be developed, on a project-specific basis.

8.19. RELATIONSHIP BETWEEN SHORT TERM USES AND LONG TERM PRODUCTIVITY

While regional conditions will improve, short-term or localized problems will undoubtedly occur. For example, in the process of improving wading bird nesting and foraging areas regionally, existing rookeries may be affected. Although overall restoration of the Everglades watershed is expected to improve habitat for nesting wading birds regionally over time, the transition period might adversely affect regional wading bird populations. Proper sequencing of project features should mitigate impacts to existing wildlife resources expected to be impacted by restoration activities within their vicinity. Further study and close monitoring will be critical to recovery and maintaining viable wading bird populations during the implementation of the Comprehensive Plan.

8.20. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Construction of the proposed project will include many features considered permanent, or modifications to existing C&SF Project features, which may be deemed irreversible. This would include, for example, construction of large reservoirs, degradation of levees and filling in of canals. Construction of regional Aquifer Storage and Recovery facilities, curtain walls, large storage reservoirs, Stormwater Treatment Areas, Water Preserve Areas, and waste water reuse facilities, are all necessary for the restoration of the natural ecosystem and maintenance of the urban and agricultural system. These features on the scale proposed in the Restudy, are probably of such a magnitude that these features would represent an irreversible and irretrievable commitment of resources. Resources committed would include state and Federal funding to purchase lands and labor, energy and project materials to build, operate, and maintain the project.

Fish and wildlife habitat will be permanently altered, (converted to open water particularly in the case of storage reservoirs and Stormwater Treatment Area facilities). These features would likely be inundated for much of the year.

8.21. CUMULATIVE EFFECTS

Large areas north of Lake Okeechobee, within the Everglades Agricultural Area, around the Lake, in the Caloosahatchee River Basin, and on the Upper East Coast will be used to increase water storage for the overall gain and long-term benefit of the regional system. These project features will provide important storage functions and are essential to the overall restoration of the freshwater marshes and the estuaries. Project features will cause some adverse consequences to agricultural land use, permanently removing tens of thousands of acres from agricultural production. These impacts may be felt locally and/or regionally as the economic base derived from agriculture is incrementally reduced relative to other sectors of the economy. The overall benefit to the regional system is expected to be far greater than the localized adverse effects. As these features occur disparately across the landscape within different hydrologic basins, and as distinct units rather than multiple features within a single watershed, they will not likely result in a significantly detrimental cumulative effect.

Overall, the Restudy project elements in the Water Preserve Areas may cumulatively affect the current rate of westward expansion of Lower East Coast cities and may increase the value of other residential or potentially residential lands. Restudy project components are not expected to result in a cumulative negative effect on the human environment of the Lower East Coast. Project components in the area, especially storage, seepage control, redirection of point source canal flows to overland flow, and water reuse plants, will act to restore more natural freshwater flows to Biscayne Bay, reduce seepage losses from the Everglades, improve recharge of the Biscayne aquifer, and should result in other beneficial environmental effects. In order to support the construction, maintenance and operation of project features contained in the Comprehensive Plan, the cost of water in urban areas may rise beyond that predicted by the Without Plan Condition.

SECTION 9
THE RECOMMENDED COMPREHENSIVE PLAN

The recommended Comprehensive Plan is the Initial Draft Plan, Alternative D-13R, together with the Other Project Elements. The plan consists of construction and operation features, real estate requirements, mitigation, a monitoring program, and operation and maintenance of the completed project. The individual features of the recommended Comprehensive Plan were designed at various levels of detail based on information available during the plan formulation and evaluation phase. The details of the recommended plan are conceptual and more site-specific analyses will be needed to optimize the design and operations of the plan. In addition, several studies are recommended to investigate additional improvements needed to support restoration, protection, and preservation of the south Florida ecosystem.

The following principles guided the development of the recommended Comprehensive Plan:

- The overarching objective of the Comprehensive Plan is the restoration, preservation and protection of the south Florida ecosystem while providing for other water related needs of the region;
- The Comprehensive Plan will be based on the best available science and independent scientific review will be an integral part of its development and implementation;
- The Comprehensive Plan will be developed through an inclusive and open process that engages all stakeholders;
- All applicable Federal, tribal, state, and local agencies will be full partners and their views will be considered fully; and
- The Comprehensive Plan must be a flexible plan that is based on the concept of adaptive assessment – recognizing that modifications will be made in the future based on new information.

9.1 CONSTRUCTION FEATURES

A large number of construction features have been identified in the recommended Comprehensive Plan. These features were designed at various levels of detail based on information available during the plan formulation and evaluation phase. As described in ***Section 7***, the engineering design of the Other Project Elements was very limited. Further, many of the design assumptions for components in the Initial Draft Plan were based solely on output from the South Florida Water Management Model (refer to ***Appendix B*** for more detailed description of this model), which averages hydrologic conditions across grid cells totaling four square miles. Consequently, the engineering details of the construction features, including the size and location, are conceptual. Conceptual planning of many of the construction and operation features did not involve detailed planning and design work necessary to optimize features to achieve all ecosystem restoration performance objectives, particularly on a smaller, local scale. In particular, conceptual planning work completed to date is not adequate to determine construction design features necessary to achieve basin-specific water quality performance objectives. Furthermore, water quality benefits of conceptual features of the recommended plan could not be fully evaluated for all regions of the study area during alternative plan formulation and evaluation because modeling and other predictive tools were not available. More site-specific analyses of the recommended plan features will be needed to determine the optimum size, location, depth and configuration in subsequent phases of this project. Subsequent site-specific analyses performed during the implementation phase will include collecting necessary physical and water quality data, finalizing hydrologic and water quality performance targets, conducting refined modeling and pilot projects, and resolving regulatory issues. In a number of cases, construction features, such as reservoirs, were not specifically sited in the Comprehensive Plan. In these cases, a cooperative effort with landowners in the areas where these features are proposed will be used to identify suitable sites in subsequent phases of this project.

The construction features in the recommended Comprehensive Plan are described in the following sub-sections by study region. In some cases, the construction features include multiple components. These components were grouped based on their dependency upon one another. For example, outlet conveyance improvements to Water Conservation Area 3 from the Central Lake Belt component were combined with the Central Lake Belt Storage Reservoir component. The component designation that was used during plan formulation is included in parentheses, e.g. (A). Other Project Elements are identified as (OPE).

9.1.1 Kissimmee River Region

9.1.1.1 North of Lake Okeechobee Storage Reservoir (A)

This feature includes an above-ground reservoir and a 2,500-acre stormwater treatment area. The total storage capacity of the reservoir is approximately 200,000 acre-feet and is located in the Kissimmee River Region, north of Lake Okeechobee. The specific location of this facility has not been identified, however, it is anticipated that the facility will be located in Glades, Highlands, or Okeechobee Counties. The initial design of this feature assumed a 20,000-acre facility (17,500-acre reservoir and 2,500-acre treatment area) with water levels in the reservoir fluctuating up to 11.5 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning, land suitability analyses, and design. Future detailed planning and design activities will also include an evaluation of degraded waterbodies within the watersheds of the storage/treatment facility to determine appropriate pollution load reduction targets, and other water quality restoration targets for the watershed.

The purpose of this facility is to detain water during wet periods for later use during dry periods and reduce nutrient loads flowing to the lower Kissimmee River and Lake Okeechobee. This increased storage capacity will reduce the duration and frequency of both high and low water levels in Lake Okeechobee that are stressful to the Lake's littoral ecosystems, and cause large discharges from the Lake that are damaging to the downstream estuary ecosystems. Depending upon the proposed location(s) of this water storage/treatment facility and pollutant loading conditions in the watershed(s), the facility could be designed to achieve significant water quality improvements, consistent with appropriate pollution load reduction targets.

The operation of this feature assumes that water from Lake Okeechobee, the Kissimmee River or the S-65E drainage basin will be pumped into the storage reservoir/stormwater treatment area when the climate-based inflow model (see ***Appendix B***) forecasts that the Lake water levels will rise significantly above desirable levels for the Lake littoral zone. Water held in the reservoir and stormwater treatment area will not be released until the lake levels decline to ecologically acceptable levels.

9.1.1.2 Taylor Creek/Nubbin Slough Storage and Treatment Area (W)

This feature includes an above-ground reservoir with a total storage capacity of approximately 50,000 acre-feet and a stormwater treatment area with a capacity of approximately 20,000 acre-feet in the Taylor Creek/Nubbin Slough Basin. The initial design of this feature assumed a reservoir of 5,000 acres with water levels fluctuating up to 10 feet above grade and a stormwater treatment facility of approximately 5,000 acres. The final size, depth and configuration of this feature will be determined through more detailed planning, land suitability analysis and design.

The purpose of this feature is to attenuate flows to Lake Okeechobee and reduce the amount of nutrients flowing to the Lake. The feature is designed to capture, store, and treat basin runoff during periods when levels in Lake Okeechobee are high or increasing. The water quality treatment element of this feature is consistent with the recommendations of the South Florida Ecosystem Restoration Working Group's Lake Okeechobee Issue Team and the Pollution Load Reduction Goals for Lake Okeechobee developed for the Lake Okeechobee Surface Water Improvement and Management Plan (SFWMD, 1997f). The water held in the reservoir would be released to Lake Okeechobee when lake levels decline to ecologically acceptable levels.

9.1.1.3 Lake Okeechobee Watershed Water Quality Treatment Facilities (OPE)

This feature includes two reservoir-assisted stormwater treatment areas and plugging of select local drainage ditches. The initial design of these reservoir-assisted stormwater treatment areas assumes a 1,775-acre facility in the S-154 Basin in Okeechobee County and a 2,600-acre facility in the S-65D sub-basin of the Kissimmee River Basin in Highlands and Okeechobee Counties. The plugged drainage ditches will result in restoration of approximately 3,500 acres of wetlands throughout the Lake Okeechobee watershed basin. This feature is also consistent with the recommendations of the South Florida Ecosystem Restoration Working Group's Lake Okeechobee Issue Team for achieving water quality restoration objectives in the Lake and should provide significant long-term water quality benefits for the Lake.

The other portion of this feature includes the purchase of conservation easements within four key basins of Lake Okeechobee to restore the hydrology of isolated wetlands by plugging the connection to drainage ditches and the diversion of canal flows to adjacent wetlands. The sites range in size from an individual wetland to an entire sub-basin and are located within the lower Kissimmee River Basins (S-65D, S-65E, and S-154) and Taylor Creek/Nubbin Slough Basin (S-191).

The purpose of this feature is to attenuate peak flows and retain phosphorus before flowing into Lake Okeechobee. Further, many of the wetlands in the Lake Okeechobee watershed have been ditched and drained for agriculture water supply and flood control. This feature will restore the hydrology of selected isolated and riverine wetlands in the region by plugging these drainage ditches.

The South Florida Ecosystem Restoration Working Group's Lake Okeechobee Issue Team identified six primary tributary basins (C-41 Basin, Fisheating Creek, Taylor Creek/Nubbin Slough, S-154 Basin, S-65D (Pool D) Basin, S-65E (Pool E) Basin) contributing significant phosphorus loads to the Lake. In order to further reduce nutrient loading to Lake Okeechobee in support of the water quality goals for the Lake, articulated in the Lake Okeechobee Surface Water Improvement Management Plan, there are potentially other reservoir-assisted stormwater treatment area facilities needed in the Lake Okeechobee watershed (such as in the C-41 and Fisheating Creek Basins) that are not included in this construction feature. Therefore, it is proposed that a comprehensive plan for the Lake Okeechobee watershed be developed before the final configuration of this construction feature is implemented. A comprehensive Lake Okeechobee watershed plan would include elements of the Lake Okeechobee Surface Water Management Plan and remediation programs developed to achieve appropriate pollution reduction targets established for the Lake.

9.1.1.4 Lake Okeechobee Tributary Sediment Dredging (OPE)

This feature includes the dredging of sediments from 10 miles of primary canals within an 8-basin area in the northern watershed of Lake Okeechobee. The initial design assumes that the dredged material will contain approximately 150 tons of phosphorus.

The purpose of this feature is to remove phosphorous in canals located in areas of the most intense agriculture in the Lake Okeechobee watershed. These sediments presently contribute to the excessive phosphorus loading to Lake Okeechobee. A partnership with local landowners will be pursued for the disposal of the dredged material on uplands. The South Florida Water Management District has programmed a demonstration project to be implemented in 1999. Findings from this demonstration project will be used for detailed planning and design of this construction feature. This feature is also consistent with the water quality restoration goals for the Lake included in the Lake Okeechobee Surface Water Management Plan and subsequently developed by the Lake Okeechobee Issue Team. Implementation of this feature will also complement other activities associated with pollution reduction for the Lake.

9.1.1.5 Lake Istokpoga Regulation Schedule (OPE)

This feature includes development of a plan to address water resource problems in the Lake Istokpoga Basin. Lake Istokpoga is a natural lake located in Highlands County, a tributary of Lake Okeechobee and the Kissimmee River. The major focus of this plan is to create a balance between the environmental needs, water supply and flood control in the Lake Istokpoga drainage basin.

The purpose of this plan is to examine the Lake Istokpoga Basin with a view towards enhancing fish and wildlife benefits and developing a long-term comprehensive management plan. It has been noted that operation of S-68, beginning in 1962, reduced the maximum annual fluctuation of the Lake (SFWMD, 1978). While the littoral zone expanded, the amount of quality habitat was reduced by this formation of extensive floating tussocks and dense cattail communities. Persistently lowered lake levels have reduced the natural frequency of seasonal drying and inundation. Without natural dewatering events, germination of diverse aquatic plant seeds is reduced, consolidation and compaction of organic sediments cannot occur, and the formation and expansion of floating mats of water hyacinths and other species common to tussock communities are promoted. These mats reduce overall productivity and diversity of the marsh.

The plan will also address the need for flood protection to the perimeter and upstream tributaries, and downstream areas west and east of C-41A. Water supply needs for agriculture and the Seminole Tribe of Florida will also be addressed.

9.1.2 Lake Okeechobee Region

9.1.2.1 Lake Okeechobee Aquifer Storage and Recovery (GG)

This feature includes a series of aquifer storage and recovery wells adjacent to Lake Okeechobee with a capacity of 1-billion gallons per day and associated pre- and post- water quality treatment in Glades and Okeechobee Counties. The initial design assumes 200 wells, each with the capacity of 5 million gallons per day with 8-ultrafiltration water quality pre-treatment facilities and aeration for post-treatment. Based on information for existing aquifer storage and recovery facilities, it is assumed that recovery of aquifer-stored water would have no adverse effects on water quality conditions in Lake Okeechobee. In fact, some level of nutrient load reduction may occur as a result of aquifer storage, which would be a long-term benefit to in-lake water quality conditions. The level and extent of treatment and number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project (U.S. Environmental Protection Agency, 1999). The pilot project would also investigate changes to water chemistry resulting from aquifer storage and identify post-retrieval water quality treatment requirements, if any, necessary to implement aquifer storage and recovery facilities. The Implementation Plan (Section 10) includes pilot studies to investigate the proposed facilities, including water quality changes associated with aquifer storage and recovery.

The purpose of this feature is to: (1) provide additional regional storage while reducing both evaporation losses and the amount of land removed from current land use (e.g. agriculture) that would normally be associated with construction and operation of above-ground storage reservoirs; (2) increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades; (3) manage a portion of regulatory releases from the Lake primarily to improve Everglades hydropatterns and to meet supplemental water supply demands of the Lower East Coast; (4) reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee Estuaries; and (5) maintain and enhance the existing level of flood protection.

The operation of this feature assumes that after treatment, water from Lake Okeechobee will be injected into the upper Floridan Aquifer when the climate-based inflow model forecasts that the Lake water level will rise significantly above those levels that are desirable for the Lake littoral zone. During the dry season, water stored in the Floridan Aquifer will be returned to the Lake after aeration either when the Lake water level is projected to fall to within three quarters of a foot of the supply-side management line or below an established water level during the dry season.

9.1.3 Caloosahatchee River Region

9.1.3.1 C-43 Basin Storage Reservoir and Aquifer Storage and Recovery (D)

This feature includes above-ground reservoir(s) with a total storage capacity of approximately 160,000 acre-feet and aquifer storage and recovery wells with a capacity of approximately 220 million gallons per day and associated pre- and post-water quality treatment located in the C-43 Basin in Hendry, Glades, or Lee Counties. The initial design of the reservoir(s) assumed 20,000 acres with water levels fluctuating up to 8 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design. The initial design of the wells assumed 44 wells, each with the capacity of 5 million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The level and extent of treatment and number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project (U.S. Environmental Protection Agency, 1999).

The purpose of this feature is to capture C-43 Basin runoff and releases from Lake Okeechobee. These facilities will be designed for water supply benefits, some flood attenuation, to provide environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. It is assumed that, depending upon the location of the facility and pollutant loading conditions in the watershed, the facility could be designed to achieve significant water quality improvements, consistent with appropriate pollution load reduction targets.

Excess runoff from the C-43 Basin and Lake Okeechobee flood control discharges will be pumped into the proposed reservoir. Water from the reservoir will be injected into the aquifer storage and recovery wellfield for long-term (multi-season) storage. Any estuarine demands, not met by basin runoff and the aquifer storage and recovery wells, will be met by Lake Okeechobee as long as the lake stage is above a pre-determined level. Lake water is also used to meet the remaining basin demands subject to supply-side management. The C-43 reservoir is operated in conjunction with the Caloosahatchee Backpumping feature, which includes a stormwater treatment area for water quality treatment. If the level of water in the reservoir exceeds 6.5 feet and Lake Okeechobee is below a pre-determined level, then water is released and sent to the backpumping facility.

9.1.3.2 Caloosahatchee Backpumping with Stormwater Treatment (DDD)

This feature includes pump stations and a stormwater treatment area with a total capacity of approximately 20,000 acre-feet located in the C-43 Basin in Hendry and Glades Counties. The initial design of the stormwater treatment area assumed 5,000 acres with the water level fluctuating up to 4 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design.

The purpose of this feature is to capture excess C-43 Basin runoff, which will be used to augment regional system water supply.

This feature operates after estuary and agricultural/urban demands have been met in the basin and when water levels in the C-43 storage reservoir exceed 6.5 feet above grade. Lake Okeechobee must also be considered to have available storage. When these conditions are met, a series of pump stations will backpump excess water from the reservoir and the C-43 Basin to Lake Okeechobee after treatment through a stormwater treatment area. The stormwater treatment area will be designed to meet Lake Okeechobee phosphorus and other pollutant loading reduction targets consistent with the Surface Water Improvement and Management Plan for the Lake and future appropriate pollution load reduction targets which may be developed for the Lake and the watershed in which the facility is to be located.

9.1.4 Upper East Coast

9.1.4.1 C-44 Basin Storage Reservoir (B)

This feature includes an above-ground reservoir with a total storage capacity of approximately 40,000 acre-feet located in the C-44 Basin in Martin County. The initial design of the reservoir assumed 10,000 acres with the water levels fluctuating up to 4 feet above grade. The final location, size, depth and configuration of this facility will be determined through more detailed analysis to be completed as a part of the ongoing Indian River Lagoon Feasibility Study.

The purpose of the feature is to capture local runoff from the C-44 Basin, then return the stored water to the C-44 when there is a water supply demand. The reservoir will be designed for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to control salinity and reduce loading of nutrients, pesticides, and other pollutants contained in runoff presently discharged to the estuary.

9.1.4.2 C-23/C-24/C-25/Northfork and Southfork Storage Reservoirs (UU)

This feature includes above-ground reservoirs with a total storage capacity of approximately 349,400 acre-feet located in the C-23/C-24/C-25/Northfork and Southfork Basins in St. Lucie and Martin Counties. The initial design of the reservoirs assumed 39,000 acres with water levels fluctuating up to 8 feet above grade and 9,350 acres with water levels fluctuating up to 4 feet above grade. The final location, size, depth and configuration of these facilities will be determined through more detailed analysis to be completed as a part of the Indian River Lagoon

Feasibility Study. It is noted that experience from the Upper St. Johns Project reveals that greater variability of water levels are more desirable for the ecology and water quality.

The purpose of this feature is to capture local runoff from the C-23/C-24/C-25/Northfork and Southfork Basins for flood flow attenuation to the St. Lucie River Estuary. It is assumed that this feature can be designed to provide significant water quality improvement benefits to the Indian River Lagoon and St. Lucie River Estuary in terms of reduced loading of nutrients, pesticides, and suspended materials in stormwater runoff which is presently conveyed to those waterbodies. Interim Pollution Load Reduction Goals for total suspended material, total nitrogen, and total phosphorus have already been developed for the Indian River Lagoon Surface Water Improvement and Management Plan (SFWMD and SJRWMD, 1994). This water will then be used to provide both water supply and environmental water supply benefits.

9.1.5 Everglades Agricultural Area

9.1.5.1 Everglades Agricultural Storage Reservoirs (G)

This feature includes above-ground reservoir(s) with a total storage capacity of approximately 360,000 acre-feet located in the Everglades Agricultural Area in western Palm Beach County and conveyance capacity increases for the Miami, North New River, and Bolles and Cross Canals. The initial design for the reservoir(s) assumed 60,000 acres, divided into three, equally sized compartments (1, 2, and 3), with the water level fluctuating up to 6 feet above grade in each compartment. The final size, depth and configuration of this facility will be determined through more detailed planning and design.

The purpose of this feature is to improve the timing of environmental deliveries to the Water Conservation Areas, including reducing damaging flood releases from the Everglades Agricultural Area to the Water Conservation Areas, reducing Lake Okeechobee regulatory releases to the estuaries, meeting Everglades Agricultural Area irrigation and Everglades water demands, and increasing flood protection in the Everglades Agricultural Area.

Runoff from the Everglades Agricultural Area, Miami and North New River Canal Basins and regulatory releases from Lake Okeechobee will be pumped into the reservoirs. Compartment 1 discharges will be used to meet Everglades Agricultural Area irrigation demands only. Compartment 2 discharges will be used to meet environmental demands as a priority and can be used to supply a portion of agricultural demands if the environmental demands equal zero. Compartment 3 discharges will be used to meet environmental demands. The storage compartments can also be designed to provide a water quality treatment function, augmenting the performance of the Everglades Construction Project and ensuring protection of water quality in the Everglades Protection Area. Design of this feature for water quality performance will be based on water quality targets for the Everglades Construction Project and other water quality targets developed to protect designated uses in Everglades Agricultural Area waters.

9.1.6 Big Cypress Region

9.1.6.1 Big Cypress/L-28 Interceptor Modifications (CCC)

This feature includes modification of levees and canals, water control structures, pumps, and stormwater treatment areas with a total storage capacity of 7,600 acre-feet located within and adjacent to the Miccosukee and Seminole Indian Reservations in Collier and Hendry Counties. The initial design of the stormwater treatment areas assumed a total acreage of 1,900 acres with the water level fluctuating up to 4 feet above grade. Conceptual sizes of the stormwater treatment areas were based on interim phosphorus concentration targets in the conceptual plan for the Everglades Construction Project. The final size, depth and configuration of this facility, including the stormwater treatment areas, will be determined through more detailed planning and design. Design of the stormwater treatment areas will be based on water quality criteria of the Seminole Tribe and criteria applicable to Big Cypress National Preserve, as appropriate.

The purpose of this feature is to reestablish sheetflow from the West Feeder Canal across the Big Cypress Reservation and into the Big Cypress National Preserve, maintain flood protection on Seminole Tribal lands, and ensure that inflows to the North and West Feeder Canals meet applicable water quality standards. Consistency with the Seminole Tribe's Conceptual Water Conservation System master plan will be maintained.

Upstream flows entering the West and North Feeder Canals will be routed through two stormwater treatment areas to be located at the upstream ends of the canals. Sheetflow will be reestablished south of the West Feeder Canal by a system to be developed consistent with the Seminole Tribe's Conceptual Water Conservation System master plan. After conversion to a pump station, S-190 will also push flows south into the L-28 Interceptor Canal where sheetflow to the southwest will also be reestablished with backfilling of and degradation of the southwest levee of the canal.

9.1.6.2 Seminole Tribe Big Cypress Water Conservation Plan (OPE)

This feature includes construction of water control, management, and treatment facilities in the Big Cypress Reservation. The construction elements include conveyance systems, major canal bypass structures, irrigation storage cells, and water resource areas.

The purpose of this feature is to improve the quality of water and runoff from phosphorus generating agricultural sources within the Reservation. The area is traversed by the L-28 and L-28I Borrow Canals and the North and West Feeder Canals, all of which were constructed as part of the C&SF Project. This comprehensive watershed management system is designed to achieve environmental restoration on the Reservation, the Big Cypress Preserve, and the Everglades Protection Area. In addition, the project will reduce flood damage and promote water conservation.

The removal of pollutants will be achieved using natural treatment processes in pretreatment cells and water storage areas. A phosphorus level of 50 ppb is the goal, which is the current level to be achieved by the stormwater treatment areas of the Everglades Construction Project. Should design performance levels for phosphorus become more stringent, this project has sufficient flexibility to incorporate additional alternative technology.

9.1.7 Water Conservation Areas

9.1.7.1 Flow to Northwest and Central Water Conservation Area 3A (II and RR)

This feature includes relocation and modifications to pump stations and development of a spreader canal system located in the northwest corner and west-central portions of Water Conservation Area 3A in western Broward County.

The purpose of this feature is to increase environmental water supply availability, increase depths and extend wetland hydropatterns in the northwest corner and west-central portions of Water Conservation Area 3A.

Additional flows will be directed to the northwest corner and west central portions of Water Conservation Area 3A by increasing the capacity of the G-404 pump station, currently a part of the Everglades Construction Project, and increasing the capacity and relocating the S-140 pump station. A spreader canal system at S-140 will reestablish sheetflow to the west-central portion of Water Conservation Area 3A. Water quality treatment of flows is assumed to be provided by the Everglades Construction Project and water quality treatment strategies developed to fulfill the Non-Everglades Construction Project requirements of the Everglades Forever Act. If additional treatment is determined to be required as a result of future detailed planning and design work, those existing facilities would be modified to provide the necessary treatment.

9.1.7.2 Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement (AA, QQ and SS)

These features include the construction of new water control structures and the modification or removal of levees, canals, and water control structures in Water Conservation Area 3A and B located in western Broward County.

The purpose of these features is to reestablish the ecological and hydrological connection between Water Conservation Areas 3A and 3B, the Everglades National Park, and Big Cypress National Preserve.

Sheetflow obstructions will be removed with the backfilling of the Miami Canal and southern 7.5 miles of L-67A Borrow Canal, removal of the L-68A, L-67C, L-29, L-28, and L-28 Tieback Levees and Borrow Canals, and elevating of Tamiami Trail. Water supply deliveries to Miami-Dade County, previously made through the Miami Canal, will be rerouted through an expanded North New River Canal and southern conveyance system. Eight passive weir structures to be located along the entire length of L-67A will also promote sheetflow from Water Conservation Area 3A to 3B during high flow conditions.

9.1.7.3 Loxahatchee National Wildlife Refuge Internal Canal Structures (KK)

This feature includes two water control structures in the northern ends of the perimeter canals encircling the Loxahatchee National Wildlife Refuge (Water Conservation Area 1) located in Palm Beach County.

The purpose of this feature is to improve the timing and location of water depths within the Refuge. It is assumed that these structures will remained closed except to pass Stormwater Treatment Area 1 East and Stormwater Treatment Area 1 West outflows and water supply deliveries to the coastal canals.

9.1.7.4 Miccosukee Tribe Water Management Plan (OPE)

This feature includes construction of a 900-acre wetland retention/detention area on the Miccosukee Tribe's Alligator Alley Reservation. The feature includes a pump station, levees, trenches and culverts to create the inflow and outflow facilities for the retention/detention area.

The purpose of this feature is to provide water storage capacity and water quality enhancement for tribal reservation waters which discharge from tribal lands and downstream into the Everglades Protection Area.

9.1.8 Lower East Coast Region

9.1.8.1 Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration (OPE)

This feature includes water control structures, canal modifications and the acquisition of 3,000 acres located between Pal-Mar and the J.W. Corbett Wildlife Management Area in Palm Beach County.

The purpose of this feature is to provide hydrologic connections between the Corbett Wildlife Management Area and: (1) the Moss Property, (2) the C-18 Canal, (3) the Indian Trail Improvement District, and (4) the L-8 Borrow Canal, in addition to extending the spatial extent of protected natural areas. These connections would relieve the detrimental effects on native vegetation frequently experienced during the wet season and form an unbroken 126,000-acre greenbelt extending from the Dupuis Reserve near Lake Okeechobee across the J.W. Corbett Wildlife Management Area and south to Jonathan Dickinson State Park.

9.1.8.2 Water Preserve Areas / L-8 Basin (K and GGG)

This feature includes a combination above-ground and in-ground reservoir with a total storage capacity of approximately 48,000 acre-feet located immediately west of the L-8 Borrow Canal and north of the C-51 Canal in Palm Beach County. Other construction features include aquifer storage and recovery wells with a capacity of 50 million gallons per day and associated pre- and post- water quality treatment to be constructed in the City of West Palm Beach (Lake Mangonia), a series of pumps, water control structures, and canal capacity improvements in the M Canal. The initial design for the reservoir assumed a 1,800-acre reservoir with 1,200 usable acres with the water level fluctuating from 10 feet above grade to 30 feet below grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design. The initial design of the wells assumed 50 wells, each with a capacity of 5 million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The level and extent of treatment and number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project.

The purpose of this feature is to increase water supply availability and flood protection for northern Palm Beach County areas. It will also provide flows to enhance hydroperiods in the Loxahatchee Slough, increase base flows to the Northwest Fork of the Loxahatchee River, and reduce high discharges to the Lake Worth Lagoon.

Water will be pumped into the reservoir from the C-51 Canal and Southern L-8 Borrow Canal during the wet season, or periods when excess water is available, and returned to the C-51 and Southern L-8 during dry periods. Additional features will also direct excess water into the West Palm Beach Water Catchment Area. During periods when the West Palm Beach Water Catchment Area is above desirable stages, 50 million gallons per day will be diverted to Lake Mangonia for storage in the aquifer storage and recovery wells. The reservoir portion of this component may be implemented under a previous authorization

9.1.8.3 Acme Basin B Discharge (OPE)

This feature includes the construction of a wetland or chemical treatment area and a storage reservoir with a combined total storage capacity of 3,800 acre-feet located adjacent to the Loxahatchee National Wildlife Refuge in Palm Beach County. The initial design for the treatment area and reservoir assumed 310 acres with the water level fluctuating up to 4 feet above grade and 620 acres with the water level fluctuating up to 8 feet above grade. The final size, depth and configuration of these facilities will be determined through more detailed planning and design.

The purpose of this feature is to provide water quality treatment and stormwater attenuation for runoff from Acme Basin "B" prior to discharge to the Loxahatchee National Wildlife Refuge or alternative locations described below. Excess available water may be used to meet water supply demands in central and southern Palm Beach County.

Stormwater runoff from Acme Basin "B" will be pumped into the wetland treatment area and then into the storage reservoir until such time as the water can be discharged into the Loxahatchee National Wildlife Refuge if water quality treatment criteria is met or into the one of two alternative locations: the Palm Beach County Agricultural Reserve Reservoir (VV) or the combination above-ground and in-ground reservoir area located adjacent to the L-8 Borrow Canal and north of the C-51 Canal(GGG).

9.1.8.4 Lake Worth Lagoon Restoration (OPE)

This feature includes sediment removal and trapping within the C-51 Canal and sediment removal or trapping within a 2.5 mile area downstream of the confluence of the C-51 Canal and the Lake Worth Lagoon located in Palm Beach County. A prototype project will be conducted to determine if the Lagoon sediments will either be removed or trapped.

The purpose of this feature is to improve water quality and allow for the reestablishment of sea grasses and benthic communities. The elimination of the organically enriched sediment from the C-51 Canal discharge will provide for long term improvements to the Lagoon and enable success for additional habitat restoration and enhancement projects planned by Palm Beach County.

9.1.8.5 Winsburg Farms Wetland Restoration (OPE)

This feature includes the construction of a 175-acre wetland east of Loxahatchee Wildlife Preserve in Palm Beach County. The feature will reduce the amount of treated water from the Southern Region Water Reclamation Facility wasted in deep injection wells by further treating and recycling the water.

The purpose of this facility is to create a wetland from water, which would be normally lost to deep well injection and any future beneficial use. The wetland will reuse a valuable resource, recharge the local aquifer system, create a new ecologically significant wildlife habitat and extend the function of the nearby Wakodahatchee Wetland.

9.1.8.6 C-17 Backpumping and Treatment (X)

This feature includes backpumping facilities and a stormwater treatment area with a total storage capacity of approximately 2,200 acre-feet located in northeastern Palm Beach County. The initial design for the stormwater treatment area assumed 550 acres with the water level fluctuating up to 4 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design, and will address appropriate pollution load reduction targets necessary to protect receiving waters (West Palm Beach Water Catchment Area).

The purpose of this feature is to increase water supplies to the West Palm Beach Water Catchment Area and Loxahatchee Slough by capturing and storing excess flows currently discharged to the Lake Worth Lagoon from the C-17 Canal.

Excess C-17 Canal water will be backpumped through existing canals and proposed water control structures to the stormwater treatment area which will provide water quality treatment prior to discharge into the West Palm Beach Water Catchment Area.

9.1.8.7 C-51 Backpumping and Treatment (Y)

This feature includes backpumping facilities and a stormwater treatment area with a total storage capacity of approximately 2,400 acre-feet located in Palm Beach County. The initial design for the stormwater treatment area assumed 600 acres in size with the water level fluctuating up to 4 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design, and will address appropriate pollution load reduction targets necessary to protect receiving waters (West Palm Beach Water Catchment Area).

The purpose of this feature is to increase water supplies to the West Palm Beach Water Catchment Area and Loxahatchee Slough by capturing and storing excess flows currently discharged to the Lake Worth Lagoon from the C-51 Canal.

Excess C-51 Canal water will be backpumped through existing and proposed water control structures and canals to the stormwater treatment area which will provide water quality treatment prior to discharge into the West Palm Beach Water Catchment Area.

9.1.8.8 C-51 Regional Groundwater Aquifer Storage and Recovery (LL)

This feature includes a series of aquifer storage and recovery wells with a capacity of 170 million gallons per day as well associated pre- and post- water quality treatment to be constructed along the C-51 Canal in Palm Beach County. The initial design of the wells assumed 34 well clusters, each with a capacity of 5 million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The level and extent of treatment and number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project.

The purpose of this feature is to capture and store excess flows from the C-51 Canal, currently discharged to the Lake Worth Lagoon, for later use during dry periods.

The aquifer storage and recovery facilities will be used to inject and store surficial aquifer ground water adjacent to the C-51 Canal into the upper Floridan Aquifer instead of discharging the canal water to tide. Water will be returned to the C-51 Canal to help maintain canal stages during the dry-season. If water is not available in the aquifer storage and recovery system, existing rules for water delivery to this region will be applied.

9.1.8.9 Palm Beach County Agricultural Reserve Reservoir and Aquifer Storage and Recovery (VV)

This feature includes an above-ground reservoir with a total storage capacity of approximately 20,000 acre-feet located in the western portion of the Palm Beach County Agricultural Reserve. Aquifer storage and recovery wells with a capacity of 75 million gallons per day and associated pre- and post- water quality treatment located adjacent to the reservoir will also be a part of this feature. The initial design for the reservoir assumed 1,660 acres with water levels fluctuating up to 12 feet above grade. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study. The initial design of the wells assumed 15 well clusters, each with a capacity of 5 million gallons per day as well as chlorination for pre-treatment and aeration for post-treatment. The source of water to be injected is surficial ground water adjacent to the reservoir. The level and extent of treatment and number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project.

The purpose of this feature is to supplement water supplies for central and southern Palm Beach County by capturing and storing excess water currently discharged to the Lake Worth Lagoon. These supplemental deliveries will reduce demands on Lake Okeechobee and Loxahatchee National Wildlife Area. It is assumed that this facility could also be designed to achieve water quality improvements in downstream receiving waters, depending upon pollutant loading conditions in the watershed.

The facilities will be filled during the wet season with excess water from the western portions of the Lake Worth Drainage District and possibly from Acme Basin B. Water will be returned to the Lake Worth Drainage District Canals to help maintain canal stages during the dry-season. If water is not available in the reservoir or the aquifer storage and recovery wells, existing rules for water delivery to this region will be applied.

9.1.8.10 Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including the Strazzulla Tract (OPE)

This feature includes water control structures and the acquisition of 3,335 acres located in Palm Beach County.

The purpose of this feature is to provide a hydrological and ecological connection to the Loxahatchee National Wildlife Refuge and expand the spatial extent of protected natural areas. This land will act as a buffer between higher water stages to the west and lands to the east that must be drained. This increase in spatial extent will provide vital habitat connectivity for species that require large unfragmented tracts of land for survival. It also contains the only remaining cypress habitat in the eastern Everglades and one of the few remaining sawgrass marshes adjacent to the coastal ridge. This is a unique and endangered habitat that must be protected. This area provides an essential Everglades landscape heterogeneity function.

9.1.8.11 Site 1 Impoundment and Aquifer Storage and Recovery (M)

This feature includes an above-ground reservoir with a total storage capacity of approximately 15,000 acre-feet located in the Hillsboro Canal Basin in southern Palm Beach County. A series of aquifer storage and recovery wells with a total capacity of approximately 150 million gallons per day and associated pre- and post- water quality treatment will also be a part of this feature located adjacent to the reservoir or along the Hillsboro Canal. The initial design of the reservoir assumed 2,460 acres with water levels fluctuating up to 6 feet above grade. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study. The initial design of the aquifer storage and recovery facility assumed 30 well clusters, each with a capacity of 5 million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The source of water to be injected is in the surficial ground water adjacent to the reservoir. The location, extent of treatment and number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project.

The purpose of this feature is to supplement water deliveries to the Hillsboro Canal during dry periods thereby reducing demands on Lake Okeechobee and the Loxahatchee National Wildlife Refuge.

Water from the Hillsboro Canal will be pumped into the reservoir during the wet season or periods when excess water is available. Water will be released back to the Hillsboro Canal to help maintain canal stages during the dry-season.

9.1.8.12 Broward County Secondary Canal System (CC)

This feature includes a series of water control structures, pumps, and canal improvements located in the C-9, C-12 and C-13 Canal Basins and east basin of the North New River Canal in central and southern Broward County.

The purpose of this feature is to reduce water shortages by recharging local wellfields and stabilizing the saltwater interface. Excess water in the basins will be pumped into the coastal canal systems to maintain canal stages at optimum levels. When basin water is not sufficient to maintain canal stages, the canals will be maintained from other construction features such as the Site 1 Impoundment and the North Lake Belt Storage Area and then from Lake Okeechobee and the Water Conservation Areas.

9.1.8.13 Western C-11 Diversion Impoundment and Canal and Water Conservation Areas 3A and 3B Levee Seepage Management (O and Q)

This feature includes canals, levees, water control structures, and a stormwater treatment area/impoundment with a total storage capacity of 6,400 acre-feet located in western Broward County. The initial design of the stormwater treatment area/impoundment assumed 1,600 acres with the water level fluctuating up to 4 feet above grade. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study. Detailed design of this feature will address appropriate pollution load reduction targets necessary to protect receiving waters.

The purpose of this feature is to divert and treat runoff from the western C-11 Basin that is presently discharged into Water Conservation Area 3A, control seepage from Water Conservation Areas 3A and 3B by improving groundwater elevations, and provide flood protection for the western C-11 Basin.

Runoff in the western C-11 Canal Basin that was previously backpumped into Water Conservation Area 3A through the S-9 pump station will be diverted into the C-11 Stormwater Treatment Area/Impoundment and then into either the North Lake Belt Storage Area, the C-9 Stormwater Treatment Area/Impoundment, or Water Conservation Area 3A after treatment, as applicable.

9.1.8.14 C-9 Stormwater Treatment Area/Impoundment (R)

This feature includes canals, levees, water control structures and a stormwater treatment area/impoundment with a total capacity of approximately 10,000 acre-feet, located in the western C-9 Basin in Broward County. The initial design of the stormwater treatment area/impoundment assumed 2,500 acres with the water level fluctuating up to 4 feet above grade. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study and will address appropriate pollution load reduction targets necessary to protect receiving waters.

The purpose of this feature is to provide treatment of runoff stored in the North Lake Belt Storage Area, enhance groundwater recharge within the basin, provide seepage control for Water Conservation Area 3 and buffer areas to the west, and provide flood protection for the western C-9 Basin.

Seepage from the C-9 Stormwater Treatment Area/Impoundment will be collected and returned to the impoundment.

9.1.8.15 North Lake Belt Storage Area (XX)

This feature includes canals, pumps, water control structures, and an in-ground storage reservoir with a total capacity of approximately 90,000 acre-feet located in Miami-Dade County. The initial design of the reservoir assumed 4,500 acres with the water level fluctuating from ground level to 20 feet below grade. A subterranean seepage barrier will be constructed around the perimeter to enable drawdown during dry periods, to prevent seepage losses, and to prevent water quality impact due to the high transmissivity of the Biscayne Aquifer in the area. The reservoir will be located within an area proposed for rock mining. A pilot test of this component will be conducted prior to final design to determine construction technologies, storage efficiencies, impacts upon local hydrology, and water quality effects. The water quality assessment will include a determination as to whether the in-ground reservoir with perimeter seepage barrier will allow storage of untreated runoff without concerns of groundwater contamination. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study and will address appropriate pollution load reduction targets necessary to protect the adjacent surficial aquifer and downstream receiving surface waters.

The purpose of this feature is to capture and store a portion of the stormwater runoff from the C-6, western C-11 and C-9 Basins. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals and to provide water deliveries to Biscayne Bay to aid in meeting salinity targets.

Runoff is pumped and gravity fed into the in-ground reservoir from the C-6 (west of Florida's Turnpike), western C-11, and C-9 Basins. Outflows from the facility will be directed into the C-9 Stormwater Treatment Area/Impoundment for treatment prior to delivery to the C-9, C-7, C-6, C-4 and C-2 Canals. If necessary, additional stormwater treatment areas will be constructed adjacent to the in-ground reservoir.

9.1.8.16 Diverting Water Conservation Area 2 and 3 flows to Central Lake Belt Storage Area (YY and ZZ)

This feature includes pumps, water control structures, canals, and conveyance improvements located adjacent to Water Conservation Areas 2 and 3 in Broward County. The final size and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

The purpose of this feature is to attenuate high stages in Water Conservation Areas 2 and 3 and transport this excess water to the Central Lake Belt Storage Area where it will be stored to meet downstream demands in Shark River Slough, Water Conservation Area 3B or Biscayne Bay.

When stages in Water Conservation Areas 2B, 3A, and 3B exceed target depths, water will be diverted to the Central Lake Belt Storage Area through water control structures and conveyance features. Water supply deliveries will be made first to Northeast Shark River Slough, then to Water Conservation Area 3B, and, finally, to Biscayne Bay, if flows are available. It is assumed that the water to be diverted from Water Conservation Areas 2 and 3 is of adequate quality to return to the Everglades Protection Area and Biscayne Bay; however, the final size, depth and configuration of these facilities, including treatment requirements, will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

9.1.8.17 Central Lake Belt Storage Area (S and EEE)

This feature includes pumps, water control structures, a stormwater treatment area, and a combination above-ground and in-ground storage reservoir with a total storage capacity of approximately 190,000 acre-feet located in Miami-Dade County. The initial design of the reservoir assumed 5,200 acres with the water level fluctuating from 16 feet above grade to 20 feet below grade. A subterranean seepage barrier will be constructed around the perimeter to enable drawdown during dry periods and to prevent seepage losses. A pilot test of this technology will be conducted prior to final design of this component to determine construction technologies, storage efficiencies, impacts upon local hydrology, and water quality effects. Since this facility is to be located within the protection area of Miami-Dade County's Northwest Wellfield, the pilot test will also be designed to identify and address potential impacts to the County's wellfield which may occur during construction and/or operation. The stormwater treatment area was assumed to be 640 acres with the water level fluctuating up to 4 feet above grade. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

The purpose of the feature is to store excess water from Water Conservation Areas 2 and 3 and provide environmental water supply deliveries to: (1) Northeast Shark River Slough, (2) Water Conservation Area 3B, and (3) to Biscayne Bay, in that order, if available. Due to the source of the water (Water Conservation Areas 2 and 3), it is assumed that water stored in this facility is of adequate quality to return to the Everglades Protection Area and Biscayne Bay; however, the final size, depth and configuration of these facilities, including treatment requirements, will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

Excess water from Water Conservation Areas 2 and 3 will be diverted into the L-37, L-33, and L-30 Borrow Canals, which run along the eastern boundaries of the Water Conservation Areas, and pumped into the Central Lake Belt Storage Area. Water supply deliveries will be pumped through a stormwater treatment area prior to discharge to the Everglades via the L-30 Borrow Canal and a reconfigured L-31N Borrow Canal. If available, deliveries will be directed to Biscayne Bay through the Snapper Creek Canal at Florida's Turnpike. A structure will be provided on the Snapper Creek Canal to provide regional system deliveries when water from the Central Lake Belt Storage Area is not available.

9.1.8.18 Dade-Broward Levee/Pennsuco Wetlands (BB)

This feature includes water control structures and modifications to the Dade-Broward Levee and associated conveyance system located in Miami-Dade County. The final size and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

The purpose of this feature is to reduce seepage losses to the east from the

Pennsuco Wetlands and southern Water Conservation Area 3B, enhance hydroperiods in the Pennsuco Wetlands, and provide recharge to Miami-Dade County's Northwest Wellfield.

9.1.8.19 C-4 Control Structures (T)

This feature includes two water control structures located in the C-4 Canal in Miami-Dade County.

The purpose of this feature will be to enhance wetland hydroperiods and enhance recharge to Miami-Dade County's Northwest Wellfield.

The eastern structure will be operated to reduce regional system deliveries by diverting dry season stormwater flows to the C-2 Canal to provide salt water intrusion protection and recharge to downstream wellfields. A western structure, being implemented under the Critical Projects Program, will be operated to control water levels in the C-4 Canal at a higher elevation to reduce seepage losses from the Pennsuco Wetlands and areas to the west of the structure.

9.1.8.20 Bird Drive Recharge Area (U)

This feature includes pumps, water control structures, canals, and an above-ground recharge area with a total storage capacity of approximately 11,500 acre-feet located in western Miami-Dade County. The initial design of the recharge feature assumed 2,877 acres with the water level fluctuating up to 4 feet above grade. Final design will seek to enhance and maintain the continued viability of wetlands within the basin. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study and will address appropriate pollution load reduction targets necessary to protect downstream receiving surface waters.

The purpose of the feature is to recharge groundwater and reduce seepage from the Everglades National Park buffer areas by increasing water table elevations east of Krome Avenue. The facility will also provide C-4 flood peak attenuation and water supply deliveries to the South Dade Conveyance System and Northeast Shark River Slough.

Inflows from the western C-4 Canal Basin and from the proposed West Miami-Dade Wastewater Treatment Plant will be pumped into the Recharge Area. Inflows from the wastewater treatment plant will stop when the Recharge Area depth exceeds 3 feet above-ground and will be diverted to a deep well injection disposal system. Recharge area outflows will be prioritized to meet: (1) groundwater recharge demands, (2) South Dade Conveyance System demands, and (3) Northeast Shark River Slough demands, when supply is available. Regional system deliveries will be routed through the seepage collection canal system of the Bird Drive Recharge Area to the South Dade Conveyance system.

9.1.8.21 L-31N Improvements for Seepage Management and S-356 Structures (V and FF)

This feature includes relocating and enhancing L-31N, groundwater wells, and sheetflow delivery system adjacent to Everglades National Park located in Miami-Dade County. More detailed planning, design and pilot studies will be conducted to determine the appropriate technology to control seepage from Everglades National Park. These studies and tests will also determine the appropriate amount of wet season groundwater flow control that will minimize potential impacts to Miami-Dade County's West Wellfield and freshwater flows to Biscayne Bay.

The purpose of this feature is to improve water deliveries to Northeast Shark River Slough and restore wetland hydropatterns in Everglades National Park by reducing levee and groundwater seepage and increasing sheetflow.

This feature reduces levee seepage flow across L-31N adjacent to Everglades National Park via a levee cutoff wall (refer to ***Appendix C***). Groundwater flows during the wet season are captured by ground water wells adjacent to L-31N and pumped to Everglades National Park. Water from upstream natural areas will be diverted into a buffer area adjacent to Everglades National Park where sheetflow will be reestablished. Further, this feature includes relocation of the Modified Water Deliveries structure S-357 to provide more effective water deliveries to Everglades National Park. New discharges to Everglades National Park will be designed to meet applicable water quality criteria.

9.1.8.22 West Miami-Dade County Reuse (HHH)

This feature includes a wastewater treatment plant expansion to produce superior, advanced treatment of wastewater from a future West Miami-Dade Wastewater Treatment Plant to be located in the Bird Drive Basin in Miami-Dade County. The initial design assumed a potential discharge volume of 100 million gallons per day from the wastewater treatment plant. The final configuration of these facilities will be determined through more detailed planning and design to be completed in the ongoing West Dade Water Reuse Feasibility Study authorized in Section 413 of the Water Resources Development Act of 1996. Superior water quality treatment features will be based on appropriate pollution load reduction targets necessary to protect downstream receiving surface waters.

The purpose of the feature is to meet the demands for: (1) the Bird Drive Recharge Area; (2) the South Dade Conveyance System, and (3) the Northeast Shark River Slough. When all demands have been met, the plant will stop treatment beyond secondary treatment standards and will dispose of the secondary treated effluent into deep injection wells.

9.1.8.23 Biscayne Bay Coastal Wetlands (FFF and OPE)

The feature includes pump stations, spreader swales, stormwater treatment areas, flowways, levees, culverts, and backfilling canals located in southeast Miami-Dade County and covers 13,600 acres from the Deering Estate at C-100C, south to the Florida Power and Light Turkey Point power plant, generally along L-31E.

The purpose of this feature is to rehydrate wetlands and reduce point source discharge to Biscayne Bay. The proposed project will replace lost overland flow and partially compensate for the reduction in groundwater seepage by redistributing, through a spreader system, available surface water entering the area from regional canals. The proposed redistribution of freshwater flow across a broad front is expected to restore or enhance freshwater wetlands, tidal wetlands, and nearshore bay habitat. Sustained lower-than-seawater salinities are required in tidal wetlands and the nearshore bay to provide nursery habitat for fish and shellfish. This project is expected to create conditions that will be conducive to the reestablishment of oysters and other components of the oyster reef community. Diversion of canal discharges into coastal wetlands is expected not only to reestablish productive nursery habitat all along the shoreline but also to reduce the abrupt freshwater discharges that are physiologically stressful to fish and benthic invertebrates in the bay near canal outlets.

More detailed analyses will be required to define target freshwater flows for Biscayne Bay and the wetlands within the redistribution system.. The target(s) will be based upon the quality, quantity, timing and distribution of flows needed to provide and maintain sustainable biological communities in Biscayne Bay, Biscayne National Park and the coastal wetlands. Additionally, potential sources of water for providing freshwater flows to Biscayne Bay will be identified and evaluated to determine their ability to provide the target flows.

The component Biscayne Bay Coastal Canals as modeled in D-13R and the Critical Project on the L-31E Flowway Redistribution are smaller components of the Biscayne Bay Coastal Wetlands feature described above.

9.1.8.24 South Miami-Dade County Reuse (BBB)

This feature includes a plant expansion to produce superior, advanced treatment of wastewater from the existing South District Wastewater Treatment Plant located north of the C-1 Canal in Miami-Dade County. The initial design of this feature assumed that the plant will have a capacity of 131 million gallons per day. More detailed analyses will be required to determine the quality and quantity of water needed to meet the ecological goals and objectives of Biscayne Bay.

Additionally, due to the water quality issues associated with discharging reclaimed water into Biscayne National Park, an Outstanding Florida Water, such as potential failures of the treatment system and the limited ability to control contaminant inputs to the sanitary sewer system serving the treatment facility, other potential sources of water to provide required freshwater flows to southern and central Biscayne Bay should be investigated before pursuing the reuse facility as a source. If it is determined that other, more appropriate sources are not available, the reuse project will be initiated by determining the parameters of concern, the necessary wastewater treatment requirements, and the appropriate treatment technology to be implemented.

The purpose of this feature is to provide additional water supply to the South Biscayne Bay and Coastal Wetlands Enhancement Project. In order to attain the superior level of treatment, construction of an add-on pretreatment and membrane treatment system to the existing secondary treatment facility will be necessary. Superior water quality treatment features will be based on appropriate pollution load reduction targets necessary to protect downstream receiving surface waters (Biscayne Bay).

9.1.8.25 Restoration of Pineland & Hardwood Hammocks in C-111 Basin (OPE)

This feature includes restoring south Florida slash pine and hardwood hammock species on a 200-foot wide strip on each side of two miles of SR 9336 from the C-111 Canal to the L-31W Borrow Canal (approximately 50 acres) and the establishment of 2, one-acre hammocks in low-lying areas on each side of the road located in Miami-Dade County.

The purpose of this feature is to restore hammocks to a portion of the Frog Pond which has been purchased by the South Florida Water Management District as part of the C-111 Project to restore the Taylor Slough portion of the Everglades. This feature will provide some water quality treatment for runoff passing through the hammocks and will demonstrate the techniques required to re-establish native conifer and hardwood forests on land that has been rock plowed.

9.1.8.26 C-111N Spreader Canal (WW)

This feature includes levees, canals, pumps, water control structures, and a stormwater treatment area to be constructed, modified or removed in the Model Lands and Southern Glades (C-111 Basin) area of Miami-Dade County. This feature enhances the C-111 Project design for the C-111N Spreader Canal with the construction of a stormwater treatment area, the enlarging of pump station S-332E and the extension of the canal under U.S. Highway 1 and Card Sound Road into the Model Lands. The initial design of this feature pumps water from the C-111 and the C-111E Canals into a stormwater treatment area prior to discharging to Southern Everglades and Model Lands. This features also calls for filling in the southern reach of the C-111 Canal and removal of structures S-18C and S-197. The final size, depth, location and configuration of this feature will be determined through more detailed planning and design.

The purpose of this feature is to improve deliveries and enhance the connectivity and sheetflow in the Model Lands and Southern Glades areas, reduce wet season flows in C-111, and decrease potential flood risk in the lower south Miami-Dade County area.

9.1.9 Southwest Florida Region

9.1.9.1 Southern Golden Gate Estates Restoration (OPE)

This feature includes a combination of spreader channels, canal plugs, road removal and pump stations in the Western Basin and Big Cypress, Collier County, south of I-75 and north of U.S. 41 between the Belle Meade Area and the Fakahatchee Strand State Preserve.

The purpose of this feature is to restore and enhance the wetlands in Golden Gate Estates and in adjacent public lands by reducing over-drainage. Implementation of the restoration plan would also improve the water quality of coastal estuaries by moderating the large salinity fluctuations caused by freshwater point discharge of the Fahka Union Canal. The plan would also aid in protecting the City of Naples' eastern Golden Gate wellfield by improving groundwater recharge.

9.1.9.2 Southern Corkscrew Regional Ecosystem Watershed Project Addition (OPE)

This feature includes the acquisition and restoration of 4,670 acres of land, replacement of the Imperial Bonita Estates bridge on the Imperial River, and replacement of the Kehl Canal Weir in southern Lee County, adjacent to Corkscrew Sanctuary.

The purpose of this feature is to: (1) re-establish historic flow patterns and hydroperiods on the project lands, as well as Corkscrew Regional Ecosystem Watershed and Corkscrew Sanctuary wetlands to the east; (2) restore historical storage potential of the Southern Corkscrew Regional Ecosystem Watershed lands; (3) reduce excessive freshwater discharges to Estero Bay during the rainy season; (4) decrease saltwater intrusion during the dry season; (5) reduce loading of nutrients and other pollutants to the Imperial River and Estero Bay; (6) increase aquifer recharge and water supply for an area frequently facing water restrictions during dry years; and (7) reduce flooding of homes and private lands west of the project area.

Hydrologic restoration of this land will include the following modifications: removal of existing road beds, removal of single family homes, removal of junk debris, filling of ditches, and removal of agricultural canals and berms. Other components within the plan include: replacement of the Kehl Canal weir, clearing and snagging on Imperial River, Estero River and Halfway Creek, reconnection of Spring Creek and Halfway Creek under U.S. Interstate 75, and replacement of the Imperial Bonita Estates bridge.

9.1.9.3 Lake Trafford Restoration (OPE)

This feature includes a lake-wide organic sediment removal to Lake Trafford near Ft. Myers, Florida. Lake Trafford has poor water quality, extensive muck accumulations, loss of native submergent plant communities, periodic aquatic weed infestations, and numerous moderate fish kills. Poor water quality is attributed to internal nutrient cycling from extensive organic much deposits throughout the Lake's basin.

The purpose of this feature is to preserve the headwaters of the Corkscrew Swamp and Camp Keais Strand. The water quality of the Lake affects these wetland resources that have been targeted for protection. These wetlands drain into important estuarine systems such as Estero Bay and Cape Ramono. Lake Trafford is an integral contributor to the sheet flow that traverses such areas as the Corkscrew Regional Ecosystem Watershed and the Southern Golden Gates Estates area. The quality of the Lake and the associated watershed affects important wildlife species and offers a sanctuary for migrating birds. As the only major lake in southwest Florida, Lake Trafford provides a sanctuary during the dry season.

9.1.9.4 Henderson Creek/Belle Meade Restoration (OPE)

This feature combines multiple individual elements to complement each other to form a larger-scale combined effect. This feature includes a 10-acre stormwater lake/marsh filtering system; four culverts under State Road 951; hydrologic restoration around Manatee Basin including culverts, ditching, removal of some roadbed; invasive, exotic plant removal; a public access point and interpretive boardwalk; construction of a swale and spreader system; and removal of the Road-to-Nowhere. This southwest Florida feature is located in Collier County. The area known locally as Belle Meade is the primary drainage basin for the Henderson Creek Estuary, which drains into Rookery Bay.

The purpose of this feature is to restore historic sheetflow to the estuary, treatment of stormwater, improvement of water quality and increase in habitat value and wetland functions.

9.1.9.5 Lakes Park Restoration (OPE)

This feature includes the construction of a 40-acre marsh/flowway in an abandoned rock mine, removal of exotic vegetation, and planting native vegetation on 11 acres of uplands and 9 acres of littoral zone. This feature is located in the Lee County Lakes Regional Park, upstream of Estero Bay.

The purpose of this feature is to enhance surface water runoff quality by creating a meandering flowway with shallow littoral zones to enhance pollution removal and oxygen content, removing aquatic and upland exotic infestation while allowing public access into upland areas of improved native habitat. The restoration will provide immediate habitat and water quality benefits at Lakes Park and improve downstream conditions in Hendry County and the Estero Bay Aquatic Preserve.

9.1.10 Florida Bay and Keys

9.1.10.1 Florida Keys Tidal Restoration (OPE)

This feature includes the use of bridges or culverts to restore the tidal connection between Florida Bay and the Atlantic Ocean in Monroe County. The four locations are as follows: (1) Tarpon Creek, just south of Mile Marker 54 on Fat Deer Key (width 150 feet); (2) unnamed creek between Fat Deer Key and Long Point Key, south of Mile Marker 56 (width 450 feet); (3) tidal connection adjacent to Little Crawl Key (width 300 feet); and (4) tidal connection between Florida Bay and Atlantic Ocean at Mile Marker 57 (width 2,400 feet).

The purpose of this feature is to restore the tidal connection that was eliminated in the early 1900's during the construction of Flagler's railroad. Restoring the circulation to areas of surface water that have been impeded and stagnant for decades will significantly improve water quality, benthic floral and faunal communities, larval distribution of both recreational and commercial species (i.e. spiney lobster), and the overall hydrology of Florida Bay.

9.1.11 System-wide

9.1.11.1 Melaleuca Eradication Project and other Exotic Plants (OPE)

This feature includes: 1) upgrading and retrofitting the current quarantine facility in Gainesville, and 2) large-scale rearing of approved biological control organisms for release at multiple sites within the south Florida ecosystem.

The purpose of this feature is to increase the effectiveness of biological control technologies to manage Melaleuca and other invasive exotic species.

9.2 OPERATIONAL FEATURES

A number of operational components have been identified in the recommended Comprehensive Plan. These components have been evaluated on a regional scale using the South Florida Water Management Model, which as noted earlier is an effective tool for analyzing regional hydrologic effects. These operational components have been evaluated along with the construction components previously described. More detailed planning and analyses will be necessary to develop the optimum operational modifications that will be implemented for the Central and Southern Florida Project.

The costs to implement these operational features are not explicitly presented in this report. Most of the operational features will be implemented in association with related construction features described previously and, as such the costs are included in those features. However, in the case of Coastal Wellfield Operations (***Section 9.2.5.1***) the magnitude and uncertainties of implementing the feature have necessitated that no cost estimates be developed. Additionally, it is assumed that the costs will be borne by the appropriate affected utilities.

9.2.1 Lake Okeechobee Region

9.2.1.1 Lake Okeechobee Regulation Schedule (F)

The Lake Okeechobee Regulation Schedule will be modified in order to take advantage of the additional storage facilities identified in the construction features. Two additional zones will be added to the schedule. The first zone will trigger discharges to the north of Lake Okeechobee reservoir and the Everglades Agricultural Area reservoir. The second higher zone will trigger the Lake Okeechobee aquifer storage and recovery facilities to begin injecting water from the Lake. Climate based forecasting will be used to guide management decisions regarding releases to the storage facilities.

It is anticipated that all flood control releases through the C-43 and C-44 Canals will be eliminated with the exception of emergency zone A. Zone A levels are expected to be similar to the levels that occur in the current regulation schedule Run 25, however, the number of times that the Lake is above zone A is expected to be dramatically reduced.

9.2.2 Caloosahatchee Region

9.2.2.1 Environmental Water Supply Deliveries to the Caloosahatchee Estuary (E)

Freshwater deliveries to the Caloosahatchee Estuary will be provided to protect and restore more natural estuarine conditions. Minimum and maximum flows were identified which would cause poor water quality conditions for the estuary. This feature includes the development of a series of operational rules for storage features in the C-43 Basin along with modifications to Lake Okeechobee operations in order to maintain the salinity conditions in the estuary to support a range of aquatic vegetation, seagrass, invertebrates, and fish communities.

9.2.3 Upper East Coast Region

9.2.3.1 Environmental Water Supply Deliveries to St. Lucie Estuary (C)

Freshwater deliveries to the St. Lucie Estuary will be provided to protect and restore more natural estuarine conditions. Minimum and maximum flows were identified which would cause poor water quality conditions for the estuary. This feature includes the development of a series of operational rules for storage features in the C-23, C-24, C-25, C-44, Northfork and Southfork Basins along with modifications to Lake Okeechobee operations in order to maintain the salinity conditions in the estuary to support a range of aquatic vegetation, seagrass, invertebrates, and fish communities.

9.2.4 Water Conservation Areas and Everglades Regions

9.2.4.1 Everglades Rain-Driven Operations (H)

Modifications to the regulation schedules for Water Conservation Areas 2A, 2B, 3A, 3B and the current Rainfall Delivery Formula for Everglades National Park will be made to implement rain-driven operations for all of these areas. These new operational rules are intended to improve timing and location of water depths in the Water Conservation Areas and Everglades National Park and to restore more natural hydropatterns.

The rain-driven operational concept is a basic shift from the current operational practice, which uses calendar-based regulation schedules for the Water Conservation Areas. Regulation schedules, also referred to as flood-control schedules, typically specify the release rules for a Water Conservation Area based on the water level at one or more key gages. Regulation schedules do not typically contain rules for importing water from an upstream source. The schedules also repeat every year and make no allowance for inter-annual variability. The rain-driven operational concept includes rules for importing and exporting water from the Water Conservation Areas in order to mimic a desired target stage hydrograph at key locations within the Everglades system. The target stage hydrographs mimic an estimate of the more natural (pre-drainage Everglades) water level response to rainfall.

9.2.4.2 Modified Holey Land Wildlife Management Area Operation Plan (DD)

Modification to the current operating plan for Holey Land Wildlife Management Area will be made to implement rain-driven operations for this area. Water deliveries are made to Holey Land from the Rotenberger Wildlife Management Area or from Stormwater Treatment Area 3 & 4 if Rotenberger flows are insufficient. The deliveries are assumed to be of acceptable water quality. These new operational rules are intended to improve the timing and location of water depths within the Holey Land Wildlife Management Area.

9.2.4.3 Modified Rotenberger Wildlife Management Area Operation Plan (EE)

Modification to the current operating plan for Rotenberger Wildlife Management Area will be made to implement rain-driven operations for this area. Water deliveries are made to Rotenberger from Stormwater Treatment Area 5. Discharges from Rotenberger are made to the Holey Land Wildlife Management Area. The deliveries are assumed to be of acceptable water quality. These new operational rules are intended to improve the timing and location of water depths within the Rotenberger Wildlife Management Area.

9.2.5 Lower East Coast Region

9.2.5.1 Change Coastal Wellfield Operations (L)

For coastal public water supply utilities in the Lower East Coast Service Area, which are expected to experience an increased threat of saltwater intrusion, demands will be shifted from eastern facilities to western facilities away from the saltwater interface. The following utilities have a portion of their demands shifted inland: Riviera Beach, Lake Worth, Lantana, Manapalan, Boca Raton, and Florida City. The volume shifted is dependent upon the degree of saltwater intrusion, but is generally proportional to the increase in demands between the 1995 existing conditions and the 2050 future without plan conditions. Eastern wellfields at Miramar, Hollywood, Broward County 3A, 3B and 3C, Dania and Hallandale are assumed to be on standby with the entire demand met from western facilities.

9.2.5.2 Lower East Coast Utility Water Conservation (AAA)

This feature reduces the Lower East Coast public water supply demands through the full implementation of the South Florida Water Management District's current mandatory water conservation program. Full implementation of the conservation program over the next 50 years is projected to decrease public water supply demand by approximately 6 percent more than conservation incorporated in the future without project public water supply demands.

The regional effect from the implementation of this additional conservation would be more efficient utilization of water resources by the public and a reduction of the volume of water delivered from Lake Okeechobee, the Water Conservation Areas, and other regional storage facilities to recharge coastal canals and wellfields.

9.2.5.3 Operational Modification to Southern Portion of L-31N and C-111 (OO)

Modifications to the operations of the C-111 Project, currently under construction, will be made to the southern portion of L-31N Borrow Canal and C-111. These operational modifications will be made to improve deliveries to Everglades National Park and decrease flood risk of adjacent agricultural areas in the Lower East Coast Service Area.

9.3 PILOT PROJECTS

In addition to the construction and operational features previously discussed, a series of pilot projects have been recommended. These pilot projects are needed to address uncertainties associated with some of the physical facilities that are proposed in the recommended plan. The pilot projects will be designed to determine the feasibility, as well as optimum design, of a facility prior to embarking upon full scale implementation of a new facility.

9.3.1 Lake Okeechobee Aquifer Storage and Recovery – Pilot Project (GG)

This feature is multi-purpose and provides benefit to environmental, urban and agricultural users (see ***Section 9.1.2.1***). The pilot project is necessary to identify the most suitable sites for the aquifer storage and recovery wells in the vicinity of Lake Okeechobee and to identify the optimum configuration of those wells. Additionally, the pilot project will determine the specific water quality characteristics of waters to be injected, the specific water quality characteristics and amount of water recovered from the aquifer, and the water quality characteristics of the receiving aquifer. Further information from the pilot project will provide the hydrogeological and geotechnical characteristics of the upper Floridan Aquifer System within the region, and the ability of the upper Floridan Aquifer System to maintain injected water for future recovery.

9.3.2 Caloosahatchee River (C-43) Basin Aquifer Storage and Recovery – Pilot Project (D)

Aquifer Storage and Recovery wells are proposed in order to maximize the benefits associated with the Caloosahatchee River Storage Reservoir (see ***Section 9.1.3.1***). A pilot project for these wells is necessary to identify the most suitable sites for the aquifer storage and recovery wells in the vicinity of the reservoir and to determine the optimum configuration of those wells. The pilot project will provide information regarding the characteristics of the aquifer system within the Caloosahatchee River Basin as well as determine the hydrogeological and geotechnical characteristics of the upper Floridan Aquifer. The pilot project will also determine the specific water quality characteristics of waters to be injected, the specific water quality characteristics and the amount of water recovered from the aquifer, and the water quality characteristics of water within the receiving aquifer.

9.3.3 Site 1 Impoundment and Aquifer Storage and Recovery – Pilot Project (M)

The Site 1 above-ground impoundment is proposed to be operated in conjunction with multiple aquifer storage and recovery wells in order to maximize the benefits of the reservoir. A pilot project for these wells is necessary to determine the most suitable sites for the aquifer storage and recovery wells in the vicinity of the reservoir and to determine the optimum configuration of those wells. The identification of the hydrogeological and geotechnical characteristics of the soils and aquifer will also be determined. The pilot project will also determine the specific water quality characteristics of water within the aquifer as well as the quality of water proposed for injection and the water quality characteristics of water recovered from the aquifer.

9.3.4 In-Ground Reservoir Technology – Pilot Project

Several features recommend the use of areas where lime rock mining will have occurred (see ***Sections 9.1.8.2, 9.1.8.15 and 9.1.8.17***). The initial design of these reservoirs includes subterranean seepage barriers around their perimeter in order to enable drawdown during dry periods, prevent seepage losses, and prevent water quality impacts due to transmissivity of the aquifer in these areas.

The pilot project is required to determine construction technologies, storage efficiencies, impacts on local hydrology, and water quality effects. Water quality assessments will include a determination as to whether the in-ground reservoirs and seepage barriers will allow for storage of untreated waters without concerns of groundwater contamination.

9.3.5 L-31N Seepage Management – Pilot Project (V)

The purpose of this feature is to reduce levee seepage flow across L-31N adjacent to Everglades National Park via a levee cutoff wall (see ***Section 9.1.8.21***). Additionally, the feature was designed to reduce groundwater flows during the wet season by capturing groundwater flows with a series of groundwater wells adjacent to L-31N, then backpumping those flows to Everglades National Park. The pilot project is necessary to determine the appropriate technology to control seepage from Everglades National Park. The pilot project will also provide necessary information to determine the appropriate amount of wet season groundwater flow to return that will minimize potential impacts to Miami-Dade County's West Wellfield and freshwater flows to Biscayne Bay.

9.3.6 Wastewater Reuse Technology – Pilot Project (HHH, BBB, and OPE)

Currently, two features involve the advanced treatment of wastewater (see ***Sections 9.1.8.22 and 9.1.8.24***). This pilot project will address water quality issues associated with discharging reclaimed water into natural areas such as the West Palm Beach Water Catchment Area, Biscayne National Park, and the Bird Drive Basin as well as determine the level of superior treatment and the appropriate methodologies for that treatment. A series of studies will be conducted to help determine the level of treatment needed.

Pilot facilities will be constructed to determine the ecological effects of using superior, advanced treated reuse water to replace and augment freshwater flows to Biscayne Bay and to determine the level of superior, advanced treatment required to prevent degradation of freshwater and estuarine wetlands and Biscayne Bay. The constituents of concern in wastewater will be identified and the ability of superior, advanced treatment to remove those constituents will be determined.

In addition, a pilot facility will be constructed to treat wastewater from the East Central Regional Wastewater Treatment Facility using advanced and superior wastewater treatment processes to remove nitrogen and phosphorus. After treatment, the wastewater will be used to restore 1500 acres of wetlands and to recharge wetlands surrounding the City of West Palm Beach's wellfield. A portion of the treated wastewater will be used to recharge a residential lake system surrounding the City's wellfield and a Palm Beach County wellfield.

Besides serving as a pilot project for wetlands based water reclamation this feature will reduce a portion of the City's dependence on surface water from Lake Okeechobee during dry or drought events. In addition, approximately 2,000 acres of wetlands would be created or restored. Other benefits include aquifer recharge and replenishment, reduction of water disposed in deep injection wells and a reduction of stormwater discharge to tide.

9.4 REAL ESTATE

The real estate requirements for the recommended Comprehensive Plan are discussed in ***Appendix F***. The land requirements are based on an analysis of the land that would be needed for the construction features described in ***Section 9.1***. Based on this analysis, an estimated cost for land acquisition was developed. More detailed planning and analyses will be necessary to develop the optimum real estate requirements in the recommended Comprehensive Plan.

9.4.1 Land Acquisition

For the construction features identified in ***Section 9.1***, the total estimated land requirement is approximately 220,000 acres as displayed in ***Table 9-1***. These lands were estimated based on the engineering assumptions made during the formulation of alternative plans. For example, in the case of a storage reservoir north of Lake Okeechobee, the Restudy Team used a conceptual reservoir and treatment area design that encompassed approximately 20,000 acres located somewhere north of Lake Okeechobee. As discussed in ***Section 9.1***, the specific areal extent and location of this feature was not critical to analyzing the regional water resources effects of the Comprehensive Plan and that specific design criteria for the features will be addressed in subsequent planning phases of this project. Consequently, the estimated land requirements will likely change as the result of more detailed analysis. However, these assumptions were used for the purpose of estimating the total real estate requirements for the Comprehensive Plan. Further, contingency costs were escalated above normal levels to address this uncertainty.

A cooperative effort, with landowners in the areas where construction features are proposed, should be used to identify suitable sites in subsequent planning phases of this project.

9.4.2 Relocation Assistance (Public Law 91-646)

In accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended (Public Law 91-646), relocation assistance will be provided to affected residents and businesses. However, due to the magnitude of the study area and the uncertainty in the location of many of the construction features, the number of residences, farms, and businesses were not estimated. These will be determined during more detailed planning and design of the construction features. For this level of planning, the unknown relocation assistance cost estimate is covered in a higher than usual contingency cost added to each construction feature.

TABLE 9-1
ESTIMATED REAL ESTATE LAND REQUIREMENTS

Report Section	Real Estate Land Requirement	Estimated Acreage	Counties
9.1.1	**Kissimmee River Region**		
9.1.1.1	North of Lake Okeechobee Storage Reservoir	20,000	Glades, Highlands, and Okeechobee,
9.1.1.2	Taylor Creek/Nubbin Slough Storage and Treatment Area	10,000	Okeechobee and St Lucie
9.1.1.3	Lake Okeechobee Watershed Water Quality Treatment Facilities	4,515	Glades, Highlands and Okeechobee
9.1.1.4	Lake Okeechobee Tributary Sediment Dredging	320	Hendry, Glades and Lee
9.1.1.5	Lake Istokpoga Regulation Schedule	0	Highlands
9.1.2.1	Lake Okeechobee Aquifer Storage and Recovery	300	Glades and Okeechobee
9.1.3	**Caloosahatchee River Region**		
9.1.3.1	C-43 Basin Storage Reservoir and Aquifer Storage and Recovery	20,000	Hendry, Glades and Lee
9.1.3.2	Caloosahatchee Backpumping with Stormwater Treatment	5,000	Glades
9.1.4	**Upper East Coast**		
9.1.4.1	C-44 Basin Storage Reservoir	10,000	Martin
9.1.4.2	C-23/C-24/C-25/Northfork and Southfork Storage Reservoirs	48,350	Martin and St Lucie
9.1.5	**Everglades Agricultural Area**		
9.1.5.1	Everglades Agricultural Storage Reservoirs	17,500	Palm Beach
9.1.6	**Big Cypress Region**		
9.1.6.1	Big Cypress/L-28 Interceptor Modifications	1,900	Hendry and Broward
9.1.6.2	Seminole Tribe Big Cypress Water Conservation Plan - East & West	3,800	Hendry and Collier
9.1.7	**Water Conservation Areas Region**		
9.1.7.1	Flow to Northwest and Central Water Conservation Area 3A	0	Broward and Miami-Dade
9.1.7.2	Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement	255	Palm Beach, Broward and Miami-Dade
9.1.7.3	Loxahatchee National Wildlife Refugee Internal Canal Structures	5	Palm Beach
9.1.7.4	Miccosukee Water Management Plan	900	Broward
9.1.8	**Lower East Coast Region**		
9.1.8.1	Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration	3,000	Palm Beach and Martin
9.1.8.2	Water Preserve Areas / L-8 Basin	2,180	Palm Beach
9.1.8.3	Acme Basin B Discharge	930	Palm Beach
9.1.8.4	Lake Worth Lagoon Restoration	0	Palm Beach
9.1.8.5	Winsburg Farms Wetland Restoration	175	Palm Beach
9.3.6	Palm Beach County Wetlands Based Water Reclamation	2,000	Palm Beach
9.1.8.6	C-17 Backpumping and Treatment	550	Palm Beach

Report Section	Real Estate Land Requirement	Estimated Acreage	Counties
9.1.8.7	C-51 Backpumping and Treatment	710	Palm Beach
9.1.8.8	C-51 Regional Groundwater Aquifer Storage and Recovery	34	Palm Beach and Broward
9.1.8.9	Palm Beach County Agricultural Reserve Reservoir and Aquifer Storage and Recovery	1,660	Palm Beach
9.1.8.10	Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including the Strazzulla Tract	3,335	Palm Beach
9.1.8.11	Site 1 Impoundment and Aquifer Storage and Recovery	2,458	Palm Beach
9.1.8.12	Broward County Secondary Canal System	245	Broward
9.1.8.13	Western C-11 Diversion Impoundment and Canal and Water Conservation Areas 3A and 3B Levee Seepage Management	5,887	Broward and Miami-Dade
9.1.8.14	C-9 Stormwater Treatment Area/Impoundment	2,500	Broward
9.1.8.15	North Lake Belt Storage Area	5,861	Miami-Dade
9.1.8.16	Diverting Water Conservation Area 2 and 3 flows to Central Lake Belt Storage	837	Broward and Miami-Dade
9.1.8.17	Central Lake Belt Storage Area	5,770	Miami-Dade
9.1.8.18	Dade-Broward Levee/Pennsuco Wetlands	384	Miami-Dade
9.1.8.19	C-4 Control Structures	2	Miami-Dade
9.1.8.20	Bird Drive Recharge Area	2,877	Miami-Dade
9.1.8.21	L-31N Levee Improvements for Seepage Management and S-356 Structures	3,947	Miami-Dade
9.1.8.22	West Miami-Dade County Reuse	100	Miami-Dade
9.1.8.23	Biscayne Bay Coastal Wetlands	13,950	Miami-Dade
9.1.8.24	South Miami-Dade County Reuse	200	Miami Dade
9.1.8.25	Restoration of Pineland & Hardwood Hammocks in C-111 Basin	0	Miami-Dade
9.1.8.26	C-111N Spreader Canal	12,415	Miami-Dade
9.1.9	**Southwest Florida Region**		
9.1.9.1	Southern Golden Gates Hydrologic Restoration	0	Collier
9.1.9.2	Southern CREW Project Addition	4,670	Lee
9.1.9.3	Lake Trafford Restoration	449	Collier
9.1.9.4	Henderson Creek/Belle Meade Restoration	125	Collier
9.1.9.5	Lake Park Restoration	40	Lee
9.1.10	**Florida Bay and Keys**		
9.1.10.1	Florida Keys Tidal Restoration	5	Monroe
9.1.11	**System-wide**		
9.1.11.1	Melaleuca Eradication Project and other Exotic Plants	0	
	TOTAL	**220,141**	

9.5 ADAPTIVE ASSESSMENT AND MONITORING PROGRAM

An extensive Adaptive Assessment Program which includes a system-wide monitoring program will be conducted to support the goals and objectives of the Comprehensive Plan. This program will provide an opportunity to continue investigating concepts and issues relative to the overall Comprehensive Plan while implementation of the initial project features are underway. The Adaptive Assessment Program will include continued system-wide evaluation and analysis among other planning activities. The monitoring program will have a dual focus on the biological (including water quality) and hydrological restoration objectives in the natural systems, and the water supply and flood protection objectives in the urban and agricultural regions.

9.5.1 Adaptive Assessment Program

Adaptive assessment is a process for evaluating how well the phases of the Comprehensive Plan achieve their expected objectives, and for using these evaluations as a basis for refining future phases of the program. To be successful, an adaptive assessment process requires that the Comprehensive Plan be implemented iteratively, that a pre-determined set of targets be appropriately monitored, that it be possible to make changes in the design and sequencing of the plan in response to information learned from the monitoring program and from new research and modeling, and that a specific protocol for conducting the adaptive assessment process be in place throughout the life of the program.

Adaptive assessment provides an organized process for confronting and reducing the levels of uncertainty caused when there is insufficient information for knowing how the natural and human systems in south Florida will respond to the long-term implementation of the Comprehensive Plan. These uncertainties are inevitable, in that we are dealing with systems that are tremendously complex, not thoroughly understood, and difficult to predict. The systems are complex in their detail (i.e., in the number of different variables to consider), and in their dynamics (i.e., the number and scales of relationships that drive responses).

In addition to the inevitable uncertainties, natural and human systems will at times respond in totally unexpected ways (i.e., in ways that are not anticipated or predicted by any existing hypotheses). It is these unexpected responses, when they result in negative changes, which often are the stimuli for “crises” at political and management levels. Adaptive assessment should moderate these crisis responses, by providing an in-place process for early detection and interpretation of the unexpected, and for maximizing the learning opportunities associated with these events.

Adaptive assessment is a process for learning, and for incorporating new information into the planning and evaluation phases of the restoration program.

Adaptive assessment is valuable in that it treats all responses, expected or not, as major learning opportunities. An unexpected response does not represent a failure for the program if it can be used to substantially improve our understanding of a complex system. Much of the design of the Comprehensive Plan, including the selection of performance measures and targets, is based on a set of causal hypotheses derived from a set of conceptual ecological models for the major landscapes of south Florida. Implementation of the Comprehensive Plan provides opportunities for loosely "testing" these hypotheses (without replications), by comparing actual system responses to those predicted by the hypotheses. Actual responses, in combination with information obtained from ongoing research and modeling, can lead to refinements in the conceptual models and hypotheses, and to reduced levels of uncertainty regarding future iterations of the Comprehensive Plan.

Adaptive assessment provides a stimulus for the development and long-term operation of a regionally comprehensive monitoring program. The application of an adaptive process requires that a monitoring program be in place that provides measures of a spatially, temporally and hierarchially appropriate set of pre-determined performance targets (indicators, endpoints). The design of such a monitoring program provides a valuable opportunity for a healthy review of existing monitoring programs for their coverages, protocols, and data management adequacies, relative to the needs of adaptive assessment.

Overall, adaptive assessment provides a much needed framework for: (1) strengthening coordination across agency and disciplinary lines by establishing a commonly accepted evaluation process and set of performance targets, (2) validating the performance of each iteration in a long-term restoration program, and (3) encouraging agencies to be flexible about the design and implementation of the Comprehensive Plan. The bottom line is that adaptive assessment substantially improves the probability that a complex, regional Comprehensive Plan will be successful, by providing a structured, well-focused process for evaluating and refining the design and performance of that program on a continuing basis throughout its implementation.

9.5.2 Monitoring Program

A fundamental component of adaptive assessment is a monitoring program that is based on the goals and objectives of the project. There must be agreement on performance targets, and on the ecological changes that constitute improvements, as a prerequisite for determining which parameters in the system must be monitored. Because of the uncertainties inherent in any effort to restore such a complex and altered ecosystem, the performance targets and the interim measures of success can only be broadly stated. Nevertheless, these targets and measures need definition to design a monitoring program that is well focused and efficient; thus, to assure that it provides the kind of information required for the implementation of an adaptive management strategy. In the following two sections, the objectives and components that should be considered for a regional monitoring program are reviewed.

A regional monitoring program should provide data for meeting several, essential objectives of the Comprehensive Plan. Although these objectives may be overlapping, each makes a discrete contribution toward the realization of the goals of the Comprehensive Plan. Monitoring will:

1. Determine problem areas as a basis for designing and setting priorities for components of the Comprehensive Plan. Knowledge of water quality, water supply and flood protection issues, which species and ecologic communities are having problems, and when and where in the system these problems are occurring, is essential information for designing a Comprehensive Plan that is well focused for correcting those problems.

2. Determine the hydrological, physical, water quality and ecological responses to each incremental step in the Comprehensive Plan, as a basis for designing and/or fine tuning subsequent steps. If each incremental step in the plan is viewed as an experiment, accompanied by one or more hypotheses that predict how that step will improve the system, monitoring will provide the measure of how well the hypotheses and the experiment achieve the expected results. This information, in turn, becomes the basis for improving the design of the experiment and the hypotheses for the next step in the program.

3. Determine the responses to each incremental step, as a means for continuing the all important process of enhancing existing knowledge of the functions and relationships in the south Florida ecosystem, and how these processes respond to alterations in the spatial temporal and hydrologic patterns in the system. Much of the uncertainty about how the overall system will respond during implementation of the Comprehensive Plan is caused by the current, incomplete knowledge of ecological and hydrological processes in the south Florida ecosystem. This is compounded by the fact that these processes have changed in ways that are not fully predictable.

4. Measure the status and trends of a wide range of hydrological, ecological, water quality and physical components of the south Florida ecosystem. A strong, ongoing monitoring program will provide a regional overview of how well the ecosystem and water management systems are functioning. This includes the status of endangered and indicator species; the range and frequencies of interannual response patterns; the effectiveness of implemented components in achieving anticipated performance; long-term effects of modified hydrological conditions on estuarine salinity gradients, saltwater intrusion protection, and on regional plant communities; and other parameters that enhance current understanding of broad trends across the ecosystem. It will determine responses

and trends at appropriate spatial and temporal scales, and from among a taxonomically representative array of components of the natural systems.

5. Contribute to an improved focus, and consensus, regarding the water quality, physical and biological elements which, collectively, will constitute a “restored” natural system, and determine when the Comprehensive Plan goals have been reached. A large number of performance targets including “ecological endpoints” for restoration have been used in the evaluation of the alternative plans and subsequent selection of the recommended plan. A regional monitoring program will reveal when and under what conditions these performance targets and endpoints have been reached and are sustainable.

9.5.3 Monitoring Program Planning Guidelines

Comprehensive, integrated ecological and water resource monitoring to measure the effects of the Comprehensive Plan components and the success of the overall Comprehensive Plan will involve coordination with the South Florida Ecosystem Restoration Working Group including it’s Science Coordination Team. The general guidelines for the monitoring program include the following:

1. A single, regionally comprehensive, and integrated multi-agency monitoring program, which will operate over the entire south Florida ecosystem, with clear assignment of lead and cooperating agency responsibilities. The program will be managed by a standing, interagency coordinating team. The geographic boundaries of the monitoring program will be consistent with the outer limits of the region that is predicted to be influenced by the Comprehensive Plan.

2. Contain adequate coverage at all trophic levels, spatial and temporal scales, among hydrological, ecological, water quality and physical components, to measure both regional and local responses to the Comprehensive Plan and the overall south Florida ecosystem restoration effort. An independent peer-review process will provide recommendations on the design and coverage of the monitoring program.

3. Be designed at scales and with objectives that are proportional to the design of each sub-regional or local, component of the Comprehensive Plan. Additional, specific elements will be added to a regional monitoring program to measure more local responses to the incremental scale steps in the Comprehensive Plan.

4. Focus on those hydrological, ecological water quality, and physical parameters that can be readily and quantitatively measured, and which are understood well enough so that the monitoring data can be adequately interpreted.

5. Collection and analysis of monitoring data at temporal scales that are appropriate to the nature of the data and the design of each component of the

Comprehensive Plan. Depending upon what is being monitored, these time scales may range from hourly for hydrological parameters (such as water stage or discharge), to daily for physical parameters (such as urban flood protection levels or saltwater intrusion), to once every several years (such as for soil thickness).

6. A formally established program for sharing and managing monitoring data and reports, among the agencies, other participants and interested parties.

7. Be in place sufficiently prior to the implementation of features of the Comprehensive Plan, so that baseline information on pre-project conditions and patterns can be established, before changes occur as a result of the projects. For elements of the natural system which typically operate on multi-year cycles, or which have relatively slow response times, monitoring to establish base-line conditions must begin years prior to the implementation of Comprehensive Plan features.

8. Develop standardized monitoring protocols at the initiation of the monitoring program. The program includes resources to maintain these monitoring protocols for the life of the program and avoid problems of data interpretation, which occur when the quality and quantity of these data vary over time and space.

9. Build on existing monitoring programs by the participating agencies, including reassessing monitoring priorities and protocols by each agency, within the context of a single, integrated regional program.

10. Finally, and most importantly, the program will measure the water quality, hydrological, physical and ecological parameters that are appropriate to the ecological restoration goals and measures of success that have been set for the program.

An essential component of this regional monitoring program is the creation of a single, integrated data management system (items 6 and 8 above). The South Florida Water Management District's Kissimmee River Restoration Evaluation Program, the U. S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP), and the National Oceanic and Atmospheric Administration and Florida Department of Environmental Protection's Integrated Marine Monitoring Program are examples of the organization and implementation of such a program.

The Kissimmee program is both multi-agency and multi-disciplinary. Its overall purposes are to organize all monitoring data as a basis for quantifying and qualifying ecosystem responses to the restoration projects, and for evaluating the success of the restoration effort. To meet these purposes, the Kissimmee program provides a holistic and integrated picture of all monitoring data to ensure the proper definition of relationships among these data, and provides a database structure for efficiently storing and managing these data to ensure efficient and timely access to restoration monitoring data. The data management system has a central location, and a single, senior program manager responsible for overall quality of the system.

The Environmental Protection Agency's EMAP has been developed based on a stratified random sampling approach, which is essential for a meaningful interpretation of landscape-scale ecological monitoring. EMAP includes a statistical survey design, which allows for ecological analysis of the effects of the Comprehensive Plan components on restoration across the entire C & SF region, not just at or near specific sampling regions.

Beginning in 1995, scientists from Federal, state and local agencies have worked together to integrate the many environmental monitoring projects taking place in south Florida's marine and estuarine waters. Led by the National Oceanic and Atmospheric Administration and Florida Department of Environmental Protection, an inventory was conducted of planned, ongoing, and completed projects in coastal waters, and information on more than 200 projects was entered into a database. Many other agencies came together to review and prioritize the major issues affecting coastal areas, determine information needs, and develop a comprehensive monitoring plan. A geographic information system for sampling sites throughout the region is now being constructed, and gaps in data collection are being filled. This extensive multi-agency coordination will help to document change at the ecosystem level, measure the effectiveness of management actions, reduce monitoring gaps and overlaps, and improve existing monitoring capabilities.

9.5.3.1 Natural Systems Monitoring

There are several major reasons, with direct applications to the restoration effort, for conducting an extensive natural systems monitoring program: construction impact assessments, adaptive assessments, and for evaluating applications to other restoration efforts.

Construction impact assessments ensure that temporary or incidental environmental impacts are documented and minimized during construction. Because of the phased construction approach, this aspect of the monitoring program could prove to be particularly valuable in reducing effects of construction-related disturbance, including potential effects on endangered species and downstream effects that could affect subsequent restoration phases.

Ecological monitoring provides a basis for adaptive assessment measures that almost certainly will be needed to facilitate early recovery, as well as, subsequent persistence of the full complement of natural resource values. Although restoration of the study area's resources will occur primarily through natural processes, the restored system will have one significant management component - inflow regulation. Modeling studies have shown that the proposed restoration features will produce hydrologic and water quality characteristics that are within the required range of variability of the ecological restoration criteria. However, to achieve restoration and persistence of all biological components, some hydrologic characteristics, particularly discharge and flood inundation characteristics, must vary over the established historic range. Moreover, early recovery of some biological components could be slowed or inhibited if management of the regional hydrology produces hydrologic and water quality characteristics that are perhaps at one end of the spectrum of required variability. Comprehensive ecological monitoring will track restoration progress and provide the necessary data to effectively modify or adjust operation and management schemes to meet restoration objectives.

The potential that the restoration program planning and implementation principles and guidelines developed by the Restudy will be applicable to other regional restoration endeavors is another reason to conduct extensive ecological monitoring studies. One approach to evaluating the broader applicability of these principles and guidelines will be through measures of the effectiveness of the Restudy process, as demonstrated by system responses. Monitoring will provide a means for demonstrating the effectiveness of the regional planning and adaptive assessment protocols developed by the Restudy. The principles of ecosystem restoration that are being employed by the Restudy are pioneering at such vast temporal and spatial scales. The adaptive assessment strategy proposed in this process may be the most environmentally sound approach to restoration, and, over the long term, the most cost effective means of restoring the natural resource values of damaged ecosystems. It is important to demonstrate whether these planning principles and guidelines are applicable to other regions.

9.5.3.1.1 Natural System Elements to be Monitored

In order for the regional monitoring program to be both effective and efficient, substantial thought must be given to the choice of the components of the natural systems that should be monitored. Some guidelines for making these selections are presented in the Monitoring Planning Program Guidelines presented above. Additionally, it is highly important to select the most parsimonious set of components which will reveal the major (i.e., most significant) responses that are relevant to the issues being addressed by the restoration program. A major failing of many monitoring programs is that they attempt to monitor too large a number of system elements, more than are needed to evaluate how well a project meets its objectives, and more than can be adequately and consistently monitored over the time frames needed to evaluate these programs. Uncertainties in long-term funding and personnel which so commonly characterize large government programs require that excessive, and perhaps ecologically unnecessary, monitoring not be made a part of essential, long-term monitoring programs.

The Restudy is using a set of conceptual ecological models of the major physiographic and landscape features in south Florida (Ogden and Davis, in prep.) to identify a parsimonious set of natural system elements for inclusion in a regional monitoring program. The conceptual models show the major hydrological stressors in these systems, and how these stressors link, ecologically, with a set of attributes, which can be used to characterize the ecological health of these systems. The hydrological stressors identified by these models include both the water quantity and water quality impacts, which have been the major sources of ecological change in the natural systems. Because of the links (major ecological pathways) between the stressors and attributes, it is assumed that measures of change among the attributes will reflect the levels of success of the restoration projects at correcting the problems caused by the stressors. Teams of regional natural resource specialists selected the ecological attributes shown in each model. These attributes were selected because they directly reflect impacts from the major stressors, they are measurable and reasonably well understood, and they represent responses that are expected to occur over a range of spatial, temporal and hierarchical scales in the natural systems.

Because the restoration projects should cause changes (improvements) to both the stressors and the attributes in the models, both should be included in a monitoring program. An understanding of responses by both stressors and attributes not only is necessary to measure effects from the restoration projects, but also to evaluate ("test") the hypotheses which were used to create the models and to set priorities during restoration planning.

The hydrological stressors and attributes for the landscapes of the central and southern Everglades and Florida Bay were reported by Ogden et al. 1997. The four conceptual models contained in this report, for the central and southern Everglades sloughs, the southern Everglades marl prairies and rocky glades, the mainland mangrove estuaries downstream from the southern Everglades, and Florida Bay, serve to illustrate the stressors and attributes which should be monitored to determine restoration effects in these regions.

For the central and southern Everglades sloughs, the conceptual model shows the major hydrological stressors to be: annual and multi-year hydroperiods, wet season surface-water depths dry-season ground water depths, wet season regulatory releases, impoundments created by levees, and phosphorus and mercury loadings. The ecological attributes which reflect the effects from these stressors are: peat soil accretion rates; flood, fire and exotic plant conditions on tree islands; the distribution, composition and structure of marsh communities; species composition and production rates in periphyton communities; composition and size structure and abundance of marsh fishes and aquatic invertebrates; the abundance and density of alligator nests and active alligator ponds; and the size, timing and location of wading bird nesting colonies (including recovery of "super" colonies).

For southern Everglades marl prairies and rocky glades, the conceptual model suggests the stressors to be monitored should include duration of annual hydroperiods, dry-season minimum water levels, and dry-season recession patterns.

Monitored attributes are: marl accretion; vegetation community mosaics and composition; abundance and species composition of fishes, crayfish and the herpetofauna; abundance and density of alligator nests and active alligator ponds; Cape Sable seaside sparrow nesting distribution and abundance; seasonal abundance and distribution of foraging wading birds; and mercury and toxin loads in vertebrates.

For the southern mangrove estuaries, the stressors are the volume and duration of freshwater flows into the estuaries. The indicator attributes are: the species composition of submerged aquatic plants and the species and abundance of waterfowl in the coastal lakes: primary production and sediment accretion in the mangrove communities; the distribution and cover of vegetation communities; the production and survival of resident mangrove fishes; recruitment rates of juvenile sport fishes; growth and survival of juvenile crocodiles; and the patterns and success of wood stork and roseate spoonbill nesting colonies.

For Florida Bay, the hydrologically related stressors shown in the conceptual model are freshwater influences on salinity patterns, and nitrogen and phosphorus inputs. The indicator attributes for these stressors are: species composition; density and productivity in the seagrass communities; water chemistry and turbidity; species composition of mollusc communities; pink shrimp abundance; species composition of sport fishes; and the abundance and distribution of fish-eating birds (brown pelican, osprey, cormorant).

Stressors and attributes for Lake Okeechobee are shown in a conceptual model reported by K. Havens (Havens, 1998). For the Lake, the hydrologically related stressors are; elevated levels of contaminants, nutrients and sediments: prolonged extreme high water levels; and prolonged extreme low water levels. Attributes for the Lake are: the quality and quantity of urban and agriculture water supply; sport and commercial fisheries; spatial extent and composition of marsh communities; abundance and nesting success of snail kites; and the population size and nesting success of water birds.

Stressors and attributes for the Caloosahatchee and St. Lucie Estuaries have been shown in a conceptual model reported by S. Gray and D. Haunert (Gray and Haunert, 1998). The major hydrologically related stressors on these estuaries are, flood control releases from Lake Okeechobee, the seasonal timing and magnitude of freshwater flows, increased loads of nutrient and dissolved organics, and agricultural toxins. Attributes for these stressors are, benthic invertebrate community structure, submerged aquatic vegetation distribution and abundance, seagrass community structure, abundance and biomass of larval, juvenile fishes, fish catch rates, nesting success and abundance of fish-eating water birds, and abundance and recruitment of manatee.

Stressors and attributes for the Big Cypress Basin are shown in a conceptual model reported by M. Duever (Duever, 1998). Hydrologically related stressors are: the bioaccumulation of mercury and other toxins; inflows of drainage water with high nutrient and mineral content; and lowered water tables and shortened hydroperiods. Attributes of these stressors are: mercury and toxin body burdens in vertebrates; composition, structure and distribution of vegetation communities; abundance and distribution of fishes, crayfish and amphibians; size, distribution and success of wood stork nesting colonies; and population size, reproductive success and mercury body burdens for Florida panther.

A written performance measure is prepared for each stressor and attribute (indicator) to be monitored. The performance measure identifies the restoration target and the specific parameters to be measured, as a basis for determining how each stressor and attribute responds to the restoration projects. A set of hydrological performance measures which covers the major stressors from the conceptual models was prepared by the Restudy, Alternative Plan Evaluation Team, and is described in **Section 7** of this report. Performance measures for the attributes in the models still remain to be created.

9.5.3.2 Hydrologic Monitoring

The current hydrologic monitoring system was devised primarily to support the current operations of the Central and Southern Florida Project. The design and implementation of the Restudy components necessitates the need for modifications to the current monitoring system. The need comes from: (1) new data requirements for modeling in the detail design phase; (2) the development of new components that dramatically modify the existing hydrologic patterns and conditions; and (3) changes needed in traditional monitoring programs to correctly monitor new features such as sheetflow. Traditional data collection sites may not be consistent with areas being targeted for specific hydrologic changes. Furthermore, new “trigger” points for future operational purposes may also require new monitoring sites.

In addition to identifying several areas that will require special operations, new monitoring techniques, and new monitoring sites, the Restudy process also identified significant data gaps in some areas. For example, during the development of performance measures by the Alternative Evaluation Team, data necessary for evaluation were not available for a number of ecologically sensitive areas. Vast areas within the Big Cypress National Preserve were ungaged; thus conclusive ecological evaluations dependent upon hydropatterns were not possible.

Development of a new hydrologic monitoring program will require a multi-disciplinary team to ensure the hydrologic factors needed for ecological evaluations, as well as operational input needs, are developed. Monitoring for ecological assessments will be different from sampling for operational purposes. New monitoring programs for ecological assessments will be especially critical in areas undergoing extensive hydrologic modification. The monitoring program will be crucial to the success of adaptive management for the ecological restoration of the Everglades.

9.5.3.3 Water Quality Monitoring

Numerous water quality monitoring programs are currently being conducted by federal, state, tribal and local governments across south Florida. The location, sampling frequency and water parameters monitored associated with these existing water quality monitoring programs relate to existing regulatory, non-regulatory, and research programs. Development of an integrated, system-wide water quality monitoring program linked to hydrological and physical process monitoring programs will be a primary objective of the recommended feasibility study supporting the creation of a Comprehensive Integrated Water Quality Plan feasibility study (see ***Section 9.7.3***).

Design of a water quality monitoring program will be driven by the need to measure appropriate water quality parameters in watersheds that will be affected by the operation and construction of Comprehensive Recommended Plan components and Other Project Elements. The Restudy monitoring program should focus on developing sufficient baseline information to characterize watersheds in order to complete detailed planning and design work necessary to construct and operate recommended plan features to achieve pollutant load reduction targets. Nutrient (e.g., nitrates, phosphorus) concentrations and loads are of particular concern in south Florida water bodies. The majority of use-impaired water bodies are impaired due to elevated nutrient levels. Water quality monitoring will be also developed to obtain critical water quality information relating to ecological performance measures and ecological responses associated with the conceptual ecological models (see ***Section 9.5.3.1***) and supporting existing and future water quality models.

The Comprehensive Integrated Water Quality Plan will be crucial to the development of the Restudy water quality monitoring program since it will address issues of fragmented, uncoordinated water quality sampling, data quality, and climatological effects and trends. The Comprehensive Integrated Water Quality Plan will also include recommendations for oversight and support of improved water quality modeling efforts in south Florida, recommendations for development of additional water quality restoration targets and appropriate pollution load reduction targets, where needed, and recommendations for remediation programs to achieve water quality restoration targets. This additional information will support changes and improvements to the Restudy water quality monitoring program consistent with the adaptive assessment monitoring process described in ***Section 5***.

9.5.3.4 Physical Process Monitoring

Physical process monitoring will encompass a number of activities in the south Florida ecosystem. These activities include saltwater intrusion, flood level protection, urban and agricultural water use, sea level rise, soil subsidence/accretion, soil genesis due to restoration, and the ability of implemented components to achieve their anticipated performance. The majority of these activities are currently underway but will require a coordinated approach with long-term commitment if they are to be successful. Saltwater intrusion monitoring will allow the interagency monitoring coordination team the ability to evaluate the implementation of the recommended plan on urban areas, detect movement of the saltwater/ freshwater interface and make changes under the adaptive management strategy of the C&SF Comprehensive Review Study Implementation Plan, to counter unwanted movement. A successful monitoring program coupled with an adaptive management strategy will ensure the long-term health and integrity of the water supply wellfields of the region.

Flood level protection monitoring will ensure that the existing level of protection is not compromised as a result of implementation of the recommended plan. Coupled with an adaptive assessment strategy any unforeseen effects of the plan could be corrected.

Urban and agricultural water use monitoring will ensure that any significant deviation from forecasts of urban consumption and estimates of agricultural consumption that were included in the assumption base for this plan will be accounted for. Periodic comparisons (e.g., every three to five years) of actual consumption with that used in the Comprehensive Plan will allow for plan adjustments through time.

Sea level rise will need to be continuously monitored so that both saltwater intrusion protection and flood protection levels within the south Florida urban areas is not compromised as a result of this global process. Sea level rise will also affect the south Florida ecosystem in ways that are not fully anticipated or understood. Monitoring in the natural system will help resource managers understand how the ecosystem is evolving in response to the changing conditions and to better understand the relative contribution that sea level rise and changes in freshwater flow into the estuaries have on vegetation composition in the coastal zones.

Soil subsidence/ accretion and soil genesis monitoring will be used as another indicator metrics to determine if the recommended plan is moving the restoration process in the predicted direction of success. A major success measure for the slough system is the recovery of organic soils. Where portions of the slough systems currently are losing organic soils through increased fire frequencies and increased soil subsidence, restoration should result in soil accretion. Longer, more natural hydroperiods are expected to recover the processes that build organic soils. A long-term monitoring program will need to be institutionalized, to provide regional measures of rates of change in soil depths.

Post-construction monitoring of the recommended components, such as reservoirs and aquifer storage and recovery facilities, will be needed to determine whether their performance is achieving that anticipated in the planning process. This monitoring is necessary to evaluate the plan's overall effectiveness in providing the water needs of the south Florida ecosystem.

9.6 FISH AND WILDLIFE MITIGATION

During subsequent phases of this project, the construction features of the Comprehensive Plan will be designed to first avoid and then minimize unavoidable impacts to wetlands or other aquatic sites and natural upland habitats. Unavoidable impacts to these habitats are expected to be offset by the ecological improvement throughout the south Florida ecosystem that results from the overall restoration achieved by the Comprehensive Plan. Accordingly, separate compensatory mitigation features are not included in the recommended Comprehensive Plan for these impacts.

However, in certain wetland or upland areas, the construction and operation of Comprehensive Plan features may adversely affect unique or scarce habitats. In such cases, the project components will be sited and engineered to be environmentally compatible when possible. As site-specific details for the components are developed during the Project Implementation Report process, land suitability analyses will be utilized as part of the site selection process. Sites with extensive unique or scarce habitats will be avoided to the greatest extent practicable. For selected sites where impacts to these habitats are unavoidable, impacts will be minimized through project design. If impacts to unique or scarce habitats can not be avoided, a separable compensatory mitigation plan may be needed.

There also could be impacts to existing wetland compensatory mitigation sites that were established by authorized regulatory permits. These compensatory mitigation sites were established as permit requirements in order to offset the adverse environmental impacts of permitted development projects and the attendant reduction of the spatial extent of wetlands at the development sites. Subsequent elimination or reduction of these environmental benefits due to Restudy activities may require reevaluation of the mitigation analysis used in the original permit decision by the District Engineer.

Furthermore, one of the Restudy goals is to increase the spatial extent of wetlands within the study area. Adverse effects to regulatory-derived mitigation sites, which were intended to offset losses in the spatial extent wetlands, could result in the Restudy contributing to losses in spatial extent. Accordingly, adverse impacts to regulatory-derived compensatory mitigation sites attributable to construction of a Comprehensive Plan component or its operation will be offset as part of Restudy implementation. This compensatory mitigation requirement for the Restudy must be derived from sources other than the benefits claimed by the Comprehensive Plan itself. Therefore, a separable compensatory mitigation plan for these impacts may be needed. The type and extent of the mitigation requirement will be determined in subsequent phases of this project on a case by case basis.

9.7 NEW FEASIBILITY STUDIES

The time frame of this feasibility study did not permit a thorough investigation of all the regional water resource problems of south Florida. Therefore, subsequent to the completion of this feasibility study, a number of new feasibility studies are proposed. They include a Florida Bay and the Florida Keys Feasibility Study, a Southwest Florida Feasibility Study, and a Comprehensive Integrated Water Quality Plan. These studies will be conducted under the authority of the Water Resources Development Act of 1996 that allows for the continuation of studies and analyses that are necessary to further the Comprehensive Plan.

9.7.1 Florida Bay and the Florida Keys Feasibility Study

Construction of Flagler's railroad to Key West and subsequent conversion into U.S. Highway 1 (US-1) involved the placement of fill material in wetlands and open water for the numerous causeways between keys. These causeways altered tidal flows between Florida Bay and the Atlantic Ocean, resulting in adverse water quality and fish and wildlife habitat impacts. One of the House of Representatives Committee on Public Works and Transportation resolutions of September 24, 1992 requested that the Corps of Engineers conduct a study of Florida Bay, including a comprehensive, coordinated ecosystem study with hydrodynamic modeling of Florida Bay and its connections to the Everglades, the Gulf of Mexico, and the Florida Keys Coral Reef ecosystem. Hydrodynamic and water quality models currently under development for Florida Bay will provide the tools necessary for evaluation of the problem in a holistic manner. A feasibility study is recommended to comprehensively evaluate Florida Bay and to determine the types of modifications that are needed to successfully restore water quality and ecological conditions of the Bay.

9.7.2 Southwest Florida Feasibility Study

The Caloosahatchee River is the only portion of the C&SF Project that lies in southwest Florida. The river serves as an outlet from Lake Okeechobee to the Gulf of

Mexico and is the major source of surface water supply for the Lower West Coast region. It provides agricultural and lawn irrigation, public water supplies and is used to recharge shallow wellfields. The river also provides drainage for private drainage systems and local drainage districts.

The facilities included in the Comprehensive Plan for the Caloosahatchee River Basin will help meet the needs of the basin. However, there are additional water resources problems and opportunities in southwest Florida that require studies that are beyond the scope of the Comprehensive Plan. For example, primary water quality and hydrologic data do not exist for much of the region. This lack of information, assessments and monitoring data is a fundamental gap for this region of the state and greatly hinders its long-term water resources management opportunities.

The Southwest Florida Feasibility Study will include Collier, Lee, Charlotte, Glades, and Hendry Counties; and provide a framework to address the health of aquatic ecosystems; water flows; water quality (including appropriate pollution reduction targets), water supply; flood protection, wildlife, and biological diversity and natural habitat. The study will also investigate non-structural alternatives.

9.7.3 Comprehensive Integrated Water Quality Plan

The recommended Comprehensive Plan includes a number of construction features, such as stormwater treatment areas, specifically designed to improve water quality conditions for the purpose of south Florida ecosystem restoration. Further, the plan includes other construction features, such as water storage reservoirs that could be designed to maximize water quality benefits to downstream water bodies. Optimizing the design and operation of construction features of the recommended plan to achieve water quality restoration targets is essential for achieving overall ecosystem restoration goals for south Florida.

Degradation of water quality throughout the study area is extensive, particularly in agricultural and urban coastal areas. The Florida Department of Environmental Protection listed approximately 160 use-impaired water bodies in south Florida in its 1998 Section 303(d) list (see ***Section 5.3***). Although there are several ongoing water quality restoration programs in the study area (e.g. National Pollutant Discharge Elimination System (NPDES) point and non-point source regulatory programs, total maximum daily loads (TMDLs) development and remediation programs, Surface Water Improvement and Management planning efforts), there is no comprehensive plan for achieving water quality restoration in south Florida which links together water quality restoration programs in the context of comprehensive planning for ecosystem restoration. It is also recognized that achieving all of the water quality goals for ecosystem restoration in all use-impaired water bodies within the study area will depend on actions outside the scope of the Restudy. The South Florida Water Management District, Florida Department of Environmental Protection, U.S. Environmental Protection Agency and other agencies have developed or are developing water quality improvement programs for several of the impaired water bodies within the Restudy area. The most notable example is the Everglades Forever Act, which focuses on achieving adequate water quality in the Everglades. Other examples include the Surface Water Improvement and Management Act planning efforts for the Indian River Lagoon, Lake Okeechobee, and Biscayne Bay, and the Florida Keys National Marine Sanctuary Water Quality Protection Program. However, the degree to which some of the existing water quality improvement programs have been implemented has been limited. To ensure that south Florida ecosystem restoration objectives are achieved, a Comprehensive Integrated Water Quality Plan that links water quality restoration targets and remediation programs to the hydrologic restoration objectives of the recommended plan must be developed for the entire study area.

Development of a comprehensive integrated water quality plan for south Florida is consistent with recommendations of the South Florida Ecosystem Restoration Task Force and the Florida Governor's Commission for a Sustainable South Florida. In its July, 1998 Interim Report on the C&SF Project Restudy (GCSSF, 1998), the Governor's Commission recommended that a water quality implementation plan for the Restudy be developed with Florida Department of Environmental Protection as the lead agency, in cooperation with the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, South Florida Water Management District, the Seminole and Miccosukee Native American Tribes, and local governments. In order to resolve water quality problems on an ecosystem wide basis, the Governor's Commission recommended that a comprehensive water quality plan be initiated as a feature of the Restudy.

The Comprehensive Integrated Water Quality Plan for south Florida would involve identifying pollution-impaired water bodies, quantifying types and sources of pollution, establishing interim and final pollution load reduction targets necessary to achieve ecosystem restoration, recommendations for development of potential source reduction programs, recommendations for baseline and future water quality monitoring programs to assess ecological responses to water quality changes, and recommendations for designing and constructing water quality treatment facilities, if necessary. Although the scope of the feasibility study has not yet been developed, it is envisioned that the feasibility study would also address issues of fragmented, uncoordinated water quality sampling, data quality, and climatological effects and trends; recommendations for oversight and support of improved water quality modeling efforts in south Florida; development of additional water quality restoration targets, where needed; recommendations for remediation programs to achieve those targets; recommendations for Best Management Practices in specific agricultural and urban areas where appropriate (including identifying those urban areas where participation in the NPDES municipal stormwater program is needed); and, recommendations for synchronizing water quality restoration programs with the implementation schedule for the components of the recommended plan. The Comprehensive Integrated Water Quality Plan would also include recommendations for locations of water storage and treatment areas and design features for optimizing recommended plan components to achieve water quality restoration targets. The comprehensive integrated water quality plan may also lead to recommendations for additional features (e.g., polishing cells, operational features) for recommended plan components currently lacking specific water quality performance elements.

A discrete task which has already been identified to be performed as part or the Comprehensive Integrated Water Quality Plan study is further evaluating the feasibility of dredging phosphorus-enriched sediments in Lake Okeechobee. For other regions of the study area, the extent of water quality problems and key water quality restoration targets are less well known. Particular regions where establishment of pollutant load reduction targets needs to be accelerated to enable optimization of recommended Comprehensive Plan components for water quality benefits are: the lower Kissimmee River region; the Lake Okeechobee watershed; the St. Lucie River and estuary and Indian River Lagoon, the Caloosahatchee River and estuary, the Lake Worth Lagoon, Biscayne Bay, Florida Bay, and the Florida Keys.

For the Florida Keys particularly, the Comprehensive Integrated Water Quality Plan would ensure that the Florida Keys Water Quality Protection Program is integrated with the recommended Comprehensive Plan and with water quality improvement activities in the Keys. The Comprehensive Integrated Water Quality Plan would also expedite development of salinity based water quality criteria for Florida Bay and appropriate pollution load reduction targets for pollutants causing impairment in nearshore waters of the Florida Keys.

9.8 FUTURE IMPROVEMENTS TO THE COMPREHENSIVE PLAN

In response to comments made by the public and in the draft Fish and Wildlife Coordination Act report, the Study Team identified a process by which key ecosystem restoration features could be further improved through optimization and adaptation of the draft comprehensive plan (D-13R). Most notably since November 1998, the Study Team has developed and run several modeling “scenarios” (described in ***Section 7***) in which the draft comprehensive plan was modified in an effort to improve restoration in key areas of the south Florida ecosystem. These scenarios were vital in demonstrating the robust and flexible nature of the recommended comprehensive plan and its ability to be manipulated to further improve performance.

A major impetus for developing these scenarios was to determine if additional water could be captured in the Lower East Coast urban areas and used to better meet performance measure targets in the Water Conservation Areas and Everglades National Park, as well as for investigating alternative sources of water for Biscayne Bay. The importance of improving the performance of the draft plan in these areas is fully understood. Also, consistent with the Governor’s Commission for a Sustainable South Florida's long held principle that no part of the ecosystem will be harmed during the implementation phase of the Restudy, such improvements cannot be undertaken at the ecological expense of the Water Conservation Areas. These efforts ultimately resulted in scenario runs D-13R$_{1-4}$. Preliminary evaluation by the interagency Alternative Evaluation Team indicates that additional captured water (about 245,000 acre-feet) helps to meet hydrologic targets for Everglades National Park, Biscayne Bay and some areas within the Water Conservation Areas. In other areas of the Water Conservation Areas and the Pennsuco Wetlands, performance declines markedly relative to D-13R. In addition, issues relative to treating urban runoff prior to discharge into the Water Conservation Areas and the Everglades, and impacts to secondary canals have not been resolved.

The Restudy is committed to implementing the final plan in a manner that provides improvements to the operation of the Water Conservation Areas as well as providing more water for Everglades National Park and Biscayne Bay. In addition, the Restudy is committed to solving the remaining operational problems of the Water Conservation Areas associated with the Comprehensive Plan. The final comprehensive plan that is implemented will provide for an improved capability for delivery of additional water to Everglades National Park and Biscayne Bay by capturing additional runoff from urban areas. The Implementation Plan (***Section 10***) includes a phased approach to provide for substantial improvements and the maximum ecological benefits to the Water Conservation Areas, Everglades National Park, Biscayne Bay, and those other natural areas that have been adversely affected by the C&SF Project. The ultimate amount of additional water recaptured and its distribution will be determined based on this phased approach and the ability to obtain the maximum ecological benefits in each of these areas. While some implementation scenarios indicate a reduction of fresh water flows to Biscayne Bay, the Comprehensive Plan will be implemented in a way that avoids such results. Scientists, including scientists from Biscayne National Park, are reviewing the performance measures for Biscayne Bay and it is possible that there will be a consensus conclusion that alternative fresh water flow patterns may be beneficial to Biscayne Bay. Only in that event would reducing flows below the 1995 base to Biscayne Bay during the implementation phase of the Restudy be considered.

Many of the issues that have been raised regarding the Restudy performance in natural areas will be addressed during the development of the Project Implementation Report for each component. The ideal restoration solution for the remnant natural areas would be one without control structures. For that reason, where control structures are required, a preference for the use of passive control structures will be established. For example, in those cases where structural controls within natural areas are unavoidable for water management, the detailed design for project components will include passive control features to the maximum extent practicable. Further, the Implementation Plan (***Section 10***) will commit to limiting the use of active features, such as pumps and gates, to those situations where passive controls are not adequate.

9.9 COST ESTIMATE

The estimated cost estimate for the Comprehensive Plan include construction and real estate costs which have been termed Initial Costs; Adaptive Assessment and Monitoring Program costs, and Operation and Maintenance Costs.

9.9.1 Initial Costs

The total estimated cost of the recommended Comprehensive Plan is $7,800,000,000 (rounded) at October 1999 price levels. The cost estimate is shown in ***Table 9-2***. This estimate is the "base line" estimate, and does not account for future price escalation.

9.9.2 Adaptive Assessment and Monitoring Costs

The adaptive assessment and monitoring program for the Comprehensive Plan is still under development. Given the conceptual nature of plan and the need to integrate the monitoring program with other ongoing efforts, it is difficult to prepare a detailed estimate of its cost at the present time. However, based on other ongoing monitoring programs such as the Kissimmee River and the C-111 Project, the annual monitoring cost was estimated to be $10,000,000 during the period of construction.

9.9.3 Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) Costs

Annual operation and maintenance costs were estimated for the construction features of the recommended Comprehensive Plan. The operation and maintenance costs were determined by extrapolating from operational cost histories supplied by the South Florida Water Management District. The costs reflect projected values based on past trends encountered and represent the difference between with versus without the Comprehensive Plan. Replacement costs were calculated for culverts and mechanical and electrical equipment related to pump plants and spillway structures. The annual OMRR&R costs are estimated to be $172,000,000 (rounded) and are provided in ***Table 9-3***.

TABLE 9-2
ESTIMATED INITIAL COST FOR CONSTRUCTION FEATURES
($1,000, October 1999 Price Levels)

Report Section	CONSTRUCTION FEATURES	Construction	Real Estate	Total Initial Cost
9.1.1	**Kissimmee River Region**			
9.1.1.1	North of Lake Okeechobee Storage Reservoir	$95,134	$189,720	$284,854
9.1.1.2	Taylor Creek/Nubbin Slough Storage and Treatment Area	$74,326	$29,700	$104,026
9.1.1.3	Lake Okeechobee Watershed Water Quality Treatment Facilities	$47,800	$14,448	$62,248
9.1.1.4	Lake Okeechobee Tributary Sediment Dredging	$3,800	$900	$4,700
9.1.1.5	Lake Istokpoga Regulation Schedule	$50	$0	$50
9.1.2.1	Lake Okeechobee Aquifer Storage and Recovery	$1,108,797	$7,515	$1,116,312
9.1.3	**Caloosahatchee River Region**			
9.1.3.1	C-43 Basin Storage Reservoir and Aquifer Storage and Recovery	$313,574	$132,621	$446,195
9.1.3.2	Caloosahatchee Backpumping with Stormwater Treatment	$69,715	$13,179	$82,894
9.1.4	**Upper East Coast**			
9.1.4.1	C-44 Basin Storage Reservoir	$21,888	$90,675	$112,563
9.1.4.2	C-23/C-24/C-25/Northfork and Southfork Storage Reservoirs	$281,175	$429,048	$710,223
9.1.5	**Everglades Agricultural Area**			
9.1.5.1	Everglades Agricultural Storage Reservoirs	$350,112	$86,536	$436,648
9.1.6	**Big Cypress Region**			
9.1.6.1	Big Cypress/L-28 Interceptor Modifications	$36,051	$6,700	$42,751
9.1.6.2	Seminole Tribe Big Cypress Water Conservation Plan - (East & West)	$69,553	$5,735	$75,288
9.1.7	**Water Conservation Areas Region**			
9.1.7.1	Flow to Northwest and Central Water Conservation Area 3A	$30,877	$0	$30,877
9.1.7.2	Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement	$185,408	$26,279	$211,687
9.1.7.3	Loxahatchee National Wildlife Refugee Internal Canal Structures	$7,324	$345	$7,669
9.1.7.4	Miccosukee Water Management Plan	$22,741	$1,718	$24,459
9.1.8	**Lower East Coast Region**			
9.1.8.1	Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration	$2,500	$8,000	$10,500
9.1.8.2	Water Preserve Areas / L-8 Basin	$383,541	$31,641	$415,182
9.1.8.3	Acme Basin B Discharge	$11,600	$8,500	$20,100
9.1.8.4	Lake Worth Lagoon Restoration	$2,000	$300	$2,300
9.1.8.5	Winsburg Farms Wetland Restoration	$10,000	$4,140	$14,140
9.3.6	Palm Beach County Wetlands Based Water Reclamation	$24,900	$2,800	$27,700
9.1.8.6	C-17 Backpumping and Treatment	$9,824	$10,367	$20,191
9.1.8.7	C-51 Backpumping and Treatment	$19,156	$13,475	$32,631

Report Section	CONSTRUCTION FEATURES	Construction	Real Estate	Total Initial Cost
9.1.8.8	C-51 Regional Groundwater Aquifer Storage and Recovery	$122,391	$9,945	$132,336
9.1.8.9	Palm Beach County Agricultural Reserve Reservoir and Aquifer Storage and Recovery	$66,442	$57,657	$124,099
9.1.8.10	Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including the Strazzulla Tract	$3,800	$48,972	$52,772
9.1.8.11	Site 1 Impoundment and Aquifer Storage and Recovery	$116,792	$23,587	$140,379
9.1.8.12	Broward County Secondary Canal System	$10,978	$1,920	$12,898
9.1.8.13	Western C-11 Diversion Impoundment and Canal and Water Conservation Areas 3A and 3B Levee Seepage Management	$57,526	$167,646	$225,172
9.1.8.14	C-9 Stormwater Treatment Area/Impoundment	$26,207	$62,939	$89,146
9.1.8.15	North Lake Belt Storage Area	$381,193	$154,868	$536,061
9.1.8.16	Diverting Water Conservation Area 2 and 3 flows to Central Lake Belt Storage	$66,336	$13,321	$79,657
9.1.8.17	Central Lake Belt Storage Area	$402,502	$100,359	$502,861
9.1.8.18	Dade-Broward Levee/Pennsuco Wetlands	$10,103	$8,676	$18,779
9.1.8.19	C-4 Control Structures	$1,834	$495	$2,329
9.1.8.20	Bird Drive Recharge Area	$52,459	$71,625	$124,084
9.1.8.21	L-31N Levee Improvements for Seepage Management and S-356 Structures	$89,514	$94,704	$184,218
9.1.8.22	West Miami-Dade County Reuse	$435,998	$3,540	$439,538
9.1.8.23	Biscayne Bay Coastal Wetlands	$93,928	$205,655	$299,583
9.1.8.24	South Miami-Dade County Reuse	$359,700	$3,324	$363,024
9.1.8.25	Restoration of Pineland & Hardwood Hammocks in C-111 Basin	$600	$0	$600
9.1.8.26	C-111N Spreader Canal	$48,268	$45,766	$94,034
9.1.9	**Southwest Florida Region**			
9.1.9.1	Southern Golden Gate Estates Restoration	$15,550	$0	$15,550
9.1.9.2	Southern CREW Project Addition	$3,434	$30,104	$33,538
9.1.9.3	Lake Trafford Restoration	$14,664	$744	$15,408
9.1.9.4	Henderson Creek/Belle Meade Restoration	$3,776	$1,029	$4,805
9.1.9.5	Lake Park Restoration	$5,000	$166	$5,166
9.1.10	**Florida Bay and Keys**			
9.1.10.1	Florida Keys Tidal Restoration	$1,200	$51	$1,251
9.1.11	**System-wide**			
9.1.11.1	Melaleuca Eradication Project and other Exotic Plants	$5,772	$0	$5,772
9.7	Additional Feasibility Studies	$20,300		$20,300
	TOTAL	$5,598,113	$2,221,435	$7,819,548
			Rounded	**$7,800,000**

TABLE 9-3
OPERATIONS, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION COSTS

Report Section	Operations and Maintenance	Cost
9.1.1	**Kissimmee River Region**	
9.1.1.1	North of Lake Okeechobee Storage Reservoir	$1,515,245
9.1.1.2	Taylor Creek/Nubbin Slough Storage and Treatment Area	$2,164,114
9.1.1.3	Lake Okeechobee Watershed Water Quality Treatment Facilities	$2,602,000
9.1.1.4	Lake Okeechobee Tributary Sediment Dredging	$0
9.1.1.5	Lake Istokpoga Regulation Schedule	$0
9.1.2.1	Lake Okeechobee Aquifer Storage and Recovery	$25,000,000
9.1.3	**Caloosahatchee River Region**	
9.1.3.1	C-43 Basin Storage Reservoir and Aquifer Storage and Recovery	$6,707,889
9.1.3.2	Caloosahatchee Backpumping with Stormwater Treatment	$2,273,076
9.1.4	**Upper East Coast**	
9.1.4.1	C-44 Basin Storage Reservoir	$759,953
9.1.4.2	C-23/C-24/C-25/Northfork and Southfork Storage Reservoirs	$4,832,774
9.1.5	**Everglades Agricultural Area**	
9.1.5.1	Everglades Agricultural Storage Reservoirs	$14,458,409
9.1.6	**Big Cypress Region**	
9.1.6.1	Big Cypress/L-28 Interceptor Modifications	$404,457
9.1.6.2	Seminole Tribe Big Cypress Water Conservation Plan	$775,000
9.1.7	**Water Conservation Areas Region**	
9.1.7.1	Flow to Northwest and Central Water Conservation Area 3A	$1,102,327
9.1.7.2	Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement	$740,111
9.1.7.3	Loxahatchee National Wildlife Refugee Internal Canal Structures	$42,045
9.1.7.4	Miccosukee Water Management Plan	$540,000
9.1.8	**Lower East Coast Region**	
9.1.8.1	Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration	$60,000
9.1.8.2	Water Preserve Areas / L-8 Basin	$2,273,929
9.1.8.3	Acme Basin B Discharge	$594,000
9.1.8.4	Lake Worth Lagoon Restoration	$0
9.1.8.5	Winsburg Farms Wetland Restoration	$200,000
9.3.6	Palm Beach County Wetlands Based Water Reclamation	$2,500,000
9.1.8.6	C-17 Backpumping and Treatment	$752,435

Report Section	Operations and Maintenance	Cost
9.1.8.7	C-51 Backpumping and Treatment	$1,089,682
9.1.8.8	C-51 Regional Groundwater Aquifer Storage and Recovery	$1,496,000
9.1.8.9	Palm Beach County Agricultural Reserve Reservoir and Aquifer Storage and Recovery	$1,019,500
9.1.8.10	Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including the Strazzulla Tract	$90,000
9.1.8.11	Site 1 Impoundment and Aquifer Storage and Recovery	$2,052,608
9.1.8.12	Broward County Secondary Canal System	$418,017
9.1.8.13	Western C-11 Diversion Impoundment and Canal and Water Conservation Areas 3A and 3B Levee Seepage Management	$783,432
9.1.8.14	C-9 Stormwater Treatment Area/Impoundment	$615,743
9.1.8.15	North Lake Belt Storage Area	$1,241,234
9.1.8.16	Diverting Water Conservation Area 2 and 3 flows to Central Lake Belt Storage	$146,635
9.1.8.17	Central Lake Belt Storage Area	$1,964,519
9.1.8.18	Dade-Broward Levee/Pennsuco Wetlands	$105,871
9.1.8.19	C-4 Control Structures	$30,015
9.1.8.20	Bird Drive Recharge Area	$1,470,869
9.1.8.21	L-31N Levee Improvements for Seepage Management and S-356 Structures	$4,647,234
9.1.8.22	West Miami-Dade County Reuse	$36,500,000
9.1.8.23	Biscayne Bay Coastal Wetlands	$923,300
9.1.8.24	South Miami-Dade County Reuse	$47,815,000
9.1.8.25	Restoration of Pineland & Hardwood Hammocks in C-111 Basin	$0
9.1.8.26	C-111N Spreader Canal	$59,586
9.1.9	**Southwest Florida Region**	
9.1.9.1	Southern Golden Gates Hydrologic Restoration	$93,000
9.1.9.2	Southern CREW Project Addition	$160,000
9.1.9.3	Lake Trafford Restoration	$0
9.1.9.4	Henderson Creek/Belle Meade Restoration	$41,000
9.1.9.5	Lake Park Restoration	$62,000
9.1.10	**Florida Bay and Keys**	
9.1.10.1	Florida Keys Tidal Restoration	$0
9.1.11	**System-wide**	
9.1.11.1	Melaleuca Eradication Project and other Exotic Plants	$5,000
	TOTAL	$172,404,805
	Rounded	**172,000,000**

9.9.4 Annual Costs

Investment costs were converted to annual costs using an interest rate of 6 7/8 percent and a project life of 50 years to compute interest and amortization. Annual operation and maintenance costs were then added to the interest and amortization costs to determine the average annual cost, which is $404,946,000 for the recommended Comprehensive Plan.

9.9.5 Cost Estimate Uncertainties

The current estimated cost of the recommended Comprehensive Plan is based on the best available information. Appropriate contingency factors were used in developing the cost estimates to reflect the uncertainties inherent at this stage of project development. It is anticipated that the cost of the plan will be modified in the future as pilot projects and individual Project Implementation Reports are completed. As more site specific analysis is completed the contingency factors will be revised to reflect the greater levels of certainty. Value engineering will be used to optimize the design of facilities in the detailed planning and design phases of implementation for individual projects. During the detailed design phases, opportunities will be sought that reduce the number of control structures as well as using more passive control structures wherever feasible, which could result in reduced construction and OMRR&R costs of projects.

In addition there are other factors which may reduce the cost of the recommended plan. For instance, the aquifer storage and recovery pilot projects will evaluate the water quality of the source water to be used for aquifer storage and recovery and help identify the level of treatment necessary as defined by the U. S. Environmental Protection Agency and Florida Department of Environmental Protection. ***Appendix C*** provides a more detailed discussion of aquifer storage and recovery treatment methods. However, preliminary water quality information and correspondence from the U.S. Environmental Protection Agency indicates that the high level of treatment for aquifer storage and recovery facilities included in the recommended Comprehensive Plan may not be required and a reduction in treatment costs up to $500,000,000 may be possible (U.S. Environmental Protection Agency, 1999). Information derived from the pilot projects will be used to conduct a risk-based analysis of treatment requirements. Reducing the requirements of treating water for aquifer storage and recovery may also result in a reduction in the OMRR&R costs for these facilities.

Further, wastewater reuse facilities included in the recommended Comprehensive Plan which provide additional water flows to Biscayne Bay is another area where project cost estimates may be modified. Refinement of ecological goals and objectives for Biscayne Bay along with evaluation of alternative sources of water for Biscayne Bay may result in a reduction in the need for superior, advanced wastewater facilities and a subsequent reduction in project costs. The two wastewater reuse facilities account for an estimated $84,000,000 (rounded) of the total OMRR&R costs. As noted previously, the evaluation of alternative water supply sources for Biscayne Bay may reduce the need for advanced treatment or the need for all or a part of the volume of wastewater that is currently identified in the recommended Comprehensive Plan.

9.10 COST SHARING

Responsibilities for implementing the recommended Comprehensive Plan will be shared by the Corps of Engineers, on behalf of the Federal government, and the non-Federal sponsor, the South Florida Water Management District. The Corps will design the project and administer construction contracts to build the project. The South Florida Water Management District will be involved in the project design; will share the design and construction costs; furnish necessary lands, easements, rights of way, relocation, and disposal areas (collectively referred to as LERRD); and operate and maintain the completed project. Rules, which determine how project responsibilities are shared, are established in Federal law and related Administration implementing policies.

9.10.1 Cost Sharing of Water Quality Features

Section 528 of the Water Resources Development Act of 1996 requires that the Comprehensive Plan include water quality features necessary to provide water to restore, preserve, and protect the south Florida ecosystem. The Act further states that if the Secretary of the Army determines that a project feature to improve water quality is essential to Everglades restoration, the non-Federal cost of the feature shall be 50 percent. This provision does not apply to any feature of the Everglades Construction Project being constructed by the State of Florida.

Ecosystem restoration in south Florida depends, in part, on improving the timing and increasing the amount of water entering the Everglades to levels more typical of pre-drainage conditions. The source of this water is stormwater now sent to the coast in drainage canals, and diversions from Lake Okeechobee and other water storage facilities.

The State of Florida has water quality standards and regulatory programs in place that include protection of natural flora and fauna. However, requisite water quality characteristics (even for the same use classification) can vary depending on the type of natural flora and fauna present, or desired to be present. For example, while the water quality for the stormwater now discharged to the coast or Lake Okeechobee through drainage canals generally meets State standards, the Comprehensive Plan will result in delivering this water to areas that have a different water quality need. Therefore, the Comprehensive Plan was formulated to clean up this water before sending it to areas for ecosystem restoration purposes.

For the purpose of analyzing Federal participation in these water quality features, it is assumed that the Clean Water Act and State/Tribal water quality standards are being met for the existing use classification. This assumes that all reasonable measures within watersheds are in place to assure that the waters being received by the C&SF Project canal system are of sufficient quality to meet published standards. If these measures did not provide water of adequate quality for south Florida ecosystem needs, then additional features for water quality improvement were deemed essential for Everglades restoration and formulated and included in the Comprehensive Plan with 50-50 cost sharing. These features were formulated as either water reuse or water reclamation projects and are list in ***Table 9-4.***

Water reclamation includes modifying the C&SF Project system so that the stormwater that was once released to coastal waters or disposed of in some other way will be pumped back into the C&SF Project system to increase the volume of water available for ecosystem restoration. An example of reclaiming water includes the authorized C-51 Project which involves diverting stormwater that was formerly discharged to the Lake Worth Lagoon into the Loxahatchee National Wildlife Refuge (WCA-1) for restoration purposes. Given the change in discharge locations from the original canal design, the water will require additional treatment in a stormwater treatment area (STA-1E) prior to discharge into the Everglades. The Water Preserve Areas features of the Comprehensive Plan are another case of reclaiming waters that are presently discharged to coastal waters. The new locations of the proposed discharges will require water quality treatment prior to diverting the water into the wetlands adjacent to the Everglades. In these cases, the modification of the C&SF Project would warrant Federal participation in Comprehensive Plan water quality features due to the diversion of stormwater for Everglades restoration.

Water reuse involves changing the final use of the water for ecosystem restoration. Water that was originally discharged for flood control or used for water supply purposes will require treatment prior to being used for Everglades restoration. For example, proposed operational changes for Lake Okeechobee include water supply deliveries to the Water Conservation Areas for Everglades restoration. Water quality standards for nutrient concentrations in Lake Okeechobee are much less stringent than those for the Everglades. Therefore, any water delivered from Lake Okeechobee must be treated prior to direct use in the Everglades for ecosystem restoration purposes. These projects include modifying the final use classification of the water for the sole purpose of ecosystem restoration. Hence, all the features in the recommended plan are essential to Everglades restoration and 50-50 cost sharing applies.

TABLE 9-4
COMPREHENSIVE PLAN
WATER QUALITY FEATURES

Report Section	Plan Feature	Reuse	Reclamation
9.1.1.1	North of Lake Okeechobee Storage Reservoir	✓	
9.1.1.2	Taylor Creek/Nubbin Slough Storage and Treatment Area	✓	
9.1.1.3	Lake Okeechobee Watershed Water Quality Treatment Facilities	✓	
9.1.1.4	Lake Okeechobee Tributary Sediment Dredging	✓	
9.1.3.2	Caloosahatchee Backpumping with Stormwater Treatment		✓
9.1.6.1	Big Cypress/L-28 Interceptor Modifications	✓	
9.1.6.2	Seminole Tribe Big Cypress Water Conservation Plan	✓	
9.1.7.4	Miccosukee Water Management Plan	✓	
9.1.8.3	Acme Basin B Discharge	✓	
9.1.8.5	Winsburg Farms Wetlands Restoration		✓
9.3.6	Palm Beach County Wetlands Based Water Reclamation		✓
9.1.8.6	C-17 Backpumping and Treatment		✓
9.1.8.7	C-51 Backpumping and Treatment		✓
9.1.8.13	Western C-11 Diversion Impoundment and Canal and WCAs 3A and 3B Levee Seepage Management		✓
9.1.8.14	C-9 Stormwater Treatment Area/Impoundment		✓
9.1.8.15	North Lake Belt Storage Area		✓
9.1.8.17	Central Lake Belt Storage Area		✓
9.1.8.22	West Miami-Dade County Reuse		✓
9.1.8.23	Biscayne Bay Coastal Wetlands		✓
9.1.8.24	South Miami-Dade County Reuse		✓
9.1.8.26	C-111N Spreader Canal		✓
9.1.9.1	Southern Golden Gates Hydrologic Restoration		✓

9.10.2 Cost Sharing of Construction and Land Costs

Section 528 of the Water Resources Development Act of 1996 and U.S. Army Corps of Engineers policy requires that:

- LERRD will be provided by the non-Federal sponsor.

- The total first cost of the project, including the value of LERRD and pre-construction engineering and design costs, will be shared equally between the Federal government and the non-Federal sponsor. The non-Federal sponsor will provide cash as necessary during project construction to meet its 50 percent share of the total first cost of the project.

Table 9-5 contains an apportionment of project costs between the Federal government and the non-Federal sponsor based on these cost sharing provisions.

TABLE 9-5
COST APPORTIONMENT OF RECOMMENDED PLAN
(First Costs - rounded)

ITEM	TOTAL	FEDERAL	NON-FEDERAL
Construction	$5,500,000,000	$3,900,000,000	$1,600,000,000
LERRD	$2,300,000,000	$0	$2,300,000,000
Total	$7,800,000,000	$3,900,000,000	$3,900,000,000

9.10.3 Cost Sharing of Adaptive Assessment and Monitoring

The Adaptive Assessment Program that includes a system-wide monitoring program has been developed as described in ***Section 9.5.*** This program is needed to provide essential information that supports the development and the implementation of the recommended Comprehensive Plan. Continued system-wide planning data collected as part of the monitoring program is critical to the continuing development of the components of the plan by providing the basis for adjustments to design and operation criteria as needed. The monitoring program is a necessary component for assuring that ecosystem benefits are achieved in Everglades National Park, Biscayne Bay National Park, Big Cypress National Preserve, and the Loxahatchee Wildlife Refuge, as well as other natural areas. Consequently, it would be appropriate that these costs be shared between the Federal government and the non-Federal sponsor and that the costs be shared the same as the construction costs (50-50). It should be noted that monitoring cost associated with the Kissimmee River Restoration Project are cost shared 50 percent Federal and 50 percent non-Federal under the Corps of Engineers Construction Program.

9.10.4 Cost Sharing of Operations and Maintenance

Section 528 of the Water Resources Development Act of 1996 specifies that operation and maintenance of the Comprehensive Plan shall be a non-Federal responsibility. However, this provision is not consistent with previous C&SF Project authorizations. Some Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs for the existing C&SF Project are cost shared between the South Florida Water Management District and the Corps of Engineers. The Corps, under the provision of the 1948 Flood Control Act (House Document 80-643) is responsible for the operation and maintenance of the levees, channels, locks, and control works of the St. Lucie Canal, Lake Okeechobee, and Caloosahatchee River and main spillways of the conservation areas. The SFWMD is responsible for operation and maintenance of the remainder (except for the Upper St. Johns Basin) of the C&SF Project Works in accordance with regulations prescribed by the Secretary of the Army.

The Flood Control Act of 1968 (Senate Document 90-369, Paragraph 119) states the following: "The cost of the project works for providing water to Everglades National Park is considered to be a wholly Federal responsibility…It was considered that the Federal Government would share in the major pumping costs for water supplies on the basis of 60 percent Federal and 40 percent non-Federal, which approximates the ratio of pumped water delivered to the Everglades National Park and the non-park users."

As a result of the Everglades National Park Expansion and Protection Act of 1989, OMRR&R costs of all proposed structure modifications of the C&SF project associated with Modified Water Deliveries to Everglades National Park are cost shared with the non-Federal sponsor. That cost sharing is set at 75 percent Federal and 25 percent non-Federal. The C-111 project is another project for which cost sharing was established on OMRR&R costs. The Flood Control Act of 1968 and Section 316 of the Water Resources Development Act of 1996 established this cost sharing at 60 percent Federal and 40 percent non-Federal for water supply to Taylor Slough and Everglades National Park. Cost sharing for both of these projects was established on the basis of benefits to Everglades National Park.

The recommended Comprehensive Plan contains a large number of components that together accomplish restoration of the south Florida ecosystem and directly benefit Everglades National Park, Biscayne National Park, Big Cypress National Preserve, and the Loxahatchee National Wildlife Refuge. The recommended Comprehensive Plan includes storage features such as in-ground and above-ground reservoirs as well as aquifer storage and recovery wells that are located outside the remaining natural Everglades. These storage facilities capture wet season excess flows that would normally be discharged into the coastal waters through the C&SF Project canals and retains them in the system until they are needed. This storage provides benefits to both the natural system (including Everglades National Park, Biscayne National Park, Big Cypress National Preserve, and the Loxahatchee National Wildlife Refuge) as well as the urban or agricultural users. The stored water that is returned to the Everglades directly benefits the natural system to achieve the goals of restoration. Further, the operation of these features of the Comprehensive Plan provides direct benefits to threatened and endangered species. These benefits will be experienced on Federal lands including Everglades National Park, Biscayne National Park, Big Cypress National Preserve, and the Loxahatchee National Wildlife Refuge, but they will also be experienced on non-Federal lands which threatened and endangered species utilize in south Florida.

The comprehensive plan contains a number of components that together accomplish restoration of the south Florida ecosystem and consequently benefit

Everglades National Park, Biscayne National Park, Big Cypress National Preserve, and the Loxahatchee National Wildlife Refuge. The Plan works as a whole to provide environmental restoration to the south Florida ecosystem. Given the multi-objective nature of these components and the difficulty of determining separable benefits for the components of the Comprehensive plan, it is appropriate that the costs for OMRR&R associated with the Comprehensive Plan be shared equally between the Federal government and the non-Federal sponsor.

SECTION 10
IMPLEMENTATION PLAN

The ultimate success of the Comprehensive Plan described in ***Section 9*** will be a reflection of its implementation over a period of more than 20 years. Simply stated, the hard work lies ahead in terms of restoring this important ecosystem. It will take a well coordinated strategy that, like the plan itself, is based on a set of principles that recognize that first and foremost, ecosystem restoration is the overarching objective. This objective will in turn be the principle driving force behind the sequence and pace at which we undertake the specific project features.

This Implementation Plan will begin to reverse, in a relatively short time, the pattern of ecological degradation that has been occurring in the natural system for many decades. As a result, the natural wetland systems of south Florida will be ecologically healthier by the year 2010.

Implementation of the recommended Comprehensive Plan will require integration of many related projects and tasks. The Comprehensive Plan is comprised of more than sixty major components representing literally hundreds of small projects that all need to be coordinated with each other and with other Federal, state and local programs and projects. Implementation will require an intense and innovative project management effort. This Section describes the project implementation process and the schedule developed to implement the recommended Comprehensive Plan described in ***Section 9***.

10.1. INTRODUCTION

Development of the Implementation Plan began after selection of the Initial Draft Plan in June 1998. Due to the complexity of this effort, an Implementation Plan Team was formed to address the development of the Implementation Plan. Invitations to participate on the Implementation Plan Team were extended to Federal agencies, state agencies, local governments, and tribal representatives. In addition to team meetings, five public workshops specific to the development of the Implementation Plan have been held with stakeholders. The first four workshops took place on July 29, 1998, August 27, 1998, November 23, 1998, and December 11, 1998. Public participants together with Implementation Plan Team members brainstormed ideas regarding: decision making guidelines for project prioritization; Implementation Plan principles; and the process that would be used to further develop the Implementation Plan. At each subsequent public meeting, an overview of the implementation planning process to date was presented. The status of the development of initial authorization options was also shared with the public from whom comments and suggestions were solicited.

During the public comment period on the draft report, the public expressed a desire to have the opportunity to review and comment on the revised Implementation Plan prior to its inclusion in this final report. Accordingly, the revised draft Implementation Plan was released for public review on January 25, 1999. A fifth Implementation Plan public workshop was held on February 1, 1999, to present the revised Implementation Plan and solicit comment. The public comment period on the draft Implementation Plan ended February 5, 1999. All public comments were considered while the Implementation Plan was finalized.

The Implementation Plan consists of a set of guidelines, the identification of a process for developing project components beyond this study, a schedule of project level activities, and an implementation program that includes pilot projects and other components recommended for initial authorization.

Because of the large number of complex features that will be developed over a long period of time and the benefits that will be gained in the south Florida ecosystem, the strategy for implementation of the recommended Comprehensive Plan will be pursued as a program. Approaching implementation as a program will allow flexibility in the management of the schedule and funding. Using a programmatic approach will allow for a structured management strategy. This strategy will allow the flexibility to continuously monitor implementation (both physical and operational) and will allow managers to take advantage of new information as well as provide for the refinement of the Implementation Plan to account for new and/or emerging information and technologies.

The magnitude of the effort involved in the implementation of the Comprehensive Plan does not lend itself to the traditional Corps of Engineers methodology for implementing water resources projects. This is due to the need to integrate many related features contained within the sixty plus components with each other as well as integrating the components with numerous ongoing Federal, State, tribal and local efforts. The need for an intense and innovative project management effort is clearly necessary to achieve the Restudy's goals and objectives within the timeframe laid out in this Implementation Plan. To meet this need, each component or group of components will be implemented as a project itself, but will additionally be linked to the overall Comprehensive Plan. As part of the next step of component development, a Project Management Plan will be developed and provide a detailed schedule of activities necessary to complete each portion of the project. The Project Management Plan will identify resource requirements and outline the management strategy for the completion of the related work. This programmatic approach will provide the flexibility to holistically manage the cost sharing in a manner equitable to the Federal government and the local sponsor.

10.2. GUIDELINES FOR IMPLEMENTING THE COMPREHENSIVE PLAN

The Implementation Plan Team created a set of basic principles called guidelines. The guidelines include management strategies for ensuring that the comprehensive plan is implemented in a manner consistent with the goals and objectives of the Restudy effort. Further, the Implementation Plan Team used these guidelines as they developed the implementation schedule for the Comprehensive Plan. The guidelines are presented in ***Table 10-1*** and discussed in detail in the following sub-sections.

TABLE 10-1
IMPLEMENTATION PLAN GUIDELINES

Utilize Interdisciplinary and Interagency Teams
Incorporate Outreach and Public Involvement
Maintain Regional System Focus
Integration with Ongoing and Future Projects
Integrate Contingency Planning
Address Water Quality Needs
Plan Evaluation Through Adaptive Assessment
Addressing Uncertainties
Assurances to Water Users
Development and Refinement of Models and Tools

10.2.1. Utilize Interdisciplinary and Interagency Teams

The Restudy effort has been an open, collaborative process involving Federal and state agencies, local governments and tribal participation. Use of the Internet has allowed Restudy Team members to interact and review information in real-time, thus reducing evaluation turn-around time and making meetings more productive. This interagency process was, and still is very effective, efficient and successful. The Restudy interagency team approach will continue throughout the implementation period to review, evaluate and adaptively manage the design, construction, monitoring, and implementation of the Comprehensive Plan. This interagency approach will be utilized for the development of pilot projects as well.

10.2.2. Incorporate Outreach and Public Involvement

The Restudy outreach and public involvement efforts have been integral parts of the process used to develop the Comprehensive Plan and will continue throughout the planning, design, construction, monitoring, and implementation of the Comprehensive Plan. The objective of all outreach activities is to ensure that the public is informed about the Restudy and that the plan that is implemented is reflective of the input received from stakeholders and the public throughout the project's implementation. ***Section 11*** of this report describes the outreach and public involvement efforts on the Restudy.

10.2.3. Maintain Regional System Focus

The Comprehensive Plan was developed and evaluated with respect to its contribution to the system-wide goals and objectives of the Restudy. Due to the size and complexity of the Comprehensive Plan, implementation of the plan will require that it be divided into smaller implementable packages of components. As these packages are further planned and designed, analyses and evaluations that measure the package's overall contribution to system-wide goals will be conducted in order to determine, and thus assure, that the system-wide goals and benefits of the Comprehensive Plan are being realized. This process will allow the Comprehensive Plan to be refined and revised as necessary as part of the adaptive assessment process described in a later sub-section.

10.2.4. Integration With Ongoing And Future Projects And Programs

There are a number of Federal, state, tribal and local water resources projects presently underway or authorized in the study area, including:

- Kissimmee River Restoration;
- C-111 Project;
- Modified Water Deliveries to Everglades National Park;
- Approved Critical Projects; and
- Everglades Construction Project.

The Comprehensive Plan includes modifications or additions to some of these projects. Consequently, implementation of all ongoing projects must be closely coordinated, and thus linked, with ongoing implementation of the Comprehensive Plan. The basic strategy will be to identify common features between the Comprehensive Plan and these projects. A review of the ongoing project's plan will then occur to ensure that all the ongoing projects and the Comprehensive Plan are consistent. It is important that these ongoing restoration projects be implemented in an expeditious manner.

In addition to these ongoing projects in the study area, there are numerous water resources planning and/or study efforts underway that are expected to affect implementation of the Comprehensive Plan. Some of the major planning efforts at the state and Federal level are:

- Lower East Coast Regional Water Supply Plan
- Lake Okeechobee Regulation Schedule Study
- Caloosahatchee Water Management Plan
- Lower West Coast Water Supply Plan
- Charlotte Harbor National Estuary Program
- Indian River Lagoon National Estuary Program

- Biscayne Bay Feasibility Study
- The Critical Project "Studies" (e.g., Florida Keys Carry Capacity Study)
- SW Florida Environmental Impact Statement (Corps wetland permitting)
- Indian River Lagoon Feasibility Study
- Water Preserve Areas Feasibility Study
- Florida Keys National Marine Sanctuary Management Plan and Water Quality Protection Program

Water Supply Plans under development by the South Florida Water Management District address the District's statutory responsibility to provide for water supplies to meet the reasonable beneficial needs of the region and form a critical connection with the Restudy. These plans are linked directly to the District's capital improvement funding process, the regulatory program for consumptive use permitting and operational protocols for C&SF Project facilities. The plans will evaluate the benefits from the existing C&SF Project and new C&SF Project facilities proposed in the Restudy with respect to the availability of water for allocation to human uses or reservation from use for protection of natural systems. Thus, the processes for developing the water supply plans is a critical element in addressing the issues related to assurances for existing legal users, discussed in ***Section 10.2.9***. The South Florida Water Management District has four regional water supply plans. The boundaries of the largest plan, the Lower East Coast Regional Water Supply Plan, have extensive overlap with C&SF Project boundaries.

To avoid duplication of effort, in 1997, the South Florida Water Management District merged its Lower East Coast Regional Water Supply Plan analysis of major proposed water supply storage facilities into the Restudy. The water supply plan process will now incorporate appropriate Restudy features into the state planning process to determine how much water can be made available from the modified regional system for human users and the natural system through the state regulatory program. The state water supply planning process will verify the construction sequencing of the proposed Restudy elements through a year 2020 time frame in order to protect existing reasonable and beneficial water users, protect the water resources and environment from harm, and balance the future water needs of the region. Likewise, the other water supply plans (Lower West Coast, Upper East Coast and the Kissimmee Valley) will consider the potential benefits from proposed Restudy projects in their current and future planning efforts and determine the availability of water for allocation and reservation under the appropriate state processes.

In addition to these studies, the Comprehensive Plan proposes several new feasibility studies for the planning area. These are:

- Florida Bay and the Keys Feasibility Study
- Southwest Florida Feasibility Study

- Comprehensive Integrated Water Quality Plan

A concerted coordination effort of all those involved is needed to ensure that information flowing from these studies is efficiently integrated on a system-wide basis into Comprehensive Plan component development. The strategies to ensure coordination and provide system-wide feedback are proposed in the Project Implementation Process described later in this section.

10.2.5. Integrate Contingency Planning

The Restudy Team recognized that there were technical and cost uncertainties associated with some of the major components included in the recommended Comprehensive Plan. As each component proceeds towards actual implementation, technical uncertainties will be addressed. The question of whether a component performs at the level anticipated within the context of the overall Comprehensive Plan is a most important consideration. For this reason, contingency plans have been explored and will be developed for all appropriate components and technologies.

In order to determine whether or not certain technologies will perform as anticipated, six pilot projects are recommended for immediate implementation. The results of these pilot projects will be used to help determine if alternatives are needed to achieve the same level of performance. The proposed pilot projects are: Lake Okeechobee Aquifer Storage and Recovery; Caloosahatchee River Aquifer Storage and Recovery; Site 1 Aquifer Storage and Recovery; L-31 Seepage Management; Lake Belt (curtain wall) Technology; and Natural Systems Reuse Technology. These pilot projects are described in greater detail in ***Section 9*** of this report.

Contingency plans will address performance deficiencies and cost-effectiveness issues that may arise as pilot projects and detailed design studies are implemented and completed. Contingency plans for uncertain technologies are described in greater detail in ***Section 7*** and ***Table 7-14*** "*Component Uncertainty*" in this report.

10.2.6. Address Water Quality Needs

One of the principal guidelines of the Implementation Plan is to ensure that the components are located, designed, and operated consistently with existing and future water quality protection criteria and restoration targets. The Comprehensive Plan includes a number of features (e.g., stormwater runoff treatment areas, treatment for water to be stored in aquifers by Aquifer Storage and Recovery facilities) to protect and improve the quality of water in receiving water bodies related to the operation of specific plan components. In addition, regional-scale surface storage reservoirs included in the Comprehensive Plan present an opportunity to improve water quality when those reservoirs are located in basins with impaired water bodies (water bodies not meeting designated uses and/or water quality criteria contained in water quality standards). Future detailed planning and engineering activities will consider water quality protection criteria for water bodies when plan components are to be located and designed with operational features necessary to achieve water quality restoration targets.

Other water quality protection efforts by state, tribal, and local agencies (e.g., National Pollutant Discharge Elimination System point and non-point source regulatory programs, routine monitoring activities, development and implementation of Total Maximum Daily Loads and Pollutant Load Reduction Goals) will compliment the implementation of the Comprehensive Plan components and the development of the comprehensive integrated water quality plan. The integration of water quality protection targets into the implementation process, together with monitoring and adaptive assessment of project components and ongoing state, tribal, and local efforts, will ensure that water quality protection is achieved and sustained for the natural and managed environments of the south Florida ecosystem.

10.2.7. Plan Evaluation Through Adaptive Assessment

It is expected that implementation of the Comprehensive Plan components will move restoration in a predicted direction. However, due to the uncertainties inherent in ecosystem restoration, adaptive assessment is an essential strategy.

The adaptive assessment strategy requires incremental implementation of plan components. Each increment will be planned and designed to carry the program one step closer to the ultimate goal of ecosystem restoration. Conceptual models were developed for each natural landscape within the greater south Florida ecosystem (e.g. Lake Okeechobee, Marl Prairies, etc.) to identify the stressors on the natural systems and the attributes that are expected to respond to the restoration plan. The hypotheses generated by the conceptual models, in conjunction with hypotheses about water quality and hydrology, reflect current understanding of how natural and managed systems in south Florida will likely respond to the improvements in hydrological patterns resulting from each increment. After modeling each increment, scientific review of the results will determine whether expectations will be met and whether they are reasonable. Either the hypotheses or the project can be altered at that time. Once a component is implemented, monitoring will confirm whether expectations have been achieved, and again, the opportunity exists to alter either the hypotheses or revisit the plan, as necessary.

Incremental implementation allows testing of hypotheses, thus providing an essential means for learning more about ecological cause and effect relationships with much greater certainty than is possible with ecological models. Incremental implementation also provides opportunities to refine plans to more effectively meet overall program objectives. An incremental process is required for the south Florida ecosystem restoration program because of the large and complex nature of the ecosystem and its problems, and because of the uncertainties regarding the ecological responses that will occur as more natural hydrological conditions are established. These uncertainties are inherent where major alterations in the region's spatial scale and landscape have substantially changed ecological relationships among species, habitats, and communities throughout the region. If an unexpected response occurs, it becomes the basis for reviewing and revising the operating set of hypotheses, which results in an ever-improving focus on the actions required to meet the ultimate restoration objectives.

A schematic flow chart showing how the adaptive assessment process is expected to function during the implementation of the Comprehensive Plan is presented in ***Figure 10-1***. The flow chart shows that each phased iteration in the overall restoration plan is modeled within the context of existing conditions, as a basis for predicting the expected ecological responses. During and following implementation of each phase of the projects, a regional monitoring program will provide the means of measuring actual hydrological and ecological responses. Expected and actual responses will be compared with overall project objectives as a means for evaluating the success of that phase. These comparisons provide opportunities for revising the conceptual ecological models and hypotheses being used to predict ecological responses within the plan and to revise either the content or sequencing of future projects within the plan.

For adaptive assessment to be successful, certain specific tasks and responsibilities for actually managing the process must be identified. ***Figure 10-1*** shows several places of assessment "feed-back" loops where design or sequencing of phases of a plan may be altered, depending on the nature of the responses. The three basic components in the feed-back loop of the adaptive assessment process are shown in ***Figure 10-2***. These basic components might require that teams be formed to: (a) review and interpret annual monitoring results in the context of the performance measure targets, and (b) use the annual assessments as a basis for designing and recommending revisions in future phases of the plan. The first of these tasks might be conducted primarily by experienced Everglades and wetland ecologists, and hydrologists; and the second task primarily by modelers and senior management personnel. The products of this internal evaluation and plan formulation process will subsequently be reviewed on a regular basis by the Science Advisory and Review Panel (See ***Section 10.4.3.1***). This panel of scientists, to be appointed by the South Florida Ecosystem Restoration Task Force and representing a broad range of expertise including biology, ecology, toxicology, hydrology, agronomy, economics, and other disciplinary backgrounds, will review any revisions to conceptual models and working hypotheses, as well as any recommended plan modifications. The current need is to decide how these tasks will be performed, and to make certain that they are adequately integrated into the overall implementation strategy, ensuring that they are routinely conducted over time. These may be tasks that can best be coordinated through the RECOVER team, described later in this section.

**FIGURE 10-1
ADAPTIVE ASSESSMENT FLOW DIAGRAM**

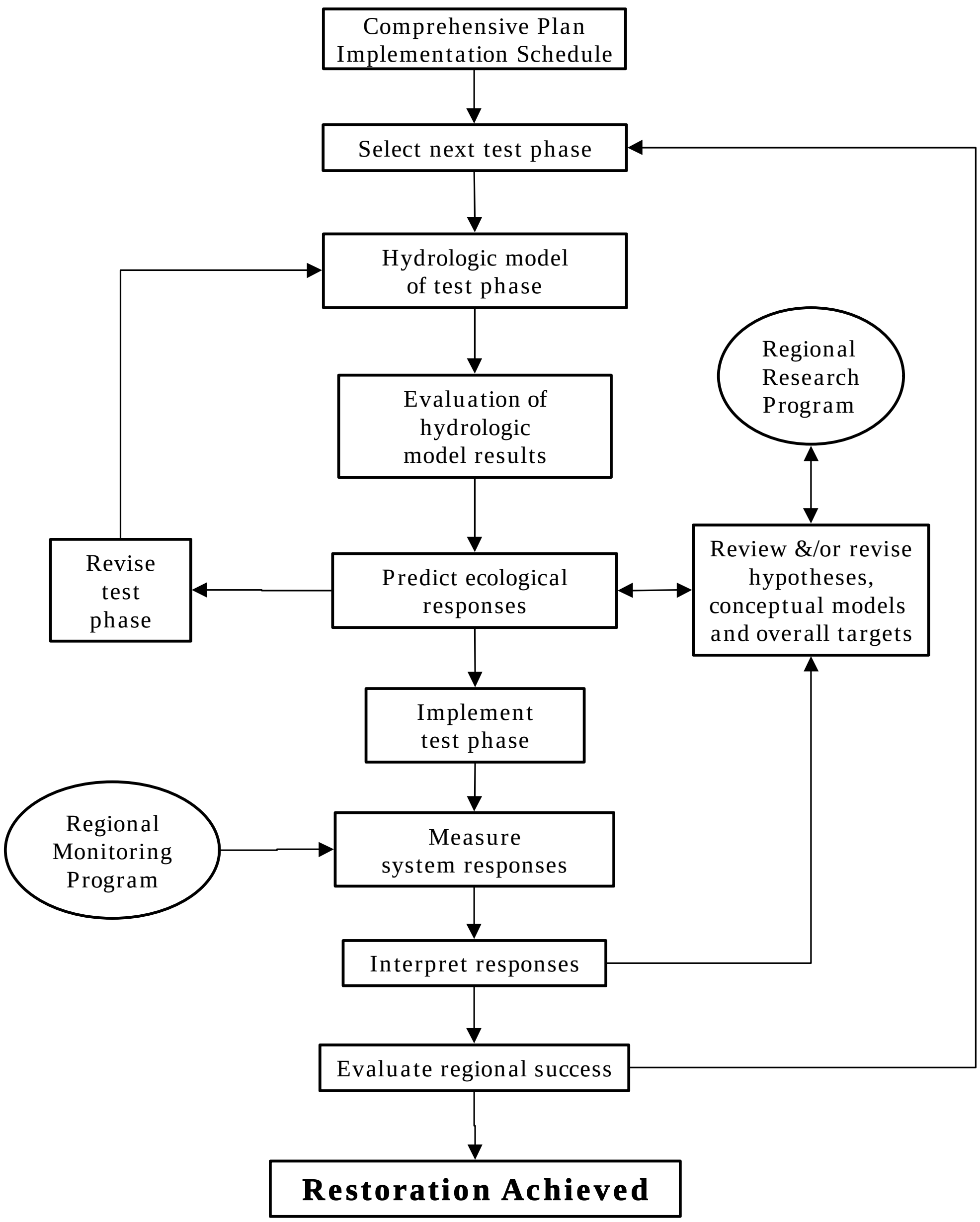
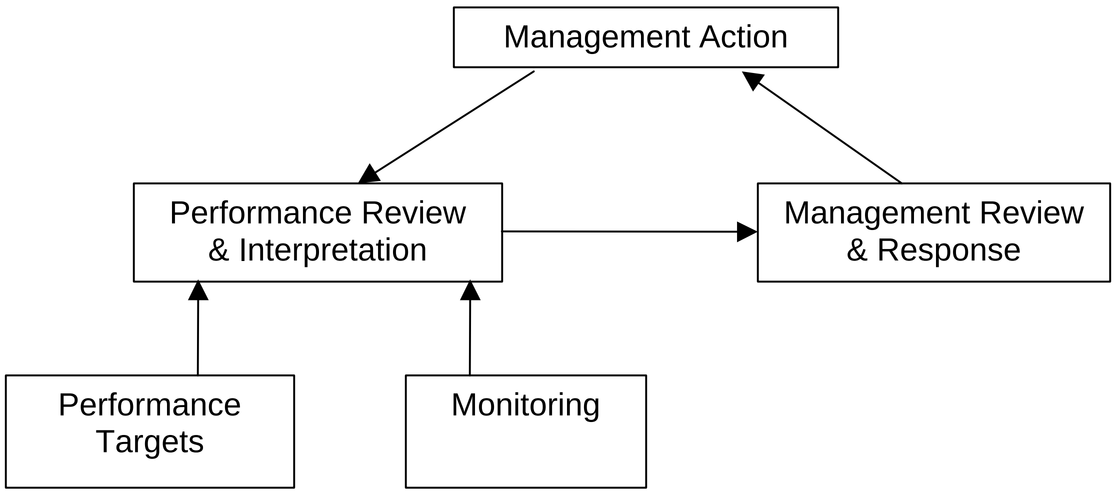


FIGURE 10-2
ADAPTIVE ASSESSMENT

Basic Components



To fully evaluate the success of a restoration program, the monitoring program must measure responses over a wide range of scales, including broad temporal scales. For a number of reasons, some significant system responses may not become apparent until several years after the project specifically responsible for these ecological changes has been completed. The time required for detectable responses may be longer than the intervals between plan iterations. In these cases, detection of cause and effect relationships, and evaluations of separate plan iterations, becomes obscured as a result of the necessary pace of the overall restoration program.

Even when system responses seem to be occurring on shorter time scales, relative to the implementation of discreet components, it may still be difficult to determine specific cause and effect relationships. These complications in the adaptive assessment process, caused by the pace of the overall program and uncertainties in causal relationships, can be substantially moderated in two ways. First, by maintaining strong ecological research and modeling programs concurrently with the implementation of the restoration program, new information necessary to better interpret system responses will consistently be accumulating. And second, by creating the recommended team of senior scientists, the best professional opinions can be focused on the adaptive assessment process. This team would be responsible for reviewing and interpreting system responses, integrating new science into the assessment process, and revising the conceptual models and working hypotheses.

10.2.8. Uncertainties

There are uncertainties associated with some of the technologies proposed in the Comprehensive Plan. Pilot projects and additional studies offer the best way to address the concerns that these uncertainties present prior to full implementation of these project components.

Further specific studies will be developed to provide additional information needed for detailed design and "value engineering" of specific components of the Comprehensive Plan. These studies could potentially include additional or revised estuary targets, flood impacts, ecological effects of reuse water and data collection.

It is likely that new technologies will emerge during the implementation process. New technologies offer the possibility of improving the Comprehensive Plan. The implementation process will allow flexibility to consider and include new technologies as they emerge.

10.2.9. Assurances To Water Users

The concept of "assurances" is key to the successful implementation of the Comprehensive Plan. Assurances can be defined in part as protecting, during the implementation phases of the Comprehensive Plan, the current level(s) of service for water supply and flood protection that exist within the current applicable Florida permitting statutes. Assurances also involve protection of the natural system.

The current C&SF Project has generally provided most urban and agricultural water users with a level of water supply and flood protection adequate to satisfy their needs. Florida law requires that all reasonable beneficial water uses and natural system demands be met. However, the C&SF Project, or regional system, is just one source of water for south Florida to be used in concert with other traditional and alternative water supplies.

The Governor's Commission for a Sustainable South Florida developed a consensus-based set of recommendations concerning assurances to existing users, including the natural system (GCFSSF, 1999). The following text is taken from the Commission's *Restudy Plan Report*, which was adopted on January 20, 1999:

> *"Assurances are needed for existing legal users during the period of plan implementation. It is an important principle that has helped gain consensus for the Restudy that human users will not suffer from the environmental restoration provided by the Restudy. At the same time, assurances are needed that, once restored, South Florida's natural environment will not again be negatively impacted by water management activities. Getting 'from here to there' is a challenge. The*

implementation plan will be the key to assuring predictability and fairness in the process.

<u>Protecting Current Levels of Service (Water Supply and Flood Protection) during the Transition from the Old to the New C&SF Project.</u>

The goal of a sustainable South Florida is to have a healthy Everglades ecosystem that can coexist with a vibrant economy and quality communities. The current C&SF Project has generally provided most urban and agricultural water users with a level of water supply and flood protection adequate to satisfy their needs. In fact, if properly managed, enough water exists within the South Florida system to meet restoration and future water supply needs for the region. However, past water management activities in South Florida, geared predominantly toward satisfying urban and agricultural demands, have often ignored the many needs of the natural system (GCSSF, 1995; transmittal letter to Governor Chiles, p. 2). Specifically, water managers of the C&SF Project historically discharged vast amounts of water to tide to satisfy their mandate to provide flood protection for South Florida residents, oftentimes adversely impacting the region's estuarine communities.

The Commission recommended that in the Restudy, the SFWMD and the Corps should ensure that the redesign of the system allows for a resilient and healthy natural system (GCSSF, 1995; p. 51) and ensure an adequate water supply and flood protection for urban, natural, and agricultural needs (GCSSF, 1996a; p.14). In response to the need to restore South Florida's ecosystem, and in light of the expected future increase of urban and agricultural water demands, the Restudy aims to capture a large percentage of water wasted to tide or lost through evapotranspiration for use by both the built and natural systems. In order to maximize water storage, the Restudy intends to use a variety of technologies located throughout the South Florida region so that no one single area bears a disproportionate share of the storage burden. This direction reinforces the Commission's recommendation that water storage must be achieved in all areas of the South Florida system using every practical option (GCSSF, 1996a; p. 25).

However, concerns have been expressed that a water user would be forced to rely on a new water storage technology before that technology is capable of fully providing a water supply source or that existing supplies would otherwise be transferred or limited, and that the user would thereby experience a loss of their current legal water supply level of service. Any widespread use of a new technology certainly has potential limitations; however, the Restudy should address technical uncertainties prior to project authorization and resolve them before implementation in the new C&SF Project. With the addition of increased water storage capabilities, water managers will likely shift many current water users to different water sources.

Additionally, stakeholders are concerned that a preservation of the current level of service for legal uses would not encompass all the urban uses, some of which are not incorporated in the term 'legal' and covered by permit. Specifically, an adequate water supply is needed to address urban environmental preservation efforts as well as water level maintenance to reduce the impact of salt water intrusion.

The Commission believes that in connection with the Restudy, the SFWMD should not transfer existing legal water users from their present sources of supply of water to alternative sources until the new sources can reliably supply the existing legal uses. The SFWMD should implement full use of the capabilities of the new sources, as they become available, while continuing to provide legal water users as needed from current sources. It is the Commission's intent that existing legal water users be protected from the potential loss of existing levels of service resulting from the implementation of the Restudy, to the extent permitted by law.

The Commission also recognizes that the SFWMD cannot transfer the Seminole Tribe of Florida from its current sources of water supply without first obtaining the Tribe's consent. This condition exists pursuant to the Seminole Tribe's Water Rights Compact, authorized by Federal (P.L. 100-228) and State Law (Section 285.165, F.S.).

However, the issues surrounding the development of specific assurances to water users are exceedingly complex and will require substantial additional effort to resolve.

RECOMMENDATION

- *The SFWMD and the Corps should work with all stakeholders to develop appropriate water user assurances to be incorporated as part of the Restudy authorizations. These water user assurances should be based on the following principles:*

  A. Physical or operational modifications to the C&SF Project by the federal government or the SFWMD will not interfere with existing legal uses and will not adversely impact existing levels of service for flood management or water use, consistent with State and federal law.

  B. Environmental and other water supply initiatives contained in the Restudy shall be implemented through appropriate State (Chapter 373 F.S.) processes.

  C. In its role as local sponsor for the Restudy, the SFWMD will comply with its responsibilities under State water law (Chapter 373 F.S.).

  D. Existing Chapter 373 F.S. authority for the SFWMD to manage and protect the water resources shall be preserved.

Water Supply for Natural Systems

Concerns have been raised about long term protection of the Everglades ecosystem. According to WRDA 1996, the C&SF Project is to be rebuilt 'for the purpose of restoring, preserving, and protecting the South Florida ecosystem' and 'to provide for all the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the C&SF Project.'

Environmental benefits achieved by the Restudy must not be lost to future water demands. When project implementation is complete, there must be ways to protect the *natural environment so that the gains of the Restudy are not lost and the natural systems, on which South Florida depends, remain sustainable.*

A proactive approach which includes early identification of future environmental water supplies and ways to protect those supplies under Chapter 373 F.S. will minimize future conflict. Reservations for protection of fish and wildlife or public health and safety can be adopted early in the process and conditioned on completion and testing of components to assure that replacement sources for existing users are on line and dependable. The SFWMD should use all available tools, consistent with Florida Statutes, to plan for a fair and predictable transition and long term protection of water resources for the natural and human systems.

Apart from the more general goals of the Restudy, there are specific expectations on the part of the joint sponsors - the State and the federal government. The more discussion that goes into an early agreement on expected outcomes, the less conflict there will be throughout the project construction and operation.

RECOMMENDATIONS

- *The SFWMD should use the tools in Chapter 373 F.S. to protect water supplies necessary for a sustainable Everglades ecosystem. This should include early planning and adoption of reservations. These reservations for the natural system should be conditioned on providing a replacement water source for existing legal users which are consistent with the public interest. Such replacement sources should be determined to be on line and dependable before users are required to transfer.*

- *The SFWMD should expeditiously develop a 'recovery plan' that identifies timely alternative water supply sources for existing legal water users. The recovery plan should consist of water supply sources that can reliably supply existing uses and whose development will not result in a loss of current levels of service, to the extent permitted by law. To assure that long term goals are met, the State and federal governments should agree on specific benefits to water users, including the natural system, that will be maintained during the recovery.*

- *In the short term, the Restudy should minimize adverse effects of implementation on critical and/or imperiled habitats and populations of State and federally listed threatened and/or endangered species. In the long term, the Restudy should contribute to the recovery of threatened species and their habitats.*

Protecting Urban Natural Systems and Water Levels

Water supply for the urban environment is connected to water supply for the Everglades and other natural areas targeted for restoration and preservation under the Restudy.

It is essential that the Restudy projects proposed to restore and preserve the environment of the Everglades do not reduce the availability of water to such an extent in urban areas that the maintenance of water levels and the preservation of natural areas becomes physically or economically infeasible.

The successful restoration of Everglades functions is dependent not only upon the establishment of correct hydropatterns within the remaining Everglades, but also upon the preservation and expansion of wetlands, including those within urban natural areas that once formed the eastern Everglades. Some of the westernmost of these areas have been incorporated in the Restudy as components of the WPAs. However, the on-going preservation efforts of local governments have acquired hundreds of millions of dollars worth of additional natural areas for protection both inside and outside of the WPA footprint.

Water supplies for these urban wetlands are not covered by existing permits or reservations and are therefore, not adequately protected. Efforts are underway at both the SFWMD and the local level to preserve these vital areas and assure their continuing function as natural areas and in ecosystem restoration.

Detailed design for the Restudy, in particular the detailed modeling associated with the WPA Feasibility Study, will make possible plans to protect these urban wetlands from damage and to assure maximum integration with Restudy components.

RECOMMENDATIONS

- *The SFWMD and the Corps should acknowledge the important role of urban natural areas as an integral part in the restoration of a functional Everglades system. As a part of the implementation plan, the SFWMD and the Corps should develop an assurance methodology in conjunction with the detailed design and modeling processes, such as the WPA Feasibility Study, to provide the availability of a water supply adequate for urban natural systems and water level maintenance during both implementation and long term operations.*

- *Expand and accelerate implementation of the WPAs. Accelerate the acquisition of all lands within the WPA footprint to restore hydrologic functions in the Everglades ecosystem, and ensure hydrologic connectivity within the WPA footprint. The WPA Feasibility Study process should be given a high priority. The WPA concept should be expanded into other SFWMD planning areas such as the Upper East Coast.*

- *The Restudy should assure that the ecological functions of the Pennsuco wetlands are preserved and enhanced."*

There is a substantial body of law that relates to the operation of Federal flood control projects, both at the state and Federal level. Much of the Governor's Commission language is directed to the South Florida Water Management District and matters of state law. To the extent that the Governor's Commission's guidance applies to the Corps' actions, the Corps will give it the highest consideration as

Restudy planning proceeds and as plan components are constructed and brought on-line consistent with state and Federal law. The recommended Comprehensive Plan does not address or recommend the creation or restriction of new legal entitlements to water supplies or flood control benefits.

10.2.10. Development And Refinement Of Models And Tools

As implementation of the Comprehensive Plan proceeds, additional models and tools or refinements to existing models and tools will be needed both at the system-wide level as well as at more localized, site-specific levels. For example, the South Florida Water Management Model with its four square mile grid size is not an appropriate tool for the analysis of flooding at a local level. More site-specific models with a much finer grid size will be needed as implementation proceeds. Additionally, the existing tools and models will be refined in order to improve their applicability and usefulness.

An example of more finite model development is depicted in the ongoing Water Preserve Areas Feasibility Study. The South Florida Water Management District is currently developing five hydrologic models in Palm Beach, Broward, and Miami-Dade Counties. These models are known as the North Palm Beach, South Palm Beach, Broward, North Miami-Dade and South Miami Dade groundwater models. Further, numerous other modeling tools have been identified that will promote a better understanding of the ecologic response of the Comprehensive Plan. These include the Everglades Landscape Model, Lake Okeechobee Water Quality Model, Florida Bay Circulation Model, Biscayne Bay Hydrodynamic Model, and Everglades Water Quality Model.

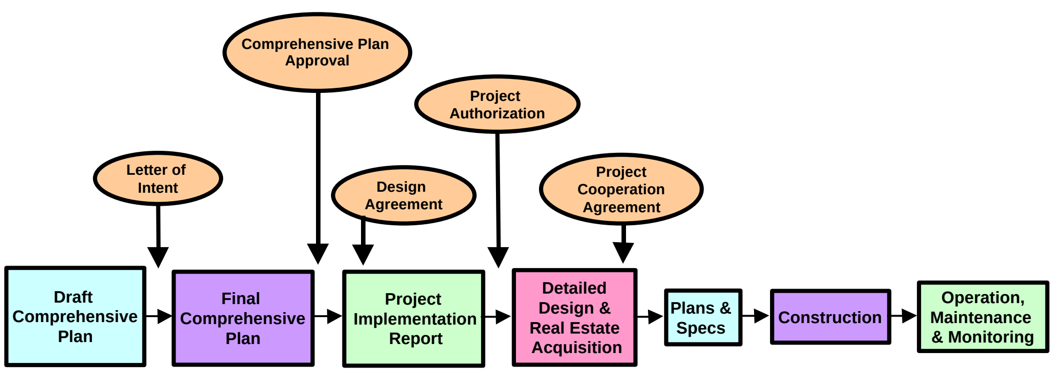
Additional data will need to be collected to further design the “next” tools needed to implement the Comprehensive Plan. These data will include items such as topographic and geologic data. The southern portion of Florida has unique features such as a very flat topography; a large, highly concentrated human population; and a very unique and fragile ecosystem. Because of this flat topography, a slight change in ground level at one location can significantly impact a large geographic area. The current lack of precision in existing vertical control can result in erroneous estimates to important hydrologic variables. There is an anticipated effort to increase the accuracy of vertical measurement called the Geodetic Vertical Control Survey, which involves second-order class I vertical control over a four-year period.

10.3. PROJECT IMPLEMENTATION PROCESS

To ensure continued progress in implementing the Comprehensive Plan, a project implementation process is needed to allow for additional studies that would support project development, and future Congressional authorizations. Further, a process is needed to reevaluate the Comprehensive Plan, as necessary, using new information that is developed during the component development and design process. This section of the Implementation Plan describes key steps that are necessary to implement the Comprehensive Plan.

Generally, implementation of the Comprehensive Plan will follow the steps shown in ***Figure 10-3***. Subsequent to the submittal of this report to Congress, a detailed planning effort in the form of a Project Implementation Report will be developed for each component or a logical group of components. Except for those projects recommended for initial authorization or accomplished under the proposed programmatic authority (described later in this section), each Project Implementation Report will be submitted to Congress for project authorization. Following completion of the Project Implementation Report, detailed design and real estate activities would commence followed by construction and operation of the project.

FIGURE 10-3
GENERALIZED PROJECT DEVELOPMENT PROCESS



Components that are authorized for construction prior to the development of a Project Implementation Report (i.e. initially authorized components and programmatic authority components) will still require completion of a Project Implementation Report. For these components, the Project Implementation Report will be completed and submitted to Corps higher authority for approval and the Project Implementation Report will not be submitted to Congress.

10.3.1. Project Implementation Reports

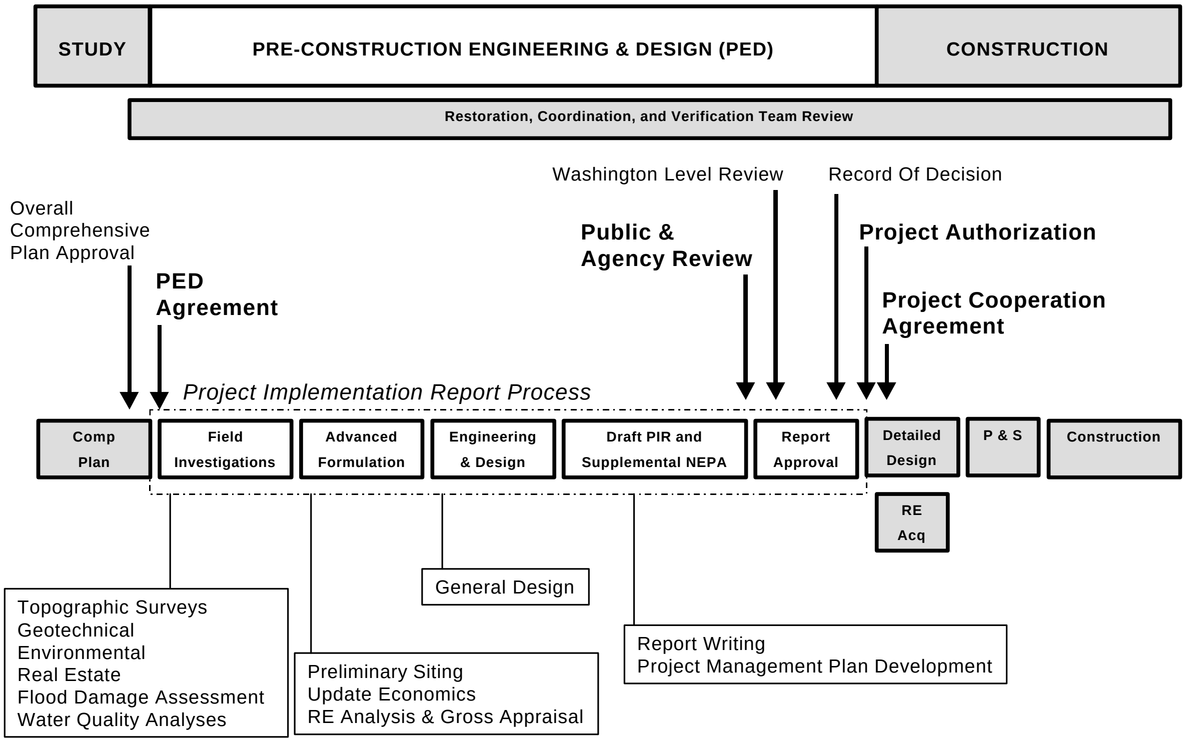
The recommended Comprehensive Plan described in ***Section 9*** has a level of detail and analysis sufficient for plan selection and cost estimation, but it is not as refined as traditional Corps of Engineers' feasibility report recommendations submitted to Congress for construction authorization. To continue project implementation, additional efforts are needed to develop the detailed technical information to implement the project. These additional efforts include:

- Additional Plan Formulation
- Engineering and Design to General Design Memorandum Levels
- Environmental Analyses
- Flood Protection Analyses
- Water Quality Analyses
- Economic Analyses
- Siting and Real Estate Analyses
- Contribution to Comprehensive Plan Performance
- Refinements/Modifications to the Comprehensive Plan
- Supplemental NEPA Document

The results of these additional efforts will be documented in a Project Implementation Report. The Project Implementation Report will bridge the gap between the conceptual design contained in the Comprehensive Plan and the detailed design necessary to proceed to construction. The steps for these future detailed studies are displayed in ***Figure 10-4***.

The Project Implementation Report is a new type of reporting document. The Project Implementation Report will be similar to a General Reevaluation Report in that it will contain additional plan formulation and evaluation, and will optimize the components. It will also contain General Design Memorandum level, or higher, engineering and design. Some of the tasks associated with the preparation of the Project Implementation Report will include surveys and mapping, geotechnical investigations, site analyses, design optimization, economics, environmental analyses, flood damage assessment, real estate analyses and preparation of supplemental National Environmental Policy Act documents. Further, each Project Implementation Report will be accompanied by a Project Management Plan. The Project Management Plan will detail schedules, funding requirements, and identify resource needs for final design and construction of the project.

FIGURE 10-4
PROJECT IMPLEMENTATION REPORT PROCESS



The objectives of Project Implementation Report are to: (1) more thoroughly investigate water resource solutions identified in the Comprehensive Plan, and (2) recommend appropriate actions. The Project Implementation Report will typically be completed in 18 to 36 months. The Project Implementation Report will document the analyses and results of the studies, and provide the basis for a final decision on the project. The Project Implementation Report will include supplemental National Environmental Policy Act (NEPA) documentation (either an Environmental Assessment or an Environmental Impact Statement). The Project Implementation Report will also contain the results of coordination activities such as the Fish and Wildlife Coordination Act Report and consultation under the Endangered Species Act. As necessary, the Comprehensive Plan will be modified as components are refined and additional information is obtained during the process.

The purpose of the Project Implementation Report is to affirm, reformulate or modify a component, or group of components, in the recommended Comprehensive Plan. All planning analyses, including economic, environmental, water quality, flood protection, real estate, and plan formulation, conducted during pre-construction design studies will be documented and included in the Project Implementation Report. The Project Implementation Report will be the vehicle to identify, quantify and attempt to resolve the uncertainties surrounding the cost or performance of each major component. These uncertainties are not limited to hydrologic performance of the specific structure component, but also include the uncertainties surrounding the expected ecosystem response to the component. A clear description of the expected environmental outcome of each component will be included in the Project Implementation Report.

The real estate analysis performed as part of the Project Implementation Report process will include siting of specific project features and a gross appraisal for all lands, easements and rights-of-way necessary for component(s) construction and operation. Field investigations will be required to provide needed information for the real estate analysis, as well as for the engineering and design analysis and advance plan formulation. These activities will typically include geotechnical and environmental investigations and topographic surveys.

The supplemental National Environmental Policy Act document prepared as a result of the Project Implementation Report will supplement this Final Programmatic Environmental Impact Statement, which is necessary for compliance with the National Environmental Policy Act. This document would be either an Environmental Assessment or an Environmental Impact Statement.

Each Project Implementation Report will also contain an analysis of the Comprehensive Plan and recommended modifications. The RECOVER team, described later in this section, will play a key role in this analysis.

The studies and preparation of the Project Implementation Report will be accomplished by an interagency interdisciplinary study team, similar to the type of team that developed the Comprehensive Plan.

10.3.2. Restoration, Coordination, And Verification Process

Throughout the project implementation process, system-wide analyses will continue. A feedback loop will be established so that each Project Implementation Report is evaluated for its contribution to the overall system and that the Comprehensive Plan is revised as necessary to reflect new information developed during the project development process.

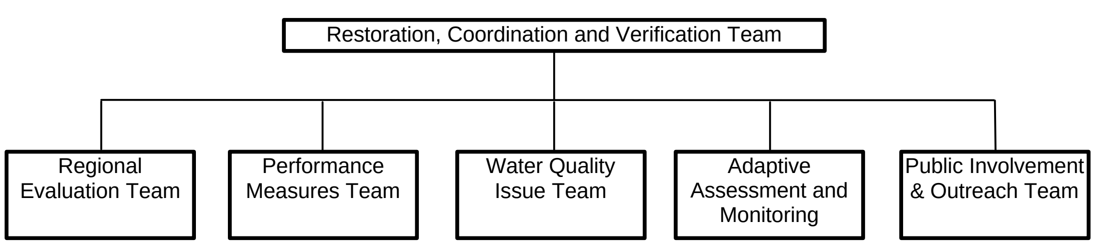
As part of this effort, a Restoration, Coordination and Verification (RECOVER) Team will be established to provide system-wide evaluations and analyses. The RECOVER Team represents the evolution of the multi-disciplinary interagency Restudy Team that was used to formulate the Comprehensive Plan. It is a system-wide evaluation and analysis team that will be responsible for helping to determine the overall regional contributions provided by individual projects and whether or not revisions to the Comprehensive Plan are necessary. The RECOVER

Team is not an oversight or management group. The RECOVER Team responsibilities will include, but not limited to, the following activities and respective coordination thereof:

- Development and Refinement of System Level Analytical Models Tools
- Continuing Re-Analysis of the Comprehensive Plan
- Development of an Information Needs Program
- Coordination of Peer Review of all Science
- Modeling Effects of Project Elements on the Comprehensive Plan
- Development and Implementation of Adaptive Assessment Protocols
- Coordination of Monitoring Program
- Interpretation of Monitoring Results as a Basis for Conducting the Adaptive Assessment Process
- Further Development and Refinement of Performance Measures and Targets
- Linkage and Coordination with Other Ongoing Projects.
- Public Involvement and Outreach
- Issue Resolution Process

The RECOVER Team will form sub-teams for specific technical evaluations as needed. Examples of currently anticipated sub-teams include: Regional Evaluation; Performance Measure Refinement and Development; Implementation Plan; Water Quality; Adaptive Assessment and Monitoring; and Public Involvement and Outreach (See ***Figure 10-5***). All RECOVER sub-teams will report status and findings to the overall RECOVER Team, and then as a team, recommendations will be developed. RECOVER Team responsibilities will not replace normal agency roles or required coordination. For example, Fish and Wildlife Coordination Act responsibilities, consultations under the Endangered Species Act, and other National Environmental Policy Act activities will not be replaced or duplicated by the RECOVER Team.

FIGURE 10-5
RECOVER TEAM COMPOSITION



The RECOVER Team is responsible for addressing system-wide issues through evaluations and analyses. These evaluations include, but not limited to addressing, hydrologic, ecological, water quality, flood protection, water supply and interim operations. This coordination activity will require the RECOVER Team, or its delegated sub-team, to provide specific input to each on-going project team regarding the linkages and affects that projects and designs have on each other.

It is envisioned that during and throughout the project development process the RECOVER Team will interactively work with the respective project team to evaluate system-wide performance and regional contributions that will be realized from full implementation of specific projects. RECOVER will utilize the most current system-wide models and evaluation tools together with the most recent performance measure information for each region. A resulting product from this effort will be a Comprehensive Plan update, which will be included within each Project Implementation Report. This update will include recommendations for Comprehensive Plan modifications if needed. This report will also act to document any changes that occurred to the project(s) formulation and design as a result of the system-wide evaluations.

In a sense the RECOVER Team will be building the system-wide incremental model by adding projects in their time-phased sequence (as they occur in the planning process) and evaluating their system-wide contribution to overall ecosystem restoration. This incremental system-wide approach will assist the adaptive assessment and monitoring sub-teams by enabling them to use the incremental information to formulate their assessments and recommendations.

10.3.3. Independent Scientific Peer Review

Sound science has always served as the basis for restoration of the south Florida ecosystem. At the heart of preserving the integrity of the science, peer review has been used to provide independent review of the science being applied to restoration efforts and to solicit advice on difficult issues.

In past years, independent panels have been formed to: (a) provide annual reviews of the overall Florida Bay science program (the Boesch panel); (b) review and advise on specific issues, such as the perceived conflict among endangered species restoration objectives (kites vs. storks), the overall high water research program, and the Cape Sable seaside sparrow research program; and (c) provide guidance and review for the Kissimmee River restoration program's ecological objectives and research and monitoring protocols.

10.3.3.1. Peer Review Previously Conducted

Fundamental documents used by the Everglades restoration planners have also received independent review. For example, the 31 chapters in *Everglades: The Ecosystem and Its Restoration* (Davis & Ogden, 1994) are a primary source for the basic hypotheses and technical understandings of the Everglades system. Each of the 31 chapters was anonymously refereed by three or more outside reviewers. Additionally, much of the natural systems research conducted by the state and federal land management agencies is published in peer-reviewed journals.

The process for developing conceptual ecological models and the models themselves have been reviewed. A team of scientists from the Restudy's participating agencies and the University of Miami's Rosenstiel School for Marine and Atmospheric Science jointly developed and managed the process of organizing existing facts and hypotheses into a format that would support the planning and evaluation of the restoration programs. The process was designed specifically to support the development of performance measures and restoration targets to guide the Everglades restoration program. The Restudy's Alternative Evaluation Team used these conceptual ecological models as a basis for developing conceptual hydrologic and biological performance measures and targets during the plan formulation and selection process. The University of Miami scientists provided the initial training and review for the conceptual models. The conceptual models were fully reported in an invited session of the 1997 annual Conference of the Society for Ecological Restoration.

The South Florida Water Management District has an "Expert Assistance" program for bringing outside experts to advise and review the scientific work of District staff. This process was used to review the River of Grass Evaluation Methodology (ROGEM). ROGEM was used during the plan formulation, evaluation, and selection process to determine the relative ecological value of different alternative plans.

The models used in the conceptual planning stage have been reviewed both to certify their integrity and to determine if they are being used appropriately. The South Florida Water Management Model has been documented (MacVicar et al., 1984 and SFWMD, 1997i) and the documentation peer reviewed (Loucks et al., 1998.). Likewise, the Natural Systems Model, Version 4.3 was reviewed by the Department of Interior, U. S. Geological Survey (Bales et al., 1997). Modifications to the Natural System Model recommended as a result of the U.S. Geological Survey review were incorporated in the version of the model that the Comprehensive Plan development process used.

10.3.3.2. Future Peer Review

The adaptive assessment protocol proposed for evaluating ecosystem responses during implementation of the restoration program includes a team of senior Everglades and wetland ecologists and hydrologists, charged with the responsibility of reviewing and interpreting system responses, revising conceptual models and working hypotheses, and recommending plan modifications. The products of this internal review process will be subsequently reviewed on a regular basis by the Science Advisory and Review Panel (SARP).

The SARP will be appointed by and provide independent scientific advice to the South Florida Ecosystem Restoration Task Force, chaired by the Secretary of the Interior. To help ensure the success of the adaptive assessment process, the SARP will at the request of the Task Force, review the science associated with the south Florida ecosystem restoration effort, including the implementation of the Comprehensive Plan on an ongoing basis. Since the Comprehensive Plan is the central component of the south Florida ecosystem restoration, the SARP will take into account the broad objectives of the Restudy as defined in the Water Resources Development Act of 1996:

> *The Secretary [of the Army] shall develop, as expeditiously as practicable, a proposed comprehensive plan for the purpose of restoring, preserving, and protecting the South Florida ecosystem. The comprehensive plan shall include such features as are necessary to provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project. (Public law 104-303, October 12, 1996).*

The SARP will be comprised of scientists representing a broad range of expertise, including biology, ecology, toxicology, hydrology, agronomy, economics, and other disciplinary backgrounds necessary to evaluate the full range of scientific issues associated with implementation of the Comprehensive Plan and the restoration of the south Florida ecosystem.

Members of the SARP will be individuals who are not personally involved in south Florida research and monitoring activities. Members will be expected to serve three to four years, rotating off the Panel at intervals that ensure sufficient continuity of activities.

The SARP will be a key element of the adaptive assessment process. The restoration of a large and complex ecosystem such as that in south Florida is a dynamic process that is continually influenced by the results of research and monitoring activities. The Science Coordination Team assists the Task Force by managing the broad range of scientific activities being undertaken by university, and Federal, state, tribal, and local governments. The SARP will evaluate the effectiveness of this scientific effort and ensure that the restoration of the south Florida ecosystem is based on the highest quality of scientific standards.

In addition to its responsibilities for providing broad scientific review during the implementation of the Comprehensive Plan, the SARP may periodically undertake special reviews or provide science advice on future directions of the program at the request of the Task Force. This may include evaluating the quality of specific research, modeling, and monitoring activities, as well as providing guidance on the significance of research results and their implications for management and restoration of the ecosystem. In addition, the SARP may be asked to identify individuals who might participate in peer review and advisory activities in specialized subject areas.

10.3.4. Water Quality Considerations

The initial authorization request includes plan components expected to provide significant regional water quality benefits (e.g., C-44 Basin Storage Area, Taylor Creek/Nubbin Slough Storage and Treatment Area, etc.). Subsequent detailed planning, engineering and design, and review by the interagency RECOVER Team, as part of the implementation process, ensures that the construction and design of initially authorized components will maximize water quality benefits to the maximum extent possible consistent with the overall performance objectives for those components.

The Project Implementation Report process described in this section includes several steps in which water quality considerations can be integrated into the overall implementation process (pre-construction, engineering and design; advanced formulation; RECOVER Team review; detailed planning and engineering; National Environmental Policy Act analyses). This will assure that water quality problems do not impede overall implementation and it will maximize opportunities to protect and restore water quality through the implementation process.

10.3.5. Flood Protection

Due to the conceptual nature of the Comprehensive Plan and the modeling tools used for the alternative analyses, detailed flood damage assessment was not performed for the Comprehensive Plan. However, maintaining levels of flood protection remains an important purpose of the C&SF Project and an objective of the Comprehensive Plan. Project Implementation Reports for individual or groups of components will include a detailed review of flood protection for the area affected by the components. Opportunities for enhancing flood protection in conjunction with other design objectives will be investigated.

10.3.6. Project Management

The magnitude of the effort involved with the implementation of the Comprehensive Plan presents a unique opportunity to utilize Federal, state, local, and tribal resources to achieve the Restudy's goals and objectives. Further, the comprehensive nature of the Restudy does not lend itself to the traditional Corps of Engineers methodology for implementing water resource projects. This is due to the need to integrate many related features contained within the sixty-plus recommended components that constitute dozens of separable project elements, as well as integrating the components with numerous ongoing Federal, State, tribal, regional and local efforts. Implementation of the Comprehensive Plan may involve multiple sponsors and numerous funding mechanisms. Coupled with a significant increase in the Jacksonville District and the South Florida Water Management District's annual programs, the need for an intense and innovative project management strategy will be necessary to complete implementation of the recommended Comprehensive Plan in a timely manner.

The scope of the recommended Comprehensive Plan warrants a management approach that is programmatic in nature. This "program" will require a management structure that is integrated into both the Corps and the local sponsor's executive, managerial, and technical staffs. The program's resources must be based on a sound strategy for implementation that includes identification of system-wide efforts, assigns responsibility for component development, and provides a projection of funding and manpower requirements supported by appropriate agreements for local cooperation. This management strategy will provide the conceptual framework for Federal, State, local, tribal, and private efforts to protect and restore the south Florida ecosystem.

The implementation process will continue to be open to the public in a manner that maximizes agency and stakeholder review and input. This Implementation Plan and the associated schedule are considered to be a "living" document. Changes to the Implementation Plan will be made when necessary by future information that is gained from pilot projects and additional studies, and other factors such as actual funding, real estate acquisition and certification, and opportunities to re-sequence portions of the project for various reasons.

10.4. SCHEDULE DEVELOPMENT

Development of the Comprehensive Plan implementation schedule was based on guidelines established by the interagency Implementation Plan Team. With these guidelines, a set of rules and assumptions were developed to form the sequencing and scheduling for components of the Comprehensive Plan. The schedule that has been developed for the Implementation Plan is consistent with the level of detail contained in the Comprehensive Plan. That is, the Implementation Plan provides a conceptual level schedule for the Comprehensive Plan. To trouble-shoot the Implementation Plan Team's sequencing of components a quality assurance and quality control modeling analysis was incorporated into the Implementation Plan Schedule development process. The results of this analysis are discussed in more detail in a later part of this section.

10.4.1. Assumptions And Rules

There are three major assumptions made in the preparation of the Implementation Plan prepared for this report. They are related to: project authorization, pilot projects and additional studies, and funding and manpower resources. These are described in the following sections. A set of factors and rules were also developed to guide development of the Implementation Plan. These factors and rules are also described in more detail in the following sections.

10.4.1.1. Project Authorization

In order to expeditiously realize the benefits of the Comprehensive Plan, implementation will be structured so that the work is not subject to institutional delays. Development and approval processes will be streamlined and time between phases will be minimized. Accordingly, it is assumed that Congressional authorizations for project elements will occur so as not to impact project sequencing and scheduling.

10.4.1.2. Pilot Projects and Additional Studies

For the purpose of developing the Implementation Plan, it is assumed that the pilot projects and needed additional studies will not substantially change the recommended Comprehensive Plan. This assumption was made in order to avoid unnecessary complexities in scheduling and sequencing of project components at the conceptual level. This alleviates the need to build every conceivable alternative solution into the network of activities. Such a level of complexity would be problematic in developing the Implementation Plan. This assumption does not negate the need to address contingency or assurance planning in this or any follow-on project document. The Implementation Plan is expected to be revised as the pilot projects and further studies are completed.

10.4.1.3. Funding and Manpower Resources

For planning purposes, the schedule for implementing the Comprehensive Plan uses an annual funding guideline of approximately $400,000,000. This annual funding guideline reflects the best professional judgement of the Implementation Plan Team. Furthermore, this guideline was coordinated between the Corps and the South Florida Water Management District to insure consistency between the potential cost sharing partners and the capability of both organizations to execute a program of this size. It is recognized that this level of funding is viewed by some as being very aggressive, and by others as not being aggressive enough. The schedule developed for this plan should be considered a model that provides scheduling data (start and completion dates) for the generalized activities associated with component development identified in the Implementation Plan, as well as projecting funding requirements by distributing the estimated activity's cost over the projected activity's duration. The Implementation Plan's schedule has been developed in a manner that provides the ability to be adjusted for different funding levels.

It is assumed that adequate manpower resources will be available to implement the Comprehensive Plan components at this funding level. Further, it is also assumed that management responsibilities for the construction of projects would be shared by the Corps and the South Florida Water Management District.

10.4.1.4. Sequencing Rules

In order for the Implementation Plan Team to develop the project implementation schedule, it first identified a series of factors and rules to consider in developing the sequence of project implementation. Factors that could expedite component implementation include:

- Components that have physiographic and functional connectivity
- Components that can provide immediate benefits
- Components that contribute to the overall system
- Components that can be implemented through ongoing projects
- Components that need to be implemented to avoid lost opportunity potential

Factors that would typically limit the ability to implement component(s) include:

- Components that have operational limitations
- Components that are dependent on other components
- Components that have land acquisition constraints

As stated previously, the implementation of the recommended Comprehensive Plan will require the integration of many related projects and tasks. The identification of component dependencies and the linking of various activities are complex tasks. The set of general sequencing rules developed by the Implementation Plan Team helped develop a sequence order for all of the components contained in the Comprehensive Plan. These rules provided the Implementation Plan Team with a starting point for establishing the overall project implementation schedule and are as follows:

- Consider earlier sequencing of components according to when the need occurs.
- Consider earlier sequencing of components that are prerequisites to other components.
- Consider earlier sequencing of components that provide replacement function.
- Consider earlier sequencing of components that provide significant benefits.

- Consider earlier sequencing of components that are most likely to provide multiple system-wide benefits.
- Consider earlier sequencing of components whose costs are expected to escalate if implementation is delayed.
- Consider earlier sequencing of tests, studies and pilot projects for components whose technical and permitting feasibility are needed to implement components at a full scale.
- Consider earlier sequencing of components that solve acute problems (i.e., degraded water quality).
- Consider earlier sequencing of components that can be implemented under existing authorizations and appropriations.
- Consider earlier sequencing of components, which if delayed, means "Loss of Opportunity."
- Consider earlier sequencing of components that have design already initiated.
- Consider earlier sequencing of components that provide definite benefits and resolve the existing conditions currently degrading the natural systems.
- Consider earlier sequencing of components that reduce losses of water from the regional system.
- Consider later sequencing of components that primarily serve to meet targets having the greatest level of uncertainty and whose revision may indicate that the component should be eliminated.

10.4.1.5. Integration With Ongoing Projects and Programs

The development of south Florida's water management system has been continuous since the original C&SF Project's authorization. Numerous efforts are currently underway to modify the project. Ongoing efforts within the planning area that are sufficiently developed to be considered in the Comprehensive Plan implementation schedule are:

- C-111 Project
- Modified Water Deliveries to Everglades National Park
- Everglades Construction Project
- Lower East Coast Regional Water Supply Plan
- Kissimmee River Restoration
- Minimum Flows and Levels
- SWIM Plans

Integration of these efforts with implementation of the Comprehensive Plan is critical. Components or features that have been identified in the Comprehensive Plan and are consistent with the authorization of other ongoing efforts will be pursued under the ongoing effort. To accomplish this, additional coordination with the ongoing Project Team will occur during the detailed planning efforts. For the purposes of this Implementation Plan, when a Comprehensive Plan component or feature will be implemented by an ongoing effort, the completion of this action will be represented as a milestone and will mark the completion of the event. No time or funding will be associated with this component or feature in the Comprehensive Plan Implementation Plan.

10.4.1.6. Modeling Preliminary Implementation Schedule

A modeling analysis for the purpose of trouble-shooting the Implementation Plan Team's preliminary sequencing of components was performed and evaluated. The results of the analysis, the 2010 Case Study, were used to aid in the development of the Implementation Plan schedule. The purpose of the analysis was to make sure that the implementation sequencing would not cause any detrimental or unanticipated adverse effects. As a result, the sequencing of some components were modified to correct identified problem areas.

This analysis consisted of identifying the components that were scheduled to be complete and fully operational by the end of year 2010. Those components were then modeled to evaluate whether the sequencing would cause ecological or water supply conditions worse than the 1995 Base Case or the 2050 future without project condition to any area or user. The modeling analysis and evaluation of the components utilized the same performance measures as the alternative plan formulation process. This analysis was used to identify problem areas and validate that the schedule was constructed in a logical order that furthered the project's goals and objectives. It is anticipated that this method will be used during further component development to identify interim solutions that will minimize further degradation of the existing system and maximize interim construction configurations and operations in the most beneficial manner as individual components are brought on-line.

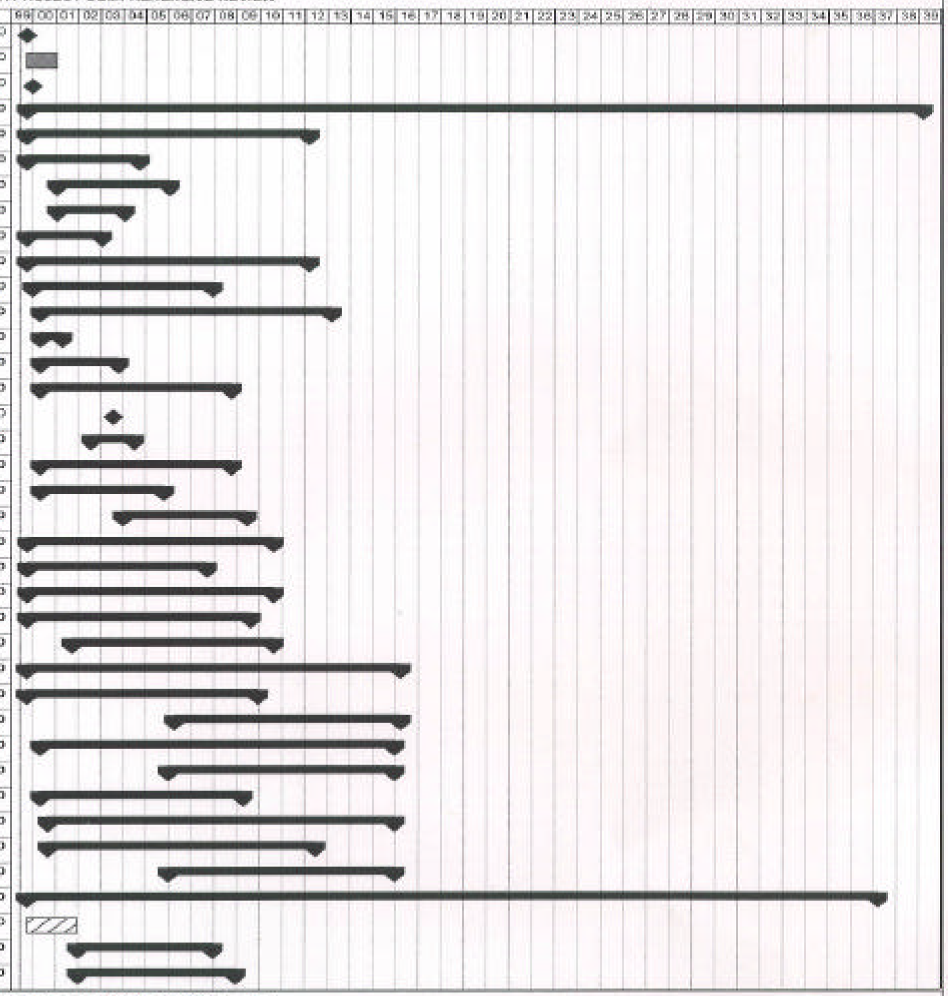
10.4.2. Implementation Schedule

The implementation schedule depicted in ***Figure 10-6*** represents scheduling of the components contained in the Comprehensive Plan. This schedule represents the Implementation Plan Team's best professional judgement and technical implementation solution for the scheduling of components using the guidelines, assumptions, and rules described earlier in this section. This Gantt chart shows the relative timeline, depicted as a "rolled-up" time scaled bars, for each component recommended in the Comprehensive Plan using the $400,000,000 annual funding guideline. A more detailed task Gantt schedule is presented in ***Appendix M – Implementation Plan Scheduling and Sequencing***.

FIGURE 10-6
ROLLED-UP SCHEDULE

CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
1		Comprehensive Plan Submitted to Congress	0 w	7/1/99	7/1/99	$0
2		Comprehensive Plan Approved	70 w	7/1/99	11/1/00	$0
3		Design Agreement Executed	0 w	9/30/99	9/30/99	$0
4		**Restoration Evaluation and Verification Team**	2060 w	7/1/99	12/22/38	$387,600,000
7		PILOT PROJECTS	650 w	7/1/99	12/14/11	$97,600,000
8		LO ASR Pilot Project	260 w	7/1/99	8/23/04	$19,600,000
12		Caloosahatchee R. ASR Pilot Project	260 w	11/1/00	10/25/05	$6,000,000
16		Seepage Mgmt Pilot Project	156 w	11/1/00	10/28/03	$10,000,000
20		Site 1 ASR Pilot Project	174.4 w	7/1/99	11/1/02	$9,000,000
24		Lakebelt Technology Pilot Project	650 w	7/1/99	12/14/11	$23,000,000
28		Reuse Technology Pilot Project	416 w	10/1/99	9/20/07	$30,000,000
35	DD	HOLEYLAND REGULATION SCHEDULE (DD)	672 w	1/31/00	12/14/12	$0
38	EE	ROTENBERGER REGULATION SCHEDULE (EE)	52 w	1/31/00	1/26/01	$0
41	KK	WCA-1 INTERNAL STRUCTURES (KK)	182 w	1/31/00	7/25/03	$7,669,000
46		C-111 MODIFICATIONS (OO, WW, T, II)	442 w	1/31/00	7/18/08	$94,035,000
47		C-111 Project Completed	0 w	4/30/03	4/30/03	$0
48	OO	C-111 Operations Modifications (OO)	100.2 w	5/1/02	4/1/04	$0
51	WW	C-111N Spreader Canal (WW)	442 w	1/31/00	7/18/08	$94,035,000
57	T	C-4 STRUCTURE (divide)	286 w	1/31/00	7/22/05	$2,330,000
63	II	G-404 PUMP STATION MODIFICATIONS	286 w	10/1/03	3/24/09	$10,138,000
69		INDIAN RIVER LAGOON (B, UU)	569 w	7/6/99	5/28/10	$822,705,000
70	B	C-44 Basin Storage (B)	416 w	7/6/99	6/22/07	$112,482,000
76	UU	C23/C24, C25, N&S-Fork Storage (UU)	569 w	7/5/99	5/28/10	$710,223,000
77	UU P1	C23 and C24 Storage (UU P1)	516 w	7/5/99	5/22/09	$369,316,000
83	UU P2	C25, North & South Fork /10 Mile Ck. (UU P2)	465 w	7/2/01	5/28/10	$340,907,000
89	G	EAA STORAGE & CONVEYANCE (G)	860.4 w	7/1/99	12/25/15	$436,648,000
90	G P1	EAA Storage Ph 1 (G P1)	533.2 w	7/1/99	9/17/09	$233,408,000
96	G P2	EAA Storage Area Ph 2 (G P2)	520 w	1/5/06	12/25/15	$203,240,000
102		LAKE OKEECHOBEE HEADWATERS STORAGE (A, W)	816 w	1/31/00	9/18/15	$388,881,000
103	A	North of Lake Storage (A)	520 w	10/3/05	9/18/15	$284,854,000
109	W	Taylor Ck Nubbin Sl Reservoir & STA (W)	468 w	1/31/00	1/16/09	$104,027,000
115		CALOOSAHATCHEE RIVER BASIN STORAGE (D, DDD)	798.4 w	6/1/00	9/18/15	$523,090,000
116	D	C43 Storage & ASR (D)	616.2 w	6/1/00	3/22/12	$440,195,000
122	DDD	Caloosahatchee STA & Backpumping (DDD)	520 w	10/3/05	9/18/15	$82,895,000
128		WATER PRESERVE AREAS	1955.4 w	7/1/99	12/19/36	$2,666,164,000
129		PIR WPA (Feasibility Study)	117 w	7/6/99	9/28/01	$0
130	R	C-9 Impoundment (R)	312 w	10/1/01	9/21/07	$89,146,000
135	Q	C-11 Impoundment & Canal (Q)	364 w	10/1/01	9/19/08	$124,837,000



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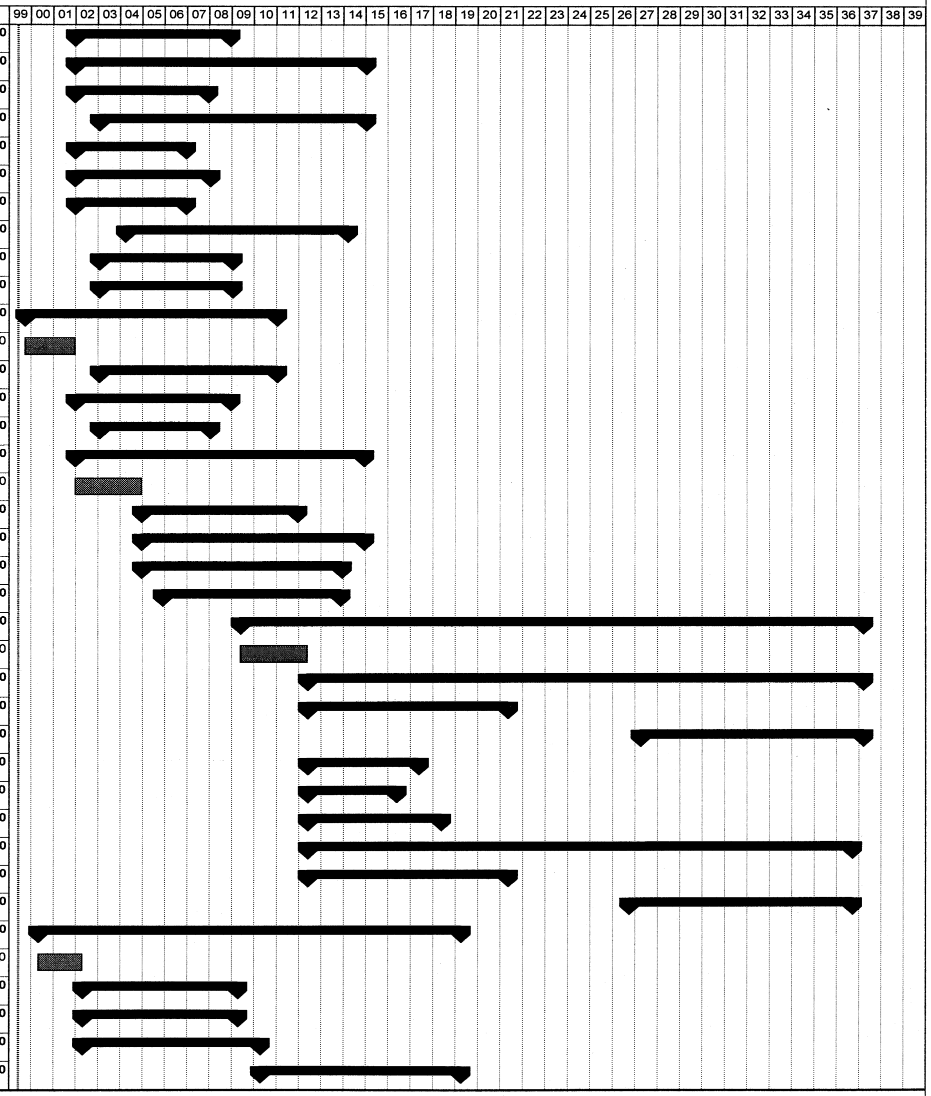
ACTIVITY ROLL-UP

CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
140	BB	Dade Broward Levee / Pensucco (BB)	364 w	10/1/01	9/19/08	$18,778,000
145	M	Site 1 Impoundment & ASR (M)	681 w	9/28/01	10/17/14	$131,379,000
146	M P1	Site 1 Impoundment Ph 1 (M P1)	312 w	9/28/01	9/21/07	$38,535,000
152	M P2	Site 1 ASR Ph 2 (M P2)	624 w	11/4/02	10/17/14	$92,844,000
157	OPE	ACME Basin B Discharge	260 w	10/1/01	9/22/06	$20,100,000
162	OPE	Protect Wetlands adjacent to LNWR (Strazulla)	317 w	9/28/01	10/26/07	$52,772,000
168	OPE	Pal-Mar Corbett Hydropattern Restoration	260 w	10/1/01	9/22/06	$10,500,000
173	U	Bird Drive Recharge Area (U)	520 w	1/1/04	12/18/13	$124,083,000
178	X	C-17 Backpumping & Treatment (X)	312 w	11/4/02	10/24/08	$20,190,000
183	Y	C-51 Backpumping & Treatment (Y)	312 w	11/4/02	10/24/08	$32,632,000
188		Levee Seepage Management (V, O, F)	589.8 w	7/1/99	10/19/10	$284,552,000
189		PIR V, O, FF	117.5 w	7/1/99	10/1/01	$4,317,000
190	V	L-31 N Levee Improvement (V)	416 w	10/30/02	10/19/10	$65,782,000
194	O	WCA-3A &3B Levee Seepage Mgmt (O)	364 w	10/1/01	9/22/08	$99,707,000
199	FF	S-356 Structures (FF)	260 w	11/4/02	10/26/07	$114,746,000
204		Storage and ASR Storage (K, GGG, LL, VV)	676 w	10/1/01	9/12/14	$671,616,000
205		PIR K, GGG, LL, VV	156 w	10/1/01	9/24/04	$23,594,000
206	K	L-8 Basin Modifications (K)	364 w	9/27/04	9/16/11	$71,316,000
211	GGG	C51 & Southern L-8 Reservoir (GGG)	520 w	9/27/04	9/12/14	$328,056,000
216	LL	C-51 Regional Groundwater ASR (LL)	468 w	9/27/04	9/13/13	$127,291,000
221	VV	Ag Reserve Reservoir (VV)	416 w	9/1/05	8/21/13	$121,359,000
226		Lakebelt Storage and Conveyance (S, EEE, ZZ, YY, XX)	1451 w	3/2/09	12/19/36	$1,085,579,000
227		PIR S, EEE, ZZ,YY,XX	156 w	3/2/09	2/24/12	$35,043,000
228	S	Central Lake Belt Storage Area	1295 w	2/27/12	12/19/36	$466,725,000
229	S P1	Central Lake Belt Storage Ph 1 (S P1)	468 w	2/27/12	2/12/21	$346,793,000
234	S P2	Central Lake Belt Storage Ph 2 (S P2)	520 w	1/4/27	12/19/36	$119,932,000
239	EEE	Flows from CLB to WCA-3B (EEE)	260 w	2/27/12	2/17/17	$6,544,000
243	ZZ	Flows from WCA-3A & 3B to CLB (ZZ)	208 w	2/27/12	2/19/16	$765,000
248	YY	Divert Flows from WCA-2 to CLB (YY)	312 w	2/27/12	2/16/18	$76,156,000
253	XX	North Lake Belt Storage Area (XX)	1269 w	2/27/12	6/20/36	$500,346,000
254	XX P1	North Lake Belt Storage Ph 1 (XX P1)	468 w	2/27/12	2/12/21	$250,173,000
259	XX P2	North Lake Belt Storage Ph 2 (XX P2)	520.6 w	7/1/26	6/20/36	$250,173,000
264		WCA CONNECTIVITY (SS, AA, QQ)	988 w	1/31/00	1/4/19	$211,687,000
265		PIR SS, AA, QQ Ph 1, Decomp Components	104 w	1/31/00	1/25/02	$5,202,000
266	SS	Reroute Miami Canal (SS)	364 w	1/28/02	1/16/09	$74,973,000
271	AA	Additional S-345 Structures (AA)	364 w	1/28/02	1/16/09	$46,453,000
275	QQ P1	WCA-3 Decomp Ph 1 (QQ P1)	416 w	1/28/02	1/15/10	$25,855,000
280	QQ P2	WCA-3 Decomp Ph 2 (QQ P2)	468 w	1/18/10	1/4/19	$59,204,000



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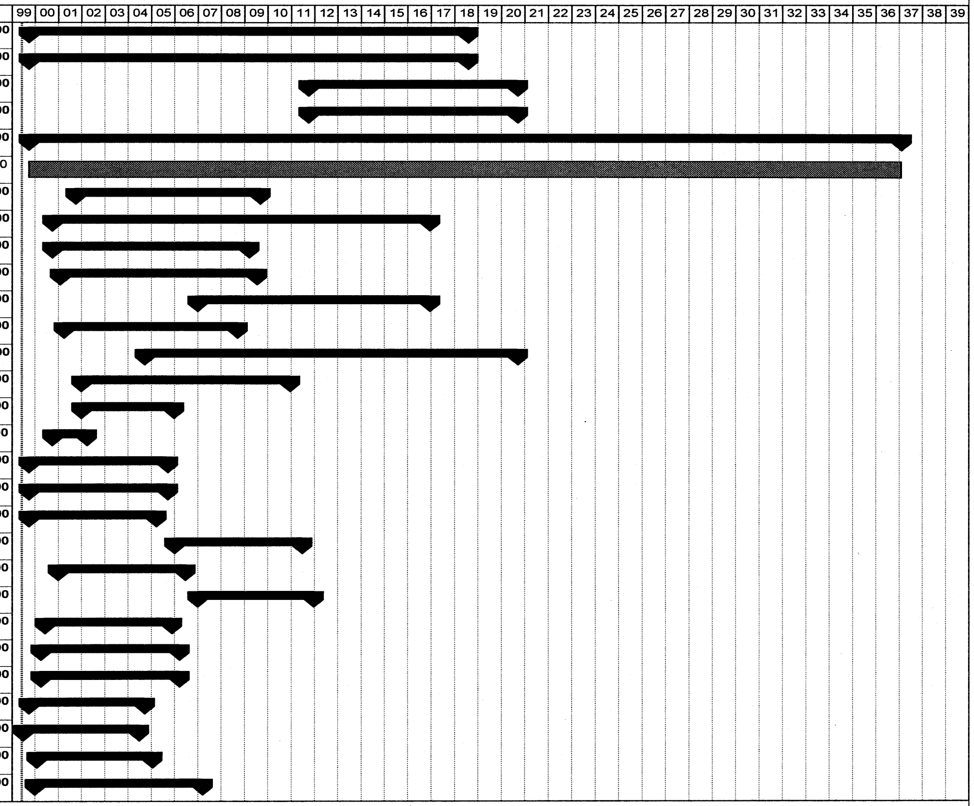
ACTIVITY ROLL-UP

CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
286		BISCAYNE BAY (FFF/OPE)	984 w	7/1/99	5/9/18	$299,583,000
287	FFF	Biscayne Bay Coastal Wetlands (FFF/OPE)	984 w	7/1/99	5/9/18	$299,583,000
295	HHH	WEST MIAMI-DADE REUSE (HHH)	468 w	7/4/11	6/19/20	$437,237,000
301	BBB	SOUTH MIAMI-DADE REUSE (BBB)	468 w	7/4/11	6/19/20	$363,024,000
307		LEC SERVICE AREAS	1950 w	7/1/99	11/12/36	$12,898,000
308	AAA	Initiate LEC Water Conservation (AAA)	1950 w	7/1/99	11/12/36	$0
309	CC	Broward County Secondary Canals (CC)	415 w	7/2/01	6/12/09	$12,898,000
315		WESTERN BASIN IMPROVEMENTS	846 w	7/3/00	9/16/16	$163,237,000
316	CP	Miccosukee Water Management Plan	442 w	7/3/00	12/19/08	$24,459,000
322	RR	Flows to NW & Central WCA 3A (RR)	442 w	11/2/00	4/22/09	$20,739,000
327	CCC	Big Cypress / L-28 interceptor (CCC)	520 w	10/2/06	9/16/16	$42,751,000
333	OPE	Seminole Water Conservation Plans (East & West)	390 w	1/1/01	6/20/08	$75,288,000
339	GG	Lake Okeechobee ASR (GG) phased	834 w	6/24/04	6/17/20	$1,097,312,000
345	OPE	LO Water Quality Treatment Facility	468 w	10/1/01	9/17/10	$62,247,000
351	OPE	LO Tributary Dredging & Water Retention Ph Removal	208 w	10/2/01	9/26/05	$4,700,000
357	CP	Lake Istakpoga Regulation Schedule	78 w	7/3/00	12/28/01	$50,000
360	CP	Southern Golden Gates Estates Hydrologic Restoration	312 w	7/1/99	6/22/05	$45,654,000
366	CP	Southern CREW Project Add'l Imperial River Flowway	312 w	7/1/99	6/22/05	$3,435,000
371	CP	Lake Trafford Restoration	286 w	7/1/99	12/22/04	$15,408,000
377	OPE	Lake Worth Lagoon Restoration	286 w	10/4/05	3/28/11	$2,300,000
383	OPE	Pineland Hardwood Restoration	286 w	10/2/00	3/24/06	$600,000
388	OPE	Melaleuca & Other Exotoc Plants	260 w	10/2/06	9/23/11	$5,772,000
393	CP	Florida Keys Tidal Restoration	286 w	3/6/00	8/26/05	$1,251,000
399	CP	Henderson Creek/Belle Meade Restoration	312 w	1/3/00	12/23/05	$4,806,000
405	CP	Winsburg Farms Wetlands	312 w	1/3/00	12/23/05	$14,140,000
411	CP	Lake Park Restoration	260 w	7/1/99	6/23/04	$5,166,000
417		SOUTHWEST FLORIDA FEASIBILITY STUDY	260 w	4/1/99	3/24/04	$8,100,000
420		FLORIDA BAY FEASIBILITY STUDY	260 w	10/29/99	10/22/04	$4,100,000
424		COMPREHENSIVE ECOSYSTEM WQ IMPROVEMENT STUDY	377.2 w	10/1/99	12/22/06	$8,100,000



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As noted previously, $400,000,000 per year served as an approximate annual funding guideline. When this guideline was applied to the component sequencing and the estimated duration associated with more detailed planning, design, real estate acquisitions, land availability and construction, all plan components, except for the Lake Belt elements, are fully implemented by the year 2020. Additionally, there are a number of years that annual funding requirements will exceed $400,000,000 in order to achieve this schedule. The North and Central Lake Belt storage components will not be fully constructed until the year 2037 due to rock mining in the area, which will not be completed for a number of years. An analysis of the project schedule that removed the $400,000,000 guideline resulted in no significant savings in time to complete implementation of the Comprehensive Plan when compared to the schedule in this report

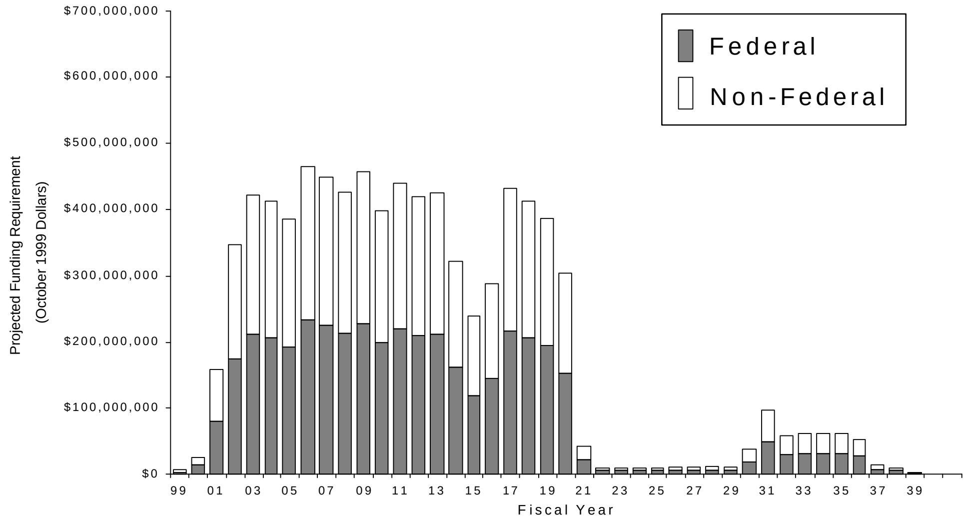
Modifications to the implementation schedule will be made as more information concerning factors that may affect future implementation are identified. Such factors would include, but not limited to future authorizations and actual funding levels. As implementation progresses, adjustments to the schedule will be made as necessary to adjust for the current situation and provide opportunities to advance work consistent with the project's purposes.

10.4.3. Funding Stream

To establish a projected annual funding requirement, the estimated cost of a given activity (Project Implementation Report preparation, Detailed Design, Plans and Specifications, Real Estate Acquisition, Construction, etc.) required to implement a component was evenly distributed over the estimated duration of that activity. It is recognized that a prorated distribution may differ from historical expenditures for construction and other types of activities. The software was limited in distribution technique: therefore, a straight-line distribution was used to establish the funding stream of the schedule developed using the $400,000,000/year funding guideline. The resulting annual funding projections are depicted in ***Figure 10-7***.

Figure 10-7 shows the annual distribution of estimated project costs for the project schedule reflected in October 1999 dollars. These annual costs will be adjusted on an annual basis as implementation progresses past the final report date. Adjustments will be based on further analyses that will be performed by the respective Project Implementation Teams during the more detailed planning and design phases.

FIGURE 10-7
C&SF RESTUDY IMPLEMENTATION PROJECTED ANNUAL COST



10.4.4. Evaluation Of The Project Schedule

This section discusses the conditions that may exist in the natural system of south Florida at approximately the half-way point in the implementation of the Comprehensive Plan, about the year 2010. Because restoration of the natural system is the principle goal of the Comprehensive Plan, this discussion uses ecological and biological criteria as measures of natural system conditions in 2010. The accuracy of predictions of system conditions for any given period in the future is substantially influenced by the quality of the models used for this purpose, and by understandings of how systems are likely to respond to specific combinations of features in the plan. These predictions will be difficult to make for any specific time-period prior to the completion of the full plan. System responses will be occurring at many different temporal scales, including some that will occur over multi-year time-frames, and some that may initially exhibit response lags. In addition, we understand less about how natural systems will respond to subsets of the total package of features in the complete plan, than we do about responses to the total package of features. Conceptually, it is agreed that the recovery of NSM-like hydrological patterns throughout the remaining natural system is likely to maximally recover the health of these systems. However, because of the weak understandings of ecological thresholds in the south Florida systems, the degree of recovery towards what are considered to be healthy systems are difficult to predict for different stages prior to full implementation.

Nevertheless, it is worthwhile to attempt to predict what these systems will be like at key stages during the implementation of the plan. This will be a useful contribution to an on-going process of plan re-evaluation and adaptive assessment. The following narrative offers an entirely conceptual and qualitative view of 2010 conditions. Just as the details of the plans will continue to be improved throughout the life of this restoration program, so too will the predictions of system responses be improved. These early predictions should be treated as guidelines for on-going evaluations of an evolving Implementation Plan, and not as concrete descriptions of conditions at a specific time in the future.

10.4.4.1. Reasonable Expectations

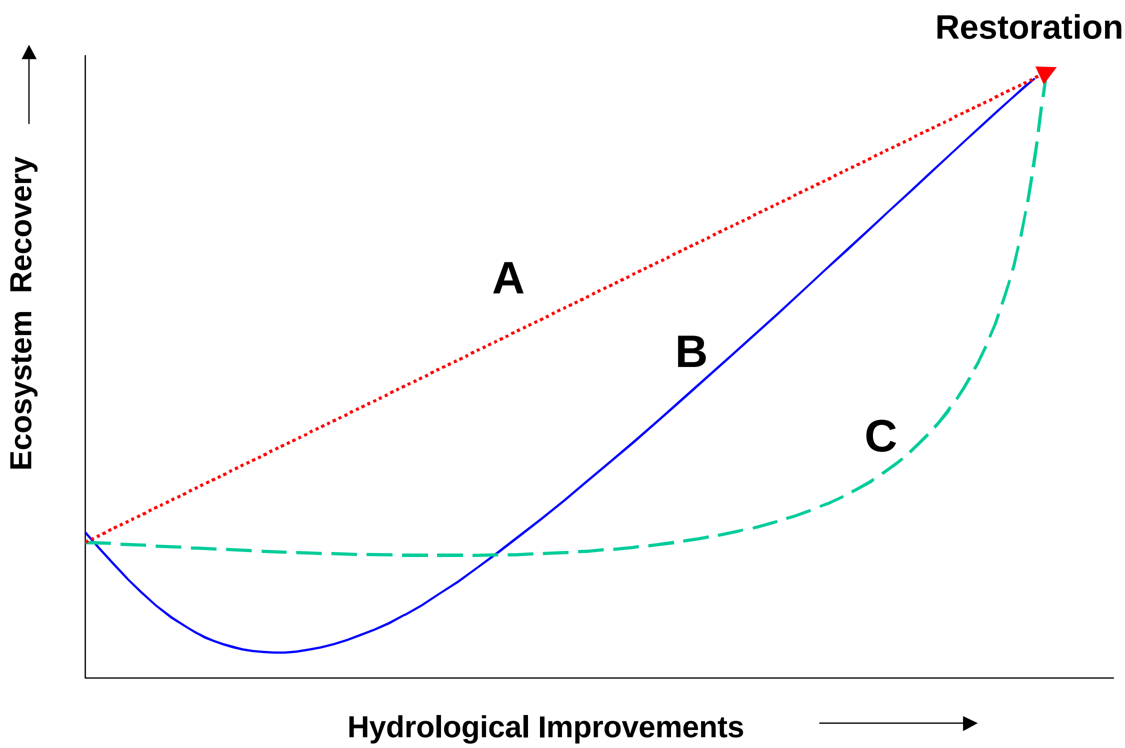
In general, the large scale hydrological improvements that will be necessary to stimulate large scale ecological improvements will only come once the features of the Comprehensive Plan which substantially increase water storage capacities of the regional system and the infrastructure needed to move this water, are in place. To the extent that certain features of the Comprehensive Plan must be in place before the additional storage and distribution components can be constructed and operated, some of the major ecological improvements anticipated by the Plan will not occur in the short-term. This unfortunate "reality" should not be viewed with surprise, when one realizes how substantially altered and degraded the south Florida ecosystem has become.

The features of the Comprehensive Plan currently proposed to be fully implemented by 2010 include the components (e.g., seepage control, land acquisition, reservoir construction, development of water preserve areas) that must be in place to set the stage for the addition of substantial amounts of clean water into the natural system. For example, in order to bring water from the urban east coast into the natural system and avoid additional water quality problems, the features required to clean that water must be in place. In order to decompartmentalize the interior Everglades and avoid additional over-drainage problems in Lake Okeechobee and the northern Everglades, the features required to substantially increase the regional storage capacity must be in place. Overall, the strategy of the Comprehensive Plan is to substantially improve hydrological performance within the remaining natural system while at the same time removing water control structures from within the natural areas. The structures that must be relocated outside of the natural system in order to make these internal improvements must be completed before the full benefits of the restoration plan will be achieved.

10.4.4.2. Ecological Responses

Notwithstanding the above considerations, the recovery of healthy ecosystems is most likely to occur in one of three ways (***Figure 10-8***). The simple, conceptual models shown in this figure depict three hypothetical ways that wetland ecosystems and the biological components within these systems can respond to improvements in hydrological conditions. Model "A" suggests that recovery can have a linear relationship with hydrological improvements. Model "B" suggests that changes in hydrological patterns can cause an initial, short-term negative response, followed by recovery. The third model "C," accounts for the effects of ecological thresholds and lag responses in the recovery process.

FIGURE 10-8
CONCEPTUAL ECOSYSTEM RECOVERY MODELS



Current understandings of organisms in the Everglades suggest that while responses to improvements in hydrological conditions may occur in all three ways, depending on the scales and the organisms measured, most response patterns will resemble "C." It is widely believed that much of the ecological recovery in the south Florida wetland systems will lag behind hydrological improvements, at a wide range of mostly unknown temporal scales. Some responses may occur within months (short-term responses, e.g., shifts in periphyton species composition), some may require one to several years (mid-term responses, e.g., recovery of fish biomass), and some may require decades (long-term responses, e.g., recovery of pre-drainage soil and plant community patterns). The expected hydrological conditions at year 2010 should result in ecological recovery at local spatial scales (e.g., at the scale of alligator holes) and at short-term temporal scales, but is unlikely to show substantial recovery for the mid-term and long-term elements of the systems.

Patterns of recovery resembling the "B" model may occur where hydrological change is more rapid than ecological responses, to the extent that the change can cause relatively short-term but reversible degradation in habitat conditions for specific organisms. A possible example might be in the first one or two years after increased flows reach the mainland mangrove estuaries below Shark Slough, resulting in reduced densities of the large sized fishes preferred by foraging wood storks. Longer periods of high flows will eventually result in increases in prey fish above current average levels. The status of organisms showing this recovery pattern, at any given point in the process of improving hydrological conditions, will depend on whether these organisms are on the early or late portions of the recovery "curve."

Model "A" patterns of recovery may be rare in the real world. It is possible that average rates of recovery over multiple years of good habitat conditions may produce recovery patterns similar to "A." Such recovery rates might be possible in populations of small fishes or aquatic invertebrates. 2010 conditions could produce hydrological patterns conducive to this type of recovery at local spatial scales.

10.4.4.3. Summary

In summary, the natural wetland systems of south Florida will be ecologically healthier by the year 2010 than they are today. This improvement reverses a pattern of ecological degradation in the natural systems that have been occurring for many decades. Most of the improvements will be at comparatively local spatial scales and among the ecological components that exhibit short-term response times. For example, alligator holes in certain regions will be healthier than today, wading birds will have a larger area of favorable feeding habitat, and estuarine conditions in such areas as the St. Lucie system will be substantially improved. The magnitude of hydrological improvements expected by 2010, and the longer time-frames required for responses by many organisms and communities in the greater Everglades basin, mean that many of the ecological benefits of the Comprehensive Plan will be realized during the second half of the project.

10.5. IMPLEMENTATION PROGRAM

Implementation of the Comprehensive Plan will require both a long-term program, which will take place over the next several decades, as well as a commitment of resources from the Federal, State, South Florida Water Management District, and local governments in the region. The recommendations for the implementation program are based on input from the Implementation Plan Team, public meetings, state and agency review, local sponsors, South Florida Water Management District's Letter-of-Intent, Governors Commission for a Sustainable South Florida, South Florida Ecosystem Restoration Task Force and Working Group.

The implementation program was developed based on an analysis of the scheduling of plan features and ongoing Federal and State programs, such as the C-111 Project and the Everglades Construction Project. This implementation program assumes:

1. Congressional approval of the Comprehensive Plan as a framework and guide for authorization;
2. initial authorization of a specific set of key components and pilot projects in the Water Resources Development Act (WRDA) of 2000;
3. a programmatic authority similar to the existing Critical Projects authority contained in WRDA 1996;
4. future Congressional authorization of components in subsequent WRDAs;
5. implementation of some components without further Congressional action;
6. completion of additional feasibility studies.

10.5.1. Approval of the Comprehensive Plan

Upon transmitting this report to the Commander of the South Atlantic Division in Atlanta, Georgia, and a favorable review by the Division office, the Division Engineer will issue a “Division Engineer’s Notice.” This notice announces the completion of this feasibility report by the Jacksonville District Engineer. Concurrently with the notice, the Division Engineer will transmit the report to Corps Headquarters in Washington D.C. This feasibility report will receive a final policy compliance review by Headquarters’ staff prior to releasing the report for final 30-day Federal agency review. A copy will also be provided to the State of Florida (via the Governor’s office) for final State review and comment. Corps headquarters will file the Programmatic Environmental Impact Statement with the Council on Environmental Quality. This will result in a mandatory 30-day review of the Programmatic Environmental Impact Statement. These mandatory review periods will run simultaneously. After addressing comments that are provided through the final review and making any necessary changes to the report, a “Chief of Engineer’s Report” will be issued. This report along with the Chief of Engineer’s Report will be transmitted to the Assistant Secretary of the Army for Civil Works (ASA(CW)) for review and transmittal to Congress (typically for inclusion in a Water Resources Development Act). By Congressional direction on the Restudy, this must occur by July 1, 1999. Congressional hearings may be held on the plan prior to Congressional action. It is currently anticipated that Congress, through enactment of a Water Resources Development Act of 2000, will approve the Comprehensive Plan as a framework and guide for authorization and implementation and will authorize construction of certain components.

10.5.2. Initial Authorization

Careful attention was given to developing an initial authorization recommendation for pilot projects and key specific components. A number of factors where considered when considering which components should be recommended for initial authorization. Consideration was given to include projects that will provide immediate system-wide water quality and flow distribution benefits to the ecosystem. Initial authorization of components associated with ongoing Federal, state and local programs will allow for integration of components from the Comprehensive Plan with these ongoing projects as soon as possible. For example, immediate authorization will allow development of comprehensive solutions to ongoing Federal and state projects such as the Modified Water Deliveries Project and the Everglades Construction Project that otherwise could not be pursued under existing authorities. Further, it is anticipated that there may be substantial cost savings by integrating the Comprehensive Plan components with these ongoing programs. The South Florida Water Management and U.S. Department of the Interior have purchased lands associated with a number of components of the Comprehensive Plan. Immediate authorization of the components that utilize these lands will ensure timely and efficient utilization and crediting of these lands.

10.5.2.1. Pilot Projects

Pilot projects are needed to address many of the technical uncertainties of the components. The Implementation Plan Team agreed early in the process that the following pilot projects should be recommended for immediate implementation. ***Table 10-2*** includes the list of the pilot projects to be recommended for authorization and the estimated cost and completion dates of these projects.

10.5.2.2. Initially Authorized Project Components

As stated previously, careful attention was given to developing an initial authorization recommendation for specific project components. The purpose of seeking authorization of select components of the Comprehensive Plan is to maximize the opportunity to integrate these features with ongoing Federal and state programs. The specific components that are recommended for this initial authorization are displayed in ***Table 10-3***.

TABLE 10-2
PILOT PROJECTS

Project	Cost	Completion Date
Lake Okeechobee ASR	$19,000,000	2004
Caloosahatchee River ASR	$6,000,000	2005
Site 1/Hillsboro ASR	$9,000,000	2002
Lake Belt Technology	$23,000,000	2011
Seepage Management	$10,000,000	2003
Reuse Technology	$30,000,000	2007
TOTAL	$97,000,000	

TABLE 10-3
CONSTRUCTION FEATURES FOR INITIAL AUTHORIZATION

Component	Report Section [1]	Project	Cost	Construction Dates
B	9.1.4.1	C-44 Basin Storage Reservoir	$112,562,000	6/04 - 6/07
G (Phase 1)	9.1.5.1	Everglades Agricultural Area Storage Reservoirs - Phase I	$233,408,000	9/05 – 9/09
M[3] (Phase 1)	9.1.8.11	Site 1 Impoundment	$38,535,000	9/04 - 9/07
O[2a]	9.1.8.13	WCA 3A/3B Levee Seepage Management	$100,335,000	9/04 - 9/08
Q[2a]	9.1.8.13	C-11 Impoundment & Stormwater Treatment Area	$124,837,000	9/04-9/08
R[2a]	9.1.8.14	C-9 Impoundment/Stormwater Treatment Area	$89,146,000	9/04-9/07
W	9.1.1.2	Taylor Creek/Nubbin Slough Storage and Treatment Area	$104,027,000	1/05-1/09
QQ[2b,3] (Phase 1)	9.1.7.2	Raise and Bridge East Portion of Tamiami Trail and Fill Miami Canal within WCA 3	$26,946,000	1/05-1/10
SS[2b]	9.1.7.2	North New River Improvements	$77,087,000	1/05 - 1/09
WW	9.1.8.26	C-111 N Spreader Canal	$94,035,000	7/05 – 7/08
	9.5	Adaptive Assessment and Monitoring Program (10 years)	$100,000,000	
		TOTAL	$1,100,918,000	

[1] Refer to the appropriate section in this Feasibility Report for a description of these features
[2a,2b] Project components are dependent upon each other and would be implemented as a single project
[3] Although the initial phase of this project component is within the cost limits of the proposed Programmatic Authority, the total cost for the component exceeds that authority and therefore is included with these recommended construction features

10.5.2.3. Implementation of Initially Authorized Projects

Due to the scope of this feasibility report, it is proposed that individual Project Implementation Reports be developed subsequent to authorization for each of the components included in the initial authorization. These Project

Implementation Reports will document advanced planning; engineering and design; real estate analyses; and supplemental requirements under the National Environmental Policy Act. It is anticipated that these reports will be approved by the Secretary of the Army without need for further Congressional action unless major changes to the Comprehensive Plan are recommended. Subsequent to the approval of the Project Implementation Report, recommended features will progress to detailed design and construction. The implementation of the initially authorized features will utilize the process depicted in ***Figure 10-9***.

10.5.3. Programmatic Authority

The Water Resources Development Act of 1996 provided authorization (see **Appendix A5**) for Everglades Ecosystem Restoration Projects (Critical Projects). These projects were defined as those projects which would *"produce independent, immediate, and substantial restoration, preservation, and protection benefits."* A similar programmatic authority is recommended to help expedite implementation of certain components in the Comprehensive Plan. It is proposed that projects included under the programmatic authority will be those components that are part of the Comprehensive Plan and have a total project cost up to $70,000,000 with a maximum Federal cost of $35,000,000. The timing of the implementation of projects receiving programmatic authority will be consistent with the schedule that has been developed for implementing the overall Comprehensive Plan. In addition, the process for project development and implementation will be consistent with the implementation of other Comprehensive Plan components recommended for authorization in Water Resource Development Act of 2000 including the development of Project Implementation Reports. The components that could be implemented under this authority are displayed in ***Table 10-4***.

FIGURE 10-9
PROCESS FOR IMPLEMENTING INITIALLY AUTHORIZED COMPONENTS

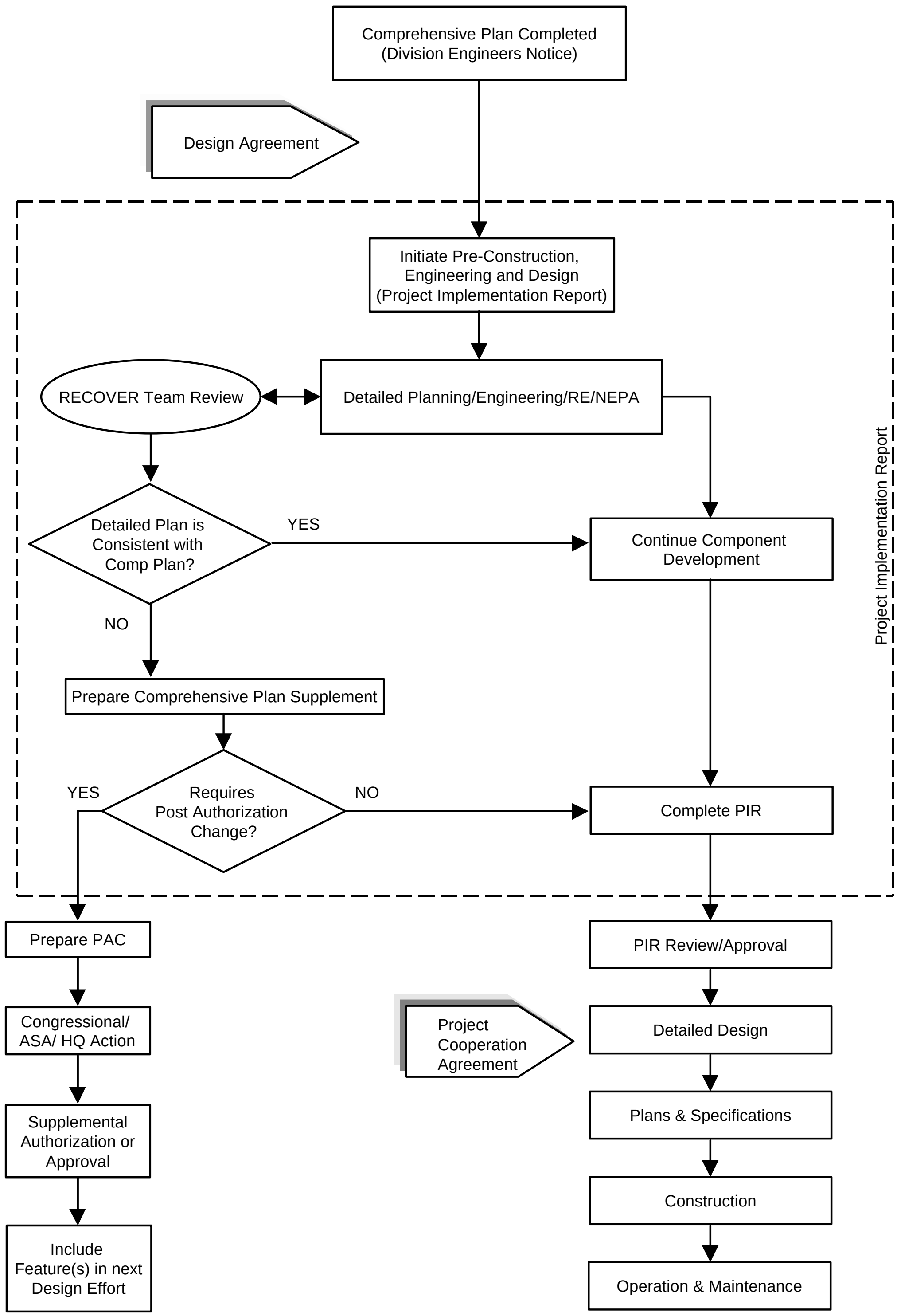


TABLE 10-4
PROGRAMMATIC AUTHORITY PROJECTS
(Assumes $35 million Federal limit; 50-50 Cost Sharing)

Item	Report Section	Project	Cost	Construction Dates
OPE	9.1.1.5	Lake Istokpoga Regulation Schedule Modification	$50,000	7/00-12/01
KK	9.1.7.3	Loxahatchee NWR Internal Canal Structures	$7,669,000	7/02–7/03
OPE	9.1.9.5	Lake Park Restoration	$5,166,000	6/02-6/04
OPE	9.1.9.3	Lake Trafford Restoration	$15,408,000	12/01–12/04
OPE	9.1.9.2	Southern Crew Project	$3,435,000	6/03–6/05
OPE	9.1.9.1	Southern Golden Gates Estates Hydraulic Restoration	$45,654,000	6/03–6/05
T	9.1.8.19	C-4 Divide Structures	$2,330,000	7/04–7/05
OPE	9.1.10.1	Florida Keys Tidal Restoration	$1,251,000	9/03-8/05
OPE	9.1.1.4	Lake Okeechobee Tributary Sediment Dredging & Phosphorus Removal	$4,700,000	9/04–9/05
OPE	9.1.9.4	Henderson Creek/Belle Meade Restoration	$4,806,000	12/03-12/05
OPE	9.1.8.5	Winsburg Farms Wetland Restoration	$14,140,000	12/03-12/05
OPE	9.1.8.25	Restoration of Pineland & Hardwood Hammocks in C-111 basin	$600,000	3/04-3/06
OPE	9.1.8.1	Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration	$10,500,000	9/04 –9/06
OPE	9.1.8.3	Acme Basin B Discharge	$20,100,000	9/04 – 9/06
OPE	9.1.8.10	Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge	$52,722,000	10/05-10/07
BB	9.1.8.18	Dade-Broward Levee / Pennsuco Wetlands	$18,778,000	9/04–9/08
X	9.1.8.6	C-17 Backpumping and Treatment	$20,190,000	10/05–10/08
Y	9.1.8.8	C-51 Backpumping and Treatment	$32,632,000	10/05–10/08
OPE	9.1.7.4	Miccosukee Water Management Plan	$24,459,000	12/04–12/08
AA	9.1.7.2	Additional S-345 Structures	$48,450,000	1/06-1/09
II	9.1.7.1	Modify G-404 Pump Station	$10,138,000	3/08–3/09
RR	9.1.7.1	Flow to Northwest and Central Water Conservation Area 3A	$20,739,000	4/05–4/09
CC	9.1.8.12	Broward County Secondary Canal System	$12,898,000	6/04–6/09
OPE	9.1.1.3	Lake Okeechobee Watershed Water Quality Treatment Facilities	$62,247,000	9/06–9/10
OPE	9.1.8.4	Lake Worth Lagoon Restoration	$2,300,000	3/09–3/11
OPE	9.1.11.1	Melaleuca Eradication Project and other Exotic Plants	$5,772,000	9/09–9/11
CCC	9.1.6.1	Big Cypress/L-28 Interceptor Modifications	$42,751,000	9/12–9/16
		TOTAL	$489,885,000	

10.5.4. Future Water Resources Development Acts

The recommended components of the Comprehensive Plan that are not initially authorized or eligible for the proposed programmatic authority will be submitted to Congress for construction authorization (as scheduled) in future Water Resources Development Acts. Project Implementation Reports that are completed by April of a Water Resources Development Act year (assumed to be biennial) will be submitted for Congressional action. Based on an analysis of the current Comprehensive Plan schedule, components will have Project Implementation Reports completed and ready to submit to Congress through fiscal year 2016. The components that will be contained in future authorization acts are contained in ***Table 10-5***.

TABLE 10-5
PROJECTS BEYOND WRDA 2000

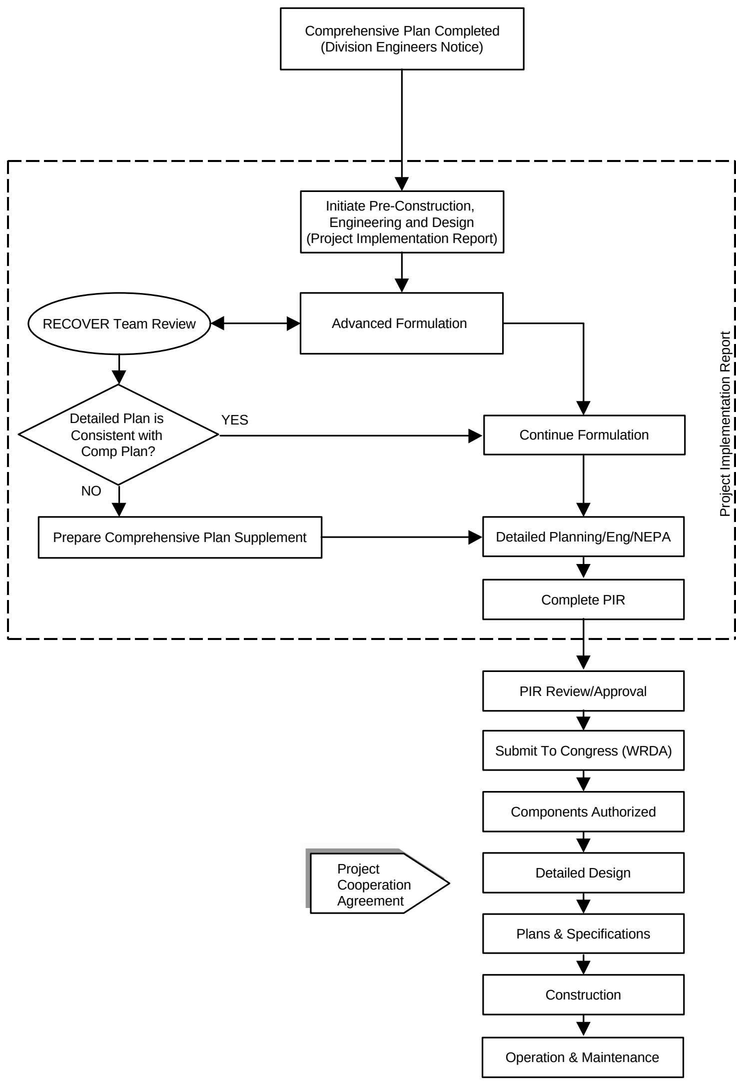
Item	Report Section	Project	Cost	WRDA	Construction Dates
V; FF[1]	9.1.8.21	L-31N Improvements for Seepage Management and S-356 Structures	$184,218,000	2002	10/05-10/10
U	9.1.8.20	Bird Drive Recharge Area	$124,083,000	2002	12/08-12/13
UU1	9.1.4.2	C-23/C-24 Storage Reservoirs	$369,316,000	2002	6/05-5/09
UU2	9.1.4.2	C-25/Northfork and Southfork Storage Reservoirs	$340,907,000	2004	7/06-5/10
OPE	9.1.6.2	Seminole Big Cypress Water Conservation Plan East & West	$75,288,000	2004	6/05-6/08
D	9.1.3.1	C-43 Basin Storage Reservoir & Aquifer Storage and Recovery	$440,195,000	2004	4/05-3/12
LL	9.1.8.8	C-51 Regional Groundwater Aquifer Storage and Recovery	$132,336,000	2004	9/08-9/13
VV	9.1.8.9	Palm Beach County Agricultural Reserve Reservoir and Aquifer Storage and Recovery	$124,099,000	2004	8/09-8/13
K;GGG[1,2]	9.1.8.2	Water Preserve Area / L-8 Basin	$415,182,000	2006	9/07-9/14
M Phase 2	9.1.8.11	Site 1 Aquifer Storage and Recovery	$92,844,000	2006	10/10-10/14
FFF;OPE[1]	9.1.8.23	Biscayne Bay Coastal Wetlands	$299,583,000	2006	5/12-5/18
DDD	9.1.3.2	Caloosahatchee Backpumping with Stormwater Treatment	$82,895,000	2008	9/11-9/15
GG	9.1.2.1	Lake Okeechobee Aquifer Storage and Recovery	$1,097,312,000	2008	7/10-6/20
G Phase 2	9.1.5.1	Everglades Agricultural Storage Phase 2	$203,240,000	2010	7/12-12/15
A	9.1.1.1	North of Lake Okeechobee Storage Reservoir	$284,854,000	2010	9/11-9/15
QQ Phase 2	9.1.7.2	Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement	$59,204,000	2012	1/15-1/19
S; EEE[1]	9.1.8.17	Central Lake Belt Storage Area	$489,861,000	2012	2/15-12/36
XX	9.1.8.15	North Lakebelt Storage Area	$516,061,000	2012	2/16-6/36
YY; ZZ[1]	9.1.8.16	Diverting Water Conservation Area 2 and 3 Flows to Central Lake Belt Storage	$79,657,000	2012	2/14-2/18
HHH	9.1.8.22	West Miami –Dade County Reuse	$437,237,000	2014	6/16-6/20
BBB	9.1.8.24	South Miami-Dade County Reuse	$363,024,000	2014	6/16-6/20
		TOTAL	$6,211,396,000		

[1] For determining projects for future WRDA authorizations, certain components were combined to form functional component packages for construction features that were clearly dependent
[2] The reservoir in component GGG may be implemented under a previous authorization

10.5.4.1. Implementation of Projects in Future WRDAs

The implementation of these components would require congressional authorization before construction could commence. Hence, implementation of these components would utilize the process depicted in ***Figure 10-10***. Based on the current scheduling, there are occasions when more than one Project Implementation Report will be completed and ready to be submitted to Congress for construction authorization. In this case, multiple components may be packaged together in a Project Implementation Report for a single decision document.

FIGURE 10-10
PROCESS FOR COMPONENTS TO BE AUTHORIZED IN FUTURE WRDAs



10.5.5. Components Not Needing Congressional Authorizations

There are several components that do not require additional congressional action to implement. These components are integral to the overall success of the project, but for various reasons (covered under a separate authorization, locally implemented program, etc.) will not require congressional action prior to design and implementation. A list of these components is provided in ***Table 10-6***.

TABLE 10-6
PROJECTS NOT REQUIRING CONGRESSIONAL ACTION

Item	Report Section	Project	Explanation
F	9.2.1.1	Lake Okeechobee Regulation Schedule	Operational change only; implement when appropriate as other facilities come on line
E	9.2.2.1	Environmental Water Supply Deliveries to the Caloosahatchee Estuary	Operational change only; implement when appropriate as other facilities come on line
C	9.2.3.1	Environmental Water Supply Deliveries to the St. Lucie Estuary	Operational change only; implement when appropriate as other facilities come on line
H	9.2.4.1	Everglades Rain Driven Operations	Operational change only; implement when appropriate as other facilities come on line
L	9.2.5.1	Change Coastal Wellfield Operations	Operational change only
DD	9.2.4.2	Modified Holey Land Wildlife Management Area Operation Plan	Implement under existing state process
EE	9.2.4.3	Modified Rotenberger Wildlife Management Area Operation Plan	Implement under existing state process
AAA	9.2.5.2	Lower East Coast Utility Water Conservation	Implement under existing state process
OO	9.2.5.3	Operational Modifications to Southern Portion of L-31N and C-111	Operational change only; implement as part of C-111 Project

10.5.6. Feasibility Studies

Three new feasibility studies – the Florida Bay and the Florida Keys Feasibility Study, Southwest Florida Feasibility Study, and Comprehensive Integrated Water Quality Plan have been identified for initiation. These studies will be conducted under the authority of the Water Resources Development Act of 1996 that allows for the continuation of studies and analyses that are necessary to further the Comprehensive Plan. For a description of these studies, refer to ***Section 9.7***.

10.6. RECOMMENDED FEATURES FOR INITIAL AUTHORIZATION

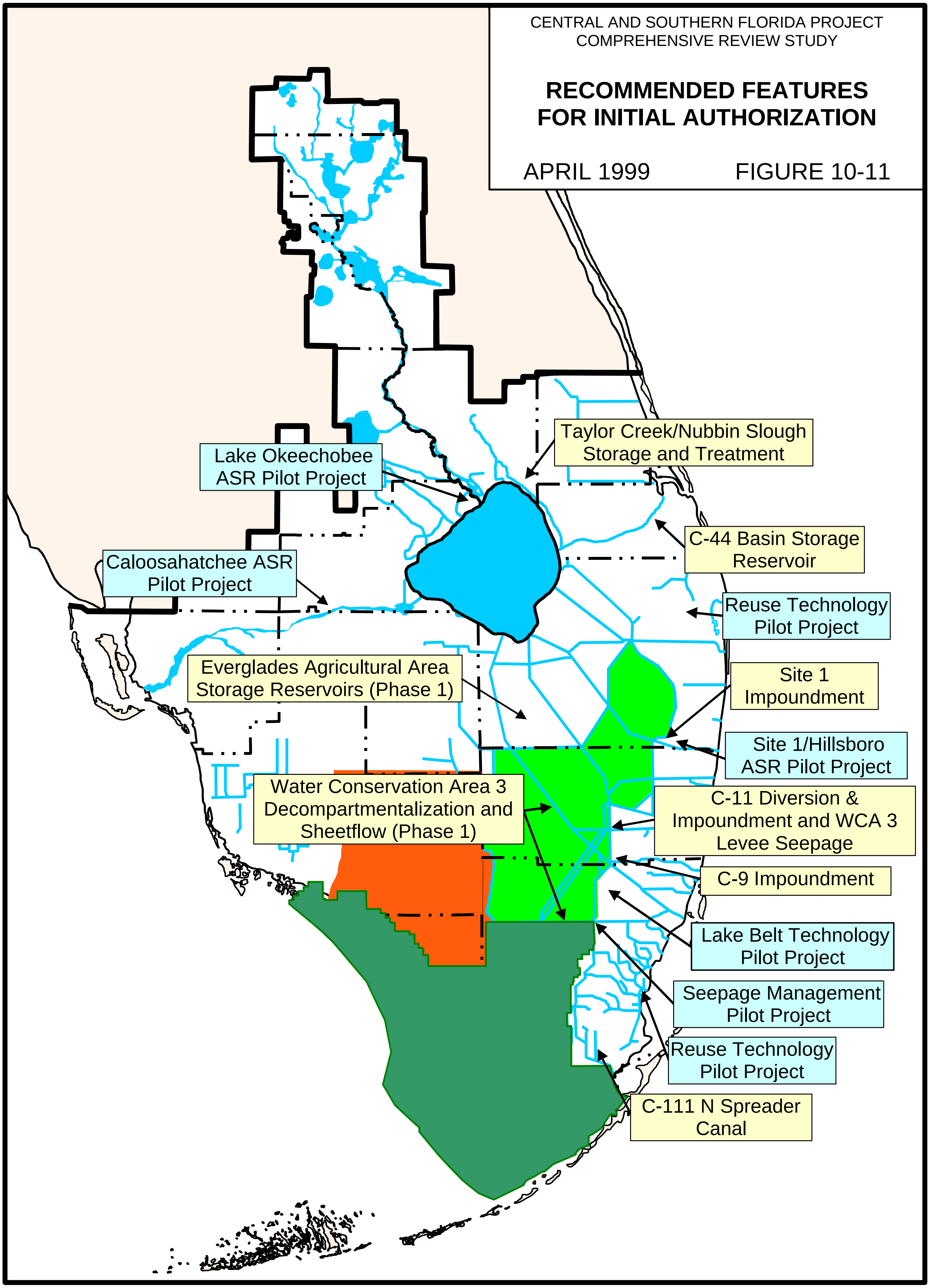
The features of the Comprehensive Plan which are recommended for initial authorization include those projects that are necessary to expedite ecological restoration of the south Florida ecosystems. Implementing these features will ensure maximum integration with ongoing Federal, State, and local ecological restoration and water quality improvement programs. The features, which are shown in ***Figure 10-11***, consist of pilot projects, initial construction features and an adaptive assessment and monitoring program. This section describes the projects recommended for initial authorization.

Subsequent to Comprehensive Plan, advanced planning and engineering design will be accomplished for each of the major features included in this recommendation. These studies will be conducted over the next few years and will result in Project Implementation Reports as previously described. These reports will document advance planning, engineering design, real estate analyses, and supplemental National Environmental Policy Act documents associated with the construction and operation of these features.

10.6.1. Pilot Projects

Pilot projects are needed to address uncertainties associated with some of the physical features that are proposed in the Comprehensive Plan. To ensure that the Comprehensive Plan is implemented in a timely manner, it is necessary to expedite the pilot projects to resolve issues before further detailed design of these facilities can be initiated. The design and analysis of the pilot projects will be coordinated through the multi-agency RECOVER Team. These pilot projects are designed to determine the feasibility, as well as optimum design, of the features prior to embarking on the full-scale development of these features. These projects include:

- Aquifer Storage and Recovery in each geographic region that the technology is proposed,
- In-ground Reservoir technology in the Lake Belt region of Miami-Dade County,
- Levee Seepage Management technology adjacent to Everglades National Park, and
- Advanced Wastewater Treatment technology to determine the feasibility of using reuse water for ecologic restoration.


CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY
RECOMMENDED FEATURES FOR INITIAL AUTHORIZATION
APRIL 1999
FIGURE 10-11
Taylor Creek/Nubbin Slough Storage and Treatment
Lake Okeechobee ASR Pilot Project
C-44 Basin Storage Reservoir
Caloosahatchee ASR Pilot Project
Reuse Technology Pilot Project
Site 1 Impoundment
Everglades Agricultural Area Storage Reservoirs (Phase 1)
Site 1/Hillsboro ASR Pilot Project
Water Conservation Area 3 Decompartmentalization and Sheetflow (Phase 1)
C-11 Diversion & Impoundment and WCA 3 Levee Seepage
C-9 Impoundment
Lake Belt Technology Pilot Project
Seepage Management Pilot Project
Reuse Technology Pilot Project
C-111 N Spreader Canal

10.6.1.1. Aquifer Storage and Recovery Pilot Projects

Aquifer Storage and Recovery is a major element in several components of the Comprehensive Plan. Due to the difference in the geomorphology and the potential for different raw water sources (i.e., surficial ground water or surface water), multiple aquifer storage and recovery pilot projects are proposed. These aquifer storage and recovery pilot projects are necessary to identify the most suitable sites for the aquifer storage and recovery wells in three areas:

- Adjacent to Lake Okeechobee
- Caloosahatchee River Basin
- the Lower East Coast area adjacent to the Site 1 and the Hillsboro Canal

In December 1998, an Aquifer Storage and Recovery Issue Team was formed by the South Florida Ecosystem Restoration Working Group to develop an action plan and identify projects to address the surface water, hydrogeological and geochemical uncertainties associated with regional aquifer storage and recovery facilities (SFERWG, 1998a). This report will serve as the basis for developing the aquifer storage and recovery pilot projects which will determine the specific water quality characteristics of waters to be injected and the water quality characteristics of the receiving aquifer. In addition, the pilot projects will provide information on the hydrogeological and geotechnical characteristics of the upper Floridan Aquifer System within the regions, and the ability of the upper Floridan Aquifer System to store injected water for future recovery.

10.6.1.2. In-Ground Reservoir Technology Pilot Project

Several components use areas where lime rock mining will have occurred (see ***Sections 9.1.8.2, 9.1.8.15 and 9.1.8.17***). The initial design of these reservoirs includes subterranean seepage barriers around their perimeter in order to enable drawdown during dry periods, prevent seepage losses and prevent water quality impacts due to transmissivity of the aquifer in these areas.

The In-ground Reservoir Technology Pilot Project is required to determine construction technologies, storage efficiencies, impacts on local hydrology and water quality effects. Water quality assessments will include a determination as to whether the in-ground reservoirs and seepage barriers will allow for storage of untreated waters without concerns of ground water contamination.

10.6.1.3. L-31N Seepage Management Pilot Project

Hydrologic modeling results have shown that controlling seepage from the Everglades produces desirable hydrologic conditions within the Everglades. However, the proposed technologies to control the seepage may have unintended consequences that must be investigated before full-scale implementation of the proposed project features. These features included reducing levee seepage flow across L-31N adjacent to Everglades National Park via a levee cutoff wall (see ***Section 9.1.8.21***). This feature was designed to reduce groundwater flows during the wet season by capturing groundwater flows with a series of ground water wells adjacent to L-31N, then backpumping those flows to Everglades National Park.

The purpose of the L-31N Seepage Management Technologies Pilot Project is to investigate seepage management technologies technology to control seepage from Everglades National Park. The pilot project will provide necessary information to determine the appropriate amount of wet season groundwater flow to return to the Park while minimizing potential impacts to Miami-Dade County's West Wellfield and freshwater flows to Biscayne Bay.

10.6.1.4. Wastewater Reuse Technology Pilot Project

The Comprehensive Plan includes two advance wastewater treatment facilities (see ***Sections 9.1.8.22 and 9.1.8.24***) to increase the quantity of water available for ecological restoration. However, the high cost and the issues concerning the quality of the water must be further investigated through a pilot project.

This pilot project will address water quality issues associated with discharging reclaimed water into natural areas such as the West Palm Beach's Catchment Area, Biscayne National Park, and the Bird Drive Basin, as well as determine the level of superior treatment and the appropriate methodologies for that treatment. A series of studies will be conducted to help determine the level of treatment needed. In addition, a small advanced wastewater treatment facility that was previously included as a Critical Project will be constructed to treat wastewater that is presently disposed by deep well injection from the East Central Regional Wastewater Treatment Facility. This treatment will be accomplished by using advanced and superior wastewater treatment processes to remove nitrogen and phosphorus. After treatment the wastewater will be used to restore 1,500 acres of wetlands and to recharge wetlands surrounding the City of West Palm Beach's wellfield. A portion of the treated wastewater will be used to recharge a residential lake system surrounding the City's wellfield and a Palm Beach County wellfield.

Besides serving as a pilot project, this project will reduce the City's dependence on surface water from Lake Okeechobee during dry or drought events. In addition, approximately 2,000 acres of wetlands would be created or restored. Other benefits include aquifer recharge and replenishment, reduction of water disposed in deep injection wells and a reduction of stormwater discharge to tide.

10.6.1.5. Pilot Project Costs

The total estimated cost of the Pilot Projects is $97,000,000, at October 1999 price levels. These costs include $9,411,000 for planning, engineering and design; $9,800,000 for real estate; and $77,789,000 for construction and associated monitoring. ***Table 10-7*** displays the total cost for the proposed pilot projects. The long-term operation cost of the pilot projects are accounted for in the operation and maintenance cost of the full-scale project feature.

10.6.2. Initial Features for Authorization

This section identifies the major features recommended for initial authorization including location, the need for early authorization, the project description, the benefits of these features, the costs of each feature and the need for additional studies as needed.

10.6.2.1. C-44 Basin Storage Reservoir

This feature is located in the Upper East Coast region of south Florida in southern Martin County and is shown in ***Figure 10-12***. The storage reservoir will be constructed in close proximity to the C-44 Canal within the C-44 Basin. The exact location of the reservoir has not been identified at this time. The location will be determined during detailed design as a result of recommendations of the Indian River Lagoon Feasibility Study.

This feature is included in the initial authorization for a number of reasons. Preliminary analyses has shown that the majority of the Restudy benefits to the natural areas will not be realized until most of the major storage features, such as reservoirs like this, are in place. Early authorization of this component is expected to provide significant regional water quality benefits, specifically to the St. Lucie River and Estuary and the Indian River Lagoon, in the form of nutrient reduction. In addition, early authorization will provide the opportunity to moderate damaging releases to St. Lucie estuary from Lake Okeechobee and the surrounding basin as soon as possible. The Indian River Lagoon and the St. Lucie Estuary experienced significant impact as a result of releases made from the lake during the spring of 1998. In addition, Martin County has shown strong support for the Restudy passing a resolution in late 1998 to generate a funding source for land acquisition for environmental restoration in the county.

This feature includes an above ground reservoir with a total storage capacity of approximately 40,000 acre-feet located in the C-44 Basin in Martin County. The initial design of the reservoir assumes 10,000 acres with the water levels fluctuating up to 4 feet above grade. The final location, size, depth and configuration of this facility will be determined through more detailed analysis to be completed as a part of the ongoing Indian River Lagoon Feasibility Study.

The purpose of the feature is to capture local runoff from the C-44 Basin, then return the stored water to the C-44 Canal when there is a water supply demand. The reservoir will be designed for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.

During the wet season, this large storage component will aid in the prevention of damaging regulatory releases to the estuary while reducing basin flooding by capturing and storing excess stormwater runoff. Subsequently, during the dry season, water supply, including environmental water supply to the estuary, will be enhanced, as stored water is metered out to the system as needed. Inflows to the storage facility include local basin runoff and releases from Lake Okeechobee when the lake stage is greater than 14.5 feet NGVD. The initial design includes inflow pump capacity of 1,000 cfs and outflow structure capacity of 800 cfs. This feature is currently scheduled for construction initiation in June 2004 with completion in June 2007.

Regulatory releases were made from Lake Okeechobee through the C-44 Canal from December 1997 until late April 1998. These regulatory releases ranged from 2,500 cfs to 7,000 cfs for most of the duration. The St. Lucie River and Estuary and the Indian River Lagoon experienced reduced salinity concentrations outside the range of the established minimums for a healthy ecosystem. During this release event, approximately 33 species of lesioned fish were discovered by local fisherman, 450 individual lesioned fish were sent to the Florida Marine Research Institute for analysis, local citizens became concerned for human health related to water quality in surrounding waters, and in addition, silting of the offshore reef system was discovered. The actual cause of the epidemic of lesioned fish is still unknown, but scientists are working from the theory that the heavy freshwater discharges and the associated water quality are connected (SFERWG, 1998).

By capturing excess stormwater runoff and storing it, harmful wet season regulatory releases will be reduced, protecting oysters, seagrasses and other estuarine organisms. Water quality benefits include protecting the estuary from excessive freshwater pulses that drastically reduce salinities, and protecting the estuary from the nutrients inherent in stormwater runoff. Controlled releases of the stored water during the dry season will protect the estuary from high salinities during the dry season as well. These freshwater deliveries to the St. Lucie Estuary will protect and restore more natural estuarine conditions. The stored water will also be returned to the C-44 Canal when needed to meet agricultural water supply demands.

Minimum and maximum flows were identified which would cause poor water quality conditions for the estuary. This feature, in combination with component UU (storage features in the C-23, C-24, C-25, Northfork and Southfork Basins) and modifications to the Lake Okeechobee operation schedule, will require development of a series of operational rules for all associated facilities. These rules will help to maintain optimal salinity conditions in the estuary in order to support a range of aquatic vegetation, seagrass, invertebrates, and fish communities.

There are other ongoing efforts in the areas affected by this feature of the Comprehensive Plan. They are the South Florida Water Management District's Upper East Coast Water Supply Plan, the Indian River Lagoon Surface Water Improvement and Management Plan and the Indian River Lagoon Feasibility Study.

The total initial cost for construction of the C-44 Basin Storage Reservoir is $112,563,000 at October 1999 price levels. This includes planning costs of $902,000, engineering and design costs of $602,000, real estate costs of $90,675,000 and construction costs of $20,384,000. The annual operations, maintenance, repair, replacement and rehabilitation costs are $760,000. The real estate land requirement for the C-44 Basin Storage Reservoir is estimated at 10,000 acres in Martin county.

Operation and maintenance costs for the C-44 Reservoir are based upon the following: levee mowing on a regular basis; routine maintenance and equipment replacement based upon an annual investment for control structures; canal maintenance that includes removal of floating and submerged vegetation plus shoreline spraying; and maintenance, operation and replacement costs for an unmanned electric inflow pump station and seepage pumps.

10.6.2.2. Everglades Agricultural Area Storage Reservoirs Phase-1

This feature is located on lands in the Everglades Agricultural Area in western Palm Beach County on lands being purchased with Department of Interior Farm Bill funds, with South Florida Water Management District funds, and through a series of exchanges for lands being purchased with these funds. The location of the Phase 1 lands, which includes both the Talisman Land purchase (including exchanges) and the Carroll Property, are shown in ***Figure 10-13.*** The area presently consists of land that is mostly under sugar cane cultivation. This feature will be implemented consistent with the Farm Bill land acquisition agreements.

This feature is included in the initial authorization for three reasons: 1) lands needed for the project have been or will be acquired by the U.S. Department of Interior and the South Florida Water Management District, 2) it provides the opportunity to construct the facility in a manner that is mutually beneficial for the Comprehensive Plan and the sponsor's Everglades Construction Project, 3) expedites construction of this facility which provides multiple environmental, water supply, and flood protection benefits. This feature will improve timing of environmental deliveries to the Water Conservation Areas including reducing damaging flood releases from the Everglades Agricultural Area to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands, and increase flood protection within the Everglades Agricultural Area.

This feature includes above ground reservoir(s) with a total storage capacity of approximately 240,000 acre-feet located on land associated with the Talisman Land purchase in the Everglades Agricultural Area. Conveyance capacity increases for the Miami, North New River, Bolles and Cross Canals are also included in the design of this feature. The initial design for the reservoir(s) assumed 40,000 acres, divided into two, equally sized compartments with the water level fluctuating up to 6 feet above grade in each compartment. As originally envisioned, Compartment 1 would be a 20,000-acre reservoir at 6 feet maximum depth with inflow pumps with a capacity of 2,700 cfs from the Miami Canal Basin and 2,300 cfs from the North New River Canal Basin for diversion of Everglades Agricultural Area runoff. Outflow to the Everglades Agricultural Area would be through a 3,000 cfs structure to Miami Canal Basin and a 4,400 cfs structure to North New River and Hillsboro Basins. Compartment 2 would be a 20,000-acre reservoir at 6 feet maximum depth with inflow pumps with a capacity of 4,500 cfs from the Miami Canal Basin and 3,000 cfs from the North New River Canal Basin for diversion of Lake Okeechobee regulatory releases. Outflow to the Everglades Construction Project's Stormwater Treatment Areas 3 and 4 would be through a 3,600 cubic foot per second structure. Canal conveyance capacities would be increased by 200 percent for the Miami, North New River and Bolles and Cross Canal in order to direct Lake Okeechobee regulatory releases to the reservoir. The Project Implementation Report for the project will address the specific location and sizing of the facility as well as more site-specific design of levees and pump stations. In addition, the extent of conveyance improvements for the North New River Canal, the Miami Canal, and the Bolles and Cross Canal will be identified.

As originally designed, Compartment 1 of the reservoir would be used to meet Everglades Agricultural Area irrigation demands. The source of water is excess Everglades Agricultural Area runoff. Overflows to Compartment 2 could occur when Compartment 1 reaches capacity and Lake Okeechobee regulatory discharges are not occurring or impending. Compartment 2 would be used to meet environmental demands as a priority, but could supply a portion of Everglades Agricultural Area irrigation demands if environmental demands equal zero. Flows will be delivered to the Water Conservation Areas through Stormwater Treatment Areas 3 and 4. The sources of water are overflow from Compartment 1 and Lake Okeechobee regulatory releases. Compartment 2 will be operated as a dry storage reservoir and discharges made down to 18 inches below ground level.

Operation and maintenance costs are based upon levee mowing on a regular basis; control structure maintenance and annualized equipment replacement; canal maintenance including removal of floating and submerged vegetation and shoreline spraying; unmanned seepage control pump maintenance, power and annualized equipment replacement; and manned diesel pump station maintenance and operation costs including direct labor, fuel and power, annualized equipment replacement and overhaul and structural maintenance and repair.

The benefits to the project derived from this feature include improved storage and conveyance features that will enhance the water supply to the natural areas and support better timing of water deliveries to the Water Conservation Areas by capturing and managing flood releases from the Everglades Agricultural Area to the Water Conservation Areas. This component will reduce the need to make damaging regulatory releases from Lake Okeechobee to the St. Lucie and Caloosahatchee estuaries and will help meet Everglades Agricultural Area irrigation needs while increasing flood protection in the area.

The total initial cost for this feature is $233,408,000, which includes planning costs of $9,621,000, engineering and design costs of $6,414,000, no real estate costs and construction costs of $217,373,000. No real estate costs are included in the initial cost for this feature, as the land being purchased with Department of Interior Farm Bill funds, with South Florida Water Management District funds, and through a series of exchanges for lands being purchased with these funds. Cost sharing allocations between the Federal government and the South Florida Water Management District for this will be determined during the Project Implementation Report. The annual operation costs are $14,458,000.

10.6.2.3. Water Conservation Area 3 Decompartmentalization and Sheetflow Phase - 1

These project modifications will occur within the Water Conservation Areas and Everglades National Park in Broward and Miami-Dade Counties and is shown in ***Figure 10-14***.

This project is included in the initial authorization for two reasons; 1) to provide immediate opportunities for enhanced sheetflow within Water Conservation Area 3 and between Water Conservation Area 3 and Everglades National Park and 2) to integrate with ongoing modifications that are being made in the detailed design and construction of the Modified Water Deliveries to Everglades National Park project.

This project as originally envisioned includes backfilling the Miami Canal in Water Conservation Area 3 from one to two miles south of the S-8 pump station down to east coast protective levee. To make up for the loss of water supply conveyance to the Lower East Coast urban areas from the Miami Canal, the capacity of the North New River Canal south of the proposed Everglades

Agricultural Area Storage Reservoir will be doubled to convey additional water supply deliveries to Miami-Dade County as necessary. The capacities of S-351 and S-150 to pass additional water supply deliveries down the North New River Canal to Miami-Dade County will be doubled. In addition, the conveyance of the L-33 and L-37 borrow canals on the west side of US 27 between L-38W and the Miami Canal will be increased as necessary to pass the additional flows. Modifications will also be made to the eastern section of Tamiami Trail which includes elevating the roadway through the installation of a series of bridges between L-31N Levee and the L-67 Levees. The eastern portion of L-29 Levee and Canal will also be degraded in the same area as Tamiami Trail modifications. The Project Implementation Report will address the scope and method to be used for Miami Canal backfilling, conveyance improvements to the North New River Canal and, the bridging of Tamiami Trail, and L-29 modifications that are necessary to enable unrestricted flow from Water Conservation Area 3 into Everglades National Park. The sequencing of these modifications will also be addressed in the Project Implementation Report. These project modifications will be coordinated with the existing Modified Water Deliveries to Everglades National Park Project as well as the development of rainfall driven operational schedules for Water Conservation Area 3 and Everglades National Park.

The modifications described above will provide the initial increment of more integrated passive management of Water Conservation Area 3 and Everglades National Park. It is anticipated that these modifications will be made in association with the implementation of rainfall driven operational schedules for both Water Conservation Area 3 and Everglades National Park.

Operation and maintenance costs are based upon control structure maintenance and annualized equipment replacement and canal maintenance including removal of floating and submerged vegetation.

The benefits to the project from this feature are that restoring sheet flow will reduce the unnatural discontinuities in the landscape. Depth patterns will be more gradual, aquatic organisms will be able to move more freely, exotic species will not have the advantage of deep water canals that provide thermal refuge or dry levees on which to grow. Normal proportions of predators/prey species in fish populations will be undisturbed. Natural interspersions of different marsh habitats will replace the current system of upstream pools and downstream dry area on either side of barriers. The result will be better quality and more easily accessible habitat for wading birds and other Everglades species.

The total initial cost for this feature is $104,033,000, which includes planning costs of $3,205,000, engineering and design costs of $2,137,000, real estate costs of $26,279,000 and construction costs of $72,412,000. The annual operation costs are $650,000.

10.6.2.4. Site 1 Impoundment

This feature is located in southern Palm Beach County adjacent to the Hillsboro Canal and Loxahatchee National Wildlife Refuge and Water Conservation Area 2A and is shown in ***Figure 10-15.***

This feature is included in the initial authorization for several reasons: 1) a large portion of the lands required for the feature have already been acquired by the sponsor, 2) benefits to the ecosystem will be gained from this feature by capturing water that is normally sent to tide and returning it to the system early in the process, and 3) uncertainty in constructing this feature is minimized by postponing the construction of the aquifer storage and recovery portion until after the pilot project for this site is completed. The purpose of this feature is to supplement water deliveries to the Hillsboro Canal during dry periods thereby reducing demands on Lake Okeechobee and Loxahatchee National Wildlife Refuge.

This feature includes an above ground reservoir with a total storage capacity of approximately 15,000 acre-feet. The initial design of the reservoir assumed 2,460 acres with water levels fluctuating up to 6 feet above grade. An inflow pump station with a capacity of 700 cfs, an outflow structure with a capacity of 200 cfs and an emergency outflow structure with a capacity of 700 cfs are proposed. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

The reservoir will be filled during the wet-season from excess water pumped from the Hillsboro Canal. Water will be released back to the Hillsboro Canal to help maintain canal stages during the dry-season. If water is not available in the reservoir, existing rules for water delivery to this region will be applied.

Operation and maintenance costs are based upon levee mowing on a regular basis; control structure maintenance and annualized equipment replacement; canal maintenance including removal of floating and submerged vegetation; shoreline spraying; unmanned pump station and seepage control pump maintenance, power and annualized equipment replacement.

The benefits to the project will be a reduction in demands on the Loxahatchee National Wildlife Refuge and Lake Okeechobee during the early dry season as well as a reduction in the amount of water discharged to tide. By reducing the demands on Lake Okeechobee the littoral zone of the Lake and the marshes in the Refuge will suffer fewer damaging low levels.

There are additional studies planned for this site. They include a small ongoing reservoir pilot project performed by the South Florida Water Management

District and as part of this initial authorization, a pilot project for aquifer storage and recovery to address the uncertainty regarding applying the technology at this feature location.

The total initial cost for this feature is $38,535,000, which includes planning costs of $616,000, engineering and design costs of $411,000, real estate costs of $23,587,000 and construction costs of $13,921,000. The annual operation costs are $733,000.

10.6.2.5. Western C-11 Diversion Impoundment and Canal and Water Conservation Areas 3A and 3B Levee Seepage Management

This feature is located in western Broward County east of Water Conservation Area 3A and 3B and is shown in ***Figure 10-16***. The diversion canal is located west of US-27 between C-11 and C-9 Canals. The C-11 stormwater treatment area/impoundment is located northeast of the intersection of U.S. Highway 27 and C-11 Canal.

Initial authorization is necessary due to the existing operation of the S-9 pump station. The original C&SF Project design provides for Western C-11 Basin drainage to be pumped into Water Conservation Area 3. This feature will provide the necessary facilities to maintain flood protection within the basin, while reducing flows through the S-9 to Water Conservation Area 3. Other factors supporting initial authorization include: 1) lands were identified as suitable by both the East Coast Buffer Feasibility Analysis and the Water Preserve Areas Land Suitability Analysis; 2) lands are being actively acquired by sponsor; 3) this feature is consistent with ongoing programs such as the Water Preserve Areas Feasibility Study and the Everglades Stormwater Program; and 4) acquisition and utilization of land which is suitable for storage and water quality treatment are rapidly being lost to urbanization.

This feature includes canals, levees, water control structures, and a stormwater treatment area/impoundment with a total storage capacity of 6,400 acre-feet. The initial design of the stormwater treatment area/impoundment assumed 1,600 acres with the water level fluctuating up to 4 feet above grade. The initial design of the diversion canal west of U.S. Highway 27 is for a conveyance capacity of 2,500 cfs. A 2,500 cfs conveyance capacity improvement is envisioned to the C-9 canal between S-30 and the C-9 Impoundment. An intermediate 2,500 cfs pump station in the C-11 canal will be used to direct runoff to the C-11 stormwater treatment area/impoundment. A seepage collection canal and inflow pump station will also be used on the C-11 stormwater treatment area/impoundment. A 2,200 cfs outflow structure is envisioned to discharge from the impoundment to C-11 west of U.S. 27 to the diversion canal. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

Runoff in the western C-11 Canal Basin that was previously backpumped into Water Conservation Area 3A through the S-9 pump station will be diverted into the C-11 Stormwater Treatment Area/Impoundment and then into either the North Lake Belt Storage Area, the C-9 Stormwater Treatment Area/Impoundment, or Water Conservation Area 3A after treatment, as applicable.

Operation and maintenance costs are based upon regular mowing of levee surfaces; control structure maintenance and annualized equipment replacement; manned diesel pump station maintenance and operation costs including direct labor, fuel and power, annualized equipment replacement and overhaul, structural maintenance and repair; canal maintenance including removal of floating and submerged vegetation; and shoreline spraying.

The benefit to the project from this feature is that Water Conservation Area 3A water quality will improve when the poor quality runoff from the western C-11 Canal basin is no longer being backpumped into it through the S-9 pump station. This component diverts that water into the C-11 Stormwater Treatment Area/Impoundment where it then becomes available for either the C-9 Stormwater Treatment Area/Impoundment, the North Lake Belt Storage Area after it is operational or Water Conservation Area 3A after treatment, as applicable. In addition, this feature will help control seepage from Water Conservation Areas 3A and 3B by increasing groundwater elevations directly east of the east coast protective levee.

The C-11 Critical Project is currently under construction at this site and is fully compatible with this feature.

The total initial cost for this feature is $225,172,000, which includes planning costs of $2,371,000, engineering and design costs of $1,581,000, real estate costs of $167,646,000 and construction costs of $53,574,000. The annual operation costs are $783,000.

10.6.2.6. C-9 Stormwater Treatment Area/Impoundment

This feature is located in the western C-9 Basin in Broward County and is shown in ***Figure 10-17***.

This feature is included in the initial authorization due to its interaction with the C-11 Stormwater Treatment Area and Impoundment. Other factors supporting initial authorization of this feature include: 1) lands were identified as suitable by both the East Coast Buffer Feasibility Analysis and the Water Preserve Areas Land Suitability Analysis; 2) lands are being actively acquired by sponsor; 3) this feature is consistent with ongoing programs such as the Water Preserve Areas Feasibility Study and the Everglades Stormwater Program; and 4) acquisition and utilization of land which is suitable for storage and water quality treatment are rapidly being lost to urbanization; 5) this area is necessary for diversion of C-11 Basin flows prior to the completion of the North Lake Belt Storage Area which is later in the implementation schedule; 6) improved flood protection in the Western C-9 Basin.

This feature includes canals, levees, water control structures and a stormwater treatment area/impoundment with a total capacity of approximately 10,000 acre-feet. The initial design of the stormwater treatment area/impoundment assumed 2,500 acres with the water level fluctuating up to 4 feet above grade. An inflow pump station with a capacity of 1,000 cfs and an outflow gravity structure with a capacity of 1,000 cfs are also envisioned for the impoundment. A seepage collection canal and pump station with a capacity of 200 cfs are needed to prevent impact to private adjacent land. The final size, depth and configuration of these facilities will be determined through more detailed planning and design to be completed as a part of the Water Preserve Areas Feasibility Study.

Operationally, excess stormwater runoff from the C-11 Basin and Western C-9 Basin will be pumped into the C-9 Stormwater Treatment Area/Impoundment for storage and water quality treatment prior to making water supply deliveries to the C-9, or C-6/C-7 Canals. Seepage from C-9 Stormwater Treatment Area/Impoundment will be collected and returned to the impoundment.

Operation and maintenance costs are based upon levee mowing on a regular basis; canal maintenance including removal of floating and submerged vegetation and shoreline spraying; unmanned seepage control pump maintenance, power and annualized equipment replacement; and manned diesel pump station maintenance and operation costs including direct labor, fuel and power, annualized equipment replacement and overhaul and structural maintenance and repair.

The benefits from this feature will include enhancing groundwater recharge within the basin, provide seepage control for Water Conservation Area 3 and buffer areas to the west thereby keeping more of the natural system's water in the natural system. In addition flood protection for the western C-9 Basin will be enhanced.

The total initial cost for this feature is $89,146,000, which includes planning costs of $1,080,000, engineering and design costs of $720,000, real estate costs of $62,939,000 and construction costs of $24,407,000. The annual operation costs are $616,000.

10.6.2.7. C-111N Spreader Canal

This feature is located in south Miami-Dade County in the Southern Glades and Model Lands areas as shown in ***Figure 10-18***

This feature is included in the initial authorization for several reasons: 1) early authorization will allow for inclusion into the ongoing detailed design and construction of the C-111 project, and 2) inclusion of a stormwater treatment area to provide water quality treatment of agricultural runoff prior to distributing water through the C-111N spreader canal. This feature will improve deliveries and enhance the connectivity and sheetflow in the Model Lands and Southern Glades areas, reduce wet season flows in C-111, and decrease potential flood risk in the lower south Miami-Dade County area.

This feature includes construction, modification or removal of levees, canals, pumps, water control structures, culverts and a stormwater treatment area. This feature enhances the C-111 Project design for the C-111N Spreader Canal with: the construction of a 3,200 acre stormwater treatment area; the enlarging of pump station S-332E from 50 cfs to 500 cfs; increasing the capacity of C-111N for the higher capacity of flow and the extension of the canal approximately two miles under U.S. Highway 1 and Card Sound Road into the Model Lands; and culverts under U.S. Highway 1 and Card Sound Road. The initial design of this feature pumps water from the C-111 and the C-111E Canals through two 250 cfs pump stations into a stormwater treatment area prior to discharging through S-332E to the Southern Glades and the Model Lands through the C-111N Canal. This feature also fills in the southern reach of the C-111 Canal below C-111N to S-197; removal of structures S-18C and S-197; completely backfilling C-110; and removal of adjacent levees and roads. The final size, depth, location and configuration of this feature will be determined through more detailed planning and design.

Operation and maintenance costs are based upon regular mowing of levee surfaces; canal maintenance including removal of floating and submerged vegetation and shoreline spraying; unmanned seepage control pump maintenance, power and annualized equipment replacement; and unmanned electric pump station maintenance and operation costs including power, annualized equipment replacement and overhaul and structural maintenance and repair.

This feature improves deliveries and enhances the connectivity and sheetflow in the Model Lands and Southern Glades areas, reduces wet season flows in C-111, and decreases potential flood risk in the lower south Miami-Dade County area while improving the quality of water discharged into the Model Lands and Southern Glades areas.

The total initial cost for this feature is $94,034,000, which includes planning costs of $1,990,000, engineering and design costs of $1,326,000, real estate costs of $45,766,000 and construction costs of $44,952,000. The annual operation costs are $60,000.

10.6.2.8. Taylor Creek/Nubbin Slough Storage and Treatment Area

This feature is located northeast of Lake Okeechobee in the Taylor Creek/Nubbin Slough (S-191) Basin. This basin is located in Okeechobee, St. Lucie and Martin Counties. An initial site for a portion of the facilities is located near the northeastern shores of Lake Okeechobee and at the base of Nubbin Slough shown in ***Figure 10-19***. The site consists of large areas of improved pasture and hayfields of an existing dairy operation.

This feature is included in the initial authorization for three reasons: 1) a portion of the lands needed for the project have been identified by the sponsor; 2) flows to Lake Okeechobee will be attenuated when lake levels are high or rising and 3) water quality treatment will be provided for flows from the Taylor Creek/Nubbin Slough basin which currently contribute the highest phosphorus inflow concentrations to Lake Okeechobee.

This feature includes an above-ground reservoir with a total storage capacity of approximately 50,000 acre-feet and a stormwater treatment area with a capacity of approximately 20,000 acre-feet in the Taylor Creek/Nubbin Slough Basin. The initial design of this feature assumed a reservoir of 5,000 acres with water levels fluctuating up to 10 feet above grade and a stormwater treatment facility of approximately 5,000 acres. It is anticipated that there will be a series of reservoir and stormwater treatment facilities located throughout the basin. The Project Implementation Report will address the location and sizing of the facilities as well as the design of levees and pump stations for the reservoirs and stormwater treatment areas.

Local runoff from the Taylor Creek/Nubbin Slough Basin will be pumped into the reservoir then into an adjacent stormwater treatment area. The stormwater treatment area will reduce phosphorus concentrations in the runoff from approximately 0.58 mg/l to 0.117 mg/l. Treated water will be pumped into Lake Okeechobee when the lake stage is falling and is at least 0.5 feet below the bottom pulse release zone.

Operation and maintenance costs are based upon levee mowing on a regular basis; canal maintenance including removal of floating and submerged vegetation and shoreline spraying; unmanned seepage control pump maintenance, power and annualized equipment replacement; and manned diesel pump station maintenance and operation including direct labor, fuel and power, annualized equipment replacement and overhaul and structural maintenance and repair.

This feature will benefit the project by protecting Lake Okeechobee from excessive high levels that impact the littoral zone as well help reduce regulatory releases from the lake to the St. Lucie and Caloosahatchee estuaries. Lake Okeechobee will also benefit from receiving the water when lake levels decline, providing protection from damaging low levels. Water quality treatment will reduce the nutrient load on the lake to the benefit of all of the Lake's native organisms including the substantial fishery.

The total initial cost for this feature is $104,026,000, which includes planning costs of $3,064,000, engineering and design costs of $2,042,000, real estate costs of $29,700,000 and construction costs of $69,220,000. The annual operation costs are $2,164,000.

10.6.3. Adaptive Assessment and Construction Monitoring Program

An extensive Adaptive Assessment Program, which includes a system-wide monitoring program will be conducted to support the ecosystem restoration objectives of the Comprehensive Plan as described in ***Section 9.5***. This program will provide an opportunity to continue investigating concepts and issues relative to the overall Comprehensive Plan while implementation of the initial project features are underway. The Adaptive Assessment Program, which will be implemented through the RECOVER Team described in ***Section 10.3.3***, will include continued system-wide evaluation and analysis among other planning activities. The construction and regional monitoring program will have a dual focus on the biological and hydrological restoration objectives in the natural systems, and the water supply and flood protection objectives in the urban and agricultural regions.

This Adaptive Assessment Program for the Comprehensive Plan is still under development. Given the conceptual nature of the Comprehensive Plan and the need to integrate the monitoring program portion with other ongoing efforts, it is difficult to prepare a detailed estimate of its cost at the present time. However, based on other ongoing programs including this feasibility study and other ecologic restoration monitoring programs such as the Kissimmee River Restoration Project, the total estimated annual cost for this program is estimated to be $10,000,000. For Corps of Engineers programming purposes, this cost is assumed to be a "Construction" cost as opposed to Operation and Maintenance cost since it is required to advance the project to completion.

10.6.4. Total Cost for Features Included in this Recommendation

The total cost includes the initial cost of planning, engineering and design, and construction as well the annual operation and maintenance costs of the features recommended for initial authorization.

10.6.4.1. Implementation Cost

The total estimated cost of the initial authorization of the recommended Comprehensive Plan is $1,198,000,000 (rounded) at October 1999 price levels. The cost estimate is shown in ***Table 10-7.*** This estimate is the "base line" estimate, and does not account for future price escalation.

TABLE 10-7
IMPLEMENTATION COST OF INITIAL AUTHORIZATION

Project		IMPLEMENTATION COSTS					Operation & Maintenance
		Planning	Engineering and Design	Real Estate	Construction	Total	
B	C-44 Basin Storage Reservoir	$902,000	$602,000	$90,675,000	$20,384,000	$112,563,000	$760,000
G (Phase 1)	Everglades Agricultural Area Storage Reservoirs – (Phase 1)	$9,621,000	$6,414,000	$0	$217,373,000	$233,408,000	$14,458,000
QQ (Phase 1) and SS	Water Conservation Area 3 Decompartmentalization and Sheetflow (Phase 1)	$3,205,000	$2,137,000	$26,279,000	$72,412,000	$104,033,000	$650,000
M (Phase 1)	Site 1 Impoundment	$616,000	$411,000	$23,587,000	$13,921,000	$38,535,000	$733,000
Q & O	Western C-11 Diversion and Impoundment and WCA 3A & B Levee Seepage Management	$2,371,000	$1,581,000	$167,646,000	$53,574,000	$225,172,000	$783,000
R	C-9 Impoundment/Stormwater Treatment Area	$1,080,000	$720,000	$62,939,000	$24,407,000	$89,146,000	$616,000
WW	C-111N Spreader Canal	$1,990,000	$1,326,000	$45,766,000	$44,952,000	$94,034,000	$60,000
W	Taylor Creek/Nubbin Slough Storage and Treatment Area	$3,064,000	$2,042,000	$29,700,000	$69,220,000	$104,026,000	$2,164,000
	Pilot Projects	$2,225,000	$7,186,000	$9,800,000	$77,789,000	$97,000,000	
	Adaptive Assessment and Monitoring (10 years)	$100,000,000				$100,000,000	
	TOTALS	**$125,074,000**	**$22,419,000**	**$456,392,000**	**$594,032,000**	**$1,197,917,000**	**$20,224,000**

10.6.4.2. Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) Costs

Annual operation and maintenance costs were estimated for the initial construction features of the recommended Comprehensive Plan. The operation and maintenance costs were determined by extrapolating from operational cost histories supplied by the South Florida Water Management District. The costs reflect projected values based on past trends encountered and represent the difference between with versus without the Comprehensive Plan. Replacement costs were calculated for culverts and mechanical and electrical equipment related to pump plants and spillway structures. The OMRR&R costs are estimated to be $20,000,000 (rounded).

10.6.5. Cost Sharing

Table 10-8 contains an apportionment of project costs between the Federal government and the non-Federal sponsor based on the cost sharing provisions described in ***Section 9.9***.

Annual operation and maintenance costs for the initial features will also be shared equally between the Federal Government and the non-Federal sponsor as described in ***Section 9.9.4***. The estimated annual Federal cost is $10,112,000 and the estimated non-Federal cost is $10,112,000.

TABLE 10-8
COST APPORTIONMENT

	Total	Federal	Non-Federal
Construction[1]	$741,525,000	$598,958,500	$142,566,500
Lands, Easements, Rights-of-way	$456,392,000	$0	$456,392,000
Total	$1,197,917,000	$598,958,500	$598,958,500
Rounded	$1,198,000,000	$599,000,000	$599,000,000

[1] Includes Planning; Preconstruction, Engineering and Design; and Construction Management.

10.6.6. Financial Analysis

It is expected that the South Florida Water Management District will have the capability to provide the required local cooperation for the recommended features identified in this Section. The South Florida Water Management District has provided a statement of financial capability which is included in ***Appendix G, Local Cooperation and Financial Analysis.***

10.6.7. Local Cooperation

The project's non-Federal sponsor must provide its share of project costs, including LERRD and cash for construction and later OMRR&R costs, as described above. LERRD are to be furnished to the Federal government prior to the advertisement of any construction contract, which involves those LERRD. In providing LERRD, the sponsor must comply with the provisions of the Uniform Relocations Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646), as amended. Any required cash payments for project construction costs are to be made during construction at a rate proportional to Federal expenditures. The sponsor's share of pre-construction engineering and design costs will be repaid during the first year of construction.

A project may be initiated only after the sponsor has entered into a binding Project Cooperation Agreement with the Department of the Army, which are normally negotiated during the pre-construction engineering and design phase. Project Cooperation Agreements will be developed for each separable project that is implemented. The Project Cooperation Agreement assigns Federal and non-Federal responsibilities, which, for the Comprehensive Plan, will include as a minimum the following items of local cooperation:

a. Provide 50 percent of the total project costs as further specified below:

1. Enter into an agreement, which provides, prior to construction, 25 percent of pre-construction engineering and design (PED) costs;

2. Provide, during construction, any additional funds needed to cover the non-Federal share of pre-construction engineering and design costs;

3. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

4. Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

5. Provide, during construction, any additional costs as necessary to make its total contribution equal to 50 percent of total project costs.

b. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

c. For so long as the project remains authorized assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features, with 50 percent of the funding provided by the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

e. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

i. To the maximum extent possible, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

j. Participate in and comply with applicable flood plain management and flood plain insurance programs in accordance with section 402 of Public Law 99-662, as amended.

k. Not less than once each year, inform affected interests of the limitations of the protection afforded by the project.

l. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain, and in adopting regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project.

m. As between the Federal Government and the non-Federal sponsor, the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

n. Prescribe and enforce regulations to prevent obstruction of or encroachment on the Project that would reduce the level of protection it affords or that would hinder operation or maintenance of the Project.

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

p. Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army.”

q. Provide 50 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to the project that are in excess of one percent of the total amount authorized to be appropriated for the project.

r. Do not use Federal funds to meet the non-Federal sponsor’s share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute.

10.6.8. Sponsor’s Views

As the non-Federal sponsor of this feasibility study, the South Florida Water Management District has worked very closely in partnership with the Corps to ensure that the study and this report fairly and accurately reflected its views. On February 10, 1999, the South Florida Water Management District provided a Letter of Intent, which indicated their strong support for the Comprehensive Plan and the processes described in this report to implement the plan. This included the initial construction features proposed for authorization in the Water Resource Development Act of 2000 as described in this Section. In addition, the Letter of Intent notes that ensuring strong support from the Governor and the State Legislature continues to remain a key goal. The South Florida Water Management District’s letter is included in ***Appendix G, Local Cooperation and Financial Analysis***.

The South Florida Water Management District’s Letter of Intent states that “as the implementation plan crystallizes, several outstanding issues of great importance” to the District and the State of Florida will need to be adequately addressed. These are: (1) capital projects cost share; (2) operation, maintenance and monitoring cost share; (3) permitting of Comprehensive Plan components and projects; (4) assurances to existing legal users; (5) provision of flood protection; (6) impacts on ongoing projects; (7) water quality; and (8) scientific peer review. A more detailed discussion of these issues was developed as an attachment to the Letter of Intent (included in ***Appendix G, Local Cooperation and Financial Analysis***).

10.7. CONCLUSION

The Comprehensive Plan recommended in this report is a roadmap that provides critical direction and organizational structure for restoring and protecting the south Florida ecosystem. The comprehensive, system-wide nature of the plan and the linkage of the elements of the plan to each other must be preserved during implementation. Implementation of the plan must proceed using the principles of adaptive assessment as outlined in this Implementation Plan. Appropriate independent scientific peer review is an integral part of the implementation process. This Implementation Plan recognizes fully the need to ensure that once restored, south Florida's natural environment will not again be negatively impacted by water management activities. Consistent with Federal and State law, the requirement to protect existing legal users of water from adverse impacts caused by implementation of the Comprehensive Plan is recognized.

The Comprehensive Plan incorporates a number of technologies such as aquifer storage and recovery, seepage management, and wastewater reuse that have not been implemented on such a large scale. The pilot projects, as described in the Implementation Plan, should be undertaken in order to resolve uncertainties associated with the use of these technologies in the Comprehensive Plan and that their performance be evaluated before full-scale implementation of these technologies is undertaken.

The aquifer storage and recovery wells fall under the provisions of the Safe Drinking Water Act and are regulated by the Underground Injection Control Program. As a result, facilities utilized for treating surface and surficial waters to meet the standards of the Underground Injection Control Program are included in the cost estimate for the Comprehensive Plan. Recently, the U. S. Environmental Protection Agency has indicated their willingness to consider a flexible approach to constructing and permitting the aquifer storage and recovery wells proposed in the Restudy. This approach involves "risk-based" analyses to confirm that this flexible approach is appropriate. If the results of water quality testing and analyses conducted as part of the aquifer storage and recovery pilot projects confirm the appropriateness of this approach, then it is possible that the total cost of the recommended comprehensive plan could be reduced by $500,000,000 and annual operation and maintenance costs could be reduced significantly as well.

The Comprehensive Plan includes a wastewater reuse facility in south Miami-Dade County. Given its high cost and the uncertainties associated with using reuse to meet the ecological goals and objectives for Biscayne Bay, other potential sources of water to provide freshwater flows to central and southern Biscayne Bay will be investigated before pursuing the reuse facility.

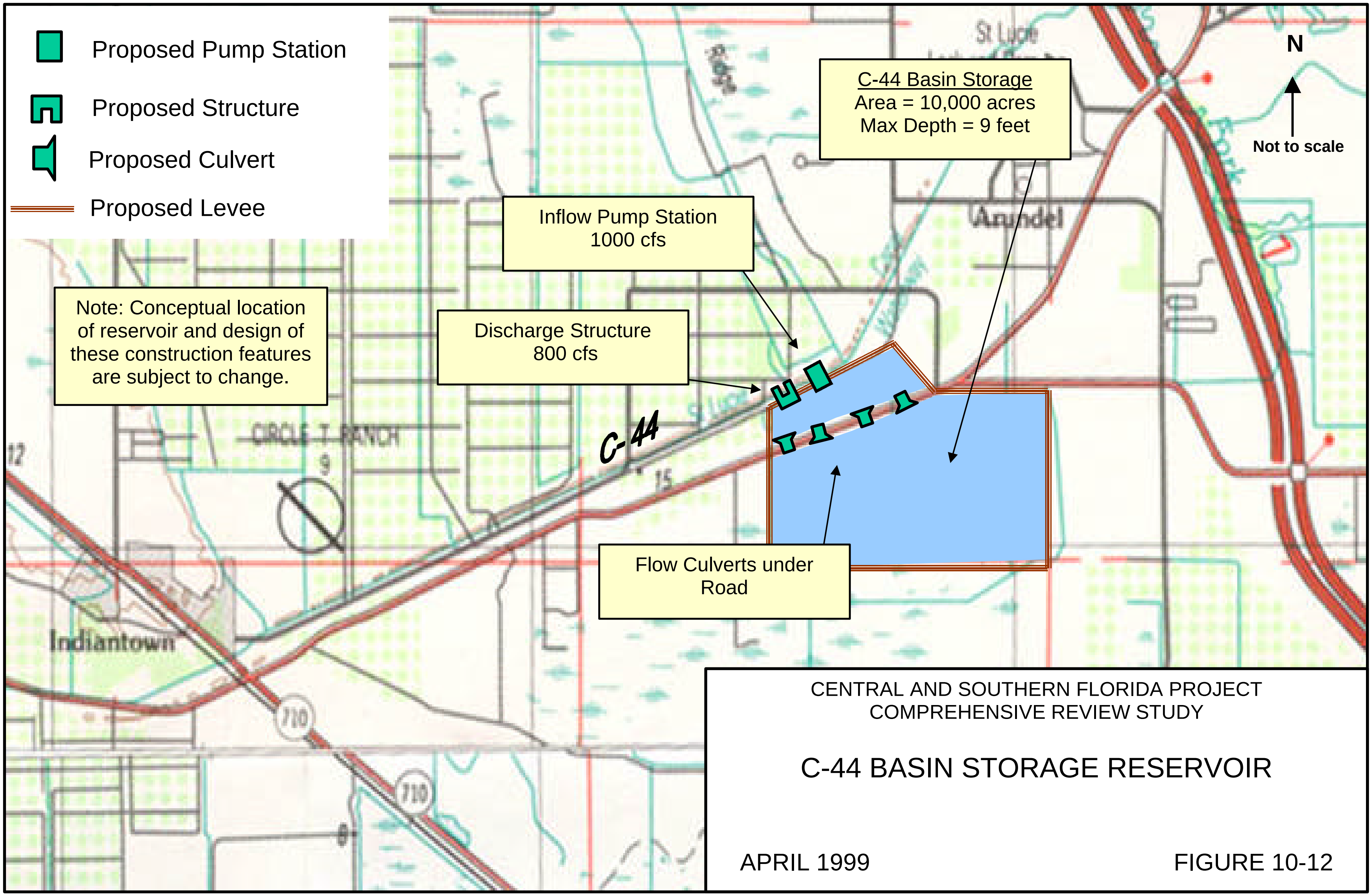
Contingency plans will address performance deficiencies and cost-effectiveness issues that may arise as pilot projects are implemented and detailed design studies are completed as part of the implementation process.

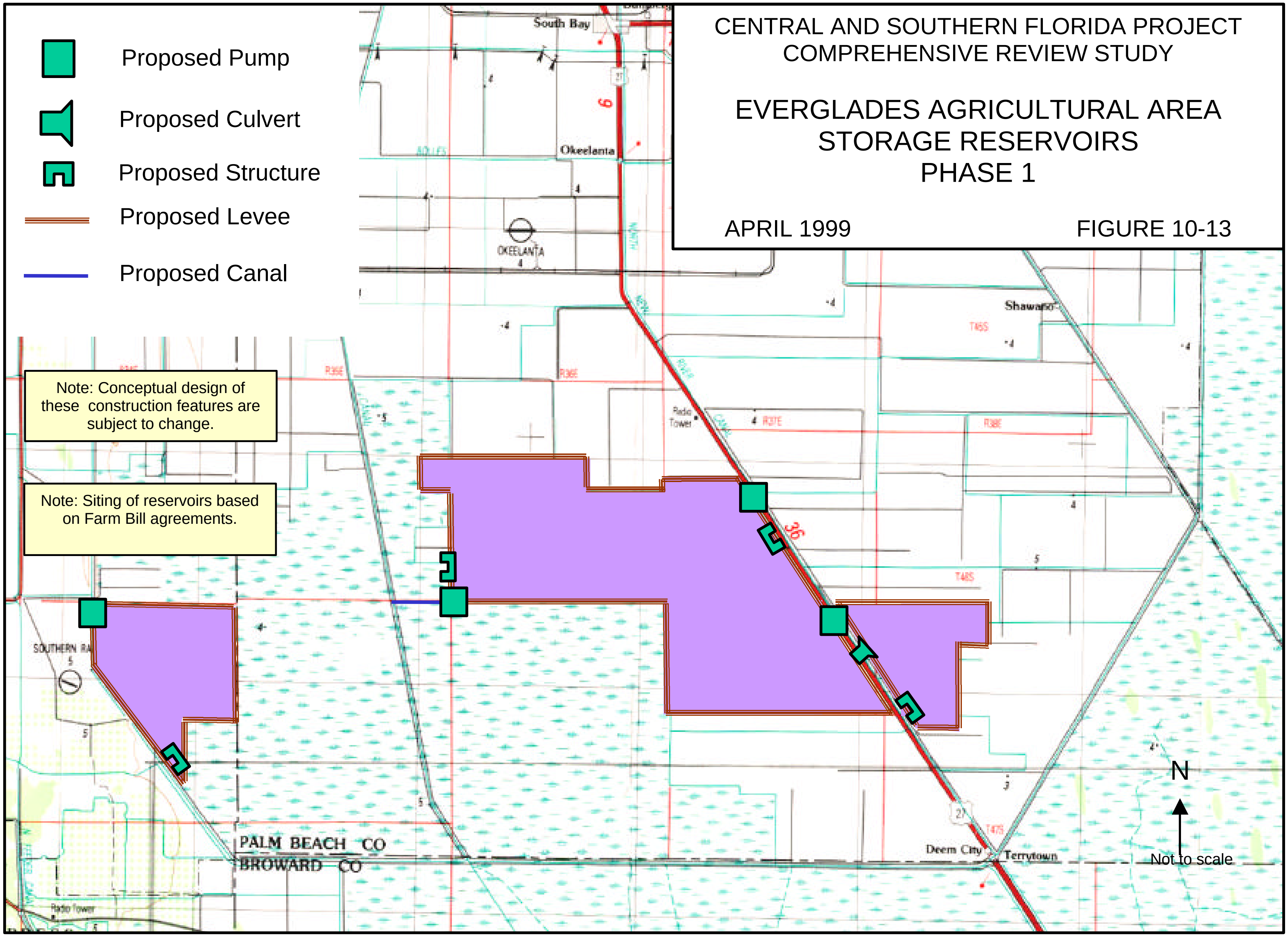
One of the principal guidelines of the Implementation Plan is to ensure that the components are located, designed, and operated consistently with existing and future water quality protection criteria and restoration targets. The Comprehensive Plan includes a number of features (e.g., stormwater treatment areas, treatment for water to be stored in aquifers by aquifer storage and recovery facilities, advanced wastewater treatment by reverse osmosis at wastewater reuse plants) to protect and improve the quality of water in receiving water bodies related to the operation of specific plan components. In addition, regional-scale surface storage reservoirs included in the Comprehensive Plan present an opportunity to improve water quality where those reservoirs are located in basins with degraded water bodies (water bodies not meeting designated uses and/or water quality criteria contained in water quality standards). Future detailed planning and engineering activities will consider water quality protection criteria for water bodies in which plan components are to be located and designed with operational features necessary to achieve water quality restoration targets. Integration of water quality protection targets into the implementation process, together with monitoring and the adaptive assessment process will ensure that water quality protection is achieved and sustained for the natural and built environments of the south Florida ecosystem.

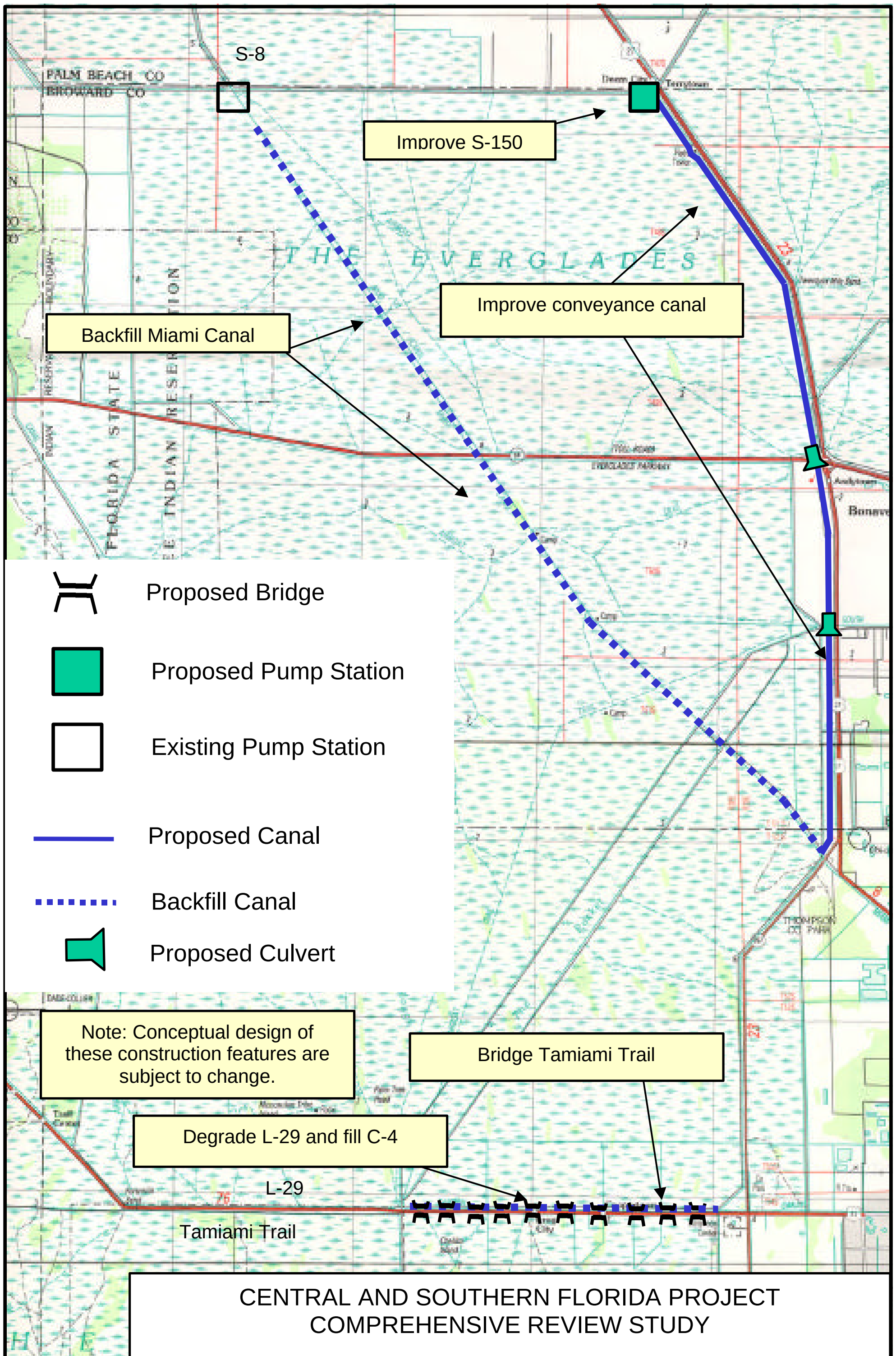
Water quality in the Keys is critical to ecosystem restoration. The Florida Keys Water Quality Protection Plan includes measures for improving wastewater and stormwater treatment within the Keys. Implementation of this plan is critical for restoration of the south Florida ecosystem.

There are a number of Federal, state, tribal, and local water resources projects presently underway or authorized in the study area such as the Kissimmee River Restoration, Modified Water Deliveries to Everglades National Park, C-111, and Everglades Construction Projects. The Comprehensive Plan includes modifications or additions to some of these projects. Consequently, implementation of all ongoing projects must be closely coordinated, and thus linked with ongoing implementation of the Comprehensive Plan.

Since 1993, with the creation of the South Florida Ecosystem Restoration Task Force, the Federal government has been working in partnership with State, tribal, and local governments, the private sector, and individual citizens to accomplish ecosystem restoration and protection objectives. It is important for the long-term restoration of the ecosystem that these efforts be continued and strengthened. Furthermore, we believe that in order for this effort to be successful, the State of Florida must be a full partner with the Federal government. It is anticipated that the Governor and Legislature will define the role of the State in the implementation process.


Proposed Pump Station
Proposed Structure
Proposed Culvert
Proposed Levee
N
Not to scale
C-44 Basin Storage
Area = 10,000 acres
Max Depth = 9 feet
Inflow Pump Station
1000 cfs
Discharge Structure
800 cfs
Note: Conceptual location of reservoir and design of these construction features are subject to change.
Flow Culverts under Road
C-44
Arundel
Indiantown
CIRCLE T RANCH
710
CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY
C-44 BASIN STORAGE RESERVOIR
APRIL 1999
FIGURE 10-12

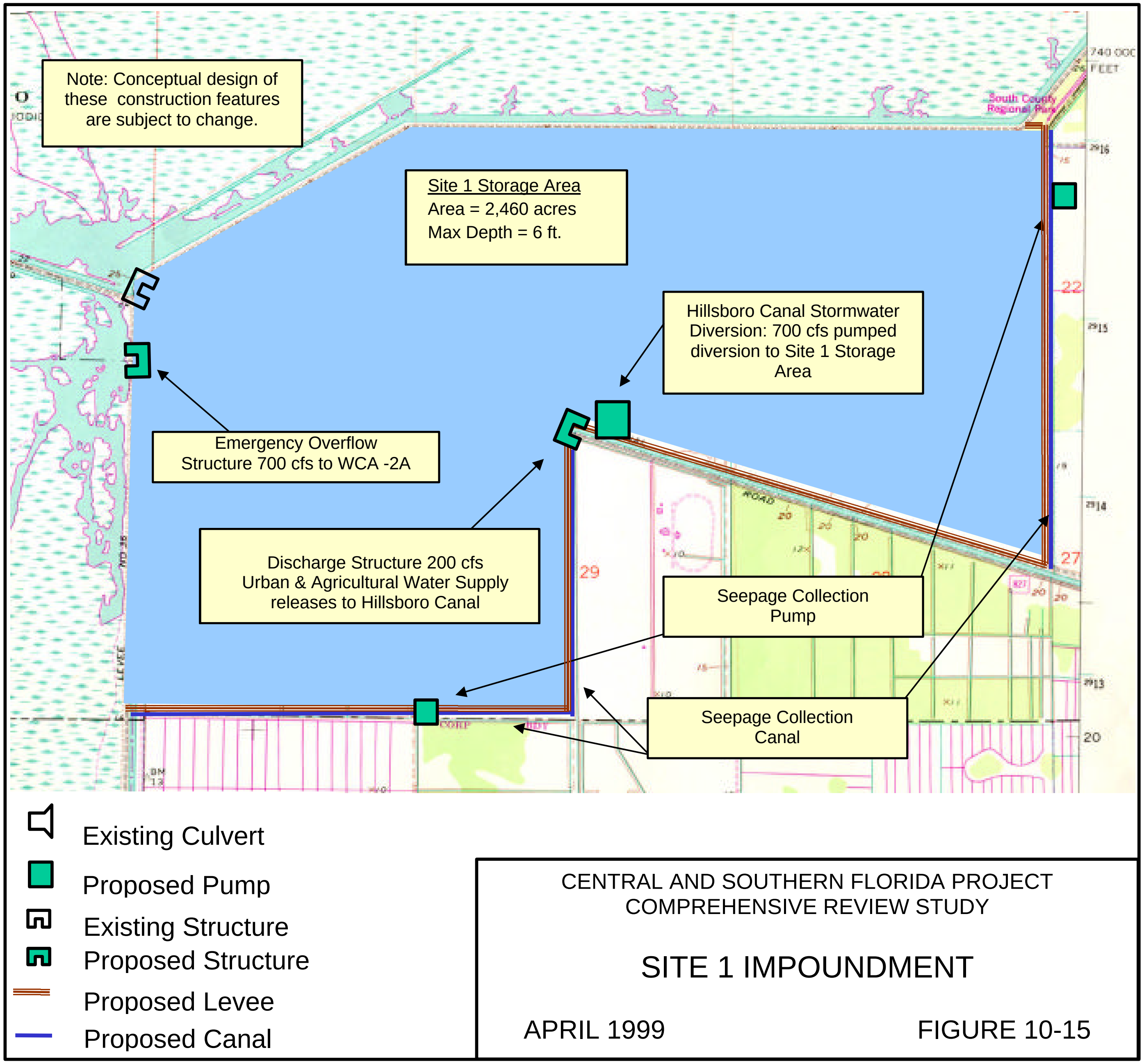

Proposed Pump
Proposed Culvert
Proposed Structure
Proposed Levee
Proposed Canal
CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY
EVERGLADES AGRICULTURAL AREA
STORAGE RESERVOIRS
PHASE 1
APRIL 1999
FIGURE 10-13
Note: Conceptual design of these construction features are subject to change.
Note: Siting of reservoirs based on Farm Bill agreements.
South Bay
Okeelanta
OKEELANTA
Shawano
Radio Tower
SOUTHERN
PALM BEACH CO
BROWARD CO
Deem City
Terrytown
N
Not to scale

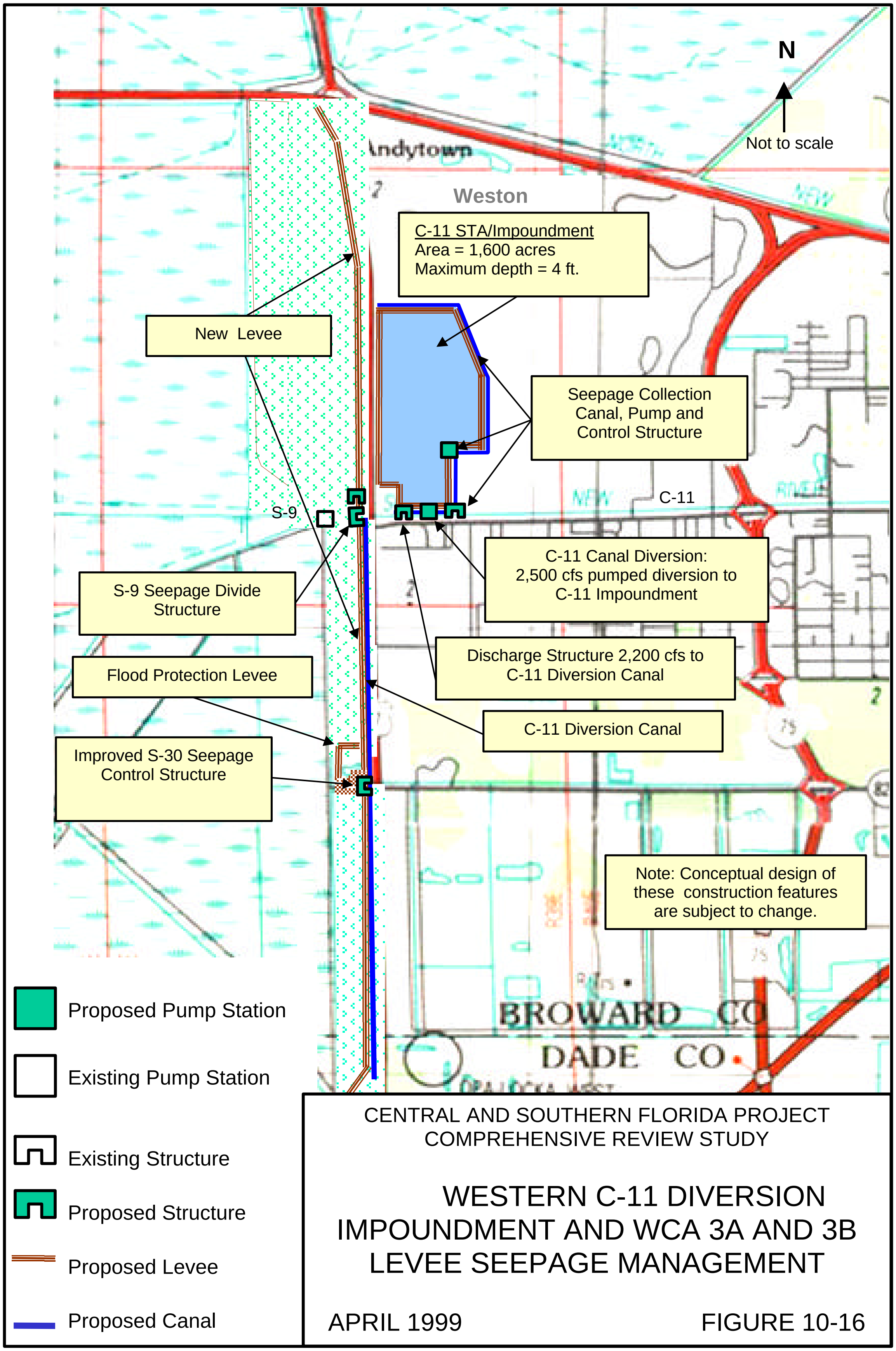


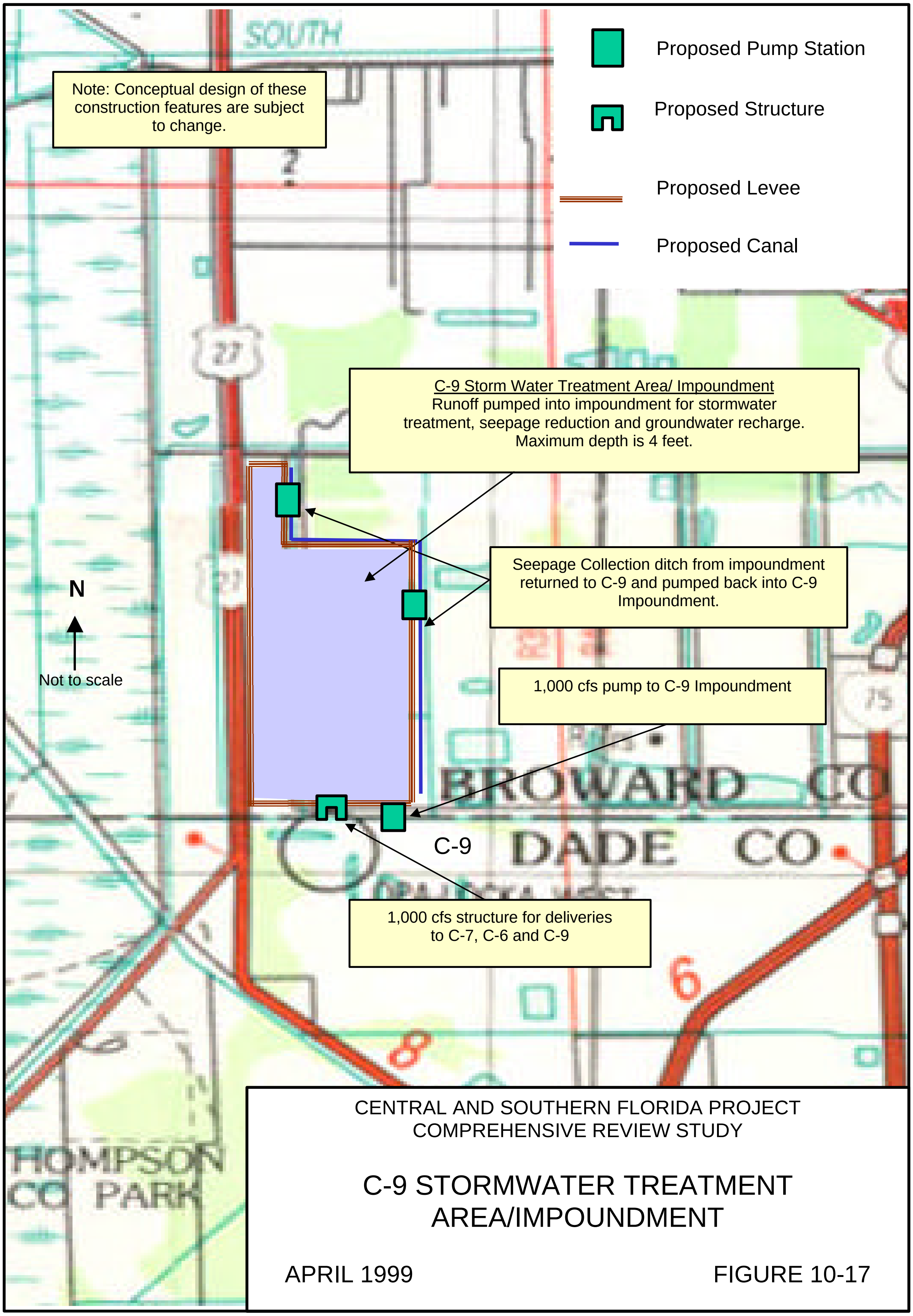
CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY

WATER CONSERVATION AREA 3 DECOMPARTMENTALIZATION AND SHEETFLOW - PHASE 1

APRIL 1999 FIGURE 10-14


Note: Conceptual design of these construction features are subject to change.
Site 1 Storage Area
Area = 2,460 acres
Max Depth = 6 ft.
Hillsboro Canal Stormwater Diversion: 700 cfs pumped diversion to Site 1 Storage Area
Emergency Overflow Structure 700 cfs to WCA -2A
Discharge Structure 200 cfs Urban & Agricultural Water Supply releases to Hillsboro Canal
Seepage Collection Pump
Seepage Collection Canal
Existing Culvert
Proposed Pump
Existing Structure
Proposed Structure
Proposed Levee
Proposed Canal
CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY
SITE 1 IMPOUNDMENT
APRIL 1999
FIGURE 10-15

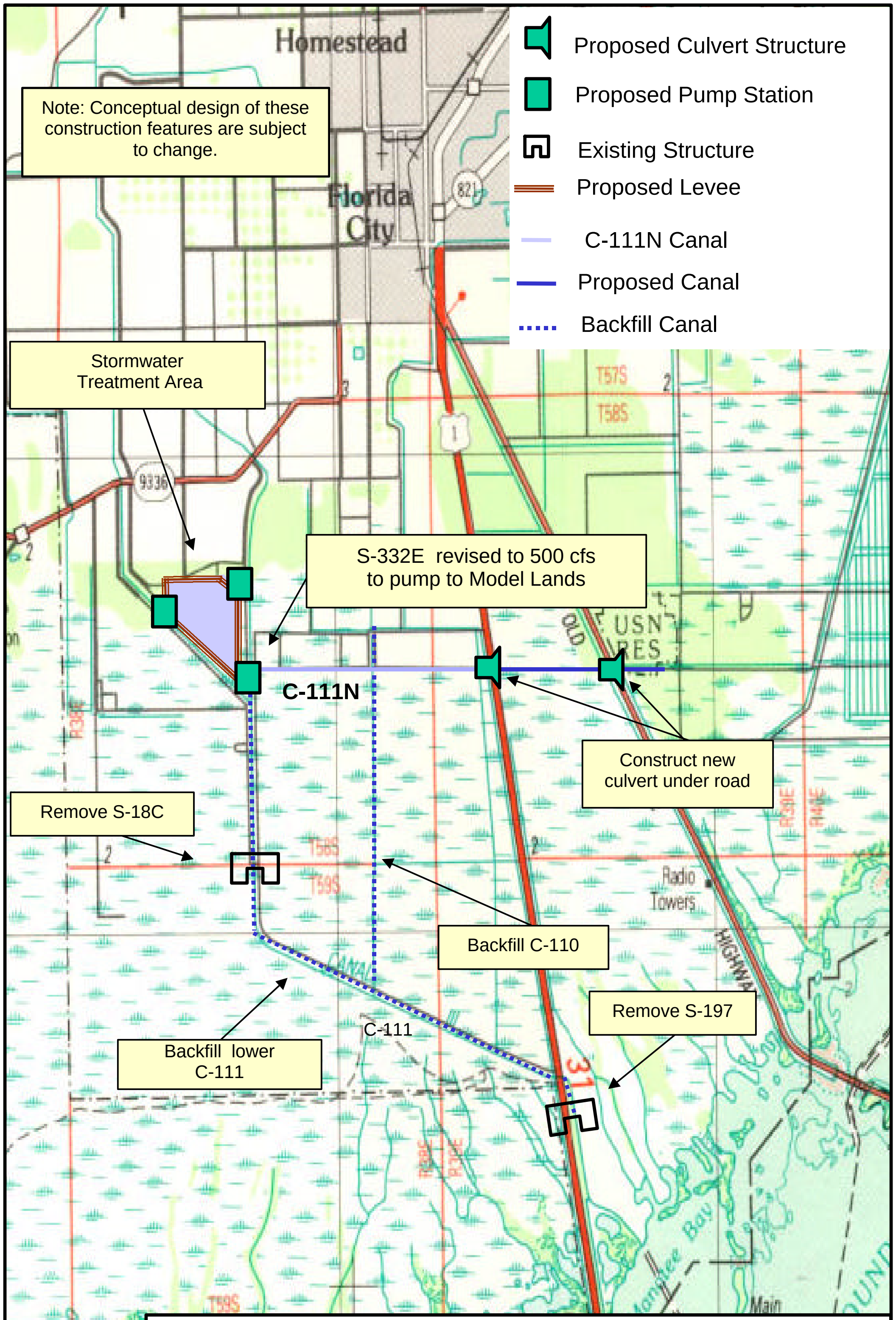

N
Not to scale
Andytown
Weston
C-11 STA/Impoundment
Area = 1,600 acres
Maximum depth = 4 ft.
New Levee
Seepage Collection Canal, Pump and Control Structure
S-9
C-11
C-11 Canal Diversion: 2,500 cfs pumped diversion to C-11 Impoundment
S-9 Seepage Divide Structure
Discharge Structure 2,200 cfs to C-11 Diversion Canal
Flood Protection Levee
C-11 Diversion Canal
Improved S-30 Seepage Control Structure
Note: Conceptual design of these construction features are subject to change.
BROWARD CO
DADE CO
Proposed Pump Station
Existing Pump Station
Existing Structure
Proposed Structure
Proposed Levee
Proposed Canal
CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY
WESTERN C-11 DIVERSION IMPOUNDMENT AND WCA 3A AND 3B LEVEE SEEPAGE MANAGEMENT
APRIL 1999
FIGURE 10-16



CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY

C-9 STORMWATER TREATMENT AREA/IMPOUNDMENT

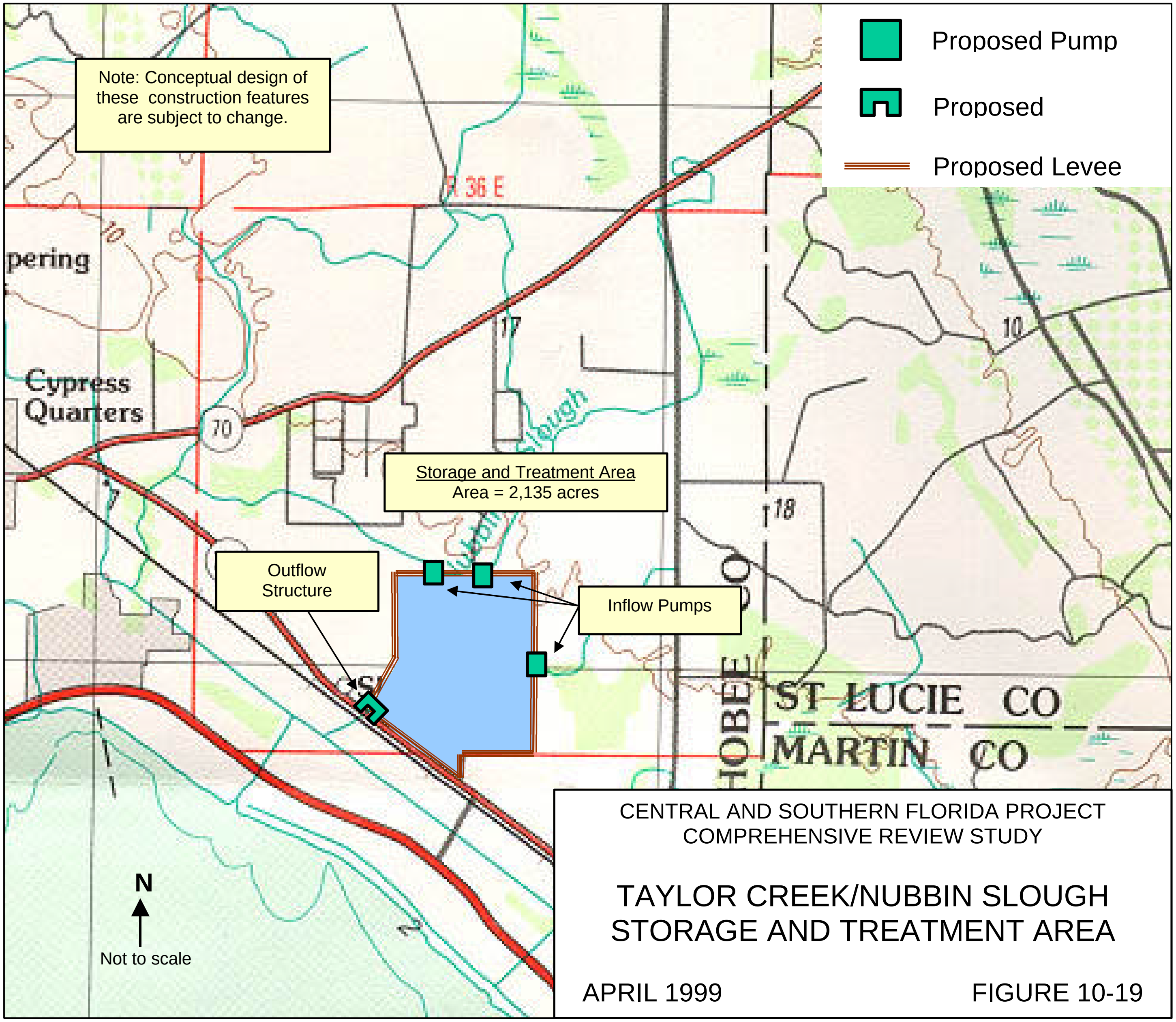
APRIL 1999 FIGURE 10-17



CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY

C-111N SPREADER CANAL

APRIL 1999 FIGURE 10-18


Proposed Pump
Proposed
Proposed Levee
Note: Conceptual design of these construction features are subject to change.
R 36 E
pering
Cypress Quarters
70
17
18
10
Slough
Storage and Treatment Area
Area = 2,135 acres
Outflow Structure
Inflow Pumps
ST LUCIE CO
MARTIN CO
N
Not to scale
CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY
TAYLOR CREEK/NUBBIN SLOUGH
STORAGE AND TREATMENT AREA
APRIL 1999
FIGURE 10-19

SECTION 11
PUBLIC INVOLVEMENT AND COORDINATION

Due to the intense public, political, and media interest in restoration of the south Florida ecosystem, public involvement is a critical component of the Restudy effort. This section describes the public involvement and coordination activities conducted during the Restudy.

11.1 PUBLIC INVOLVEMENT PROGRAM

Public involvement is a process by which interested and affected individuals, organizations, agencies, and governmental entities are consulted with and participate in a decision-making process. Public involvement in the Restudy had two main functions: to inform the public about the Restudy and to generate their input on key issues and concerns. This dialogue helped guide the Restudy, making it inclusive, balanced, and comprehensive. Public involvement activities also facilitated open and frank discussions that enhanced efforts to develop consensus on important issues. Supporting an exchange of ideas and information among interested individuals and groups has been critical to resolving the challenges involved in performing the Restudy.

Due to the large geographic area the Restudy encompasses, issues were complex and diversity of interests great. In recognition of these factors, the Corps of Engineers and the South Florida Water Management District as the non-Federal sponsor of the C&SF Project, intensified public involvement activities during the feasibility phase that were begun in the reconnaissance phase of the Restudy. A public involvement program was developed that was inclusive of all interests and concerns and balanced the sometimes-competing interests of this diverse region. This program was based upon a two-way communication and collaborative problem-solving model with the goal of reaching better, more informed decisions.

Public involvement activities ranged from workshops, focus group meetings, educational and technical briefings, presentations to interested parties, public meetings, fact sheets, and newsletters, to having the results of alternative plan formulation efforts available on a web site for comment back to the Restudy Team. Stakeholders and other interested parties were also invited to participate in the development of the Project Study Plan, which was the blueprint the Restudy Team used to perform the work necessary to accomplish the feasibility study.

Public involvement and coordination were identified as critical components of the feasibility study effort, due to the concentrated public, political, and media interest in the objectives of the Restudy. A public participation / public outreach plan was formulated to 1) inform the public, 2) gather information, 3) identify public concerns, 4) develop consensus, and 5) develop and maintain credibility. The overall objective of all outreach activities was to ensure that the south Florida community was informed about the Restudy and that the recommended Comprehensive Plan was reflective of the input received from stakeholders and the public.

Three additional objectives for public involvement were identified:

- Gather input from the diverse groups outside of the Restudy Team to assist in problem identification and the formulation and evaluation of alternative plans;

- Develop relationships critical to the success of the Restudy and the implementation of the recommendations of the Restudy; and

- Promote realistic expectations within an atmosphere where there is widespread public interest about the health of south Florida ecosystems, but a lack of awareness about the Corps' study.

Further, it was the obligation of the Restudy Team to:

- Keep people informed so that they could make educated choices;

- Provide visible ways to participate in the process; and

- Provide equal access to information and decision-makers regardless of viewpoint.

11.2 SCOPING

A Notice of Intent to prepare a Programmatic Environmental Impact Statement for the study was published in the Federal Register, Volume 61, No. 19, on January 29, 1996. The Notice of Intent outlined in summary form the project purpose and objective; described the study area; project features and scope; and laid out the Scoping process utilized to involve Federal, state, and local agencies; affected Native American Tribes; and interested private organizations and parties.

A Scoping Letter, dated February 7, 1996, was sent out by the Corps to over 5,000 recipients, including Federal, state, and local agencies; Native American Tribes; and private organizations and parties soliciting their views, comments, and information about resources, study objectives, alternatives, and important features within the study area. The record was held open for a 90-day comment period. Over 70 written responses were received within the comment period, representing hundreds of issues. These issues were compiled and infused into the Restudy plan formulation process over the subsequent two and one-half years.

A sampling of issues resulting from the Scoping process included:

- Proper identification and selection of alternative evaluation tools/models;
- The need to restore more natural timing, volume, and flow patterns of water (i.e. hydroperiods and hydropatterns);
- Increasing spatial extent and restoration of landscape heterogeneity and biodiversity;
- The desire to employ adaptive management and flexibility in decision-making;
- Maintenance of flood protection and water supply functions of the C&SF Project;
- The need to ensure economic and environmental sustainability;
- A process directed at total ecosystem restoration, rather than strictly a species-specific approach to recovery;
- Concept of linkage and sequencing of separable restoration components;
- The importance of identifying clear restoration goals and objectives; and
- The Restudy interagency team process or approach, including the opinion that the study process is too long or too short.

A broad and all-encompassing array of specific issues and/or physiographic areas were discussed in written responses to the Scoping Letter. These included, among others:

- The need for close coordination between existing projects (e.g. the C-111 and Modified Water Deliveries to Everglades National Park Projects) with the Restudy;

- The need to improve hydropatterns in Shark River and Taylor Sloughs;
- The need to control exotic flora and fauna, particularly Melaleuca; protection and restoration of sea grass beds;
- Protection of tree island communities in the Everglades;
- Soil subsidence in the Everglades Agricultural Area;
- The need to capture water lost to tide and return it to the natural system through a series of Water Preserve Areas;
- And the desire to protect the natural resources of Lake Okeechobee, while still maintaining its water supply, flood control, and other functions.

11.3 OTHER REQUIRED COORDINATION

In addition to the Scoping required by the National Environmental Policy Act, coordination required by other Federal laws and regulations has been conducted with the following agencies:

11.3.1 U.S. Fish and Wildlife Service

Three Planning Aid Letters were received as part of the process for developing alternative plans and the information received was incorporated into the plan formulation process. A fourth Planning Aid Letter was received in response to coordination of the draft Implementation Plan. Draft and final *Fish and Wildlife Coordination Act Reports* were prepared and are included at *Annex A*. Conclusions and recommendations in the *draft Fish and Wildlife Coordination Act Report* were as follows:

- Alternative D-13R, if fully implemented, would do much toward restoring ecological function and structure in south Florida, particularly in the central and southern Everglades.
- Improvements to ecological performance need to be made in Northeast Shark River Slough, the Water Conservation Areas, Biscayne Bay, and St. Lucie Estuary. Further, water quality must be addressed throughout the entire system.
- The Department of Interior has every confidence that these issues can be satisfactorily addressed, resulting in a feasible conceptual strategy for

south Florida ecosystem restoration that the Department of Interior can fully endorse.

The Department of Interior recommends further refinement of Alternative D-13R prior to release of the *Final Integrated Feasibility Report and Programmatic Environmental Impact Statement* including:

- Northeast Shark River Slough: Total overland flow volumes to Florida Bay through Taylor Slough and Shark River Slough should be increased to better meet historic conditions as predicted by the Natural System Model.

- Water Conservation Areas 3B, 2B and Northeast 3A: Eliminate the potentially damaging high and low water events.

- Biscayne Bay: Restore more natural flows to the bay. The Department of Interior questions the feasibility of wastewater reuse and recommends that the Other Project Elements (refer to ***Section 7 - Formulation and Evaluation of Alternative Plans****)* be prioritized and other means of restoration be explored. The Department of Interior also recommended that the ongoing Biscayne Bay Feasibility Study include consideration of these other alternatives.

- St. Lucie Estuary: Although Alternative D-13R succeeds in eliminating Lake Okeechobee regulatory releases to the estuary, the runoff within St. Lucie Basin still exceeds the restoration target.

- Water Quality: The Department of Interior questions the adequacy of the water quality plan and the treatment of water returned to the natural system. Specifically, the Department of Interior recommends that specific pollutant loading targets be developed within each watershed. Further, the water quality problem is not limited to nutrients; other water quality parameters, such as pesticides and mercury, should be studied.

- Uncertainty: The Department of Interior is concerned about the reliance on unproven technologies such as regional-scale Aquifer Storage and Recovery, seepage barriers, and wastewater reuse.

Conclusions and recommendations in the ***final Fish and Wildlife Coordination Act Report*** were as follows:

- The final plan as implemented should include components from the D-13R_4 scenario that can provide for delivery of additional water to

Everglades National Park and Biscayne Bay by capturing additional runoff from urban areas.

- The Corps should give high priority to examining those groups of components related to movement of water from the central Everglades to the southern Everglades, including but not limited to, L-29 and L-67 A and C.
- The final Plan as implemented should be flexible enough to develop and substitute components during implementation.
- The Department of Interior recommends that the Corps not commit to the specific details of the L-67 levee component as conceived in either Alternative D-13R or the $D\text{-}13R_4$ scenario.
- The use of the currently designed S-140 as a means to restore hydropatterns in northern WCA 3A needs to be further evaluated during the Project Implementation Report process and in detailed design.
- Until the Comprehensive Plan is implemented, surface water flows for Biscayne National Park and the bay should meet or exceed the 1995 base condition.
- Waste water reuse as a means to supply additional flow to Biscayne National Park and Biscayne Bay should be considered as a last resort to other mechanisms that have more reasonably predictable environmental and economic consequences.
- Studies to verify restoration targets for Biscayne National Park and the bay should be funded and prioritized early during the implementation phase. The Biscayne Bay Feasibility Study, in particular, must be given a very high priority.
- Sufficient water treatment capacity needs to be built into the Comprehensive Plan to handle the increased water volumes needed to achieve the hydrologic characteristics as were observed in Biscayne Bay and Everglades National Park under $D\text{-}13R_4$.
- The Comprehensive Integrated Water Quality Plan needs to be given priority and specific funding identified for this purpose in WRDA 2000.
- The 2010 case study should be revisited to see if optimizing reservoir performance, reordering the implementation schedule, or phasing

components into increments, would improve performance of the comprehensive plan by the year 2010.

- High priority needs to be placed on further refinement of the Natural Systems Model early in the implementation of the Comprehensive Plan.

- The Corps and cooperating agencies should develop and test active management techniques that accelerate recovery of damaged soils in the Water Conservation Areas, including the development of peat/soil accretion/risk assessment models.

- The Corps should support an ongoing and in-depth scientific review throughout implementation.

11.3.2 Florida Game and Fresh Water Fish Commission

Two Planning Aid Letters from the Commission were received as part of the process for developing alternative plans and the information received was incorporated into the plan formulation process. A third Planning Aid Letter was received in response to coordination of the draft Implementation Plan. Three Fish and Wildlife *Coordination Act Reports* from the Commission were prepared and are included at ***Annex A***. Conclusions and recommendations in the first (Part I) ***Fish and Wildlife Coordination Act Report*** were as follows:

- Alternative D-13R makes substantial progress towards restoration of the south Florida ecosystem.

- Alternative D-13R shows the most promise for restoring the natural areas.

- A fundamental result of Alternative D-13R is that it restores an enormous amount of fresh water to a southward flow resulting in improvements in timing and reducing unnatural flows to the Caloosahatchee and St. Lucie Estuaries without undue reliance on Lake Okeechobee.

The Florida Game and Fresh Water Fish Commission supports Alternative D-13R as an alternative that merits further development during the detailed design phase. The following issues should be addressed during the subsequent phases of this project:

- Water Conservation Area 3B: The increase in water depths and duration appear to be at the acceptable limit and any additional increase in these hydrologic characteristics could be ecologically damaging.

- Overall hydrologic pattern: The alternative plans extend periods of inundation with fewer drying events than what we would expect to see in the pre-drainage ecosystem as predicted by the Natural System Model. This is a trade-off between decompartmentalizing the remaining natural areas of the Everglades and achieving pre-drainage hydrologic characteristics. This trade-off could have a potential long-term biologic effect.

- Eastern Water Conservation Area 3A: Alternative D-13R will affect wading bird nesting and foraging areas. Improvements in some areas, possible damage in others (sequencing and timing is key).

- Lost recreation opportunities: Alternative D-13R has the potential of reducing recreational opportunities by the removal of L-67A and L-29 Canals.

- Reliance on aquifer storage and recovery technology: Contingency plans should be developed in the event that aquifer storage and recovery is deemed not feasible.

- Water Conservation Area 2B: Alternatives should be considered to improve the "poor performance" of Water Conservation Area 2B.

The Florida Game and Fresh Water Fish Commission provided additional comments regarding:

- Uncertainty: Topography information in the natural areas, feasibility of Aquifer Storage and Recovery, and potential long-term ecological effects, such as, unintended shifts in community structure (cattail expansion).

- Implementation Plan: The staging of hydrologic changes is critical to avoid large environmental shocks that could induce ecological damage.

- Adaptive Management Strategy: The plan must include flexible water management actions including a well designed and comprehensive monitoring plan.

- Monitoring Plan: The results of the monitoring program must be acted upon expeditiously.

Conclusions and recommendations in the second (Part II) ***Fish and Wildlife Coordination Act Report*** were as follows:

- The performance of D-13R may provide insufficient flow volumes to Shark River Slough as predicted by the Natural System Model. Concerns in the Water Conservation Areas include: extended hydroperiods in much of WCA-3A, particularly south of I-75; deep water in eastern and northeastern WCA-3A and; extremely high and low water levels predicted in WCA-2B.

- The S-140 should be expanded to allow more water to be shunted to areas further south and a gradual rehydration of northern areas be implemented to allow areas time to acclimate to the new water regime. A water quality treatment facility is also recommended to be added upstream of the new structure.

- Accurate and up to date topographic information needs to be collected in order ensure future hydrologic restoration success.

- Most of the Other Project Elements need more information at a level of detail on which to base an assessment of their potential impacts on fish and wildlife.

- The removal of canals must be well justified in terms of hydrological and ecological benefits. The Florida Game and Fresh Water Fish Commission is further concerned with the potential loss of existing recreation access points, particularly off the Tamiami Trail.

- Portions of existing levees internal to the Water Conservation Areas should be retained and restored such that they provide a similar function as natural tree islands.

- The Corps should seek authorization, at least at the conceptual level, for the entire recommended Comprehensive Plan.

- Close coordination under the Fish and Wildlife Coordination Act will be necessary throughout the refinement and implementation of the comprehensive plan in order to ensure that the intended benefits to fish and wildlife are realized.

Conclusions and recommendations in the third (Part III) ***Fish and Wildlife Coordination Act Report*** were as follows:

- $D\text{-}13R_4$, while providing additional flow to Everglades National Park and Biscayne National Park, adversely impacts Water Conservation Area 2A and Water Conservation Area 3B, which would fare worse than they do under the 1995 or 2050 Base Cases.

- There are significant water quality issues to be resolved regarding the urban runoff component of $D\text{-}13R_4$ that may result in significant adverse impacts to native flora and fauna in the natural areas.

- There remains a lack of accurate topographic information that led to the conclusion that substantially more water than that provided by D-13R is needed in Shark River Slough. The Florida Game and Fresh Water Fish Commission suggests that a soil subsidence factor for south of Tamiami Trail should be factored into model assumptions for the Natural System Model.

- Improvements to one reggion of the natural systems should not be done at the expense of another region within the natural system.

11.3.3 Florida State Historic Officer

Coordination has been ongoing with the State Historic Preservation Officer in accordance with the procedure of the Advisory Council on Historic Preservation.

11.4 RECONNAISSANCE STUDY PUBLIC WORKSHOPS

In order to involve the public in the reconnaissance study, a strategy of three rounds of public participation was developed. The information developed through these rounds of workshops and meetings was used extensively in the reconnaissance study.

In December 1993, the Restudy Team conducted ten public workshops across south Florida. These workshops were the first of three scheduled rounds of workshops. The purpose of this first round was to provide information to the public about the study and gather input for the initial “problem definition” phase of the Restudy.

In June 1994, the Restudy Team conducted the second round of scheduled public workshops in south Florida. Four workshops were held. The purpose of the second round of workshops was to: 1) give the public feedback on the first round of workshops — that is laying out the problems and opportunities that were identified, and 2) presenting some of the preliminary ideas which had been developed to fix a problem or take advantage of an opportunity.

The third round of public meetings was held in October 1994 and consisted of five public meetings. The purpose of this round was to: 1) provide feedback on the results of the second round of workshops, and 2) present the preliminary plans, conclusions, and recommendations.

The three rounds of public workshops and meetings generated a large amount of correspondence from the public. During the 18 months of the reconnaissance study, thousands of letters concerning restoration and the Restudy were received from all over the country. The *Central and Southern Florida Project Comprehensive Review Study Reconnaissance Report* dated November 1994 contains a more detailed discussion of the public involvement activities conducted during the reconnaissance phase of the Restudy.

11.5 FOCUS GROUPS

As part of this feasibility study, the Restudy Team conducted two rounds of focus group meetings throughout south Florida. The first set of meetings, held from January to May 1997, were conducted to provide information to targeted area stakeholders and to get comments about the initial plan formulation effort. Twenty-one meetings were held in Palm Beach, Broward, Miami-Dade, Monroe, Lee, Hendry, and Okeechobee Counties, as well as meetings with tribal representatives and National Wildlife Refuge managers. ***Table 11-1*** gives the scheduling of the meetings.

During this first set of meetings, the Governor's Commission for a Sustainable South Florida's *Conceptual Plan for the Restudy*, which provides a guiding framework for the Restudy, and the *Water Resources Development Act of 1996* were reviewed, as was the Restudy schedule. It was also explained that the Comprehensive Plan for the Restudy must be submitted to Congress by July 1, 1999. The meetings proved a useful process by allowing the various constituencies to comment on whether the appropriate components to be evaluated had been identified and to note what may have been missed in the initial plan formulation phase. A summary of concerns from these meetings is found in ***Table 11-2***.

The second round of meetings, which took place from September through December 1997, informed the participants about the progress of the plan formulation process. Fifteen meetings took place in Palm Beach, Broward, Miami-Dade, Monroe, Lee, and Okeechobee Counties and Tallahassee. Approximately 150 community leaders attended, representing a cross-section of interests including agriculture, the environment, water supply, and urban residents. In addition to specific interest groups, the Restudy Team held sessions with Florida Department of Environmental Protection and other State managers, Florida Game and Fresh

Water Fish Commission, and U.S. Fish and Wildlife Service managers. ***Table 11-3*** shows the meeting schedule.

A portion of these second round of meetings showed how the comments and concerns provided at the first round of meetings had been incorporated and/or addressed. Participants were also able to see the hydrologic results of the "screening" phase of plan evaluation and preliminary information on ecological restoration targets and how these were going to be linked to hydrologic targets and socio-economic targets. Summarized comments from these meetings are found in ***Table 11-4***.

TABLE 11-1
RESTUDY FOCUS GROUP MEETING SCHEDULE
JANUARY – MAY 1997

January 28 Gulf Citrus Growers	**February 20** Palm Beach County and municipal utilities and county administrator
January 28 Caloosahatchee River Citizens Association	**February 21** Environmental Coalition of Broward County
February 10 Florida Keys environmental interests	**February 24** Broward County staff (DNRP, OES)
February 10 Florida Keys commercial fishing interests	**February 24** Broward County regulated / community interests
February 11 Various Florida Keys county and city commissioners	**March 19** Seminole Tribe of Florida
February 12 Friends of the Everglades / National Audubon Society / Tropical Audubon Society / Sierra Club	**March 20** Miccosukee Tribe of Indians of Florida
February 12 Miami-Dade County staff (DERM, WASA, Planning Department)	**April 15** Okeechobee County agricultural interests
February 13 Florida City / Homestead Chamber of Commerce	**April 15** Okeechobee County economic / recreational interests
February 18 Palm Beach County environmentalists	**April 15** Okeechobee and Highlands Counties governmental interests
February 18 Everglades Agricultural Area agricultural interests	**May 14** National Wildlife Refuge managers
February 20 Palm Beach County Water Control Districts	

TABLE 11-2
SUMMARY OF FIRST ROUND FOCUS GROUP MEETING CONCERNS

CONCERN*	FOCUS GROUP
Regional Aquifer Storage and Recovery: technical feasibility and permitability	Florida Keys environmental interests, National Audubon Society / Sierra Club, Palm Beach County utilities
8 1/2 square mile area: disposition of land and providing flood protection	Florida Keys environmental interests, Florida Keys commercial fishing interests, Various Florida Keys commissioners, Miami-Dade County staff
Curtain walls: technical feasibility and impacts to the aquifers and bays	Florida Keys environmental interests, Florida Keys commercial fishing interests, National Audubon Society / Sierra Club, Miami-Dade County staff, Broward County staff
On-site retention: as a method of regional water storage	Gulf Citrus Growers, Caloosahatchee River Citizens Association, Okeechobee County agricultural interests
Use of Lake Okeechobee and Water Conservation Areas for storage: retention of multi-purpose functions	Gulf Citrus Growers, Everglades Agricultural Area agricultural interests, Palm Beach County utilities, Okeechobee County agricultural interests, Okeechobee County economic / recreational interests
Water Preserve Areas: how the different areas will function	Gulf Citrus Growers, Various Florida Keys commissioners, National Audubon Society / Sierra Club, Homestead Florida City Chamber of Commerce, Palm Beach County environmentalists, Palm Beach County Water Control Districts, Palm Beach County utilities, Environmental Coalition of Broward County, Broward County staff, Broward County regulated / community interests, Seminole Tribe of Indians
Storage area seepage: will seepage be excessive?	Gulf Citrus Growers, Everglades Agricultural Area agricultural interests
Restoration goals and performance criteria: what will they be and how will they be generated?	National Audubon Society / Sierra Club, Everglades Agricultural Area agricultural interests, Palm Beach County utilities, Broward County staff, Miccosukee Tribe of Indians of Florida, Okeechobee County agricultural interests
South Miami-Dade modeling: lack of detailed information for the area	Homestead Florida City Chamber of Commerce
Peer review: how will this be handled for technical documents?	Everglades Agricultural Area agricultural interests, Broward County staff

*Note: concerns about water quality and the need for the study to be based on sound science were universal.

TABLE 11-3
RESTUDY FOCUS GROUP MEETING SCHEDULE
SEPTEMBER – DECEMBER 1997

September 15 Broward County / two meetings	**October 6** Okeechobee County
September 16 Miami-Dade County / two meetings	**October 7** FGFWFC & USFWS, West Palm Beach
September 17 Monroe County / two meetings	**October 16** FDEP / state resource managers, Tallahassee
September 18 Gulf Citrus Growers, Clewiston	**December 9** South Miami-Dade Agriculture, Homestead
September 19 Caloosahatchee River Basin Advisory Board, Ft. Myers	**December 4** Martin and St. Lucie counties
September 23 Palm Beach County / two meetings	

TABLE 11-4
FOCUS GROUP ISSUES AND CONCERNS

Level of detail of recommended Comprehensive Plan and timing of implementation (prioritization). Also, what will be the ‘interim’ operating plan?
The need for the Restudy to be based upon accurate technical data and science.
The Restudy’s coordination with other on-going efforts (e.g., Lower East Coast Regional Water Supply Plan, Southern Everglades Restoration Alliance).
Ensuring appropriate water quality for natural and urban systems.
Utilization of Lake Okeechobee and the Water Conservation Areas for water supply and the use of other publicly owned lands for water storage including the ability to backpump into these areas.
Operational flexibility needs to be incorporated into the system for the timing and distribution of water supplies and drainage.
Function, operation, and technical feasibility of reservoirs and seepage management measures.
Does the Internet web site take the place of traditional public involvement?
What are the environmental goals; concern about using the Natural System Model as a target?
Was cost effectiveness taken into consideration in the screening analysis and when will costs for construction and operations be determined?
Need to address the lack of adequate criteria (performance measures) for evaluating alternative plans for urban and agricultural areas.
Will the Comprehensive Plan provide for the 1 in 10 level of certainty for water supply (statutory requirement of HB 715) and flood protection?

11.6 STAKEHOLDER INVOLVEMENT AND OUTREACH

Subsequent to gathering input for the initial plan formulation process, a Restudy Strategic Communications and Public Outreach Plan was developed in January 1998. The Restudy Strategic Communications and Public Outreach Plan was comprised of four components: 1) stakeholder involvement, 2) media program, 3) a public information/awareness program, and 4) public meetings on the *Draft Integrated Feasibility Report and Integrated Programmatic Environmental Impact Statement*.

Further, the activities carried out through the Restudy Strategic Communications and Public Outreach Plan were divided into three phases:

- Near term – Through alternative plan analysis and leading up to the November 1998 public meetings;
- Intermediate – Through plan delivery to Congress on 1 July 1999 and its subsequent authorization; and
- Long-term – Multi-year information and outreach activities associated with plan implementation.

The following activities occurred within the near-term timeframe of Restudy Strategic Communications and Public Outreach Plan activities. ***Table 11-5*** summarizes these activities.

11.6.1 Stakeholder Involvement

There are specific stakeholder groups that are most affected by and interested in the Restudy. Environmental interests expect that restoration will be the highest priority of the feasibility study. Agricultural interests are seeking assurances that water supply and flood protection needs are met and that they will not bear more than their fair share of the Project costs. Finally, local governments and water utility representatives desire continued access to an inexpensive supply of potable water. A fundamental component of the Restudy Strategic Communications and Public Outreach Plan was to work closely with stakeholders during each stage of plan development to gather input and address concerns.

TABLE 11-5
STAKEHOLDER INVOLVEMENT ACTIVITIES
(Since September 1997)

DATE	LOCATION	PARTICIPATION
Stakeholder/Interest Group Meetings		
18 September 1997	Clewiston	Agricultural Interests
21 November 1997	Ft. Myers	AWRA Conference
4 December 1997	Miami	Greater Miami Chamber of Commerce
1 January 1998	Tamarac	Tamarac Garden Club
16 January 1998	Key Largo	Everglades Coalition
2 February 1998	West Palm Beach	Environmental Interests
17 February 1998	Ft. Lauderdale	Coastal Zone Management Committee
17 February 1998	Miami	South Miami-Dade County Agricultural Interests
25 February 1998	Clewiston	West Coast Agricultural Interests
4 March 1998	La Belle	Gulf Citrus League
18 March 1998	Okeechobee	Okeechobee County Commission; Utility Commission; other stakeholders
19 March 1998	Clewiston	EAA Interests
13 April 1998	Tamarac	Tamarac Garden Club
25 April 1998	Miami	NAACP Conference
17 May 1998	Miami	Friends of the Everglades
20 May 1998	West Palm Beach	Sustainable Agriculture Conference – various agricultural, business, and environmental groups
27 May 1998	Palm Beach Gardens	Loxahatchee River Coordinating Council
19 June 1998	West Palm Beach	Chamber of Commerce of Palm Beaches
1 July 1998	West Palm Beach	Palm Beach County Board of Realtors
15 July 1998	Cooper City	Everglades Coalition
23 July 1998	Miami	Miami Rotary Club
29 July 1998	Miami	Lake Belt land owners, Miami-Dade County, DERM, SFWMD
30 July 1998	Key West	AWRA Conference
3 August 1998	Delray Beach	Environmental Coalition of Palm Beach County
5 August 1998	Palm Beach Gardens	Northern Palm Beach County of Commerce
16 August 1998	Jupiter	Northern Palm Beach County of Commerce
27 August 1998	Tallahassee	State Legislature Lobbyists
28 August 1998	Miami	Hispanic Community Leaders
1 September 1998	Ft. Myers	Southwest Florida Environmental Advisory Committee
1 September 1998	Wilton Manors	Wilton Manors Sport Fisherman Club
3 September 1998	Hollywood	EAA Interests
4 September 1998	Hollywood	Agricultural Interests
15 September 1998	Okeechobee	Okeechobee County Stakeholders
15 September 1998	Okeechobee	Okeechobee County Agricultural and Economic Development Interests
17 September 1998	Naples	Conservancy of Southwest Florida Corporate Interests
17 September 1998	Bonita Springs	Lee County Building Industries Association
18 September 1998	Miami	Miami-Dade Environmental Task Force
23 September 1998	West Palm Beach	Palm Beach County Municipal League
1 October 1998	Miami	Latin Builders Association
7 October 1998	West Palm Beach	South Miami-Dade Agricultural Interests
16 October 1998	Stuart	Treasure Coast Restudy Celebration

DATE	LOCATION	PARTICIPATION
20 October 1998	Miami	Hispanic Community Leaders
21 October 1998	Delray Beach	League of Women Voters
21 October 1998	Miami	Hispanic Community
22 October 1998	Miami	Hispanic Community Leaders
22 October 1998	Overtown	African-American Community
23 October 1998	Naples	The Conservancy of Southwest Florida
24 October 1998	Tampa	Florida Farm Bureau Conference
29 October 1998	Jacksonville	Society of American Military Engineers
4 November 1998	Clewiston	Agricultural Interests
12 November 1998	Stuart	Stuart Rotary Club
13 November 1998	Stuart	Conservation Alliance
13 November 1998	Ft. Lauderdale	Broward County Technical Advisory Committee
20 November 1998	Miami	Chamber of Commerce; Beacon Council
30 November 1998	Miami	Chamber of Commerce; South
1 December 1998	La Belle	Agricultural Interests
4 December 1998	Tallahassee	State Legislature Lobbyists
8 December 1998	Washington, DC	Environmental Interests
8 December 1998	Washington, DC	Agricultural Interests
10 December 1998	Miami	Greater Miami Chamber of Commerce
10 December 1998	Boca Raton	Royal Palm Audubon
18 December 1998	Miami	Lake Belt Advisory Committee
21 December 1998	Naples	League of Women Voters
21 December 1998	Belle Glade	Florida Farm Bureau
1 January 1999	Tamarac	Tamarac Garden Club
12 January 1999	West Palm Beach	American Society of Civil Engineers
21-23 January 1999	Miami	Everglades Coalition
4 February 1999	West Palm Beach	EAA Interests
12 February 1999	Washington, DC	Environmental Interests
Advisory Committee Meetings		
25 September 1997	West Palm Beach	SFWMD Agricultural Advisory Committee
24 October 1997	Ft. Myers	Caloosahatchee Advisory Committee
27 October 1997	West Palm Beach	SFWMD Agricultural Advisory Committee
25 November 1997	West Palm Beach	SFWMD Agricultural Advisory Committee
12 January 1998	West Palm Beach	SFWMD Environmental Advisory Committee, National Park Service
23 January 1998	West Palm Beach	SFWMD Water Utility Advisory Committee
27 January 1998	West Palm Beach	SFWMD Agricultural Advisory Committee
17 February 1998	La Belle	Caloosahatchee Advisory Committee
20 March 1998	West Palm Beach	SFWMD Water Utility Advisory Committee
20 March 1998	West Palm Beach	SFWMD Agricultural Advisory Committee
23 March 1998	West Palm Beach	SFWMD Water Utility Advisory Committee
9 April 1998	Immokalee	Caloosahatchee Advisory Committee
22 May 1998	La Belle	Caloosahatchee Advisory Committee
28 May 1998	West Palm Beach	SFWMD Agricultural Advisory Committee
28 July 1998	West Palm Beach	SFWMD Agricultural Advisory Committee
20 August 1998	Sebring	Lake Istokpoga Interagency Team
16 September 1998	Fort Myers	Caloosahatchee Advisory Committee
25 September 1998	West Palm Beach	SFWMD Agricultural Advisory Committee
1 November 1998	Ft. Myers	Estero Bay ADM
5 November 1998	La Belle	Caloosahatchee Advisory Committee
21 January 1999	Ft. Myers	Caloosahatchee Advisory Committee
28 January 1999	West Palm Beach	SFWMD Agricultural Advisory Committee
3 February 1999	West Palm Beach	LEC Regional Water Supply Advisory Committee

DATE	LOCATION	PARTICIPATION
Technical Workshops		
3 November 1997	West Palm Beach	SFWMD Agriculture, Water Utility, Environmental Advisory Committees
18 December 1998	West Palm Beach	SFWMD Agriculture, Water Utility, Environmental Advisory Committees
2 February 1998	West Palm Beach	SFWMD Agriculture, Water Utility, Environmental Advisory Committees
20 March 1998	West Palm Beach	SFWMD Agriculture, Water Utility, Environmental Advisory Committees
29 July 1998	West Palm Beach	SFWMD Agriculture, Water Utility, Environmental Advisory Committees
29 July 1998	West Palm Beach	Implementation Plan Workshop
27 August 1998	West Palm Beach	Implementation Plan Workshop
23 November 1998	West Palm Beach	Implementation Plan Workshop
11 December 1998	West Palm Beach	Implementation Plan Workshop
1 February 1999	West Palm Beach	Implementation Plan Workshop
Federal/State Agency Meetings		
16 October 1997	Tallahassee	State Agencies
31 October 1997	Miami	Department of the Interior
19 February 1998	Dania	Office of Management and Budget
2 April 1998	Washington, DC	Department of the Interior
11 June 1998	Washington, DC	Department of the Interior
25 June 1998	Jensen Beach	Department of the Interior
21 July 1998	Washington, DC	Office of Management and Budget
31 July 1998	Washington, DC	U.S. Environmental Protection Agency
18 September 1998	Washington, DC	Council on Environmental Quality
3 November 1998	West Palm Beach	Department of the Interior
14 December 1998	West Palm Beach	Gov. Elect Bush Transition Team
22 December 1998	Washington, DC	Department of Justice
7 January 1999	Washington, DC	Office of Management and Budget
15 January 1999	Washington, DC	Department of the Interior
23 January 1999	Miami	Department of the Interior
2 February 1999	Tallahassee	State Agencies
8 February 1999	Jacksonville	Government Accounting Office
12 February 1999	Washington, DC	Office of Management and Budget
18 February 1999	Marathon	Florida Keys Marine Sanctuary Water Quality Protection Program Steering Committee
Local Government Briefings		
1 February 1998	Ft. Lauderdale	City of Ft. Lauderdale Leadership
1 March 1998	Ft. Lauderdale	298 Drainage District Directors
18 March 1998	Okeechobee	Okeechobee Co. Commission, Okeechobee City Council, Okeechobee Water Utility
1 April 1998	Hollywood	South Florida Regional Planning Council
19 March 1998	Jupiter	Martin County Commissioners
9 June 1998	Palm Beach Gardens	Northern Palm Beach County Improvement District
10 June 1998	Palm Beach Gardens	Palm Beach Gardens
9 June 1998	Jupiter	Town of Jupiter
15 June 1998	Jupiter	Loxahatchee Council of Governments
24 June 1998	Palm Springs	Palm Beach County Municipal League
18 July 1998	Miami	Miami-Dade County Commissioner
21 July 1998	Florida City	Florida City

DATE	LOCATION	PARTICIPATION
22 July 1998	Marathon	Miami-Dade County
20 August 1998	Fort Myers	Southwest Florida Regional Planning Council
21 August 1998	Stuart	Treasure Coast Regional Planning Council
26 August 1998	South Palm Beach	Palm Beach County Municipal League
1 September 1998	Naples	Collier County Commission
8 September 1998	Naples	Big Cypress Basin Board
14 September 1998	Sebring	Highlands County Commission
15 September 1998	Ft. Lauderdale	Broward League of Cities
14 September 1998	Clewiston	Okeechobee County Commission
16 September 1998	Ft. Myers	Lee County Commissioners
18 September 1998	Stuart	Treasure Coast Regional Planning Council
22 September 1998	West Palm Beach	Palm Beach County Staff
1 October 1998	Ft. Lauderdale	Broward County Commissioners
14 October 1998	Miramar	Miramar City Council
15 October 1998	Ft. Lauderdale	League of Cities
21 October 1998	Pembroke Pines	Pembroke Pines City Council
22 October 1998	Okeechobee	Glades County Administrator
26 October 1998	Moore Haven	Glades County Commission
28 October 1998	Homestead	Homestead & Florida City Councils
28 October 1998	North Palm Beach	Palm Beach County Municipal League
1 November 1998	La Belle	Hendry County Commission
1 November 1998	Ft. Myers	Southwest Florida Regional Planning Council
3 November 1998	Weston	City of Weston
3 November 1998	Charlotte	Charlotte County Commissioners
3 November 1998	Stuart	Martin County Commission
16-30 November 1998	Naples	Collier County Commissioners
19 November 1998	Ft. Myers	Lee County Commission
16 November 1998	Homestead	Mayor of Homestead
16 November 1998	Naples	Collier County Commissioner
17 November 1998	Lorida	Highlands County Staff
24 November 1998	Ft. Pierce	St. Lucie County Commission
24 November 1998	Naples	Collier County Commissioner
25 November 1998	Naples	Collier County Commissioner
30 November 1998	Naples	Collier County Commissioner
1 December 1998	Everglades City	Everglades City Council
18 December 1998	Stuart	Treasure Coast Regional Planning Council
18 December 1998	Naples	Collier County Commissioner
29 December 1998	Ft. Lauderdale	Ft. Lauderdale Commissioner
22 January 1999	Miami	Miami-Dade County
29 January 1999	Stuart	Treasure Coast Regional Planning Council
Legislative Briefings		
21 January 1998	Washington, DC	Congressional staff
30 March 1998	Tallahassee	Joint Legislative Everglades Oversight Committee
20 May 1998	Tallahassee	Florida Governor and Cabinet staff
17 June 1998	Washington, DC	Congressional Briefs
19 June 1998	Tallahassee	Joint Legislative Everglades Oversight Committee staff
19 June 1998	Tallahassee	Florida Cabinet Aides
25 June 1998	Miami	State Legislator
1 July 1998	Highlands County	Legislative Tour of Kissimmee River
1 July 1998	Ft. Lauderdale	Broward County Legislative Delegation
30 July 1998	Washington, DC	Congressional Briefs
5 August 1998	Miami	State Legislator

DATE	LOCATION	PARTICIPATION
2 September 1998	Ft. Lauderdale	Broward County Legislative Delegation
8 September 1998	Orlando	State Legislator
18 September 1998	Washington, DC	Florida Delegation Aides
1 October 1998	Orlando	Florida Black Legislators Conference
24 November 1998	Ft. Lauderdale	State Legislator
30 November 1998	Tallahassee	Joint Legislative Committee on Everglades Oversight
15 December 1998	Ft. Lauderdale	State Legislator
17 December 1998	Ft. Lauderdale	Broward County Legislative Delegation
29 December 1998	Ft. Lauderdale	State Legislator
8 January 1999	Tallahassee	Joint Legislative Committee on Everglades Oversight
2 February 1999	Tallahassee	Joint Legislative Committee on Everglades Oversight
11 February 1999	Washington, DC	Congressional Briefs
SFWMD Governing Board Meetings		
11 September 1997	West Palm Beach	SFWMD Governing Board
8 October 1997	West Palm Beach	SFWMD Governing Board
13 November 1997	West Palm Beach	SFWMD Governing Board
4 December 1997	West Palm Beach	SFWMD Governing Board
14 January 1998	West Palm Beach	SFWMD Governing Board
11 February 1998	West Palm Beach	SFWMD Governing Board
11 March 1998	West Palm Beach	SFWMD Governing Board
15 April 1998	West Palm Beach	SFWMD Governing Board
13 May 1998	West Palm Beach	SFWMD Governing Board
10 June 1998	West Palm Beach	SFWMD Governing Board
8 July 1998	West Palm Beach	SFWMD Governing Board
13 August 1998	West Palm Beach	SFWMD Governing Board
10 September 1998	West Palm Beach	SFWMD Governing Board
15 October 1998	West Palm Beach	SFWMD Governing Board
13 November1998	West Palm Beach	SFWMD Governing Board
9 December 1998	West Palm Beach	SFWMD Governing Board
13-14 January 1999	West Palm Beach	SFWMD Governing Board
10 February 1999	West Palm Beach	SFWMD Governing Board
10 March 1999	West Palm Beach	SFWMD Governing Board
Governor's Commission Meetings		
3-4 September 1997	Orlando	Member organizations: Governor's Office; Florida Legislature; Enterprise Florida; FGFWFC; FDACS; FDEP; FDOT; SFWMD; SWFRPC; TCRPC; City of Ft. Myers; Miami-Dade Co.; Monroe Co.; Broward Co.; Homestead; City of Riviera Beach; Bermello, Ajamil & Partners; Berry Holding Co.; Florida Keys Guide Assoc.; Sunshine State Milk Producers; Hendrix Farms; U.S. Sugar; Southeast Banking Corp.; Arvida/ JMB Partners; FAU/FIU Joint Center for Environmental and Urban Problems; Florida Wildlife Federation; World Wildlife Federation; Miccosukee Tribe of Indians of Florida; Seminole Tribe of Florida; Miami-Dade & Broward League of Women Voters; Miami-Dade Community College; National Audubon Society; NOAA; U.S. EPA; U.S. DOI; South Florida Ecosystem Restoration Task Force
6-7 November 1997	Naples	
8-9 January 1998	West Palm Beach	
19-20 February 1998	Dania	
26-27 March 1998	Homestead	
23-24 April 1998	Ft. Myers	
28-29 May 1998	West Palm Beach	
25-26 June 1998	Jensen Beach	
23-24 July 1998	Duck Key	
3-4 September 1998	Hollywood	
9-10 October 1998	West Palm Beach	
19-20 November 1998	Coral Gables	
17-18 December 1998	Naples	
19-21 January 1999	West Palm Beach	
4 February 1999	West Palm Beach	
2-3 March 1999	Naples	

DATE	LOCATION	PARTICIPATION
Working Group Meetings		
4-5 September 1997	Orlando	Member organizations: FDACS; FDEP; NOAA; Florida Keys National Marine Sanctuary; FDOT; SWFRPC; Miccosukee Tribe of Indians of Florida; Seminole Tribe of Florida; U.S. FWS; Bureau of Indian Affairs; USACE; U.S. EPA; USGS-Water Resources Division; Dept. of Justice; FGFWFC; SFWMD; Palm Beach Co. Water Utilities Dept.; Miami-Dade Co. DERM; Everglades National Park; U.S. DOT; Governor's Office; U.S. Dept. of Agriculture; Broward Co. DNR; FDCA; Governor's Commission
30 September-1 October 1997	Ft. Lauderdale	
5-6 November 1997	Naples	
10-11 December 1997	Miami	
6-7 January 1998	West Palm Beach	
27-28 January 1998	Key Largo	
17-18 February 1998	Dania	
24-25 March 1998	Homestead	
21-22 April 1998	Ft. Myers	
26-27 May 1998	West Palm Beach	
23-24 June 1998	Jensen Beach	
22-23 July 1998	Duck Key	
1-2 September 1998	Hollywood	
7-8 October 1998	West Palm Beach	
17-18 November 1998	Coral Gables	
15-16 December 1998	Naples	
15 January 1999	West Palm Beach	
3-4 March 1999	Naples	
South Florida Ecosystem Restoration Task Force Meetings		
15 December 1997	Washington, DC	Member organizations: City of South Bay; U.S. DOI; U.S. Army; U.S. DOT; U.S. Dept. of Agriculture; Miccosukee Tribe of Indians of Florida; Seminole Tribe of Florida; Governor's Office; Miami-Dade Co. U.S. EPA; U.S. Dept. of Justice; NOAA; SFWMD; FDEP
28 January 1998	Key Largo	
8 April 1998	West Palm Beach	
25 June 1998	Jensen Beach	
27 July 1998	Hollywood	
2 September 1998	Hollywood	
3 December 1998	Miami	
3 February 1999	Ft. Lauderdale	

A variety of meetings, workshops and briefings were held throughout the alternative plan and draft plan development processes:

- Stakeholder group meetings
- Small group meetings
- Technical workshops
- Legislative briefings
- Local government briefings
- Staff briefings

Each of these activities is described in more detail in the following sections.

11.6.1.1 Stakeholder Group Meetings

Numerous meetings were held with representatives of stakeholder groups including the Everglades Coalition; the Caloosahatchee Advisory Committee; the South Florida Water Management District Agricultural, Utility and Environmental

Advisory Committees; environmental, municipal, economic development, and agricultural interests.

11.6.1.2 Small Group Meetings

Throughout the alternative plan development processes, numerous informal meetings were held by request to maintain dialogue, clarify issues, and identify concerns. Meetings were held with representatives of the Department of Interior (e.g., U.S. Fish and Wildlife Service and National Park Service), local government resource and water utility agencies, and non-governmental organizations (e.g., environmental groups and agricultural interests).

11.6.1.3 Technical Workshops

Due to the high level of interest in the restoration of the south Florida ecosystem and the potential impacts resulting from implementation of the study, the Restudy Team gave numerous briefings and held workshops to inform interested parties about the more technical aspects of the study. This effort supported the Restudy philosophy that a more informed public can make more informed decisions.

The South Florida Water Management District's three standing advisory committees - Agricultural, Environmental, and Utility - were briefed separately and collectively on the Restudy's progress at several key points during the process. A series of four workshops were held with the committees to answer questions concerning the technical analyses of the study. The output of these workshops developed into a list of "Frequently Asked Questions," which in turn, were posted on the Restudy web site. Four technical workshops specific to the development of the Implementation Plan were held with stakeholders between July 1998 and February 1999.

11.6.1.4 Legislative Briefings

Presentations to members of Congress and Congressional aides were given periodically to provide an update on the plan development process and to ensure that key decision-makers were able to give timely input throughout the plan development process.

Presentations and briefings were also given to state legislators and their staffs. A briefing was made to the Governor and Cabinet in May 1998. The Florida Joint Legislative Committee on Everglades Oversight, whose purpose it is to oversee implementation of the Everglades Construction Project, expressed a keen interest in the Restudy and the South Florida Water Management District Governing Board's role and responsibilities as non-Federal sponsor of the project. A number of briefings were made to the Joint Legislative Committee on Everglades Oversight.

11.6.1.5 Local Government Briefings

Formal presentations to County Commissions were made periodically during the alternative evaluation and plan development processes. Presentations were made during both regularly scheduled commission meetings, as well as during "town hall" – type meetings. Presentations were also made to committees established by local governments (e.g., Broward County Water Advisory Board and Miami-Dade County Environmental Task Force). Local government officials were also briefed through the South Florida, Treasure Coast and Southwest Florida Regional Planning Councils.

11.6.1.6 Staff Briefings

Briefings of managers, technical and outreach staff of the South Florida Water Management District and the Corps were made throughout the process to provide updates on plan development activities and to discuss stakeholder concerns and possible remedies.

11.6.2 Public Information and Outreach

The Restudy public information and outreach effort was comprised of a media program, a public information/awareness program, minority outreach, and environmental education. Many of the activities conducted in 1998 are listed in ***Table 11-6.***

11.6.2.1 Media Program

A media program was also used to educate the public and stakeholder groups about the Restudy.

Specific media tools included press conferences (including three to announce the release of the draft plan), press releases, press kits, editorial board meetings, and discussing the Restudy individually with reporters. Numerous Restudy public events (such as monthly Governing Board and Governor's Commission meetings, and other conferences and events) provided opportunities for the media to remain apprised on the Restudy.

On a local level, efforts were made to inform small community newspapers about the Restudy. In particular, seven region-specific articles were written for placement in weekly newspapers. Guest editorials by the District Engineer and the Executive Director of the South Florida Water Management District were published in the larger papers. Editorial boards were arranged for a number of newspapers in advance of the November public meetings. Radio public service announcements also were produced and broadcast in advance of the November public meetings.

Efforts were made to reach minority groups. Team members communicated to African-American and Hispanic publications on the Restudy. A half-hour program on the Restudy was taped in Spanish and broadcast on a Spanish language television station. A Spanish language public service announcement was recorded and was also broadcast on a Spanish language radio station.

TABLE 11-6
PUBLIC INFORMATION AND OUTREACH ACTIVITIES

ORGANIZATION	DATE	COUNTY, CITY
Oceanview United Methodist Church	1/9/98	Palm Beach, Juno Beach
Sheriff's Eagle Academy	1/19/98	Palm Beach, Belle Glade
Lions Club	1/22/98	Palm Beach, Jupiter
City Of Hollywood Leadership	2/1/98	Broward, Hollywood
Soroptimist Int'l of the Palm Beaches	2/4/98	Palm Beach, West Palm Beach
Fort Valley State University	2/7/98	Palm Beach, West Palm Beach
Florida Survey & Mapping Society	2/12/98	Palm Beach, West Palm Beach
Palm Beach Rotary	2/12/98	Palm Beach, West Palm Beach
Century Village	2/20/98	Palm Beach, Deerfield
Miramar Leadership	3/1/98	Broward, Miramar
Pembroke Pines Leadership	3/1/98	Broward, Pembroke
Hispanic Leadership in Broward	3/3/98	Broward
Middle School of the Arts	3/4/98	Palm Beach, West Palm Beach
Hialeah-Miami Springs Chamber of Com. Board	3/5/98	Miami-Dade
Hispanic Heritage Council Board	3/10/98	Broward
Hispanic Leadership Roundtable	3/11/98	Broward
Forest Hill High School Env. Academy	3/11/98	Palm Beach, West Palm Beach
Cadena Azul Radio Station	3/17/98	Miami-Dade
Boca Delray Golf & Country Club	3/25/98	Palm Beach, Boca Raton
“Women and the Environment” Seminar	3/28/98	Miami-Dade, Key Biscayne
Taping of TV Program at WLRN	4/4/98	Miami-Dade
Lakes of Sherbrooke Yacht Club	5/17/98	Palm Beach, Lantana
Rotary of Lake Worth	5/18/98	Palm Beach, Lake Worth
South East Florida Public Relations Conference	6/1/98	Broward, Ft. Lauderdale
Wellington Exchange Club	6/1/98	Palm Beach, Wellington
Chamber of Commerce of Palm Beaches	6/19/98	Palm Beach, West Palm Beach
Delray Beach Sunrise Rotary Club	6/26/98	Palm Beach, Delray
Palm Beach County Board of Realtors	7/1/98	Palm Beach, West Palm Beach
U.S. Coast Guard	7/9/98	Miami-Dade
Richmond Heights Homeowners Association	7/23/98	Miami-Dade
West Palm Beach Black Chamber of Commerce	7/24/98	Palm Beach, West Palm Beach
Black Executive Forum	7/28/98	Miami-Dade
Family Radio / Fort Pierce and Okeechobee	7/29/98	Martin, St. Lucie, Okeechobee

ORGANIZATION	DATE	COUNTY, CITY
Chairman's Club, Palms West Chamber	7/29/98	Palm Beach, Wellington
Broward County Women's Executive Forum	8/1/98	Broward, Ft. Lauderdale
Leadership Broward	8/1/98	Broward, Ft. Lauderdale
FAU Regional Planners Grad Course	8/1/98	Broward, Ft. Lauderdale
Delray Beach Kiwanis	8/6/98	Palm Beach, Delray
West Boca Rotary	8/10/98	Palm Beach, Boca Raton
Black Pastors Caucus	8/11/98	Miami-Dade
Goulds Community Association Meeting	8/12/98	Miami-Dade
100 Black Men of South Florida	8/15/98	Miami-Dade
Black Business Association	8/19/98	Miami-Dade
Miami Dade Teachers in Key Largo Marine Center	8/19/98	Key Largo, Monroe
River Walk Forum	8/19/98	Palm Beach, West Palm Beach
Black Business Association	8/20/98	Broward
General Meeting of NAACP	8/25/98	Miami-Dade
Broward African-American Cultural Alliance	8/27/98	Broward
Broward Black Newspaper Summit	8/28/98	Broward
Sweet Home Missionary Baptist Church	8/28/98	Miami-Dade
Hollywood Ladies Club	9/1/98	Broward, Hollywood
Goulds Coalition of Lay Ministers	9/2/98	Miami-Dade
Earlington Heights Community Association	9/3/98	Palm Beach
West Perrine Community Development Corporation	9/4/98	Miami-Dade
Health Care Committee, N.P.B. Chamber	9/4/98	Palm Beach, West Palm Beach
Christian Community Service Agency	9/8/98	Broward
Haitian Organization for Women	9/9/98	Miami-Dade
Lake Lucerne Beautification Committee	9/9/98	Miami-Dade
Palm Beach Atlantic University	9/10/98	Palm Beach, Palm Beach Gardens
Nova Law Students	9/11/98	Palm Beach, West Palm Beach
Men's Club of Covered Bridge	9/13/98	Palm Beach, West Palm Beach
Commissioner Carlton Moore	9/14/98	Broward
Opa-Locka Community Development Corporation	9/15/98	Miami-Dade
Underrepresented People Positive Action Cncl. Mtg.	9/19/98	Miami-Dade
Underrepresented People Positive Action Cncl. Mtg.	9/19/98	Miami-Dade
Coalition of 100 Black Women	9/20/98	Miami-Dade
Mount Zion Missionary Baptist Church	9/21/98	Palm Beach
Caribbean American Business Network	9/22/98	Broward
North Dade Homeowners Association	9/22/98	Miami-Dade
NAACP Palm Beach Chapter	9/25/98	Palm Beach
National Association of Black Journalists (SF Chap)	9/28/98	Broward
WDZL TV 39-Lift Every Voice and Sing	9/30/98	Broward
Belle-Aire Elementary School Open House	10/1/98	Miami-Dade
Estero Civic Association	10/98	Lee
Omega Psi Phi Fraternity Inc.	10/3/98	Miami-Dade
West Perrine Housing Opportunity Center	10/6/98	Miami-Dade
EPA's Hispanic Heritage Month Event	10/7/98	Washington, DC
Miami-Dade Community College	10/9/98	Miami Dade

ORGANIZATION	DATE	COUNTY, CITY
SF Super Bowl Minority Business Workshop	10/10/98	Broward
Southland Pines Community Association	10/12/98	Miami-Dade
Goulds Coalition of Ministers in South Miami-Dade	10/13/98	Miami-Dade
Junior Lg. Miami-African Ame. Provisional Mem.	10/14/98	Miami-Dade
Bowen Realty	10/14/98	Palm Beach, West Palm Beach
Prominence Inc. Investment Group	10/15/98	Broward
John I. Leonard High School (9th grade science class)	10/19/98	Palm Beach, West Palm Beach
Metro Miami Action Plan Trust Board Meeting	10/20/98	Miami-Dade
Elementary Teachers Workshop on Water Education	10/22/98	Collier, Naples
Meeting of Impact Miami	10/22/98	Miami-Dade
Professional Speakers Network	10/24/98	Miami-Dade
Water Symposium	10/27/98	Hillsboro, Tampa
WPB Minority Business Development Group	10/27/98	Palm Beach
River Walk Town Hall	10/28/98	Palm Beach, West Palm Beach
Broward Ecumenical Group	10/29/98	Broward
Public and Private High School Principles	11/1/98	Broward, Ft. Lauderdale
Youth Leadership Broward	11/1/98	Broward, Ft. Lauderdale
Environmental Ed. Adv. Council	11/98	Charlotte, Sarasota
Corkscrew Swamp Sanctuary	11/98	Collier
Edison Comm. College	11/98	Lee
WINK Radio	11/98	Lee
Bonita Springs Chamber of Commerce	11/98	Lee
Environmental Ed. Adv. Council	11/98	Lee
Cape Coral Lions Club	11/98	Lee
Environmental Ed. Adv. Council	11/98	Lee
Riverside High School	11/98	Lee
Sanibel/Pinewoods/Elem.	11/98	Lee
Tree Oaks Middle School	11/98	Lee
NBC-2 Television	11/98	South West Florida
WINK Radio	11/98	South West Florida
Political Women's Club Rally/Forum	11/2/98	Broward
Miami Times Editorial Board	11/9/98	Miami-Dade
WLYF/WAXY	11/10/98	Miami-Dade
Deerfield Beach Rotary	11/10/98	Palm Beach, Deerfield Beach
Region VI of Miami-Dade County School Principals	11/12/98	Miami-Dade
Ft. Pierce Rotary	11/12/98	St. Lucie, Ft. Pierce
Palm Beach County Municipal League	11/18/98	Palm Beach
Farm City Week Luncheon	11/19/98	Okeechobee
Boynton Beach High School	11/23/98	Palm Beach, Boynton
Naples High School (2 science classes)	11/24/98	Collier, Naples
Pineridge Middle School (3 Science Classes)	11/30/98	Collier, Naples
Prominence Inc. Investment Group	12/3/98	Miami-Dade
Goulds Coalition of Ministers at Centennial Middle	12/8/98	Miami-Dade
Lake Scott Home Owners Association	12/8/98	Palm Beach
Wellington Rotary Club	12/8/98	Palm Beach, West Palm Beach

ORGANIZATION	DATE	COUNTY, CITY
Hot105 Radio-Evelyn Dixon, Kervin Clenance	12/10/98	Palm Beach
Black Consortium of Marketing Professionals	12/16/98	Miami-Dade
N. Miami Beach Senior High-Environmental. Magnet Partners	12/16/98	Miami Dade
Hot105 Radio	12/21/98	Broward
Abbey Delray South Men's Club	1/7/99	Palm Beach, Delray
South Fork High School	1/11/99	Martin/St. Lucie

11.6.2.2 Public Information/Awareness Program

Besides the use of television and newspapers, a number of other means for informing the public were utilized. While a media program is the most effective method to reach the general public, equally important are more specialized efforts to reach people on a more personal level. These efforts include the following:

- Speaker’s Bureau: A speaker’s bureau was established. A Restudy-specific slide show was developed for use with lay audiences.

- Standing Displays: Five large standing displays were produced for the November public meetings. These explain the: 1) history of the C&SF Project, 2) problems associated with the project, 3) public participation for the Restudy planning effort, 4) the draft plan, and 5) benefits the Restudy will provide. The displays hold printed material to give to the public, as well. These displays continue to be used.

- Conferences: Restudy exhibits were organized for two conferences in 1998: the 72nd Annual Florida League of Cities in Miami Beach in August, and the 1998 Annual Conference on Water Management in Tampa in October. In January 1999, a Restudy exhibit was on display at the Everglades Coalition Conference held in Miami.

- Mailing List: A mailing list of approximately 2,300 people and groups who have an interest in the Restudy was developed. This includes groups such as drainage districts, the Florida Legislature, the Florida congressional delegation, environmentalists and others. It was essential to keep these key audiences apprised of Restudy activities, and provide them the most current information possible.

- Newsletter: A four-page newsletter, *C&SF Restudy Update*, was developed in 1998 to educate people on the Restudy’s progress. Issues were produced in June and October 1998, and in March 1999. It was mailed to the general mailing list, and was provided at the November public meetings, and other venues. The C&SF Restudy Update also was translated into Spanish.

- Restudy Focus: A series of information papers, *Restudy Focus*, were prepared on a number of topics and distributed to the public.

- Overview: A 30-page color overview on the draft report, designed for a lay audience, was prepared and released in October along with the draft report. A tri-fold summary document on the Restudy also was produced in conjunction with the draft report.

- Toll-Free Telephone Line: In October 1998, the South Florida Water Management District launched a toll-free telephone line (within Florida) for the Restudy. Produced in English and Spanish, the line has five options for listeners. Options initially included hearing about the November public meetings, receiving printed information, and learning how to comment on the draft plan. Listeners can also speak to a person, if they wish.

11.6.2.3 Minority Outreach

The Restudy Minority Outreach Program focused on the region's African-American and Hispanic communities. This program arose out of a need to increase participation by whole segments of the community who have been recognized as traditionally unaware, unengaged, or even disenfranchised from ongoing stakeholder and public outreach efforts. These two communities comprise a majority of Miami-Dade County's population and a significant portion of those of Broward and Palm Beach Counties. It is well recognized, however, that members of these communities have been largely absent from meetings, hearings, and other traditional venues for informing and gathering input on the plan.

Community leaders and organized interest groups were targeted as the primary contacts for these outreach efforts. The objective of the near-term minority outreach activities was to increase the knowledge and awareness of the African-American and Hispanic community leaders and activists with the goal of increasing minority engagement in the November public meetings. The ultimate goal of these activities was to increase the amount of meaningful and productive comment on the draft plan from the region's minority community.

A number of meetings were held with members of the minority communities. The objectives of these meetings were to inform participants, gather input, and cultivate other venues for increasing the broader minority communities' knowledge of and interest in the Restudy.

Specific minority outreach efforts included the following:

- Preparation of articles for distribution in local newspapers and other media outlets;
- Preparation of public service announcements for use on television and radio;
- Pocus groups involving community leaders and other key opinion leaders and decision makers;
- Briefings of key members and organizations of each minority community; and
- Preparation of Spanish language printed materials for distribution at the public meetings and through other appropriate outlets.

11.6.2.4 Environmental Education

In an effort to accomplish wide-ranging outreach to the community and to reach parents of school age children, an environmental education program was undertaken. The focus was on engaging high school students and teachers, as well as area elementary school children and teachers, in conjunction with the public review of the *Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement*. High school teachers were encouraged to produce a lesson plan related to south Florida's water resources, and bring participating students to the meetings. In some cases, students commented about the Restudy at the meetings. Elementary students created posters with their vision of the Everglades, which were subsequently judged and displayed at the meetings.

11.6.3 Governor's Commission for a Sustainable South Florida

On March 3, 1994, Governor Lawton Chiles created the Governor's Commission for a Sustainable South Florida through Executive Order 94-54. The Commission's charge was to make recommendations that will move south Florida toward a healthy ecosystem that can co-exist with, and be mutually supportive of, a sustainable south Florida economy and quality communities. This commission consists of business, agriculture, government, public interest, and environmental organization representatives. A number of Federal agencies are represented on the Commission as non-voting members.

The Commission's *Initial Report* (October 1, 1995) contained 110 recommendations with a central theme of sustainability – meeting the needs of the present without endangering the ability of future generations to meet their needs – revolving around the management of water. In that report, the south Florida ecosystem was defined as a community of organisms, including humans, interacting with one another and the environment in which they live. The Commission recognized that *"Our quality of life is inextricably linked to the health and viability of natural systems"* and *"that a healthy Everglades system is vital to natural plant, animal and human population alike."* The Commission also unanimously agreed that the south Florida ecosystem is not sustainable on its present course. A number of recommendations concerned water resources management and the Restudy. Specifically recommended was:

> *"...the Commission should provide the South Florida Water Management District and the Corps with specific recommendations describing its preferred alternatives in the Restudy." (Initial Report, 1995)*

Consequently, in October 1995, the Commission began to develop preferred alternatives for the Restudy and in August 1996 completed a *Conceptual Plan for the Restudy.* As described in the *Conceptual Plan*, the Commission envisioned the Restudy as an important component of sustainability and recognized it as the vehicle to address many of the regional water resources issues identified in its *Initial Report*. The Commission, in introducing its *Conceptual Plan*, also noted that it wished to ensure that the *Initial Report* objectives for sustainability and the interests of all south Florida were addressed by the Restudy.

In March of 1998, the Governor's Commission for a Sustainable South Florida began an intensive assessment of the Restudy process and products. This assessment was made for the expressed purpose of providing broad based recommendations and comments to Governor Lawton Chiles, the U.S. Army Corps of Engineers, the South Florida Water Management District Governing Board and the South Florida Ecosystem Restoration Task Force. Public input played a large role in the development of the Governor's Commission assessment. At the onset of this effort, the Commission spent many hours listening to the views and concerns of a variety of stakeholder groups (e.g., agriculture, water utility, rock mining, and environmental). Furthermore, each meeting of the Commission provided at least two opportunities for the public to express their views on the Restudy.

In July 1998, the Governor's Commission unanimously adopted its "*Interim Report on the C&SF Project Restudy*." The Interim Report both reiterated guidance originally included in the *Commission's Conceptual Plan for the Restudy*, and provided new recommendations for consideration during development of this *Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement.*

After release of the *Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement* in October 1998, the Commission convened panels of stakeholders in November and December 1998 to obtain input on stakeholder concerns about the draft report. Following that, the Commission prepared a document entitled "*Restudy Plan Report*" that was unanimously adopted by the Commission on January 20, 1999. The report provides recommendations on the Restudy on a number of issues including increasing water storage, Restudy scope expansion and coordination, improving water quality, and assurances to water users. The Commission's February and March 1999 meetings focussed primarily on the Implementation Plan and funding options and guidelines.

11.6.4 South Florida Ecosystem Task Force and Working Group

In an effort to ensure the coordination of Everglades restoration efforts at the Federal level, U.S. Interior Secretary Bruce Babbitt created in 1993, through an-interagency agreement, the South Florida Ecosystem Restoration Task Force. Establishment of the Task Force at the Cabinet level led in turn to the formation of a more local, Federal manager-level South Florida Ecosystem Restoration Working Group to help assist the Task Force in technical issues and actual implementation of restoration efforts. Subsequently, the Task Force and Working Group were expanded to include Tribal and state members and were formally established by Section 528 of the *Water Resources Development Act of 1996.* The Task Force now includes seven Federal members: the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida, two representatives of the state, the South Florida Water Management District, and two representatives of local governments in south Florida. The Working Group is larger and more broadly based, consisting of 14 local Federal members, the two tribes, five state agencies, the Governor's Office, the South Florida Water Management District and five representatives of local governments and regional planning councils.

In accordance with the provisions of the *Water Resources Development Act of 1996*, one of the duties of the Task Force includes consulting with, and providing recommendations to the Secretary of the Army during the development of the Comprehensive Plan. As part of its charter, the Working Group was charged with generally supporting and assisting the Task Force in undertaking its many duties, especially the development of the Comprehensive Plan.

Restudy Team members consistently briefed the Task Force and Working Group as work on the feasibility report progressed. While some of the Task Force meetings took place in Washington, Working Group meetings were held monthly throughout the south Florida region. All were open to the public. These meetings allowed for interagency discussion of the many complex technical and policy issues that arose during the course of the Restudy. In addition, there was opportunity for public comment at each meeting.

At the July 1998, meeting of the Task Force, the Initial Draft Plan was presented. In response to this presentation and as a result of many meetings during which complex technical and policy issues were considered by the Task Force and

Working Group, the Task Force adopted its initial recommendations on the Restudy and transmitted them to the Secretary of the Army in August 1998. The Task Force intends to transmit its final recommendations on the Restudy to the Secretary of the Army during the Washington Level review of the final feasibility report.

11.6.5 South Florida Water Management District Governing Board

As the non-Federal sponsor of the C&SF Project and as the state governmental body charged with water resource management in south Florida, the District's Governing Board provided policy guidance during the course of the study. Periodically after the feasibility phase began and monthly since October 1997, the Restudy Team briefed Governing Board members on the progress of the study. These meetings were open to the public and time was allotted for public comment. In April 1998, the Governing Board held a workshop with a panel of stakeholder representatives from their Environmental, Agriculture, and Urban Utilities Advisory Committees. The workshop provided the opportunity to the advisory committees to express their views on the Restudy to the Governing Board. The workshop also provided committee members and the Governing Board with the ability to engage in a question and answer dialogue with a panel of the interagency Restudy Team members. In January 1999, the Governing Board held a workshop with a panel of stakeholder representatives to discuss the issue of assurances to water users. At their February 1999, meeting, the Governing Board approved the letter of intent to be the non-Federal sponsor for implementation of the Restudy.

11.7 INTERNET WEB SITE

In order to facilitate communication between Restudy Team members and to provide the public with information about the Restudy and the formulation and evaluation of alternative plans, a web site for the Restudy was established (**http://www.restudy.org**). Information available on the web site includes: description of the planning objectives; assumptions for the with-and without-plan conditions; description of the alternative plans being evaluated; descriptions and applications of the hydrologic, ecologic, and water quality models being used to evaluate the alternative plans; summaries of technical workshops in the form of "Frequently Asked Questions"; hydrologic model output for each alternative in the form of performance measures; summaries of the evaluations of each of the alternatives; and Restudy documents such as this report.

11.8 REVIEW CONFERENCES

Four review conferences involving various agencies involved in the study were conducted during the feasibility study to review work and decide courses of action related to specific policy and technical issues. The conferences were:

- Special Resolution Conference (SRC): December 5-6, 1996 –Jacksonville, Florida. Representatives of the South Florida Water Management District, the Office of the Assistant Secretary of the Army for Civil Works, the U.S. Fish and Wildlife Service, Florida Department of Environmental Protection, the Natural Resources Conservation Service, the Environmental Protection Agency, and the Corps met to discuss procedural and policy issues related to implementing the provisions of Section 528 of the *Water Resources Development Act of 1996* that relate to the Restudy.

- In-Progress Review (IPR): December 17, 1997 – Jacksonville, Florida. Representatives of the Restudy Team and Corps higher authority met to discuss the on-going plan formulation and evaluation activities.

- Alternative Formulation Briefing (AFB): August 18-19, 1998 – West Palm Beach, Florida. Representatives of the South Florida Water Management District, Office of the Assistant Secretary of the Army for Civil Works, U.S. Fish and Wildlife Service, National Park Service, U.S. Environmental Protection Agency, Natural Resources Conservation Service, Florida Game and Fresh Water Fish Commission, Florida Department of Agriculture and Consumer Services, Florida Department of Environmental Protection, and the Corps met to discuss the development of the Initial Draft Plan and the preparation of the draft Integrated Feasibility report and Programmatic Environmental Impact Statement.

- In-Progress Review (IPR): January 12, 1999 – Atlanta, Georgia. Representatives of the Corps Jacksonville District, SFWMD, Corps higher authority, and the Office of the Assistant Secretary of the Army for Civil Works met to discuss remaining issues associated with completing the final Integrated Feasibility Report and Programmatic Environmental Impact Statement.

11.9 COORDINATION

11.9.1 Cooperating State and Federal Agencies

Regulations for implementing the *National Environmental Policy Act* state that, when requested by the lead agency, any other Federal agency which has jurisdiction by law shall be a cooperating agency. In addition, any other Federal agency which has special expertise with respect to any environmental issue which should be addressed in the statement, may be a cooperating agency upon request of the lead agency (40 CFR, Parts 1500-1508, § 1501.6). In November and December 1996, the Corps, through official correspondence, invited several state and Federal agencies to assist with preparation of a Programmatic Environmental Impact Statement for the Restudy. The geographic scope and range of issues involved in the Restudy and the desire to resolve, through consensus building, the many complex restoration issues under an interagency team format, made this cooperation desirable. The Corps, as the lead agency, organized cooperating agency meetings, assigned relevant tasks to the various cooperating agencies depending on agency authority and/or particular expertise, led and orchestrated preparation of the Programmatic Environmental Impact Statement, and coordinated issues, information and resources within and between the cooperating agency and the Corps.

The state and Federal agencies involved in the preparation of the Programmatic Environmental Impact Statement as cooperating agencies are the: National Park Service (Everglades National Park, Biscayne National Park, and Big Cypress National Preserve), Natural Resources Conservation Service, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, Florida Game and Fresh Water Fish Commission, U.S. Geological Survey, and Florida Department of Environmental Protection. Cooperating agency responsibilities included, but were not limited to: conducting internal agency coordination and communication with the lead agency; preparation of existing baseline conditions within the ten physiographic regions comprising the study area; environmental impact assessment of the alternatives as developed during the plan formulation process; making available relevant information and technical resources for consideration in the Programmatic Environmental Impact Statement; assessment of benefits and environmental impacts of the Comprehensive Plan; and preparation of appropriate sections of the environmental effects section of the Programmatic Environmental Impact Statement.

11.10 REVIEW OF DRAFT INTEGRATED FEASIBILITY REPORT AND PROGRAMMATIC ENVIROMENTAL IMPACT STATEMENT

The draft *Integrated Feasibility Report and Programmatic Environmental Impact Statement* was sent to numerous local, state and Federal agencies and private interest groups for review and comment in accordance with the Council on Environmental Quality's *National Environmental Policy Act* regulations and related Corps guidance. Comments received during the review were considered in preparing the final study documents, and will be considered by subsequent reviewers and decision-makers in the Washington-level Federal review process.

11.10.1 Report and PEIS Recipients

The following agencies, groups and individuals were sent copies of the draft *Integrated Feasibility Report and Programmatic Environmental Impact Statement.*

Native American Tribes

Miccosukee Tribe of Indians of Florida
Seminole Tribe of Florida

Federal Agencies

Advisory Council on Historic Preservation
Federal Emergency Management Agency
Council on Environmental Quality
General Accounting Office
Gulf of Mexico Fishery Management Council
U.S. Environmental Protection Agency
    Charlotte Harbor National Estuary Program
U.S. Department of Agriculture
    Forestry Service
    Natural Resources Conservation Service
U.S. Department of Commerce
    National Oceanic and Atmospheric Administration
        Florida Keys National Marine Sanctuary
U.S. Department of Energy
U.S. Department of Housing and Urban Development
U.S. Department of the Interior
    Bureau of Indian Affairs
    Fish and Wildlife Service
    Geological Survey
    National Park Service
    Office of Environmental Policy and Compliance
U.S. Department of Justice

U.S. Department of Transportation
    Coast Guard
    Federal Highway Administration
U.S. Public Health Service

State Agencies
The Governor
The Florida Legislature
Florida State Clearinghouse - Office of the Governor
Florida Department of Agriculture and Consumer Services
Florida Department of Community Affairs
Florida Department of Environmental Protection
Florida Game and Fresh Water Fish Commission
Florida Department of Transportation
Florida Division of Historical Resources - SHPO
Governors Commission for Sustainable South Florida
South Florida Water Management District

Regional Governments
Central Florida Regional Planning Council
South Florida Regional Planning Council
Southwest Florida Regional Planning Council
Treasure Coast Regional Planning Council

County Governments
Broward County
Collier County
Charlotte County
Glades County
Hendry County
Highlands County
Lee County
Martin County
Miami-Dade County
Monroe County
Okeechobee County
Orange County
Osceola County
Palm Beach County
Polk County
St. Lucie County

Municipal Governments
City of Cooper City

City of Jacksonville
City of Fort Myers
City of Homestead
City of Key Colony Beach
City of Naples
City of Riviera Beach
City of Sanibel
City of South Bay
Economic Council of Okeechobee
Immokalee Chamber of Commerce
Sunrise Utility Department

Universities
Edison Community College
Florida Memorial College
Miami-Dade Commerce College
Miami-Dade Community College
NOVA Southeast University
St. Thomas University
University of California Los Angeles
University of Miami
University of Florida
University of New Hampshire
University of South Florida
University of Tennessee

Libraries
Belle Glade Public Library
Broward County Library System
Charlotte County Library System
Clewiston Public Library
Collier County Public Library
Colorado State University Libraries
Florida Atlantic University Library
Florida Institute of Technology
Florida Legislative Library
George Washington University, Gelman Library
Glades County Public Library
Hendry County Library System
Highlands County Library System
Homestead Public Library
Indiantown Public Library
Key Largo Public Library
Labelle Public Library

Lee County Library System
Martin County Library System
Miami-Dade Community College
Miami-Dade Public Library System
Monroe County Library System
Okeechobee County Library
Orange County Library District
Osceola County Library System
Palm Beach County Library System
Polk County Bartow Public Library
South Bay Public Library
St. Lucie County Library System
University of Miami Law Library
University of South Florida Library
U.S. EPA, Region IV, Library

Groups

Audubon Society of the Everglades
Biodiversity Legal Foundation
Brownfields Committee
Caloosahatchee River Citizens Association
Caloosahatchee River Conservation Alliance
Conservancy of Southwest Florida
Miami-Dade County Farm Bureau
Dairy Farmers, Inc.
Defenders of Wildlife
Environmental Coalition of Broward County
Environmental Defense Fund
Everglades Coordinating Council
Everglades Foundation
Florida Audubon Society
Florida Biodiversity Project
Florida Cattlemen's Association
Florida Citrus Mutual
Florida City / Homestead Chamber of Commerce
Florida Defenders of the Environment
Florida League of Anglers, Inc.
Florida Power and Light Company
Florida Sportsman Conservation Association
Florida Sugar Cane Growers Cooperative
Florida Sugar Cane League
Florida Wetlands
Florida Wildlife Federation
Friends of Florida

Friends of the Everglades
Friends of Whales and Panther Action Coalition
Gulf Citrus Growers
Izaak Walton League of America, Inc.
Lake Region Audubon Society
Lake Worth Drainage District
League of Women Voters
National Audubon Society
National Parks and Conservation Association
National Park Trust
National Resources Defense Council
National Wildlife Federation
Ornithological Council
Potomac River Pilots Association
Ridge Audubon Society
Sanibel – Captiva Audubon Society
Save the Manatee Club
Sierra Club, Florida Chapter
South Florida Agricultural Council
St. Lucie River Initiative
Tamarac Garden Club
The Environmental Coalition
The Nature Conservancy
The Wilderness Society
Tropical Audubon Society
Trust for Public Lands
World Wildlife Fund
1000 Friends of Florida

Individuals

A list of individuals who received the *Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement* is on file in the Jacksonville District of the U.S. Army Corps of Engineers at the address shown on the cover page of this document.

11.10.2 Comments and Responses

The *Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement* was made available to the public on October 13, 1998. The draft PEIS was officially noticed in the Federal Register, Volume 63, Number 205 on October 23, 1998 and the public comment period ended on December 31, 1998. Review comments were received from approximately 200 state, Federal and local agencies, the native American Tribes, non-governmental organizations and concerned individuals. The comment letters received are on file in the Jacksonville

District of the U.S. Army Corps of Engineers at the address shown on the cover page of this document. A paraphrased list of the comments and the responses to them is contained in ***Appendix N: Comments and Responses***.

11.11 PUBLIC MEETINGS

A series of 12 public meetings were held in November and December 1998, to present the draft recommended plan to the public. Of these, 11 were held within the study area. The final public meeting was held in Washington D.C. ***Table 11-7*** shows the locations, dates, and approximate attendance for the public meetings.

All the south Florida meetings followed the same format. An informal "open house" was held from 5 p.m. to 7 p.m. for students, educators, local residents and other interested people to talk with Restudy Team members about the Restudy. Visitors were able to discuss issues with team members one-on-one and have specific questions answered. Five large, colorful standing exhibits were created explaining the C&SF Project and Restudy, from its past history to planned benefits. Displays featured public participation, problems with the C&SF Project, and the draft plan. Restudy Team members staffed each display.

The formal meeting to take public comment began at 7 p.m. A brief presentation on the Restudy, including introductory remarks from the District Engineer and the South Florida Water Management District Executive Director was presented. Then, public comment was taken throughout the evening.

TABLE 11-7
RESTUDY PUBLIC MEETINGS

Meeting	Date	Location	Approximate Attendance
1	November 2	Clewiston	165
2	November 4	Stuart	120
3	November 5	Okeechobee	160
4	November 9	Miami	75
5	November 10	Fort Lauderdale	150
6	November 12	West Palm Beach	190
7	November 16	Marathon	85
8	November 17	Homestead	85
9	November 18	Kendall	175
10	November 30	Naples	110
11	December 1	Fort Myers	100
12	December 8	Washington D.C	135

At almost every meeting, the public was able to view artwork from local elementary schools students. These students were participating in a poster contest. Participation was an optional part of the environmental education pilot program. The poster theme was “Our Florida, Our Everglades”. Students were asked to depict their vision of the Everglades when they grow up. Seven hundred and thirty-eight students from 21 schools participated in the contest.

Efforts were made to include south Florida minority groups as well. Meetings were advertised in minority community newspapers. Pre-meetings were held to brief African-American leaders on Restudy issues. The North Miami meeting was located in a community with a significant African-American population. The Kendall meeting was presented in English and Spanish, and publications were translated into Spanish.

A court reporter was present at each meeting and a transcript was made which serves as the official record of each meeting. Each of the meetings was also videotaped.

The following is a summary of the public meetings:

Clewiston

Primary concerns articulated by the Clewiston audience focused on the effect of proposed land acquisition and the effect it will have on land owners and on communities as a whole. Several speakers expressed concern that agricultural lands would be acquired for storage reservoirs and that the plan was designed to meet water supply needs of the lower east coast, further enabling population growth. Acquisition from willing sellers was stressed, as well as outright opposition to acquiring more lands in the Everglades Agricultural Area. Others asserted the plan was heavily weighted towards environmental restoration and asked for more information on measuring successful environmental restoration. Several speakers asked for water assurances to existing users and asked that state laws prevail in the implementation of the plan.

Concerns were raised about aquifer storage and recovery technology, water quality, seepage control for proposed reservoirs and whether the technology proposed will work. Some speakers questioned the process, specifically what Congress would authorize, the sequencing of projects and the implementation schedule. Concerns about funding were raised by several speakers.

Stuart

Many speakers expressed concern about the health of the St. Lucie Estuary, having experienced the negative effects of discharges made during the winter and spring of 1998. Several speakers recounted the negative economic impact caused by the discharge of fresh water and the resultant salinity changes, poor water quality and lesioned fish. Most speakers urged expedited implementation of Restudy projects that will stop these damaging discharges.

Several citizens reminded the group that Martin County had approved a one-cent sales tax increase to acquire land to be used for Restudy projects. Expedited land acquisition for Restudy projects was urged, especially north of the St. Lucie locks and in the Ten Mile Creek area. Concerns about the ooze in the St. Lucie River prompted some speakers to ask about the impact on human health of this and other possible water contaminants.

Okeechobee

Many speakers expressed concern about land acquisition, when lands would be needed, how much land would be required, and whether lands would be taken through eminent domain. Questions were raised about whether the benefits of the recommended Comprehensive Plan justified the negative impact on the rural lifestyle of the community and the loss of tax base such land acquisition would cause. Several speakers cited negative experiences with the Kissimmee River Restoration Project land acquisition process.

Several speakers expressed their concern that rural communities were being asked to bear the burden of supplying water to the growing East Coast and expressed a desire to see water storage areas constructed along the coast rather than in the Lake Okeechobee area. Others questioned proposed aquifer storage and recovery technology, seepage management and water reuse, water quality and how the plan will deal with uncertainties associated with technologies proposed for capturing and storing water.

Questions were raised about lake levels and whether the Restudy will improve fishing in Lake Okeechobee. Several speakers stated their objections to building a dike through the middle of the lake and were informed that that option had been modeled and rejected. Concerns were raised about the cost of the Restudy. Concerns about water assurance for existing users and flood protection were also voiced.

Miami (North)

The public expressed concern about the effect the Restudy will have on growth and urbanization. There were many concerns expressed about aquifer storage and recovery technology, seepage management and wastewater reuse, water quality and how the plan will deal with uncertainties associated with technologies proposed for capturing and storing water. Questions were raised about restoration of sheet flow, decompartmentalization, removal of canals or levees in the Water Conservation Areas and what goals would be accomplished through these strategies.

Questions were raised concerning land acquisition - specifically, how much land and through what process will these lands be acquired. The overall process for implementing the plan was of concern for many of the attendees. Several speakers raised concerns about funding, costs, and economic feasibility.

Several speakers mentioned water quality concerns associated with aquifer storage and recovery, wastewater reuse and backpumping. Questions were raised on whether the Restudy would improve water quality in local canals used for fishing. Additional concerns were raised concerning future water assurances for existing users and the percentage of African-American contractors to be used to construct the project. Several speakers objected to the engineering solutions proposed in the Restudy and urged more natural methods like flowways. Some citizens asked for an independent scientific peer review of the recommended Comprehensive Plan.

Plantation

Concerns were expressed about aquifer storage and recovery technology, seepage management and wastewater reuse, water quality and how the plan will deal with the uncertainties associated with technologies proposed for capturing and storing water. Several speakers asked that more “natural” methods be used to capture and store water and suggested that more land be acquired in the Everglades Agricultural Area and in the Water Preserve Areas for these purposes. Water assurance for existing users and the need for continued flood protection for the area were two issues raised by several long-time residents of the county.

Many speakers voiced their dissatisfaction with the plan’s impact on the ecological health of Water Conservation Area 2B and asked that modeling continue until the needs of this part of the Everglades are more fully met. Recreational users of the Water Conservation Areas expressed their concern about the removal of levees and canals and possible loss of access to favorite areas. Several citizens voiced their concern about the plan’s impact on the North New River, urban redevelopment on the coastal ridge, and the issues associated with that redevelopment like brownfields, gentrification and displacement of current residents. Concerns were raised that the plan will accelerate development in south Florida.

Some speakers questioned the wisdom of presenting a conceptual plan without a full implementation plan, detailed cost benefit analysis and a funding strategy. Others spoke to the need to proceed with haste as the area cannot afford more problems with water supply and contaminated wellfields. Several speakers asked for assurances that the plan place the greatest emphasis on restoring the environment, that enough water will be reserved for that purpose and short-hydroperiod wetlands not be lost in exchange for more water storage. Concerns were raised about the reliance on engineering solutions as opposed to more “natural” methods of water management.

West Palm Beach

Concerns were expressed about the effect the Restudy will have on growth and urbanization. There were many concerns expressed about aquifer storage and recovery technology, seepage management, wastewater reuse, water quality and how the plan will deal with uncertainties associated with these technologies. Several speakers mentioned the need for flood control and water assurances for existing users.

Land acquisition was an issue for many residents. Some citizens questioned the process, the impact on tax rolls, the amount of land to be acquired, and advocated fairness to property owners. Other speakers asked for more lands to be acquired in the Everglades Agricultural Area and the Water Preserve Areas in order to increase the spatial extent of wetlands and allow for more “natural” water management strategies as opposed to a reliance on engineering solutions. Several speakers from Martin County reminded the group that this county had serious concerns about the health of their estuary and expressed their desire to accelerate plan implementation in their area through passage of a sales tax to fund land acquisition.

Several speakers raised concerns about funding, costs and economic feasibility. Other citizens spoke to the need to expedite implementation of the plan for a sustainable south Florida, questioning whether we can afford the cost of doing nothing and asked that environmental restoration receive the highest priority. Local control of the system to be built and the lack of historic water management data were raised as issues.

Marathon

The majority of the speakers were concerned that the Restudy boundaries did not include the Florida Keys. They asserted that the Keys are part of the ecosystem and that there is a Federal interest in improving water quality as the Keys are home to a National Marine Sanctuary. Some recognized that the map boundary delineated the original C & SF Project canal system. One speaker expressed concern that including the near shore waters of the Keys in the plan would introduce too many variables for sound scientific analysis.

Many noted that poor quality waters from Everglades National Park negatively impacts Florida Bay and the reef. Several speakers asked for monetary and technical assistance in retrofitting the sewage treatment system for the Keys to protect the coral reef, Florida Bay, the Everglades and Biscayne National Park. Questions were raised about the adaptive management strategy outlined in the Restudy and how effectively on-going research on Florida Bay would be integrated into project design. The Corps was asked to include monitoring for salinity and toxins in the waters in the on-going analysis.

Some citizens stated their distrust of government, especially the Federal government. Some speakers expressed concerns about paying higher taxes for the project and asserted that the Restudy focused too much on environmental restoration to the detriment of water supply. Concerns were raised about aquifer storage and recovery technology and several speakers suggested more land acquisition in the Everglades Agricultural Area would allow more “natural” water management strategies instead of high tech solutions. Many expressed concern that the plan would facilitate more growth in south Florida.

Homestead

Concerns were expressed about decompartmentalization, specifically what levees and canals would be removed and what effect that would have on flood control in the area. Agricultural land owners asked for assurances that water levels in south Miami-Dade will not rise to levels that will saturate the root structures of their crops and orchards. Several speakers requested better modeling to understand the elevation of the agricultural lands in south Miami-Dade and the impact of altering groundwater levels. Other concerns pertained to water supply assurances for agriculture, an economic analysis of the impact of acquiring farmland in south Miami-Dade, and the lack of certainty about which lands may be taken out of production. Several speakers challenged the legality of the process, especially as it relates to land acquisition, and asked for more scientific information, a cost-benefit analysis and an economic impact study.

Some citizens from the Upper Keys asked to expand the boundaries of the Restudy to include the Keys and provide resources to improve water quality in Florida Bay and in the reef tract. There were questions raised about relying on engineering solutions like Aquifer Storage and Recovery, waste water reuse, water quality and seepage controls. Several speakers asserted that natural strategies like flow ways would be more cost effective. Concerns were raised about the cost of the project and the science behind the plan was questioned.

Integration of the C-111 project into the study was mentioned by several speakers. Some citizens questioned whether the plan was too weighted towards water supply for people and that not enough water was reserved for the environment. Issues were raised about population projections and the need to preserve agriculture in south Miami-Dade while providing water for the residents.

Kendall (South Miami)

Land acquisition was a great concern to many speakers, especially those with property in the Lake Belt Region and the 8 1/2 square-mile area. They expressed concerns about fair compensation, unfair targeting of small landowners, and questioned the constitutionality of the process. Several suggested that existing public lands be used for the components of the Restudy. Other citizens advocated more land acquisition, especially in the Everglades Agricultural Area.

The Miami-Dade Water and Sewer Department presented a list of concerns about water supply, water quality, water assurances, costs and future levels of flood control which were shared by the City of Medley. The Water and Sewer Department also expressed concerns about the cost of wastewater reuse and sought assurances that this technology would not affect existing wellfields and questioned whether reuse water was the best source for Biscayne Bay.

Several speakers expressed concern about more water for Biscayne Bay as well as the need for clean water for the most southern reach of the Everglades ecosystem. It was suggested that the Restudy consider another feasibility study on Biscayne Bay. Research was advocated for nitrogen as well as phosphorus limitations in the coastal waters. Some citizens voiced their concerns about the aquifer storage and recovery technology, the lack of a cost-benefit analysis and the reliance on engineering solutions as opposed to more “natural” strategies like flow ways and more above ground storage.

One speaker traveled from Martin County to remind this group of how tightly the whole system is woven together. Several speakers advocated proceeding with speed and expressed the view that the cost of not doing the Restudy far outweighs the costs of the plan.

Naples

Many speakers expressed concerns about how the Restudy will deal with southwest Florida issues and asked how the proposed Southwest Florida Feasibility Study will reflect recent citizen planning efforts. Several speakers asked for a better link between land use and water supply planning and asked for a carrying capacity study for the area that defines the water supplies available for future growth. Concerns were voiced that the Restudy will fuel growth and not protect natural resources.

Several attendees expressed their distrust of government, especially the Federal government. Some small landowners expressed their concerns about land acquisition and flood control. The cost of the project was of concern to some members of the public, as well as the lack of a full economic impact statement. Concerns were raised about aquifer storage and recovery technology and the uncertainties associated with that technology, with special concerns expressed about these wells in the Caloosahatchee basin. A few residents raised water quality and salinity issues.

Several speakers urged haste in implementing both the Restudy and the Southwest Florida feasibility study. Some residents suggested that the cost of inaction was unacceptable in terms of future generations and reminded the public that the Everglades is an important economic resource. Some speakers asserted that the costs could be reduced by using natural methods for water storage and management like reservoirs and flowways as opposed to engineering solutions.

Ft. Myers

Several speakers voiced their support for the Restudy and the feasibility study as an opportunity to develop water supply data for the region, steer growth to the right areas, and protect wetlands and other natural areas. Some asked for the feasibility study to become a carrying capacity study and spoke of their concerns that the Restudy will encourage more growth than the region's natural resources will sustain. Several members of the public had served on a local planning body that developed a vision for the area and asserted that the Alternatives Development Group's product should be incorporate into the Southwest Florida feasibility study.

Many citizens wanted assurances that the Caloosahatchee River Estuary would be protected from future freshwater releases and urged that more water be held in Lake Okeechobee and that the Everglades Agricultural Area hold more water on its own lands. Several speakers asked for more land acquisition to facilitate more natural methods of water management and storage like flowways and reservoirs as opposed to engineering solutions. Concerns were expressed about aquifer storage and recovery and the uncertainties associated with that technology.

Utilities and agricultural representatives sought water supply assurances and continued levels of flood control.

Many speakers expressed concern that the Restudy will accelerate growth and that the water needs of people would take precedence over the water needs of the natural system. Others feared that local government permitting decisions would undercut any benefit of the feasibility study.

The cost of the project was an issue for several citizens. Concerns were raised about seeking Congressional authorization for the Restudy without more information on costs, the proposed technologies and a detailed implementation plan. Some speakers expressed their distrust of government, especially the federal government, and were concerned that the Restudy would result in land condemnation. Several citizens asserted that the cost of the Restudy and the feasibility study are cheap compared to a water shortage in southwest Florida.

Washington, D.C

The overwhelming majority of the speakers supported the Restudy but did voice some concerns. The Corps was urged to use the principle of adaptive assessment as the plan moves forward and to be open to revisions as new information becomes available.

Members of the agricultural community expressed concerns about the reliance on aquifer storage and recovery, seepage control, and aboveground reservoirs. The lack of a funding proposal and questions about implementation and scheduling projects raised many concerns in this sector of the public. Questions were raised about the models used and issues were raised about the process used to formulate the conceptual plan. More detailed engineering and an economic feasibility study were requested. The agricultural community asked for a better integration of water quality standards into plan design and assurances that permitting built components would not become an issue in the future. Some questioned the model used to formulate the plan.

The industry sought assurances on water supply and flood control. Speakers asserted that Florida's Governor and Legislature must be formally involved in the implementation of the plan and that state laws govern all land acquisition and water supply requirements. The industry asserted that the conceptual plan had too many uncertainties to be authorized by Congress, but favored a limited authorization including pilot projects to test aquifer storage and recovery, seepage controls and a group of identified early action or critical projects that are technically and economically feasible. The industry asserted that all authorized projects undergo the traditional Corps analysis prior to implementation.

Land acquisition was a concern raised by every representative of the agricultural community. Speakers questioned the amount of land to be used for reservoirs and stormwater treatment areas. Representatives petitioned for a complete engineering and scientific justification for any land acquisition, asked that the Corps seek willing sellers, consider using public lands first and if condemnation is necessary, that the state condemnation process prevail. Concerns were raised about the economic impact on rural communities when lands are removed from the tax rolls and asked for fairness to landowners. Concerns were also raised about the devaluation of agricultural lands in a target area and the possible negative affect on crops on higher ground water levels.

The cost of the project was an issue with several speakers who raised concerns not only about the state's ability to cost share with the Federal government but also of the impact on individual citizens. Several speakers spoke of the link between the health of the ecosystem and a healthy economy and suggested that the price of inaction was unacceptable in terms of the continued sustainability of south Florida. Many speakers urged haste in implementing the plan and it was suggested that first priority be given to projects with a local cost share in place.

Several speakers from the environmental community voiced concerns that the Restudy will fuel continued growth in south Florida and that water will be diverted from the natural system to meet human needs. Several representatives asserted that the primary focus of the Restudy must be to improve the greater Everglades ecosystem and the secondary purpose was to meet human water supply and flood control needs. Speakers asked that a more concentrated modeling effort be undertaken to improve ecological performance in the Water Conservation Areas, Northeast Shark River Slough, Taylor Slough, Everglades National Park, the Model Lands, Biscayne and Florida Bays. It was suggested that the Restudy boundaries be expanded to include the Florida Keys.

Representatives of this segment of the public raised concerns about aquifer storage and recovery and other engineered solutions to water storage and management and suggested that more passive solutions like reservoirs and flowways would reduce the cost of the Restudy. This group sought more land acquisition for these purposes. Issues were raised about water quality with an emphasis on monitoring all toxins in the water column. Representatives for the southwest coast welcomed the proposed Southwest Florida Feasibility Study as an opportunity to protect their natural resources and provide for sustainable growth.

11.12 IMPLEMENTATION PLAN COORDINATION

The Implementation Plan presented in the *draft Integrated Feasibility Report and Programmatic Environmental Impact Statement* was very preliminary.

Additional work to refine and improve the Implementation Plan for this final report has been underway since the completion of the draft report. In addition to team meetings, five public workshops specific to the development of the Implementation Plan have been held with stakeholders. The first four workshops took place on July 29, 1998, August 27, 1998, November 23, 1998, and December 11, 1998. During these workshops and during the public comment period on the draft report, the public expressed a desire to have the opportunity to review and comment on the revised Implementation Plan prior to its inclusion in this final report. Accordingly, the revised draft Implementation Plan was released for public review on January 25, 1999. A public workshop on the Implementation Plan was held on February 1, 1999, to present the refined plan and solicit comment. Written comments on the draft Implementation Plan were received until February 5, 1999. The comments received from the public were used to finalize the Implementation Plan presented in ***Section 10*** of this report.

Comments on the Implementation Plan were received from agencies, stakeholders, and the public. Concerns were expressed about the level of restoration that will be achieved within the first ten years of implementation and the use of $400 million per year as an average for funding. The public was also concerned about accelerating land acquisition for the project. There were comments about integrating water quality improvements into the Implementation Plan. Some comments supported independent scientific peer review of the recommended Comprehensive Plan. Comments about the Project Implementation Report process and the list of projects recommended for initial authorization were also received.

SECTION 12
COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The alternative plans were considered in relation to compliance with Federal environmental review and consultation requirements.

12.1 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

Environmental information on the project has been compiled and a Draft Programmatic Environmental Impact Statement (PEIS), Central & Southern Florida Project Comprehensive Review study, was prepared on October 1998. A systematic interdisciplinary approach to planning has been utilized; alternatives have been studied, developed and described, and ecological information has been developed and utilized. A notice of availability for the Draft PEIS was published in the Federal Register, Volume 63, Number 205, on October 23, 1998. The Draft PEIS was coordinated with state, Federal and local agencies, native American Tribes, non-governmental agencies, and the public for seventy-one days until December 31, 1998. A Final PEIS has been prepared incorporating comments and recommendations provided by state, Federal and local agencies, native American Tribes, non-governmental agencies, and the public and including a compilation of reviewer comments and agency responses in ***Appendix N***. This Final PEIS is being circulated in accordance with the National Environmental Policy Act for a period not less than thirty days.

12.2 FISH AND WILDLIFE COORDINATION ACT OF 1958

In response to the requirements of this Act, the U.S. Army Corps of Engineers has and will continue to maintain continuous coordination with the U.S. Fish and Wildlife Service and the Florida Game and Freshwater Fish Commission during all stages of the planning and implementation of this project. Previous to completing the Draft PEIS, the Florida Game and Fresh Water Fish Commission submitted a Fish and Wildlife Coordination Act report on August 6, 1998. The U.S. Fish and Wildlife Service also submitted, under separate cover, a Draft Fish and Wildlife Coordination Act report dated August 7, 1998.. The comments provided as a part of these reports were reviewed by the Corps and served to provide a framework for future investigation of scenarios and modifications to the Initial Draft Plan. Following release and coordination of the Draft PEIS and prior to completion of the Final PEIS, the U.S. Fish and Wildlife Service, submitted a Final Fish and Wildlife Coordination Act Report (as a supplement to the draft) on March 1, 1999. The Florida Game and Fresh Water Fish Commission also submitted two additional Fish and Wildlife Coordination Act Reports (Part II and Part III) on

January 19, 1999 and February 19, 1999 respectively. These reports are included in their entirety in ***Annex A.***

The Fish and Wildlife Service and Florida Game and Fresh Water Fish Commission recognize that while implementation of the Comprehensive Plan should result in widespread restoration of natural systems in south Florida, the plan also continues to include some unresolved issues. These remaining issues are a source of concern among the resource agencies. Both of the Fish and Wildlife Coordination Act reports contain recommendations for addressing these concerns. An interagency effort was begun in September 1999, led by the Alternatives Evaluation Team, to better define, prioritize, and develop a strategy to resolve each of these concerns. Although resolution of these issues is on a fast track, the Alternatives Evaluation Team has shown that substantial new technical information, to be provided by additional research and modeling, will be required to address these efforts. The Restudy is committed to seeking resolutions to these concerns, in an interagency, consensus-building setting. Issue resolution will be an important function of the RECOVER process that will help guide the program through implementation. The following paragraphs contain recommendations as presented in the Fish and Wildlife Coordination Act Reports prepared by the U.S. Fish and Wildlife Service and Florida Game and Fresh Water Fish Commission and responses to the recommendations prepared by the Corps.

12.2.1 U.S. Fish and Wildlife Service draft Fish and Wildlife Coordination Act Report Recommendations

Comment #1 – The Department of Interior recommended that all progress toward achieving ecosystem restoration be continuously evaluated in a scientific forum. A peer-reviewed science-based adaptive management strategy, coupled with a sound monitoring program, is the recommended means for integrating all the past knowledge of the south Florida ecosystem with recent findings of the scientific community. Based on the monitoring information, the interagency adaptive management team will prepare annual reports and provide recommendations to decision-makers on how to proceed. This strategy will ensure that refinements to the Initial Draft Plan will be based on the best and most recent information. The annual reports will also be an avenue for keeping the general public fully informed.

Response – A specific strategy has been developed for conducting regular, science-based evaluations to determine how well the components of the Recommended Plan achieve the ecological targets set by the performance measures. A team of senior ecologists and hydrologists will compare actual ecological responses with predicted responses, as a basis for considering changes in plan components and for improving and redefining overall ecological measures of restoration success. The products of this internal review will be independently reviewed on a regular basis by the Science Advisory and Review Panel, appointed by the South Florida Ecosystem Restoration Task Force. The measures of ecological responses will be determined through a regional, integrated monitoring program. All evaluations and recommendations will be made widely available for review by means of annual reports.

Comment #2 – Proper sequencing of presently authorized projects and the components to be authorized in the C&SF Restudy must be determined and followed. Effective sequencing of actions proposed by the C&SF Restudy (relative to each other and to existing authorized projects) must be thoroughly analyzed and integrated in construction schedules.

Response – A multi-agency team, similar to the Alternative Development and Alternative Evaluation Teams, was formed to develop the implementation plan. The team has developed guidelines for the development of the implementation plan, an initial packaging of components, and initial sequencing of projects for the draft report. The implementation plan has been reviewed by the AET and other members of the Restudy team and has been considerably expanded in scope and detail in the final feasibility report.

Comment #3 – The Department of Interior strongly supported the completion of feasibility studies on the Water Preserve Areas, the Indian River Lagoon, and initiation of a feasibility studies on Southwest Florida, and Biscayne Bay.

Response – The Corps of Engineers completed a Reconnaissance Report for Biscayne Bay in 1995. The study proposed the development of a multi-phase modeling system to investigate the effects of Federal projects on water circulation, biological communities, and water quality in the bay. The first phase, which includes development of a hydrodynamic model with associated surface and groundwater models, is presently underway. The Biscayne Bay Feasibility Study is cost-shared with Miami-Dade County. The Indian River Lagoon and Water Preserve Areas Feasibility studies are currently ongoing and alternatives are being assessed by their respective inter-agency study teams. The NEPA process in support of regulatory actions for Southwest Florida has been ongoing for the past year and a draft Environmental Impact Statement will be coordinated in the near future with state, Federal and local agencies, native American Tribes, and the public.

Comment #4 – The Department of Interior recommended that Other Project Elements that provide the most significant ecological benefit receive the highest priority for future detailed planning and implementation.

Response – The Department of Interior participated in the evaluation of the Other Projects Elements. This evaluation is described in ***Appendix A5***. Based on this evaluation, and adjustments to the scope of the plan, nineteen Other Project Elements are recommended for inclusion in the Comprehensive Plan.

Comment #5 – Recreational opportunities in the natural areas of south Florida must be considered in detailed project design and in policy development as well as the perception that Federal lands are receiving restoration priority over state lands.

Response – Concur. Recreation is one of the C&SF Project purposes and future planning should attempt to minimize impacts which may affect existing recreation resources, while still restoring the natural functions and values inherent in a restored Everglades ecosystem. The Recommended Comprehensive Plan has been developed to benefit all natural areas of the ecosystem, not just Federal lands.

Comment #6 – Aquifer Storage and Recovery should be used in combination with surface storage reservoirs since the reservoirs would modulate peak flows to the wells. For water quality reasons, it would be preferable to recover the water from Aquifer Storage and Recovery wells into a buffer zone area designated for this purpose rather than directly into natural environments. Other water storage options should be investigated in the event Aquifer Storage and Recovery cannot be implemented on the scale proposed for the Restudy.

Response – A number of the construction features that involve surface storage include Aquifer Storage and Recovery features. Post-treatment of water withdrawn from Aquifer Storage and Recovery wells is included in the Comprehensive Plan but further planning and design, including pilot projects, will be needed to address the water quality effects of water recovered from these facilities.

Comment #7 – Opportunities for removal of structures that impede restoration should be a guiding principle; addition of structures must be clearly demonstrated to be unavoidable before being included in designs.

Response – The Restudy Team investigated a number of alternatives to remove barriers between natural areas in the Everglades. The Comprehensive Plan is a compromise between fully reconnecting the Everglades by removing the barriers that hinder continuous sheetflow and achieving ecologically based targets in the Everglades. Future refinements to the plan will reflect the importance of connectivity at a landscape scale and the desire of the team to reduce fragmentation along with the other problems artificial structures cause.

Comment #8 – Detailed design of all components should continually consider approaches that will promote passive systems over intensely active management.

Response – The Corps of Engineers prefers low cost and low energy consumption features to high cost features, as long as they produce the desired results. Preliminary studies have shown that passive management may work very well within Everglades National Park but less well in the bounded Water Conservation Areas, for example. Future studies will promote passive systems wherever they create and protect natural hydropatterns and the habitats that depend on them.

Comment #9 – Policies governing Clean Water Act authorization of wetland mitigation within the study area must be consistent with the goals of the C&SF Restudy. Enhancement of wetland function attributable to the C&SF Restudy should not be credited to other interests who are required to mitigate for wetland functional losses. As a policy, using lands inside the C&SF Restudy boundary to replace wetland functional losses occurring outside the C&SF Restudy boundary should be prohibited. To meet the stated goal of "increasing the spatial extent of wetlands" wetland mitigation should supplement, not supplant ecosystem restoration benefits attributable to the C&SF Restudy. Information on the location of features proposed in the C&SF Restudy must be made accessible to reviewers of permit applications, and all permit decisions must be compatible with the design and purposes of the C&SF Restudy.

Response **-** For unavoidable impacts to existing Regulatory mitigation sites, separable mitigation, on a case by case basis will be developed in subsequent phases of the project. This mitigation will be derived from sources other than the benefits identified in this report. The Corps of Engineers and the U.S. Fish and Wildlife Service are members of the interagency team developing the South Florida Comprehensive Conservation, Permitting and Mitigation Strategy. When completed, this strategy should provide consensus based guidance regarding the siting of mitigation sites, including banks, in relation to proposed features of the Comprehensive Plan. In addition, the Mitigation Bank Review Team should work closely with the Restudy Team and potential mitigation bankers regarding opportunities for environmentally compatible private mitigation banks in the project area that will supplement, not supplant, potential benefits of the Comprehensive Plan.

Comment #10 – Land acquisition funding should receive priority before restoration opportunities are lost. Although current activity is largely dependent on willing sellers, the Department of Interior finds that eminent domain procedures will likely be required to complete the plan.

Response – Lands, which can be identified as required for implementation of the plan, should be acquired as soon as possible from willing sellers to the extent possible. Normally, eminent domain may be used to acquire lands for authorized projects: (1) in the event the lands identified for the plan cannot be acquired from willing sellers; (2) only after the completion of necessary documents that identify what particular lands are required for the plan and approval of construction of the particular component by the State and Federal government; and (3) after execution of a Project Cooperation Agreement between the U.S. Army Corps of Engineers and the non-Federal Sponsor.

Comment #11 – The Water Preserve Areas of Palm Beach, Broward and Miami-Dade Counties are an essential feature of the C&SF Restudy that should proceed rapidly to detailed design, while preserving areas of existing high habitat value and providing fish and wildlife habitat enhancement features in others. The Department of Interior recommends that land acquisition in this critical area be accelerated and that the U.S. Army Corps of Engineers begin an expedited Feasibility Study of the area as soon as possible before restoration opportunities are supplanted by continued urban and agricultural development. Water storage and treatment in other portions of the C&SF Restudy area should also minimize impacts on fish and wildlife habitat.

Response – The Water Preserve Areas of Palm Beach, Broward and Miami-Dade Counties are essential features of the C&SF Restudy and are proceeding as part of the ongoing Water Preserve Areas Feasibility Study estimated for completion in September 2001. This study will take the features identified in the recommended plan in Palm Beach, Broward and Miami-Dade Counties and further formulate their concept in a Project Implementation Report that contains appropriate NEPA documentation.

Comment #12 – The Department of Interior recommended that an equivalent Task Team for invasive exotic animals be established, similar to the statewide strategic plan for managing and controlling exotic pest plants, being developed by the South Florida Ecosystem Restoration Task Force and Working Group Exotic Pest Plant Task Team.

Response – Concur. However, the issue of invasive exotic animals in south Florida reaches beyond the scope of the Restudy. The Department of Interior should present this recommendation to the South Florida Ecosystem Restoration Task Force so appropriate agencies can be tasked to develop a plan.

Comment #13 – The Department of Interior recommended that further refinement of the Initial Draft Plan be completed prior to release of the Final Integrated Feasibility Report and Programmatic Environmental Impact Statement. These refinements are described in Recommendations 13a - 13e, below.

Comment #13a – Total overland flow volumes to Florida Bay, through Shark River Slough, and Taylor Slough, should be increased to more fully reach Natural System Model targets, without adversely affecting the Water Conservation Areas, particularly eastern Water Conservation Area 3A, and 3B

Response - The Alternatives Evaluation Team has coordinated a process for creating a stronger technical consensus and a refined set of performance measures pertaining to the ecological implications of recovering various hydrological targets, including flow volumes, in the Shark Slough and Taylor Slough estuaries. The current range of technical opinion is that the combination of meeting or substantially improving a number of different hydrological targets, rather than a single parameter such as flow volume, is the best route to ecological restoration. The hydrological priorities suggested by the Conceptual Ecological Models, and in numerous documents of the Department of the Interior, indicate that hydroperiod duration and stages are the hydrological targets which can best be related to ecological needs. The southern Everglades sub-team of the Alternatives Evaluation Team developed multiple performance measures to gauge the effects of alternative plans on different needs of the system. The timing of flows, duration of hydroperiods, and stages were considered the higher priority restoration targets for the southern Everglades slough systems. The team chose to protect critical dry season flows even if wet season depths were somewhat reduced. Where an array of hydrological parameters are used to evaluate alternative plans, some weighting of the different values is necessary as a means of dealing with ecological priorities and modeling uncertainties. Because the U.S. Geological Survey (Bales et al. 1997) suggested that the Natural System Model could not be reliably used to simulate discharges (flows) in pre-drainage Florida, any targets based on predicted pre-drainage flows were weighted accordingly.

Comment #13b – The Corps should continue to seek opportunities that are not dependent on wastewater reuse in order to restore more natural flows to Biscayne Bay. Two Other Project Elements would benefit Biscayne Bay with or without the additional water that may be available through reuse facilities. These two Other Project Elements are entitled: South Dade Agriculture Rural Land Use and Water Management Plan and Biscayne Bay Coastal Wetlands. The Department of Interior believes that these projects and any others developed to improve ecological conditions in Biscayne Bay should be given priority. Under any future circumstances, total flow volumes to Biscayne Bay should be no less than those simulated in the 1995 Base.

Response – Concur. Additionally, investigations of less expensive forms of wastewater treatment will be explored that may substantially reduce the cost of that feature. As a point of clarification, the OPE Biscayne Bay Coastal Wetlands, is included as a part of the Comprehensive Plan. The South Dade Agricultural Rural Land Use and Water Management Plan is one of the Critical Projects nominated by the Working Group. This project is not included in the Comprehensive Plan as an OPE. Rather, it is considered to be a research/data collection activity that may be useful during the Project Implementation phase. In addition, this project (or a subset thereof) is being undertaken through the Biscayne Bay Feasibility Study.

Comment #13c – Restoration goals for minimum flows of fresh water to the St. Lucie Estuary and the elimination of regulatory releases to the estuary from Lake Okeechobee would be generally met in the Initial Draft Plan. However, runoff generated within the St. Lucie drainage basin is still significantly greater than the restoration target. The Department of Interior recommended further hydrologic modeling efforts be undertaken to restore the St. Lucie Estuary prior to release of the Final Programmatic Environmental Impact Statement. Moreover, this important restoration effort should be highlighted as a priority for future analysis and refinement under the authority of the U.S. Army Corps of Engineer's Indian River Feasibility Study.

Response – Hydrologic modeling of the St. Lucie Basin is ongoing although new information was not available for the Final Programmatic Environmental Impact. The Indian River Feasibility Study was initiated to ensure the modeling and analysis necessary to support the restoration effort continues beyond the completion of the Comprehensive Plan.

Comment #13d – The Department of Interior expressed concern that the C&SF Restudy does not include an adequate plan for treatment of water destined to be returned to the natural system. The Department of Interior recommended that specific pollutant loading targets be established and an implementation plan developed to reach defined targets within the watershed. Finally, planning should not be limited to nutrient loading; a variety of water quality parameters and pollutants also need to be addressed (e.g., pesticides and mercury contamination).

Response – The Comprehensive Plan includes stormwater treatment areas and other treatment facilities (e.g., aeration of Aquifer Storage and Recovery-recovered water) for treatment of water prior to return to the natural system. Except for total phosphorus (e.g., Taylor Creek/Nubbins Slough Stormwater Treatment Area [Component W2], L-28 Interceptor Modification Stormwater Treatment Areas [Component CCC6]), the stormwater treatment areas were not designed considering specific pollutant load and concentration targets. The State of Florida's Everglades Forever Act addresses specific phosphorus and non-phosphorus pollutant targets in the Everglades Protection Area; however, specific targets have not yet been developed for all pollutants in other impaired water bodies within the study area.

Under the Federal Clean Water Act, the State of Florida and Miccosukee and Seminole Tribes are required to identify impaired water bodies within their jurisdictions and develop specific pollution loading targets (Total Maximum Daily Loads). This requirement applies to all pollutants contributing to the impairment of the water body. While these actions are outside the scope of the Restudy, it is expected that development of Total Maximum Daily Loads will be integrated into the overall implementation of Restudy components. Specific targets, as they are developed, will be considered during future detailed design activities.

Comment #13e – The Department of Interior believes that water supply for all users (urban, agricultural, natural system) cannot be met in the year 2050, unless unconstrained water demands by urban and agricultural users is reevaluated. The Department of Interior recommended that a guaranteed water allocation to the natural system be developed and instituted as soon as possible.

Response - The Alternatives Evaluation Team has developed a process to better define the technical issues associated with any potential, future conflicts among water requirements for natural, agricultural and urban portions of the total system. In the future, as a part of the RECOVER program, an interagency task team would be assigned to determine the specific water supply issues that could result in conflicts and to make recommendations for prioritizing and preventing these conflicts. The Comprehensive Plan does include water conservation in both the future without plan condition and as a component of the recommended plan. A total reduction in urban water supply demands of 18 percent is estimated to occur as a result. All increases in water supply to agriculture are based on using high efficiency low volume irrigation now required as a part of the South Florida Water Management District's consumptive use permitting process. There are provisions in Florida law (Chapter 373) for the South Florida Water Management District to provide water for the natural system. These include establishing and implementing minimum flows and levels, implementing hydropattern restoration for the Everglades Protection Area and any other natural systems which are being restored, reserving water quantities necessary for the protection of fish and wildlife, and limiting consumptive use permit allocations to prevent harm to the water resources.

Comment #14 – The Department of Interior noted that the Restudy is proposing as many as 225 deep storage wells (Aquifer Storage and Recovery) as an option to improve water supply. In order to ensure the feasibility of regional Aquifer Storage and Recovery facilities, and the long term management of each site, the Department of Interior recommended the initiation of an Aquifer Storage and Recovery feasibility study including hydrologic modeling to evaluate technical uncertainty associated with regional scale Aquifer Storage and Recovery proposed in the Restudy. The feasibility study should investigate placing water removed from storage wells into "buffer zones", before being discharged into the natural environment, and other water storage options in the event that Aquifer Storage and Recovery cannot be implemented on the scale proposed for the Restudy.

Response – Aquifer Storage and Recovery is an important component in the Comprehensive Plan. It is recognized that there are technical and regulatory issues associated with the regional scale Aquifer Storage and Recovery components, therefore, pilot projects have been recommended prior to embarking upon full scale implementation of the technology. In addition, section 7 of the report includes a discussion of the potential alternatives to the Aquifer Storage and Recovery components.

Comment #15 – The Department of Interior recommended that improvements be made to hydrologic models that will be used in detailed planning for Restudy components to better account for water flows, including groundwater flow, identifying areas where more data are needed, securing better topographic data, particularly in critical areas, and addressing water quality concerns.

Response – Concur. The Corps and South Florida Water Management District have developed more detailed models that will be used for the Water Preserve Area Feasibility Study. It is anticipated that additional, more detailed models and data will need to be developed as the Restudy progresses into the detailed planning and design phase for other areas where modifications to the project will be made.

12.2.2 U.S. Fish and Wildlife Service final Fish and Wildlife Coordination Act Report Recommendations

Comment #1 – The final plan as implemented should include components from the $D13R_4$ scenario that can provide an improved capability for delivery of additional water to Everglades National Park and Biscayne Bay up to the amount in the $D13R_4$ scenario by capturing additional runoff from urban areas. The Implementation Plan should include a phased approach to provide for improvement and eventual full recovery of the WCAs, ENP, Biscayne Bay and those other natural areas that have been adversely affected to by the C&SF Project.

Response – The Corps has committed to implementing a final Comprehensive Plan that increases the capability for delivery of additional water to Everglades National Park and Biscayne Bay. Approximately 253,000 acre-feet of additional water, from urban canal basins, has been identified in the $D13R_4$ scenario that may provide this additional source of water. Implementation of this type of scenario necessitates resolving water quality issues prior to hydrologic restoration. Furthermore, the Corps is committed to protecting the environmental integrity of the Water Conservation Areas, such that incorporation of any elements of $D13R_4$, or future plan features which capture, store and convey additional water to ENP and BNP, will not adversely affect conditions in the Water Conservation Areas. Finally, the Implementation Plan includes a phased approach, as described in correspondence dated February 19, 1999 from the Corps to the U.S. Fish and Wildlife Service and Everglades National Park, providing clarification on the Comprehensive Plan.

Comment #2 - The Corps should give high priority to examining those groups of components related to movement of water from the central Everglades to the southern Everglades, including but not limited to, L-29 and L-67 A and C. The final Comprehensive Plan should be flexible enough to develop and substitute components during implementation that significantly reduce the operational and ecological trade-offs in balancing the restoration of flow patterns and volumes with the maintenance of appropriate water depths in the remnant Everglades, particularly in the WCA 3B/Pennsuco Wetlands/Northeast Shark Slough areas.

Response – The Comprehensive Plan has demonstrated flexibility in capturing, storing, and conveying water to various areas in the system to meet natural system and urban/agricultural demands. This was most recently illustrated during the scenario process that resulted in $D13R_4$ that was evaluated by the Alternative Evaluation Team. $D\text{-}13R_4$ was described in the Department of Interior Fish and Wildlife Coordination Act Report, dated March 1, 1999, as having "... demonstrated the flexibility in the conceptual plan for more closely approaching restoration targets for the southern Everglades and Biscayne Bay." The Corps is therefore confident that indeed, the Comprehensive Plan is sufficiently robust in its ability to meet restoration of flow volume, depths, duration and distribution of flows, while maintaining appropriate depths elsewhere in the system.

The components mentioned will be revisited during detailed design. The Corps, through an interagency process, has developed an Implementation Plan that will continue to consider ecological priorities (see ***Section 10***). Section 10.5.1.4 of the Implementation Plan describes a series of factors and rules to consider in developing the sequence of project implementation. These factors included: components that have physiographic and functional connectivity, provide immediate benefits, contribute to the overall system, components that may be implemented through ongoing projects, and components that need to be implemented to avoid lost opportunity potential.

Comment #3 - The Department of Interior recommends that the Corps not commit to the specific details of the L-67 levee component as conceived in either Alternative D13R or the $D13R_4$ scenario.

Response – All of the more than sixty components contained in the Comprehensive Plan were formulated and evaluated with a great deal of involvement from state, Federal and local agencies. This particular component was developed and evaluated through the Restudy interagency plan formulation process (AET/ADT), including U.S. Fish and Wildlife Service, and the National Park Service staff, and was done in response to a desire for more passive features over mechanical, engineered solutions. This component makes maximum use of passive features eg. earthen plugs and weirs, and is fundamental to the overall restoration of flows to the southern Everglades, while approaching appropriate depths in

Water Conservation Area 3B. However, as we progress into more detailed planning, we will be willing to consider more suitable methods to achieve the same goals.

Comment #4 - The use of the currently designed S-140 as a means to restore hydropatterns in northern WCA 3A needs to be further evaluated during the PIR process and in detailed design. The Department of Interior suggests a better balance between the use of the S-140 as a point of discharge and a series of inflow structures to spread out flow along the northern and western boundary of WCA 3A.

Response – Concur. This plan feature will be further evaluated during detailed planning, including preparation of appropriate NEPA documentation, to determine the precise implementation strategy for the S-140 in order to meet hydroperiod targets in northern WCA 3A without incurring unacceptable adverse impacts such as an expansion and proliferation of cattails.

Comment #5 - Until the Comprehensive Plan is implemented, surface water flows for Biscayne National Park and the bay should meet or exceed the 1995 base condition. Furthermore, there should be neither any annual or seasonal net loss in the total volume or any reduction in the spatial and temporal distribution of combined surface and groundwater flows.

Response – Concur in part. To the extent that the C&SF Project currently controls fresh water flows to Biscayne National Park, and the bay, operation of the Project will strive to meet or exceed 1995 base condition target flows. Only if there should arise a consensus conclusion, based on development of new performance measures for Biscayne Bay, that alternative flow patterns may be beneficial for restoration of the bay, would the Corps consider reducing flows below the 1995 base.

Comment #6 - Every effort should be made to find sources storage and means of distribution of water to Biscayne Bay that a) require minimal water treatment, b) are likely to receive adequate funding and have the greatest probability of success, and c) can achieve current and future restoration targets, with reasonably predictable environmental and economic consequences. Wastewater reuse should be considered as a last resort.

Response – Concur. The use of waste water reuse is already acknowledged to be a "last resort" feature in that the expense of building, operating and maintaining waste water reuse facilities is very high relative to other features. See component BBB; South Miami-Dade County Reuse, Section 9.1.8.24 of main report.

Comment #7 - Studies to verify restoration targets for Biscayne National Park and the bay should be funded and prioritized early during the implementation phase. The Biscayne Bay Feasibility Study, in particular, must be given a very high priority.

Response – The Biscayne Bay Feasibility Study is ongoing. Its first phase includes development of a hydrodynamic and circulation model for the bay. Later phases will investigate water quality and ecological baseline restoration needs. It will be vital for Department of Interior to play an active role in the development of this study as it progresses.

Comment #8 - The Department of Interior recommends that sufficient water treatment capacity be built into the Plan to handle the increased water volumes needed to achieve the hydrologic characteristics as were observed under $D13R_4$. Furthermore, the Department of Interior recommends that the Comprehensive Integrated Water Quality Plan be given priority and that specific funding be identified for this purpose in WRDA 2000.

Response – The Corps and its planning partners share these concerns and recognizes their significance in terms of creating potential significant adverse impacts to the natural area. The Corps is committed to full resolution and consensus based solutions to water quality issues prior to implementing hydrologic modifications throughout the south Florida ecosystem including the Everglades and Biscayne Bay. The Comprehensive Integrated Water Quality Plan will be initiated under the existing authorization for the Restudy, Section 309(l) of the Water Resources Development Act of 1992 (Public Law 102-580).

Comment #9 - The Department of Interior re-emphasizes its recommendation described in a February 18, 1999 Planning Aid Letter, that the 2010 case study be revisited to see if optimizing reservoir performance, reordering the implementation schedule, or phasing components into increments, would improve performance of the Comprehensive Plan by the year 2010.

Response – The 2010 case study was conducted to help to provide additional information relating to the sequencing of Comprehensive Plan components. Subsequently, the Comprehensive Plan schedule has been refined in an effort to expedite restoration efforts. The project implementation report process will also look for opportunities to enhance the performance of individual components through the detailed planning and design phases of implementation.

Comment #10 - High priority needs to be placed on further refinement of the Natural Systems Model early in the implementation of the Comprehensive Plan. Particular attention needs to be placed on the assumption that the ground elevation in the SFWMM is equivalent to the NSM model elevation south of Tamiami Trail, when evidence supports the fact that subsidence has occurred south of the Trail.

Response – Concur. Although further refinement of the NSM is an ongoing scientific information need and not a project feature of the Restudy Comprehensive Plan per se. The Corps and its sponsor agency, the SFWMD, actively support further development and refinement of the NSM in cooperation with the Department of Interior.

Comment #11 - The Comprehensive Plan should include support for development and verification of a peat accretion model, development of a risk analysis for chronic and acute loss of soil, and research on the effect of water depth on the expansion of cattails in the areas of greater soil subsidence in northern WCA 3A. The Corps and cooperating agencies should develop and test active management techniques that accelerate recovery of damaged soils in the WCAs.

Response – Concur. These are laudable and worthwhile research initiatives and the information derived from them will certainly help to improve performance of the Comprehensive Plan. Although the monitoring and adaptive assessment budget does not specify support for particular information needs, funds may be periodically programmed in support of these key information needs. The Corps looks forward to working cooperatively with the Department of Interior on these efforts.

Comment #12 - The Corps should support an ongoing and in-depth scientific review throughout implementation to help achieve the most appropriate balance in restoration of flows, patterns, volumes, and depths in maximizing overall ecosystem benefits.

Response – The Corps has supported, and will continue to support ongoing independent scientific peer review throughout the implementation of the Comprehensive Plan. Section 10.4.3 provides a more detailed review of past efforts and the plans for future peer review of the Comprehensive Plan including a discussion on the proposed Science Advisory and Review Panel to be appointed by the South Florida Ecosystem Restoration Task Force.

12.2.3 Florida Game and Fresh Water Fish Commission, Fish and Wildlife Coordination Act Report, Part I Recommendations

Comment #1 – Both Alternative D and D-13R perform very well for the lake; however, if regional Aquifer Storage and Recovery fails to perform adequately, we strongly recommend that the contingency plans avoid transferring the brunt of the storage lost to any part of the natural system.

Response – Concur. ***Section 7*** of the report includes a discussion of potential alternatives to Lake Okeechobee Aquifer Storage and Recovery.

Comment #2 – The Florida Game and Fresh Water Fish Commission recommended that the U.S. Army Corps of Engineers work closely with staff of the Florida Game and Fresh Water Fish Commission's Division of Fisheries to reduce or eliminate the potential for impingement and entrainment of fishes by new pumping facilities.

Response – Concur.

Comment #3 – In order to rectify hydrologic problems in Water Conservation Area 2B, every attempt must be made in the future to identify why the modeled alternatives, particularly Alternative D-13R, have failed to provide hydropatterns that would be conducive to an Everglades landscape. The Florida Game and Fresh Water Fish Commission suggested that the first area to be investigated is the operation of Water Conservation Area 2A and 2B.

Response – There is a clear understanding of the existing problem, but there is a lack of feasible solutions. The problem is related to the severed flow paths of the historic Everglades. When water is introduced to the northwestern side of Water Conservation Area 2A, at Natural System Model like values, water will pond along the southeastern side because the natural flow lines cannot be maintained in the remnant Everglades. Removal of the levee between Water Conservation Area 2A and 2B only exacerbates the problem. Because Water Conservation Area 2B has no natural outflow zone, water cannot flow through in a natural manner. Alternative D-13R, like other alternatives, provides an outflow at the southern rim of Water Conservation Area 2B, but it cannot remove water at the rate that water accumulates in Water Conservation Area 2B, even if there was an area in which to store the excess water. Complete flow through during a wet season would result in a larger dry season demand. At the time of alternative development, no solution existed. Clearly, more effort is needed to find appropriate targets and feasible solutions for these areas.

Comment #4 – Hydrologic performance in northeastern Water Conservation Area 3A should be improved during further modeling efforts. It is possible that changes in Stormwater Treatment Area 3/4 operational rules alone could lead to improved performance. Additional storage to the north, or the development of structures that would provide a more balanced distribution of inflows to the Water Conservation Areas during high rainfall periods, may also need to be included in the final plan.

Response – The operation rules for Stormwater Treatment Area 3/4 are based upon water quality and hydrologic characteristics of the treatment area and should not be changed. The problem again is related to the severed flow path of the historic Everglades. Water cannot flow from the area as it did under historical conditions. Water spread at the northeastern side of Water Conservation Area 3A for hydropattern improvement ultimately combines with water from Water Conservation Area 2A (unnaturally) and causes ponding since it can no longer flow in historical directions. Alternative D-13R removes a limited amount of the water that ponds in eastern Water Conservation Area 3A and passes it to Northeast Shark River Slough via the Central Lake Belt.

Comment #5 – The Florida Game and Fresh Water Fish Commission recommended that the U.S. Army Corps of Engineers and the South Florida Water Management District run a sensitivity analysis to determine whether the L-67A canal can be extended farther south and still capture the hydrologic benefits that the currently proposed design is anticipated to accomplish. In addition, it is the Florida Game and Fresh Water Fish Commission understanding that the removal of the L-29 levee automatically included removal of the L-29 canal, as well. In short, we would strongly support a design that clearly aids in restoring the overall hydrologic characteristics of the predrainage system; however, we would be opposed to removing canals that currently provide recreational fishing benefits when that removal provides little or no hydrologic restoration benefit. The Florida Game and Fresh Water Fish Commission recommended that the U.S. Army Corps of Engineers work in close cooperation with the their Division of Fisheries during the detailed design phase in order to determine the degree to which recreational amenities can be maintained and to fully mitigate for any losses (e.g., by designing the Water Preserve Areas so that they support recreational fishing).

Response – Concur in part. The Water Preserve Areas and the storage reservoirs proposed for the Caloosahatchee River Basin, north of Lake Okeechobee, St. Lucie Basin and the Everglades Agriculture Area may have recreation benefits, which could, in part, offset those lost due to filling canals within the Everglades. Those opportunities should be fully explored during the detailed design phase. Canals have been shown to function more than simply interrupting the natural hydrology of the Everglades, however. They also transport exotic plants and animals into relatively pristine areas, transport nutrients, and biocides from urban and agricultural areas into the natural system, and facilitate overdrainage of natural areas. For these reasons, it has been among the restoration objectives of the Restudy to address this previous negative impact of the C&SF Project.

Comment #6 – Because the long-term ecological effects of shifting to a hydroperiod longer than Natural System Model predictions in northern and central Water Conservation Area 3A are unknown, further modeling and design of the preferred alternative should include an effort to develop operational flexibility within the Everglades watershed. Operational and structural details should be explored that will allow hydroperiods within the remnant Everglades to be reduced in some regions without causing an overall loss of flow to more downstream parts of the system. The use of the S-140 structure and an associated spreader-canal system would be an example, as it might allow more water to be discharged into central Water Conservation Area 3A, if it became desirable to send less water into northern Water Conservation Area 3A as a means of discouraging cattail expansion.

Response – Concur. Further modeling, which will include structural and operational changes, will be explored during the detailed design phases of the project in an effort to improve the hydrologic performance of the recommended plan.

Comment #7 – The U.S. Army Corps of Engineers and local sponsor should work with the U.S. Geological Survey and others to expedite the collection of high-resolution topographic data in Rotenberger and Holey Land Wildlife Management Areas and throughout the Water Conservation Areas and Everglades National Park.

Response – Concur. High-resolution topographic data is needed for future modeling efforts for both South Florida Water Management Model and Across Trophic Levels System Simulation model, as well as future operational water management decisions. The Corps of Engineers is committed to working with the South Florida Water Management District and other agencies in achieving this goal.

Comment #8 – A concerted effort is needed to ensure that performance measures are developed that can more accurately predict the responses of peat soils, tree island vegetation communities, and wildlife (including wading birds) to hydrologic changes. Such measures should be scientifically supportable as best current estimates of ecological responses to changed hydrologic conditions, and they will need to be developed prior to detailed design of structures and operations that will alter hydrologic conditions within the Everglades watershed. Performance measures developed during the Restudy were acceptable for comparing between model runs, however existing measures are not yet sufficient to use as "real world" management goals.

Response – The Conceptual Ecological Models developed by teams of south Florida scientists will be used as a basis for further refining a set of ecological performance measures and targets. The conceptual models identify the hydrological stressors and ecological attributes (indicators) for each major landscape feature in south Florida. Workshops are planned for the purpose of reviewing the models, and for developing the specific measures and targets for the ecological attributes, which are shown by the models to be the best indicators of how these systems respond to the restoration efforts.

Comment #9 – In order to avoid unintended shifts in vegetative structure, the Comprehensive Plan should include two well-crafted sections: (1) an implementation plan that allows for careful staging of hydrologic changes so as to avoid large environmental "shocks" that could induce ecological damage to the marsh communities; and (2) an adaptive management strategy that ensures that monitoring is well designed and comprehensive over the total system. It will be crucial for monitoring results to be evaluated within an objective scientific framework, and to be acted upon expeditiously. Maintaining flexibility in water management actions in response to monitoring results will be critical during project implementation. Water management changes likely to be identified as part of an adaptive management process would generally take place on a time scale of months-to-years; hence, operational flexibility need not be incompatible with a system in which passive forms of water management play a dominant role.

Response – The draft Integrated Feasibility Report and Programmatic Environmental Impact Statement includes an implementation plan (***Section 10***). This implementation plan has been considerably expanded in scope and detail in the final Integrated Feasibility Report and Programmatic Environmental Impact Statement. It has also undergone independent review by agencies prior to incorporation into the final report. Recommendations in this plan for how plan components should be grouped, and for the sequencing of components during implementation, will be designed to maximize ecological benefits, and minimize or avoid ecological damage. The Conceptual Ecological Models should be used to link an adaptive assessment strategy with a well focused, regional monitoring program.

Comment #10 – The Florida Game and Fresh Water Fish Commission recommended that, if ecological restoration is to become a reality, a process be established to coordinate and balance the responsibilities and goals of the many resource and water management agencies responsible for different parts of the south Florida ecosystem.

Response – A multi-agency team, similar to the Alternative Development and Alternative Evaluation Teams, was formed to develop the implementation plan. The team has developed a set of guidelines for the implementation plan that includes continuing the multi-agency approach used throughout the Restudy process. The implementation plan also includes a RECOVER process that will provide continuing re-analysis of the Comprehensive Plan, refinement of performance measures and targets, implementation of the monitoring program, and the development and implementation of adaptive assessment protocols.

12.2.4 Florida Game and Fresh Water Fish Commission, Fish and Wildlife Coordination Act Report, Part II Recommendations

Comment #1 - The Florida Game and Fresh Water Fish Commission is concerned with the restoration of portions of the Water Conservation Areas, Shark River Slough in Everglades National Park, and the St. Lucie estuary. The performance of alternative D-13R may provide insufficient flow volumes to Shark River Slough as predicted by the NSM. Further concerns are with the performance of D-13R with respect to the Water Conservation Areas including: extended hydroperiods in much of WCA-3A, particularly south of I-75; deep water in eastern and northeastern WCA-3A and; extremely high and low water levels predicted in WCA-2B.

Response - The Corps shares the concerns of the Florida Game and Fresh Water Fish Commission with regard to possible further adverse environmental impacts to certain areas of the Water Conservation Areas identified with D13R and scenario $D13R_4$. The Corps, in its correspondence to the Florida Game and Fresh Water Fish Commission and U.S. Fish and Wildlife Service, dated February 19, 1999 stated its emphatic support for resolving the remaining operational problems of the Water Conservation Areas associated with implementation of the Comprehensive Plan and in not adversely impacting the Water Conservation Areas during development of scenarios designed to send more water to Everglades National Park and Biscayne National Park.

Comment #2 - The Florida Game and Fresh Water Fish Commission is concerned with the need to treat water discharged from the new S-140 structure. The Florida Game and Fresh Water Fish Commission recommends an expansion of the S-140 allowing more water to be shunted to areas further south and a gradual rehydration of northern areas be implemented to allow areas time to acclimate to the new water regime. A water quality treatment facility is also recommended to be added upstream of the new structure.

Response - Additional water quality treatment has been added to the Comprehensive Plan in the form of the Miccosukee Tribe Water Management Plan which includes a 900 acre facility which will treat water from tribal lands. Furthermore, additional water quality analyses will be conducted during the detailed design phase of implementing this component.

Comment #3 - Accurate and up to date topographic information needs to be collected in order to ensure future hydrologic restoration success.

Response - Concur. The Corps agrees that this is a key information need, necessary to resolve the uncertainty associated with several project features such as those designed to restore sheet flow. See response #7, Section 12.2.3, above.

Comment #4 - Most of the Other Project Elements do not contain sufficient information at a level of detail on which to base an assessment of their potential impacts on fish and wildlife. The Other Project Elements will have to be reviewed under the Fish and Wildlife Coordination Act individually as they are further developed.

Response - Concur. As stated in the report, the Other Project Elements will need to be further evaluated during detailed planning and design. Preparation of

Project Implementation Reports will include appropriate NEPA documentation and the Corps will continue to coordinate with the Florida Game and Fresh Water Fish Commission and the U.S. Fish and Wildlife Service under the Fish and Wildlife Coordination Act for each separable project element.

Comment #5 - The removal of canals, which are in some cases, important recreational amenities, must be well justified in terms of hydrological and ecological benefits. The Florida Game and Fresh Water Fish Commission is further concerned with the potential loss of existing recreation access points, particularly off the Tamiami Trail. The Florida Game and Fresh Water Fish Commission recommends providing suitable alternative access sites for those access sites removed under the Comprehensive Plan.

Response - Concur. At this time, modeling has shown that removal of certain levees and canals is necessary for the overall restoration of sheet flow and in attaining hydroperiod targets within the natural areas. One of the principal goals of the Restudy since the reconnaissance phase was the re-establishment of sheet flow and to reduce fragmentation (caused largely by canals and levees) of the ecosystem. The removal of levees and canals as specified in the Comprehensive Plan, is expected to advance these goals as well as to reduce the overdrainage of natural areas and slow the rapid conveyance of pollutants and exotic plants and animals that are often associated with canals. The loss of recreational access points eg. along the L-29, may ultimately be compensated for by establishing new recreational amenities on project features proposed under the Comprehensive Plan. The extent of removal of canals and levees to meet ecological objectives will be further evaluated in the detailed design phase of these project modifications. At this time the Florida Game and Fresh Water Fish Commission will be called upon to play an active role in plan formulation and evaluation.

Comment #6 - The Florida Game and Fresh Water Fish Commission recommends retaining portions of existing levees internal to the Water Conservation Areas and restore these remnant levee sections such that they provide a similar function as natural tree islands. This restoration initiative would be carried out only to the extent that the remnant levee sections, replanted with native trees and vegetation, would not inhibit the restoration of sheet flow.

Response - This is an interesting and innovative idea and one which should receive consideration during future detailed design. This idea fits well with the Restudy concept of adaptive assessment and monitoring in that the precise design (size, scale, location, and type) of project features will be further evaluated during future detailed studies, based on this programmatic document. The Corps looks forward to working with the Florida Game and Fresh Water Fish Commission to further evaluate this proposal during the detailed planning phase.

Comment #7 - The Florida Game and Fresh Water Fish Commission recommends that the Corps seek authorization, at least at the conceptual level, for the entire Restudy Comprehensive Plan.

Response - The Corps, as noted in Section 10.6.1, has proposed to seek Congressional approval of the Comprehensive Plan as a framework and guide for authorization. In addition, a series of pilot projects and specific components are proposed for initial authorization in the Water Resources Development Act of 2000.

Comment #8 – Close coordinated under Fish and Wildlife Coordination Act will be necessary throughout the refinement and implementation of the comprehensive plan in order to ensure that the intended benefits to fish and wildlife are realized.

Response – Concur. The Corps fully intends to continue coordination with the FGFWFC and USFWS under the Fish and Wildlife Coordination Act throughout the detailed planning and design phase. Furthermore, the Corps looks to expand the existing role of the FGFWFC under the Cooperating Agency Agreement currently in effect between all agencies (40 CFR, Part 1501.6(6)(3).

12.2.5 Florida Game and Fresh Water Fish Commission, Fish and Wildlife Coordination Act Report, Part III Recommendations

Comment #1 – The Florida Game and Fresh Water Fish Commission assessment of D-13R_4 is that while providing additional flow to Everglades National Park and Biscayne National Park, these benefits come at great cost to Water Conservation Area 2A and Water Conservation Area 3B, which would fare worse than they do under the 1995 or 2050 Base Cases.

Response – Concur. See response to comment #1, Section 12.2.4, above.

Comment #2 – The Florida Game and Fresh Water Fish Commission expressed concern with the feasibility of implementing D-13R_4 in terms of treating urban runoff to acceptable standards necessary for discharge into natural areas without significant adverse impacts to native flora and fauna.

Response – Concur. See response #8, Section 12.2.2, above

Comment #3 – The Florida Game and Fresh Water Fish Commission expressed concern over the lack of accurate topographic information that led to the conclusion that substantially more water than that provided by D-13R is needed in Shark River Slough, thus leading to the development of the D-13R_4 scenario and additional impacts to the Water Conservation Areas. The Florida Game and Fresh Water Fish Commission suggests that if soil subsidence south of Tamiami Trail were factored into model assumptions for the NSM then it is very possible that less water would be necessary to achieve desirable water depths in Shark River Slough.

Response - Concur. Sensitivity modeling has been done and the Corps is awaiting those results. See response #3, Section 12.2.4, and response #7, Section 12.2.3, above.

Comment #4 – Improvements to one region of the natural system should not be done at the expense of another region within the natural system.

Response – The Corps is fully committed to restoration of the natural system to the utmost extent possible. Development of the Comprehensive Plan has produced the best overall framework for restoring the natural system, given the level of information and evaluation tools currently available. In some instances, construction of the plan elements may result in localized adverse impacts to upland and wetland resources. Conceptually, these impacts have been determined to be justified in order to enhance the overall system hydrologically and ecologically. Siting of such facilities in subsequent phases of this project will endeavor to avoid or minimize adverse impacts to sensitive upland and wetland resources areas, and the Corps will coordinate with the U.S. Fish and Wildlife Service and Florida Game and Fresh Water Fish Commission, and other agencies as appropriate. In some instances, however, potentially adverse impacts, or plan underperformance relative to restoration targets, may result in certain areas of the system, in an attempt to improve performance in critically important areas. The study team will attempt to improve performance of the plan, while reducing ecological trade-offs to there areas of the natural system during the detailed planning phase which is already underway. The Implementation Plan for instance, includes a phased approach to provide for improvements and the maximum ecological benefits to the WCAs, Everglades National Park, Biscayne Bay, and those other areas that have been adversely affected by the C&SF Project. The Corps remains committed to resolving any outstanding operational problems and seeks full consensus on trade-offs wherever they may occur, with a view to implementing the best plan, which is acceptable and beneficial to all.

12.3 ENDANGERED SPECIES ACT OF 1973

Formal consultation was initiated on June 11, 1998, and a preliminary programmatic biological opinion was received from the U.S. Fish and Wildlife Service on August 7, 1998 (see ***Annex B***). The U.S. Fish and Wildlife Service has confirmed, by letter dated March 1,, 1999, the preliminary programmatic biological opinion as the final biological opinion (see Annex B). This project is in full compliance with the Act. The Corps will reopen consultation with the U.S. Fish and

Wildlife Service upon initiation of future tiered feasibility studies under this programmatic EIS.

12.4 NATIONAL HISTORIC PRESERVATION ACT OF 1966

The study is in partial compliance at this stage. Consultation with the Florida State Historic Preservation Officer has been initiated. Cultural resources investigations are ongoing to determine effects to historic properties. When completed, results will be coordinated with the State Historic Preservation Officer and the Advisory Council on Historic Preservation.

12.5 CLEAN WATER ACT OF 1972

The study is in partial compliance at this stage. Full compliance will be achieved with issuance of a Section 401 permit from the State of Florida. A Section 404(b) Evaluation is included in this report as ***Annex C***.

12.6 CLEAN AIR ACT OF 1972

Coordination with the U.S. Environmental Protection Agency and the Florida Department of Environmental Protection, Air Quality Division determined the proposed project is in partial compliance with the Clean Air Act. No permits will be required at this stage of planning. Full compliance will be achieved with receipt of comments on the Final Programmatic Environmental Impact Statement from the U.S. Environmental Protection Agency.

12.7 COASTAL ZONE MANAGEMENT ACT OF 1972

The study is in partial compliance at this time. Full compliance would be achieved with receipt of comments from the Florida State Clearinghouse. A Federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as ***Annex D***.

12.8 FARMLAND PROTECTION POLICY ACT OF 1981

Coordination with the U.S. Department of Agriculture, Natural Resources Conservation Service in Gainesville, Florida to meet the requirements of the Farmland Protection Policy Act is ongoing. Almost all land in central and southern Florida used for agricultural production has been designated unique farmland. This land has a unique combination of soil quality, location, growing season, and moisture supply for producing high value food and fiber crops. The Initial Draft Plan includes several components that may require land in central and southern Florida to be removed from agricultural production. When detailed design information that locates each of the plan components becomes available, it can be determined how many acres of unique farmland will be affected. The Natural Resources Conservation Service will then be asked to complete the required Form AD 1006 to inventory the loss of acres of unique farmland from agricultural production.

12.9 WILD AND SCENIC RIVER ACT OF 1968

The Northwest Fork of the Loxahatchee River is designated a Wild and Scenic River. This resource is not expected to be negatively impacted, and in fact, should benefit from implementation of the proposed Comprehensive Plan. The study is in full compliance.

12.10 ESTUARY PROTECTION ACT OF 1968

The study is in full compliance. The Recommended Plan takes into account the restoration of all the estuaries in the project area. The Draft Fish and Wildlife Coordination Act report (***Annex A***) discuses the restoration components for each of the estuaries and the benefits to the estuaries.

12.11 FEDERAL WATER PROJECT RECREATION ACT OF 1965

The project is in full compliance at this stage. The effects of the proposed action on outdoor recreation have been considered. Continued recreation planning would be performed during detailed project engineering and design.

12.12 RESOURCE CONSERVATION AND RECOVERY ACT OF 1976

This law has been determined to be not applicable, as there are no items regulated under this act either being disposed of or affected by this project.

12.13 TOXIC SUBSTANCES CONTROL ACT OF 1976

This law has been determined to be not applicable, as there are no items regulated under this act either being disposed of or affected by this project.

12.14 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT OF 1972

This Act is not applicable. Ocean disposal of dredged material is not proposed as a part of the C&SF Restudy.

12.15 RIVERS AND HARBORS APPROPRIATION ACT OF 1899

The study is in full compliance. The proposed work would not obstruct navigable waters of the United States.

12.16 COASTAL BARRIER RESOURCES ACT

This Act is not applicable. The study area is not in a designated Coastal Barrier Resources Act unit.

12.17 SECTION 904 OF THE 1986 WATER RESOURCES DEVELOPMENT ACT

Section 904 of the 1986 Water Resources Development Act requires that the plan formulation and evaluation process consider both quantifiable and unquantifiable benefits and costs of the quality of the total environment, and preservation of cultural and historical values. The study and report are in full compliance.

12.18 SECTION 307 OF THE 1990 WATER RESOURCES DEVELOPMENT ACT

Section 307 of the 1990 Water Resources Development Act establishes, as part of the water resources development program, an interim goal of no overall net loss of the Nation's remaining wetlands, and a long-term goal of increasing the quality and quantity of the Nation's wetlands. The recommended plan is in full compliance.

12.19 E.O. 11988, FLOODPLAIN MANAGEMENT

The study is in full compliance. The considered alternatives support avoidance of development in the flood plain, continue to reduce hazards and risks associated with floods and to minimize the impact of floods on human safety, health and welfare, and restores and preserves the natural and beneficial values of the base flood plain.

12.20 E.O. 11990, PROTECTION OF WETLANDS

The study is in full compliance. By nature of the project, it involves work in wetlands, and no practicable alternative to working in wetlands exists. Losses and degradation to the beneficial values of wetlands are minimized, and such values are preserved and enhanced. The public has been involved in early planning.

12.21 E.O. 12114, ENVIRONMENTAL EFFECTS ABROAD OF MAJOR FEDERAL ACTIONS

This executive order is not applicable to this study.

12.22 E.O. 12898, ENVIRONMENTAL JUSTICE

Executive Order 12898 requires the Federal government to achieve environmental justice by identifying and addressing disproportionately high adverse effects of its activities on minority and low-income populations. It also requires the analysis of information such as the race, national origin, and income level for areas expected to be impacted by environmental actions. Populations at risk have been profiled in Appendix E (Socio-Economics) in Section 2 (Population and Economy) and Section 12 (Other Social Effects). This profile data includes racial/ethnic population distribution, aged population, percentage of households below the poverty threshold, income, and unemployment, by county for the 16-county study area, as well as for the State and Nation for ranking comparison purposes. Section 12 (Appendix E) also discusses potential community impacts, acknowledging that some negative economic impacts may occur, particularly in rural areas where agricultural land may be converted to water storage facilities. On the one hand, it is acknowledged that the rural communities where reservoirs may be sited are characterized by low income and high unemployment populations, and therefore may be vulnerable to the effects of this part of project implementation. On the other hand, these are areas of low population, so that the affected populations are likely to be small. Further analysis of community impacts will be undertaken when more specific site information is obtained. During detailed implementation of the C&SF project modifications, facilities will be sited with care regarding low income, minority, and other at-risk populations, so as to minimize adverse effects, and if adverse effects cannot be avoided, affected parties will be engaged in dialogue to determine appropriate mitigation.

One of the largest anticipated economic impacts of project implementation (Appendix E, Section 11, Regional Economic Impacts) would be as a result of project spending on construction, land purchases, operation and maintenance. As with all Corps of Engineers projects, contracting action to implement the C&SF Comprehensive Plan will comply with The Small Business Act, as implemented by the Federal Acquisition Regulations and its supplements. Adhering to this policy helps to ensure that a certain percentage of contracting will be directed toward small and disadvantaged firms, which would have a significant positive economic effect on minorities.

Executive Order 12898 also requires Federal agencies to identify the need to ensure the protection of populations relying on subsistence consumption of fish and wildlife, through analysis of information on such consumption patterns, and communication to the public of associated risks. Potential patterns of subsistence consumption of fish and wildlife resources by Native American Tribal members and others, to the extent they exist, are likely to be positively enhanced by the outcome of the Comprehensive Plan. Implementation is expected to increase ecological values in the Everglades natural system, likely resulting in improved opportunities for those engaged in subsistence consumption.

SECTION 13
RECOMMENDATIONS

I am recommending a Comprehensive Plan that will restore, protect, and preserve a natural resource treasure – the south Florida ecosystem. Including the Everglades, this ecosystem is unique and nationally important. I believe that failing to act now will result in the irretrievable loss of an ecosystem, which exist no where else in the world. I am convinced that the Comprehensive Plan will allow us to reverse the course of the past fifty years and leave an Everglades legacy that future generations will be able to enjoy and benefit from.

I find that the south Florida ecosystem, which extends from the Kissimmee River - Lake Okeechobee region through the Everglades and Florida Keys and includes significant estuarine and near-shore communities, provides habitat for diverse species of fish and wildlife while providing important water supply, water quality, flood control, and recreation functions. The south Florida ecosystem, which has been reduced by almost 50 percent, is endangered as a result of adverse changes in the quantity and distribution of water, the timing of flows, and the degradation of water quality. Restoration of this ecosystem is vital to achieve environmental and economic sustainability in the region and to prevent an ecological disaster of unprecedented proportions. Modifications to the Central and Southern Florida Project are required to provide for the restoration, preservation, and protection of the Everglades and the south Florida ecosystem. Such modifications can be undertaken in a manner that allows us to continue to provide and enhance benefits necessary for the economic and social sustainability of the region.

Therefore, I recommend that the Comprehensive Plan, as described in the section of this report entitled “The Recommended Comprehensive Plan,” be approved as a framework and guide for modifications to the Central and Southern Florida Project. I further recommend that the pilot projects and the components for initial authorization, including monitoring, as described in the section of this report entitled “Implementation Plan,” be authorized for construction at 50 percent Federal cost sharing at a total estimated cost of $1,198,000,000 and an annual cost of $20,000,000 for operation and maintenance. The estimated Federal first cost is $599,000,000 with estimated annual operation and maintenance costs of $10,000,000; and the estimated non-Federal first cost is $599,000,000 with estimated annual operation and maintenance costs of $10,000,000. The Water Resources Development Act of 1996 provided authorization for Critical Restoration Projects in order to expedite implementation of the restoration effort. I also recommend approval of a similar programmatic authority to help expedite implementation of some components in the Comprehensive Plan and that the programmatic authority be limited to those components of the Comprehensive Plan that have a total project cost of $70,000,000 with a maximum Federal cost of $35,000,000. Authorization for the remaining components of the Comprehensive Plan will be sought after completion of more detailed planning and submission of Project Implementation Reports to Congress. Each Project Implementation Report will also contain an analysis of the Comprehensive Plan and any recommendations concerning modifications to the plan.

The above recommendations are made with the provision that prior to implementation of each project, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army to perform the following items of local cooperation:

a. Provide 50 percent of the total project costs as further specified below:

(1) Enter into an agreement which provides, prior to construction, 25 percent of pre-construction engineering and design (PED) costs;

(2) Provide, during construction, any additional funds needed to cover the non-Federal share of pre-construction engineering and design costs;

(3) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

(4) Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

(5) Provide, during construction, any additional costs as necessary to make its total contribution equal to 50 percent of total project costs.

b. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

c. For so long as the project remains authorized assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features, with 50 percent of the funding provided by the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

e. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

i. To the maximum extent possible, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

j. Participate in and comply with applicable flood plain management and flood plain insurance programs in accordance with section 402 of Public Law 99-662, as amended.

k. Not less than once each year, inform affected interests of the limitations of the protection afforded by the project.

l. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain, and in adopting regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project.

m. As between the Federal Government and the non-Federal sponsor, the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

n. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder operation or maintenance of the project.

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

p. Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army.”

q. Provide 50 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to the project that are in excess of one percent of the total amount authorized to be appropriated for the project.

r. Do not use Federal funds to meet the non-Federal sponsor’s share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Joe R. Miller
Colonel, Corps of Engineers
District Engineer

SECTION 14
LIST OF STUDY TEAM MEMBERS AND REPORT PREPARERS

Table 14-1 of this section includes a list of Study Team members and preparers of the Final *Feasibility Report and Programmatic Environmental Impact Statement.*

Table 14-1. List of Participants

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Alspach, Sue	Biological Administrator	Miami-Dade DERM	X	X	X	Report Preparation; LEC
Appelbaum, Stuart	Civil Engineer	USACE	X			Report Preparation; Restudy Study Manager
Arnold, Tom	Economist	USACE	X			Report Preparation; Economics
Barnes, Jennifer	Engineering Associate	SFWMD				INTERNET Team
Bass, Sonny	Biologist	ENP	X			F&W CAR
Bates, Christine	Hydrologist	Big Cypress National Preserve	X	X		PEIS Review; BCNP
Bellmund, Sarah	Ecologist	ENP	X			PEIS Preparation; ENP
Benkly, Chris	Biologist	Palm Beach Co. ERM	X			
Bennett, Debra	Engineering Associate	SFWMD				Report Preparation
Bernardo, Elena	Public Involvement and Outreach	SFWMD				Public Meetings
Besrutschko, Peter	Environmental Engineer	USACE				PEIS Preparation; HTRW
Best, Ronnie	Administrator	USGS-BRD	X			
Brion, Lehar	Civil Engineer	SFWMD	X		X	
Browder, Joan	Ecologist	NOAA/NMFS	X	X	X	PEIS Preparation

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Brown, Ed	Civil Engineer	USACE				Report Preparation
Buckingham, Cheryl	Biologist	USFWS	X	X		F&W CAR, PEIS & Report Preparation
Bunnell, Richard	Civil Engineer	USACE	X			Report Preparation:Hydraulic Criteria and Design
Burzycki, Gwen	Botanist	Miami-Dade DERM	X	X		Report Preparation
Bush, Eric	Biologist	DEP	X	X		PEIS Preparation; Water Quality
Bush, Randy	Civil Engineer	USACE	X			PEIS Preparation; Geotech
Cadavid, Luis	Civil Engineer	SFWMD	X		X	Report Preparation
Carey, Alice	Budget Analyst	USACE	X			Report Preparation
Carter, Nancy	Real Estate Specialist	USACE	X			Real Estate
Case, Debra	Engineering Associate	SFWMD				Report Preparation
Chen, Zhenquan	Engineer	SFWMD	X			Water Quality
Choate, Mike	Civil Engineer	USACE	X			
Cintron, Barbara	Biologist	USACE	X			Internal Technical Review; PEIS

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Clifton, Ray	Civil Engineer	USACE	X			Report Preparation: Project Cost Estimates
Comiskey, Jane	Ecological Modeler	UT				ATLSS
Cunningham, Kevin	Hydrologist	USGS				PEIS Preparation; Soils & Geology
Curnutt, John	Ecologist	UT				ATLSS
Davis, Steve	Ecologist	SFWMD	X	X		PEIS Preparation; Existing Conditions
Dawdy, Richard	Planner	SFWMD	X			Report Preparation
Day, Max	Civil Engineer	SFWMD	X		X	Report Preparation
DeAngelis, Don	Ecologist	USGS/BRD	X			ATLSS
Devillon, Louis	Civil Engineer	SFWMD	X	X		Report Preparation
Doren, Bob	Ecologist	ENP	X	X	X	F&W CAR
Drum, Deborah	Scientist	SFWMD-Miami Service Cntr	X			Report Preparation
Drungil, Carol	Hydrologist	USDA/NRCS	X		X	PEIS Preparation; Agriculture
Duever, Mike	Ecologist/ hydrology and ecology of wetlands	Nature Conservancy (SFWMD Contractor)	X	X		PEIS Preparation; BCNP
Duncan, Gene	Water Resources Manager	Miccosukee Tribe	X			
Evoy, Jean	Botanist	Miami-Dade DERM	X			
Fascher, Mark	Civil Engineer	USACE	X			Report Preparation: Project Cost Estimates

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Fennema, Robert	Hydrologist	ENP	X		X	F&W CAR
Ferrell, Dave	Biologist	USFWS	X	X		F&W CAR
Ferro, Karyn	Social Scientist	ENP				PEIS Preparation; Socio-Economics, Land Use ENP
Fitz, Carl	Scientist	SFWMD-ESR	X	X		Water Quality
Fitzgerald, Pat	Civil Engineer	USACE	X			
Folks, John		FDACS	X			
Fontaine, Tom	Scientist	SFWMD	X			Water Quality
Formati, Sandra	Scientist	SFWMD				PEIS Preparation; Caloosahatchee River
Forsythe, Stephen	State Supervisor	USFWS				F&W CAR
Fuderer, Greg	Public Involvement and Outreach	USACE	X			Report Preparation
Gassman, Nancy J.	Water Resources	Broward Co. DNRP	X			
Gent-Howard, Stacy E.	Environmental Engineer	EPA				PEIS Preparation: Air Quality
Giddings, Jeff	Hydrogeologist	SFWMD	X	X	X	
Goldenberg, Bertha	Engineer	Miami-Dade Water & Sewer Dept.	X		X	Report Preparation

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Goodwin, Carl	Scientist	USGS	X			
Graves, Greg	Biologist	DEP	X			Water Quality Team
Grizzle, Betty	Biologist	USFWS	X			F&W CAR
Gross, Lou Dr.	Biologist	UT				ATLSS
Gwin, Vern	Civil Engineer	USACE	X			Internal Technical Review; Coordinator
Hardee, Harold K	Civil Engineer	USACE	X			Report Preparation: Soils and Geology
Harrington, Keith	Economist	David Miller & Associates (USACE Contractor)				Economics
Hastings, Harriet	Graphic Artist	USACE				Report Preparation
Haunert, Dan	Scientist	SFWMD	X	X		Report Preparation
Havens, Karl	Scientist	SFWMD	X	X		Report Preparation; PEIS Review
Heisler, Lorraine	Biologist	FGFWFC	X	X		F&W CAR
Higer, Aaron	Hydrologist	USGS-SFWMD	X			
Hiscock, Jenni	Civil Engineer	SFWMD	X		X	Report Preparation
Hoberg, Chris	Life Scientist	EPA				PEIS Preparation: Water Quality; NEPA Review
Hughes, Eric	Ecologist	EPA	X	X		PEIS Preparation: Water Quality

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Hunt, Bill	Economist	USACE	X	X		Report Preparation; Economics
Huston, Michael	Biologist	UT/ORNL				ATLSS
Jackson, Jim	Planner	SFWMD	X			Report Preparation
James, Freddie	Hydrologist	ENP	X		X	
James, Tom	Scientist	SFWMD - OSR	X	X		Water Quality
Jewell, Su	Biologist	USFWS	X	X	X	Report Preparation; Water Quality
Johnson, Bob	Hydrologist	ENP	X			F&W CAR
Jones, David	Botanist	ENP				F&W CAR; Report Preparation
Kennedy, Sally	Planner	SFWMD	X	X		Report Preparation; Water Quality
Kone, Siaka	Civil Engineer	SFWMD	X		X	Report Preparation; Water Quality
Konyha, Ken	Civil Engineer	SFWMD	X		X	Report Preparation
Kulich, Christy	Para-legal	Seminole Tribe - Lewis Longman & Walker, PA				
Lal, Wasantha	Hydrologist	SFWMD				Report Preparation
Lee, David	Water Resource Manager	Broward Co. DNRP	X	X		Implementation Team
Leech, J. Scott	Civil Engineer	USACE	X			Report Preparation; Geotech

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Linton, Paul	Civil Engineer	SFWMD	X			Report Preparation
Loftin, Kent	Civil Engineer	SFWMD	X			
Loftus, Bill	Biologist	USGS/BRD	X			F&W CAR
Lynch, Patrick	Natural Resources Manager	BNP				PEIS Preparation; BNP
Mahoney, Katie	Secretary	USACE	X			Report Preparation
Mahoney, Laura	Civil Engineer	USACE	X	X		Report Preparation
Manners, Liz	Biologist	USACE	X	X		Report Preparation; Environmental Evaluation
Mazzotti, Frank J.	Biologist	Everglades Research & Education Center	X			
McCarthy, Linda	Water Management Liaison	FDACS @ SFWMD	X	X	X	Report Preparation
McCullough, David L.	Archeologist	USACE	X			PEIS Preparation; cultural resources
McLean, Agnes	Planner	SFWMD	X	X	X	Report Preparation
McSharry, Heather	Biologist	USFWS	X	X		Preliminary Programmatic Biological Opinion
Miller, David	Economist	David Miller & Associates (USACE Contractor)	X			Economics
Mills, Brenda J.	Planner	SFWMD	X	X	X	Report Preparation; PEIS Review LEC

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Moulding, Jon	Ecologist	USACE	X			PEIS Preparation; WCAs
Moulding, Alison	Intern	BNP				PEIS Preparation; BNP
Mulliken, John	Planner	SFWMD	X			Report Preparation; Implementation Team
Needle, Jeff	Civil Engineer	SFWMD	X		X	Report Preparation
Negley, Ellen	Graphic Artist	SFWMD				Public Meetings
Neidrauer, Cal	Civil Engineer	SFWMD	X	X	X	Report Preparation
Nelson, Donald G.	Real Estate; Senior Attorney Advisor	USACE	X			Report Preparation
Nott, Phil	Ecologist	UT				ATLSS
Obeysekera, Jayantha	Civil Engineer	SFWMD	X			Report Preparation
Ogden, John	Ecologist	SFWMD	X	X	X	Report Preparation
Olson, Susan	Civil Engineer	SFWMD	X			
Ornella, Mike	Civil Engineer	USACE	X			Report Preparation; Project Manager
Orth, Ken	Planner	USACE - IWR	X			Report Preparation
Pace, Bob	Biologist	USFWS	X	X		F&W CAR
Park, Winifred	Scientist	SFWMD	X	X		Report Preparation

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Peck, Dan	Economist	USACE	X			Report Preparation; Economics
Perry, Bill	Biologist	BNP				F&W CAR
Perry, Sue	Aquatic Ecologist	ENP	X	X		PEIS Preparation; ENP
Pietrucha, Marie	GIS Specialist	SFWMD				Performance Measure Development
Pfueffer, Richard J.	Environmental Scientist	SFWMD	X			Report Preparation: Water Quality, Pesticides
Poole, Mary Ann	Biologist	FGFWFC	X	X		F&W CAR
Porter, Bill	Ecologist	USACE	X		X	PEIS Preparation/co-lead
Punnett, Richard	Civil Engineer	USACE	X	X	X	Report Preparation: Hydrology Section
Rapach, Fred	Utilities Program Coordinator	Palm Beach County	X		X	Report Preparation
Reed, Russell	Civil Engineer	USACE	X		X	Report Preparation; Comprehensive Plan Study Manager
Reel, Steve	Scientist	SFWMD	X			
Regalado, Nanciann	Public Involvement and Outreach	USACE	X			Report Preparation
Reichle, Erich	Civil Engineer	USACE	X			Report Preparation
Reid, Dawn	Planner	SFWMD	X		X	Report Preparation
Riley, James M.	Environmental Engineer	USACE	X			Water Quality Team

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Robblee, Mike	Biologist	USGS/BRD				Report Preparation
Rosen, Barry	Scientist	SFWMD	X	X		Report Preparation
Sanders, Carol	Public Involvement and Outreach	USACE	X			Public Affairs
Santee, Ray	Civil Engineer	SFWMD	X		X	Hydrologic Modeling
Savabi, Reza	Hydrologist	USDA-ARS	X			
Scheidt, Dan	Scientist	EPA	X	X		Report Preparation: Water Quality, Mercury
Schmidt, Tom	Marine Biologist	ENP	X	X		Report Preparation; Marine Estuarine Group
Sculley, Shawn	Hydrologist	SFWMD	X			
Sime, Patti	Scientist	SFWMD	X			Report Preparation
Skaggs, Leigh	Geographer	USACE - IWR	X			Cost Effectiveness Analysis
Sklar, Fred	Scientist	SFWMD	X	X		
Smith, Chris	Civil Engineer	USACE	X			Report Preparation
Smith, Tom	Ecologist	USGS/BRD		X		Report Preparation
Smith, Lisa	Planner	SFWMD	X			
Snow, Skip	Biologist	ENP	X			Report Preparation

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Sofia, Suzanne C.	Civil Engineer	USACE	X		X	PEIS Preparation; Water Management/Water Supply
Steinman, Al	Scientist	SFWMD	X			
Stevenson, Paul	Landscape Architect	USACE				PEIS Preparation; recreation/aesthetics
Stober, Jerry J.	Zoologist	EPA	X			Report Preparation; Water Quality, Mercury
Story, Graham	Civil Engineer	USACE	X	X		Report Preparation; Other Project Elements
Strom, Doug	Biologist	DEP	X			Water Quality Team; Implementation Team
Strowd, Tommy	Civil Engineer	SFWMD	X			
Sutterfield, Steve	Civil Engineer	USACE	X		X	Report Preparation
Swift, Dave	Scientist	SFWMD	X			Report Preparation
Sylvester, Scott	Ecological Modeler	UT				ATLSS
Tarboton, Ken	Civil Engineer	SFWMD	X	X	X	Report Preparation INTERNET Team
Teets, Tom	Planner	SFWMD	X		X	Report Preparation Restudy Project Manager
Tepper, Craig	Administrator	Seminole Tribe	X			
Tihansky, Ann B.	Hydrologist	USGS - Tampa, FL				PEIS Preparation; Geology and Soils
Towles, Tim	Wildlife Biologist	FGFWFC				Report Preparation

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
Tisdale, Todd	Civil Engineer	SFWMD	X	X		Report Preparation; Water Quality
Traver, Steve	Engineering Associate	SFWMD				INTERNET Team
Traxler, Steve	Biologist	USACE	X	X		PEIS Preparation
Trimble, Paul	Civil Engineer	SFWMD	X		X	Report Preparation
Trefry, Allan	Biologist, Environmental Director	Palm Beach County	X			Water Quality
Trigg Arnold, Priscilla	Civil Engineer	USACE	X			Report Preparation
Tucker, Rob	Civil Engineer	USACE	X			Report Preparation
Underwood, Ellen	Public Involvement and Outreach	SFWMD	X			Report Preparation; Public Meetings
Unsell, Dave	Civil Engineer	SFWMD	X	X		Report Preparation
Van Arman, Joel	Scientist	SFWMD	X			
VanLent, Tom	Hydrologist	ENP	X		X	Report Preparation; ENP
VanZee, Randy	Civil Engineer	SFWMD	X			Report Preparation; Hydrologic Modeling
Wagner, Len	Planner	SFWMD	X			Report Preparation
Warner, Michael	Engineering Associate	SFWMD				Hydrologic Modeling
Weisskoff, Richard	Economist	University of Miami	X			

Name	Discipline	Affiliation	Study Team	AET	ADT	Other
White, Cary	Civil Engineer	SFWMD	X		X	Report Preparation
Whitehead, Dawn	Biologist	USFWS	X			F&W CAR
Woehlcke, Carl	Economist	SFWMD	X	X	X	Report Preparation
Woody, Theresa	Public Involvement and Outreach	USACE				Report Preparation; Public Meetings
Yoe, Charles	Economist	USACE - IWR	X			Uncertainty
Zattau, Bill	Plant Ecologist	USACE	X			Report Preparation
Zebuth, Herb	Biologist	DEP	X	X	X	
Ziminske, Mark	Biologist	USACE	X			PEIS Preparation/co-lead
Zimmerman, Mike	Environmental Engineer	ENP	X	X		Report Preparation; Water Quality

Affiliation:

Broward Co. – OES-WMD	Broward County, Office of Environmental Services, Water Management Division
Broward Co. DNRP	Broward County, Department of Natural Resources Protection
USACE	U.S. Army Corps of Engineers
USACE – IWR	U.S. Army Corps of Engineers – Institute for Water Resources
DEP	Florida Department of Environmental Protection
ENP	National Park Service, Everglades National Park
EPA	U.S. Environmental Protection Agency
FDACS	Florida Department of Agriculture and Consumer Services
FGFWFC	Florida Game and Fresh Water Fish Commission
FIU	Florida International University
Miami-Dade DERM	Miami-Dade County Environmental Resources Management
NOAA/NMFS	National Oceanic and Atmospheric Administration/ National Marine Fisheries Service

Palm Beach ERM	Palm Beach Environmental Resources Management
SFWMD	South Florida Water Management District
SFWMD-OSR	South Florida Water Management District – Okeechobee Systems Research
SFWMD-ESR	South Florida Water Management District – Everglades Systems Research
SFWMD-Miami Service Cntr	South Florida Water Management District – Miami Service Center
USDA/NRCS	U.S. Department of Agriculture/ National Resources Conservation Service
USDA/ARS	U.S. Department of Agriculture/ Agriculture Research Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Service
USGS/NWRC	U.S. Geologic Service/ National Wetlands Research Center
USGS/BRD	U.S. Geologic Service/ Biological Resources Division
USGS-ENP	U.S. Geologic Service – Everglades National Park
USGS-SFWMD	U.S. Geologic Service – at South Florida Water Management District
UT	University of Tennessee/Inst. for Environmental Modeling
UTenn/ORNL	University of Tennessee/ Oak Ridge National Laboratory

SECTION 15
GLOSSARY OF TERMS,
ACRONYMS AND ABBREVIATIONS,
AND CONVERSION TABLES

GLOSSARY OF TERMS

A

Acre-foot—The quantity of water required to cover 1 acre to a depth of 1 foot. Equal to 43,560 cubic feet (1,233.5 cubic meters).

Affected environment—Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action.

Air quality—Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.

Anthropogenic—Human-created.

Aquatic—Living or growing in or on the water.

Aquifer—An underground geologic formation in which water can be stored.

Authorization—An act by the Congress of the United States which authorizes use of public funds to carry out a prescribed action.

B

Back Pumping—The process of pumping water in a manner where the water is pumped from a site to a location of source. (e.g. from lake to contributory river).

Benthic—Bottom of rivers, lakes, or oceans; organisms that live on the bottom of water bodies.

Best Management Practice—(BMP) The best available technology or process that is practical and achieves the desired goal or objective.

Biodiversity—The number of different species inhabiting a specific area or region.

Biological opinion—Document issued under the authority of the Endangered Species Act stating the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service (NMFS) finding as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat. This document may include:

> ***Critical habitat***—A description of the specific areas with physical or biological features essential to the conservation of a listed species and which may require special management considerations or protection. These areas have been legally designated via Federal Register notices.
>
> ***Jeopardy opinion***—The U.S. Fish and Wildlife Service or NMFS opinion that an action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. The finding includes reasonable and prudent alternatives, if any.
>
> ***No jeopardy opinion***—U.S. Fish and Wildlife Service or NMFS finding that an action is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat.

C

Candidate species—Plant or animal species not yet officially listed as threatened or endangered, but which is undergoing status review by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Catch—At a recreational fishery, refers to the number of fish captured.

Channel—Natural or artificial watercourse, with a definite bed and banks to confine and conduct continuously or periodically flowing water.

Coastal Ridge—Area of land bordering the coast whose topography is elevated higher than land further inland.

Confined aquifer—An aquifer bounded above and below by impermeable or confining layers of distinctly lower permeability than the aquifer itself.

Conjunctive use—The planned use of groundwater in conjunction with surface water in overall management to optimize water resources.

Conveyance capacity—The rate at which water can be transported by a canal, aqueduct, or ditch. In this document, conveyance capacity is generally measured in cubic feet per second (cfs).

Cooperating agency—This is defined as an agency that meets the following criteria: (1) is included in 40 CFR Chapter V, Council on Environmental Quality (CEQ) Rules and Regulations, Appendix 1 - Federal and Federal-State agency National Environmental Policy Act (NEPA) contacts; and/or (2) has study area-wide jurisdiction by law or special expertise on environmental quality issues; (3) has been invited by the lead agency to participate as a cooperating agency; and (4) has made a commitment of resources (staff and/or funds), for regular attendance at meetings, participation in workgroups, in actual preparation of portions of the programmatic environmental impact statement (PEIS), and in providing review and comment on activities associated with the PEIS as it progresses. The role of the cooperating agency is documented in a formal memorandum of agreement with the lead agency.

Cubic feet per second—A measure of the volume rate of water movement. As a rate of streamflow, a cubic foot of water passing a reference section in 1 second of time. One cubic foot per second equals 0.0283 meter /second (7.48 gallons per minute). One cubic foot per second flowing for 24 hours produces approximately 2 acre-feet.

D

Density—The mass of a substance per unit of volume of that substance; i.e., the density of water changes with changes in temperature.

Dissolved oxygen (D.O.)—A commonly employed measure of water quality.

Dry Season—Hydrologically, for south Florida, two months associated with a lower incident of rainfall, December through April.

E

Ecosystem—A functional group of animal and plant species that operate in a unique setting that is mostly self-contained.

Endangered species—Any species or subspecies of bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of its range. Federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Enhancement—Measures which develop or improve the quality or quantity of existing conditions or resources beyond a condition or level that would have occurred without an action; i.e., beyond compensation.

Environmental consequences—The impacts to the Affected Environment that are expected from implementation of a given alternative.

Environmental Impact Statement (EIS)—An analysis required by the National Environmental Policy Act for all major federal actions, which evaluates the environmental risks of alternative actions.

Estuary—A water passage where the tide meets a river current; an arm of the sea at the lower end of a river.

Evaporation—The change of a substance from the solid or liquid phase to the gaseous (vapor) phase.

Evapotranspiration (ET)—Water evaporated from plant and soil surfaces or transpired by plant tissues.

Exotic species—Introduced species not native to the place where they are found.

Extirpated species—A species which has become extinct in a given area.

F

Fallowed land—Cultivated land that lies idle during a growing season.

Feasibility study—The second phase of a project. The purpose is to describe and evaluate alternative plans and fully describe recommended project.

Flow—The volume of water passing a given point per unit of time.

> ***Instream flow requirements***—Amount of water flowing through a stream course needed to sustain instream values.
>
> ***Minimum flow***—Lowest flow in a specified period of time.
>
> ***Peak flow***—Maximum instantaneous flow in a specified period of time.

G

Groundwater—Water stored underground in pore spaces between rocks and in other alluvial materials and in fractures of hard rock occurring in the saturated zone.

Groundwater level—Refers to the water level in a well, and is defined as a measure of the hydraulic head in the aquifer system.

Groundwater pumping—Quantity of water extracted from groundwater storage.

Groundwater seepage—Groundwater flow in response to a hydraulic gradient.

Groundwater table—The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

H

Habitat—Area where a plant or animal lives.

Heterogeneity—Unlike, dissimilar, not uniform

Hydrologic condition—The state of an area pertaining to the amount and form of water present. For example, saturated ground (water table at surface), lake stage, river flow rate.

Hydrologic response—An observed decrease or increase of water in a particular area.

Hydroperiod—For non-tidal wetlands, the average annual duration of flooding is called the *hydroperiod*, which is based only on the presence of surface water and not its depth.

Hydropattern—A less frequently used but nonetheless important term that refers to depth as well as hydroperiod is *hydropattern*. Hydropatterns are best understood by a graphic depiction of water level (above as well as below the ground) through annual cycles.

I

Indicator species—Organism, species, or community which indicates presence of certain environmental conditions.

Irrigation water—Water made available from the project which is used primarily in the production of agricultural crops or livestock, including domestic use incidental thereto, and the watering of livestock. Irrigation water also includes water used for domestic uses such as the watering of landscaping or pasture for animals (e.g., horses) which are kept for personal enjoyment.

J

Juvenile—Young fish older than 1 year but not having reached reproductive age.

L

Land classification—An economic classification of variations in land reflecting its ability to sustain long-term agricultural production.

Limnology—Scientific study of the physical characteristics and biology of lakes, streams, and ponds.

Littoral zone—The shore of land surrounding a water body that is characterized by periodic inundation or partial saturation by water level. Typically defined by species of vegetation found.

M

Marl—Soil comprised of clays, carbonates and shell remains.

Marsh—An area of low-lying wetland.

Mercury—Heavy metal that is toxic to most organisms when converted into a byproduct of inorganic-organic reaction. Distributed into the environment mostly as residual particles from industrial processes.

Mitigation—One or all of the following: (1) Avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating an impact over time by preservation and maintenance operations during the life of an action; and (5) compensating for an impact by replacing or providing substitute resources or environments.

Model—A tool used to mathematically represent a process which could be based upon empirical or mathematical functions. Models can be computer programs, spreadsheets, or statistical analyses.

Muck lands—Fertile soil containing putrid vegetative matter.

N

Nonconsumptive water use—Water uses including swimming, boating, waterskiing, fishing, maintenance of stream-related fish and wildlife habitat, hydropower generation, and other uses that do not substantially deplete water supplies.

O

Oxygen demand—The biological or chemical demand of dissolved oxygen in water. Required by biological processes for respiration.

P

Peat—Soil rich in humus or organic (exerts of oxygen demand) and is highly porous.

Percolation—In the context of this report, the downward movement of water through the soil or alluvium to the ground-water table.

Phosphorus—Element or nutrient required for energy production in living organisms. Distributed into the environment mostly as phosphates by agricultural runoff (fertilizer) and life cycles. Frequently the limiting factor for growth of microbes and plants.

Physiographic—The genesis and evolution of land forms.

Programmatic environmental impact statement—An environmental impact statement prepared prior to a Federal agency's decision regarding a major program, plan, or policy. It is usually broad in scope and followed by subsequent more narrowly focused National Environmental Policy Act compliance documents such as site-specific environmental assessments and environmental impact statements.

Proposed action—Plan that a Federal agency intends to implement or undertake and which is the subject of an environmental analysis. Usually, but not always, the proposed action is the agency's preferred alternative for a project. The proposed action and all reasonable alternatives are evaluated against the no action alternative.

Public involvement—Process of obtaining citizen input into each stage of the development of planning documents. Required as a major input into any EIS.

R

Recharge—The processes of water filling the voids in an aquifer, which causes the piezometric head or water table to rise in elevation.

Reconnaissance study—The first phase of a project. It has four phases (1) to define problem, (2) asses sponsor’s level of interest and support, (3) decide to progress to feasibility phase based on Federal interest, (4) estimate time and money to complete feasibility study.

Record of Decision—Concise, public, legal document which identifies and publicly and officially discloses the responsible official's decision on the alternative selected for implementation. It is prepared following completion of an Environmental Impact Statement.

Release—For this report, release is an intentional opening up of water control structures to allow stored water to flow out for 2 reasons. First, to lower water stage to acceptable levels. Second, to make available water for water supply demand (e.g., ecological, agricultural, or urban).

Release zone—Zone representing water level differentiation determining manner of release to be performed (e.g. gates wide-open, pulse release to simulate a storm).

Reservoir—Artificially impounded body of water.

Reservoir storage capacity—Reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements.

> ***Flood control storage capacity***—Reservoir capacity reserved for the purpose of regulating flood inflows to reduce flood damage downstream.

Riparian—Areas along or adjacent to a river or stream bank whose waters provide soil moisture significantly in excess of that otherwise available through local precipitation.

S

Scoping—The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Seepage—Water that escapes control through levees, canals or other holding or conveyance systems.

Semi-confined Aquifer—A condition where the movement of groundwater is restricted sufficiently to cause differences in head between different depth zones of the aquifer during periods of heavy pumping, but during periods of minimal pumping the water levels recover to a level coincident with the water table.

Slough—A depression associated with swamps and marshlands as part of a bayou, inlet or backwater.

Spillway—Overflow structure of a dam.

Stream—Natural water course.

> ***Ephemeral stream***—Flows briefly only in direct response to precipitation.
>
> ***Intermittent or seasonal stream***—Stream on or in contact with the groundwater table that flows only at certain times of the year when the groundwater table is high.
>
> ***Perennial stream***—Flows continuously throughout the year.

Subsidence—A local mass movement that principally involves the gradual downward settling or sinking of the earth's surface with little or no horizontal motion. It may be due to natural geologic processes or mass activity such as removal of subsurface solids, liquids, or gases, ground water extraction, and wetting of some types of moisture-deficient loose or porous deposits.

Surficial aquifer—An aquifer that is closest to the surface and is unconfined. The water level of a surficial aquifer is typically associated with the groundwater table of an area.

T

Tailwater—Water immediately downstream of a water control structure.

Threatened species—Legal status afforded to plant or animals species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Tide—Water with relatively high salinity levels and is influenced by earth's diurnal tide cycle.

Tiering—Procedure which allows an agency to avoid duplication of paperwork through incorporation by reference of the general discussions and relevant specific discussions from an environmental impact statement (EIS) of broader scope into a subsequent EIS of narrower scope.

Total supply—Total water supply available to area (surface water plus groundwater).

Tributary—A stream feeding into a larger stream, canal or waterbody.

W

Wastewater reuse—Utilization of water whose source contains contaminants from man-made activities. For example, runoff from developed areas and sewage. Treatment levels are typically associated with deactivation of microbial activity and nutrient removal.

Water budget—An account of all water inflows, outflows and change in storage for a prespecified period of time.

Watershed—A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Wetland—A zone periodically or continuously submerged or having high soil moisture, which has aquatic and/or riparian vegetation components, and is maintained by water supplies significantly in excess of those otherwise available through local precipitation.

Wet season—Hydrologically, for south Florida the months associated with a higher than average incident of rainfall, May through October.

Wildlife corridor—A relatively wide pathway used by animals to transverse from one habitat arena to another.

Wildlife habitat—An area that provides a water supply and vegetative habitat for wildlife.

Willing sellers—A term used to describe individuals who would be interested in selling real estate holdings.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

C	Canal
C&SF	Central and Southern Florida
Co.	County
Corps	U.S. Army Corps of Engineers
I-95	Interstate 95
L	Levee
mgd	Million gallons per day
mg/l	Milligrams per liter
NGVD	National Geodetic Vertical Datum
PEIS	Programmatic Environmental Impact Statement
ppb	Parts per billion
S	Structure
SFWMD	South Florida Water Management District
SR	State Route
USACE	U.S. Army Corps of Engineers
°F	degrees Fahrenheit

CONVERSION TABLES

U.S. CUSTOMARY TO METRIC

Multiply	By	To Obtain
inches (in)	25.4	millimeters
inches (ft)	2.54	centimeters
feet (ft)	0.3048	meters
miles (mi)	1.609	kilometers
square feet (ft)	0.0929	square kilometers
acres (ac)	0.4047	hectares
square miles (mi)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft)	0.02832	cubic meters
acre-feet (af)	1,233.0	cubic meters
pounds (lb)	0.4536	kilograms
tons (ton)	0.9072	metric tons

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = 5/9\ (°F - 32)$$

OTHER USEFUL CONVERSION FACTORS

Multiply	By	To Obtain
acre-feet (af)	43,560	cubic-feet
acre-feet (af)	325,851	gallons
cubic feet per second (cfs)	1.9835	acre-feet per day
cubic feet per second (cfs)	724.0	acre-feet per year
million gallons per day (mgd)	1.55	cfs per day
square miles	640	acres

SECTION 16
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ANNEX A

COORDINATION ACT REPORTS

A1 – U.S. FISH AND WILDLIFE SERVICE
A2 – FLORIDA GAME AND FRESH WATER FISH COMMISSION

ANNEX A1

U.S. FISH AND WILDLIFE SERVICE COORDINATION ACT REPORTS

United States Department of the Interior

National Park Service
Everglades National Park
4001 State Road 9336
Homestead, FL 33034

Fish and Wildlife Service
South Florida Restoration Projects
P.O. Box 2676
Vero Beach, FL 32962

March 1, 1999

Colonel Joe R. Miller
District Commander, Jacksonville District
U.S. Army Corps of Engineers
400 West Bay Street
Jacksonville, Florida 32232

Attention: Planning Division

Re: Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement for the Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy)

Dear Colonel Miller:

Thank you for your letter, dated February 19, 1999, clarifying the U.S. Army Corps of Engineers'(Corps) description of the Comprehensive Plan that will be presented in the Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (PEIS) for the Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy). The C&SF Restudy was authorized by section 309(I) of the Water Resources Development Act (WRDA) of 1992 (P.L. 102-580). The Department of the Interior (Department) has prepared the enclosed final Fish and Wildlife Coordination Act (FWCA) report. This fulfills the requirements of section 2(b) of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) and represents the Secretary of the Interior's report to Congress on the C&SF Restudy.

This report supplements the draft FWCA report we provided on August 7, 1998. The majority of our findings in the draft report remain in effect; the attached report serves as an update on the progress made in dealing with the most significant issues raised in the draft. We ask that the Corps include the draft report and this final report as the complete findings of the Secretary of the Interior in publishing the Final PEIS.

We also provided a preliminary programmatic biological opinion on August 7, 1998. Your February 19, 1999, letter requested that the Fish and Wildlife Service (FWS) confirm the preliminary biological opinion as the final biological opinion, based on the Corps' retention of Alternative D13R (addressed in the preliminary biological opinion) as the preferred alternative in the Final PEIS. We concur with your request. Therefore, this concludes consultation at the programmatic level in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*). Please refer to the closing statement of our preliminary biological opinion regarding circumstances that would trigger the need to re-initiate consultation. We look forward to assisting the Corps in fulfilling its responsibilities under the Endangered Species Act as we proceed into detailed planning of the components of the Comprehensive Plan. The enclosed final FWCA report includes brief reviews of our findings relative to effects on federally listed threatened and endangered species for the 2010 Case Study and the D13R4 scenario, which have been analyzed since issuance of our preliminary biological opinion.

The Conceptual Plan you described in your February 19, 1999, letter creates the opportunity to provide enormous benefit to the South Florida Ecosystem. We commend your staff on their dedication and accomplishment. In particular, we wish to express gratitude to the technical staffs of the Corps and the South Florida Water Management District who worked tirelessly under extreme time constraints to address the most significant issues raised in the draft FWCA report. We are extremely encouraged by the progress made in addressing these issues, which is summarized in a table in the enclosed final FWCA report. Your February 19 letter included a number of commitments to approach future efforts in a manner consistent with the Department's recommendations in the enclosed report, and we express the Department's commitment to cooperate with you during detailed project design to translate those concepts to specific structural and operational features.

We believe that the multi-agency Restudy Team displayed a strong commitment to fully resolve the issues we raised in the draft FWCA report. Sustaining this level of commitment as we proceed with implementation will ensure that the Comprehensive Plan serves as the foundation for restoration of the natural values of the South Florida Ecosystem. We look forward to working with you on these next steps in implementation of the Comprehensive Plan.

Sincerely,

Stephen W. Forsythe
State Supervisor
U.S. Fish and Wildlife Service

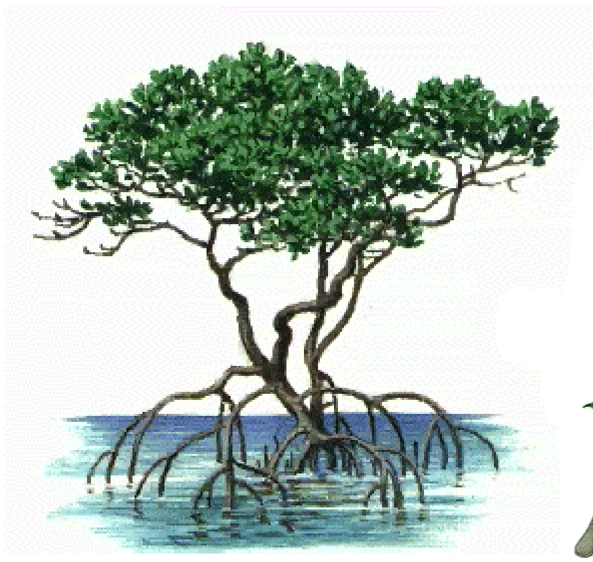
Sincerely,

Richard G. Ring
Superintendent
Everglades National Park

Enclosure: Final FWCA report w/appendices

cc:
Assistant Secretary for Water and Science, DOI, Washington, DC
Assistant Secretary for Fish and Wildlife and Parks, DOI, Washington, DC
Director, FWS, Washington, DC
Director, NPS, Washington, DC
Regional Director, FWS, Atlanta, GA
Regional Director, NPS, Atlanta, GA
Executive Director, South Florida Ecosystem Restoration Task Force, Miami, FL
Executive Director, SFWMD, West Palm Beach, FL
Executive Director, GFC, Tallahassee, FL
Environmental Services, GFC, Vero Beach, FL
Governor's Commission for a Sustainable South Florida, Coral Gables, FL
Biscayne National Park, Homestead, FL
Big Cypress National Preserve, Ochopee, FL
Loxahatchee NWR, Boynton Beach, FL
Ding Darling NWR, Sanibel Island, FL
Florida Panther NWR, Naples, FL
Biological Resources Division, USGS, Miami, FL
Miccosukee Tribe of Florida, Miami, FL
Seminole Tribe of Florida, Hollywood, FL

FINAL
FISH AND WILDLIFE
COORDINATION ACT REPORT
March 1999



CENTRAL AND SOUTHERN FLORIDA
COMPREHENSIVE REVIEW STUDY

Prepared by:
South Florida Restoration Office
Vero Beach, Florida
U.S. Fish and Wildlife Service

Submitted to:
Jacksonville District
U.S. Army Corps of Engineers

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APPENDICES

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Appendix C – Issue Paper on Flows to Biscayne National Park Utilizing Reuse

Appendix D – St. Lucie Estuary Issue Paper

Appendix E – Planning Aid Letter dated February 18, 1999

Draft Fish and Wildlife Coordination Act Report

I. Introduction

This final Fish and Wildlife Coordination Act (FWCA) report supplements the August 7, 1998, draft FWCA report, providing an update of the progress in addressing the outstanding issues raised in the draft report. Both the draft and final FWCA reports should be included as attachments to the Corps of Engineers' (Corps) final Programmatic EIS, and the coupled FWCA reports, constitute the report of the Secretary of the Interior in accordance with section 2(b) of the FWCA. The Florida Game and Fresh Water Fish Commission (GFC) is providing a separate FWCA report, which will constitute the views and recommendations of the State wildlife agency.

Development of the Implementation Plan and the associated modeling of the 2010 Case Study are among the more significant accomplishments since delivery of the draft FWCA report. The Department of the Interior's (Department) comments on these efforts were addressed in a Planning Aid Letter (PAL), dated February 18, 1999, which is incorporated into this report as Appendix E. This final FWCA report supplements the discussion of the 2010 Case Study in the PAL with a discussion of its potential effects on federally listed threatened and endangered species. This report highlights selected recommendations provided in the PAL.

This report includes important analyses of recent modeling scenarios ($D13R_{1-4}$) and the preparation of issue papers on the most significant outstanding issues raised in the draft FWCA report.

The purpose, scope, and authority for the C&SF Restudy are described in the draft report. That report also provided brief summaries of the evolution of project designs and the evaluation methodology, which can be reviewed in more detail on the Restudy website: http://141.232.1.11/org/pld/restudy/hpm/index.html.

II. Progress Report on Key Issues Raised by the Department

The list of 14 issues in Table 1 was derived from the draft FWCA report (August 1998). This table is provided to summarize any progress in addressing these issues between September 1998 and January 1999. The Department understands that the issues raised in the draft FWCA will require long-term efforts to resolve. The additional modeling of the D13R1 through D13R4 scenarios was largely in response to the most prominent of the issues raised in the draft FWCA report.

Members of the Restudy Team held a series of multi-agency meetings, to deal with the highest priority issues, which were directly related to identified inadequacies in the performance of Alternative D13R. The participants decided that issue papers were needed for the first four items listed in Table 1. The intent was to circulate these issue papers for discussion and approval by the full membership of the Alternative Evaluation Team (AET). Issue papers on the St. Lucie Estuary, Biscayne Bay ecological restoration, and Biscayne Bay reuse followed that procedure. The original plan called for separate issue papers for the southern Everglades and Florida Bay, and for the northern and central Everglades. However, issues in these two areas were combined into a single issue paper for the Everglades, and this is attached as Appendix A. An issue paper has also been prepared on water quality, but it is being revised to include the proposed features of the D13R4 scenario, and it is not available to be included as an appendix to this report. The issue papers included as appendices to this report are the following:

Appendix A – Everglades Issue Paper
Appendix B – Issue Paper on Freshwater Flow to Biscayne Bay
Appendix C – Issue Paper on Flows to Biscayne National Park Utilizing Reuse
Appendix D – St. Lucie Estuary Issue Paper

Table 1. Summary of Progress on the Fourteen Issues in the Draft FWCA Report

ISSUE	PROGRESS
1) Increase total overland flow to Florida Bay, Northeast Shark River Slough (NESRS) and Taylor Slough to more fully reach NSM targets.	The D13R4 scenario was developed and evaluated by the AET. This demonstrated the flexibility in the conceptual plan for more closely approaching restoration targets for the southern Everglades and Biscayne Bay. D13R4 would substantially increase flows through Shark River Slough, improve hydroperiod in the Rocky Glades, and improve the salinity regime in the coastal basins adjacent to Florida Bay. An Everglades issue paper has been prepared discussing the performance of D13R4 and the trade-offs in meeting all restoration goals in the Everglades basin. **ACTIONS NEEDED:** Develop and implement a phased approach which resolves problems related to water delivery and water quality as increased volumes of water are captured.
2) Increase ecological performance in the WCAs by eliminating damaging high and low water conditions.	The D13R4 scenario was not entirely successful in producing desirable depth regimes in the WCAs while at the same time improving flows to NESRS. The Everglades issue paper discusses points of complete and partial agreement on restoration goals and recommends steps to better define and resolve the relative importance of hydrologic parameters in reaching short-term and long-term restoration goals. **ACTIONS NEEDED:** Resolve remaining operational problems affecting ecological performance in the WCAs, with emphasis on meeting all restoration goals.
3) Improve ecological conditions in Biscayne Bay by restoring more natural fresh water inflows, separate from the wastewater reuse proposed in D13R.	The D13R4 scenario demonstrated the potential to increase the average annual flow to Biscayne Bay by 77,000 acre-feet. This would significantly improve ecological conditions in the southern Bay, including Biscayne National Park, and the central Bay. Implementation of the D13R4, however, is contingent on resolving the water quality concerns and the effects on the WCAs. Two issue papers were prepared for Biscayne Bay, one dealing with the implications of the proposed water reuse component, the other with ecological implications of increased flow to the estuaries. **ACTIONS NEEDED:** Continue to emphasize the natural delivery of good quality fresh water flows to Biscayne Bay, in lieu of wastewater reuse.

ISSUE	PROGRESS
4) Restore target fresh water inflows and water quality in the St. Lucie Estuary.	A St. Lucie Estuary issue paper was prepared that summarizes views on the performance of Alternative D13R and recommends ways to enhance current planning activities through the Indian River Lagoon Feasibility Study. The C-44 basin storage is included in the proposed initial authorization (WRDA 2000). The St. Lucie Issue Team Interim Report (October 1998) recommended more immediate restoration actions to the Working Group. **ACTIONS NEEDED:** Ensure compatibility of Issue Team Interim Report recommendations with the Comprehensive Plan and proceed with Indian River Lagoon Feasibility Study.
5) Restore water quality throughout the Kissimmee-Okeechobee-Everglades watershed.	The Water Quality Subteam for the Restudy has met several times since September and has prepared an issue paper that includes discussion of the most significant aspects of the Restudy related to water quality. That issue paper is being updated to address the features included in the D13R4 scenario. The PEIS proposes to initiate a Comprehensive Integrated Water Quality Plan Feasibility Study. **ACTIONS NEEDED:** Expedite completion of the Water Quality Plan Feasibility Study to ensure that sufficient water quality components are included in the Comprehensive Plan.
6) Ensure adequate water volume is available to restore natural areas.	The Governor's Commission for a Sustainable South Florida report on the Restudy recommends that a "reservation" of water for natural areas can only be considered after urban and agricultural consumers have an assured water supply. This brings into question whether sufficient water volumes will ultimately be available to restore natural areas. **ACTIONS NEEDED:** Develop assurances that adequate water volumes remain available to restore the natural areas.
7) Establish an Exotic Animal Task Team.	The Working Group has established an interagency team led by NOAA. This will involve a long-term effort. **ACTIONS NEEDED:** Continue to work on this issue during project implementation, with the goal of developing an exotic animal plan in the next five years.
8) Current wetland mitigation permitting practices are shrinking the spatial extent of wetlands and supplanting ecological benefits attributable to the C&SF Restudy.	A threshold for determining when wetland restoration benefits attributable to the Comprehensive Plan are supplanted by regulatory permit actions, and a separable mitigation plan to compensate for losses of existing mitigation sites during implementation of the Comprehensive Plan, are immediate issues yet to be resolved. **ACTIONS NEEDED:** Expedite the development and implementation of the Comprehensive Wetland Permitting and Mitigation Strategy, ensuring coordination with the Restudy and State and Federal wetland regulatory programs.
9) The Water Preserve Areas are under continued and rapid threat of development.	The Project Implementation Report (PIR) for the Water Preserve Areas is a high priority in the Restudy's Implementation Plan. Detailed hydrologic modeling will commence this year. A multi-agency baseline field survey has been initiated, including an evaluation of existing wetland conditions in the Water Preserve Areas (WPAs) using the Wetlands Rapid Assessment Procedure. **ACTIONS NEEDED:** Ensure that the Water Preserve Area Feasibility Study is expedited, and that adequate land is purchased to ensure its full implementation.

ISSUE	PROGRESS
10) Improve identification of suitable lands to site water storage and treatment areas to minimize impacts on fish and wildlife resources.	Land acquisition is proceeding in the EAA; the Department is not concerned about the siting within the EAA. The Indian River Lagoon Study has made some progress in identifying storage sites in Martin and St. Lucie counties. The Department will assist the Corps in siting storage in the Caloosahatchee basin, north of Lake Okeechobee, Taylor Creek/Nubbin Slough, and other areas to minimize impacts on wildlife habitat. **ACTIONS NEEDED:** Integrate fish and wildlife conservation and enhancement measures during site selection for project land acquisition.
11) Develop a Scheduling, Sequencing and Priorities Strategy for implementing the Comprehensive Plan.	The Department has participated in meetings of the Restudy Implementation Team and has commented on the draft Implementation Plan (See Appendix E). **ACTIONS NEEDED:** Review and refine final Implementation Plan as necessary.
12) Expedite Feasibility Studies to further overall ecosystem restoration.	The PEIS and the Implementation Plan have included the intent to carry out the Southwest Florida, WPAs, Indian River Lagoon, Biscayne Bay, Florida Bay and Florida Keys, and Comprehensive Integrated Water Quality Feasibility Studies. **ACTIONS NEEDED:** Continue emphasis on expeditious completion of these feasibility studies.
13) Recreational opportunities must be maintained during implementation of the Comprehensive Plan.	This task must be carried out in development of the PIRs for each set of components. The GFC and DEP should be consulted regarding development of recreational plans on all State lands. **ACTIONS NEEDED:** Plan for and accommodate recreational needs during project implementation.
14) Develop a strategy to manage technological uncertainty and trade-off decision making.	The Implementation Plan has included six high priority pilot studies to test the feasibility of uncertain technologies presently included in the Comprehensive Plan. Several of the issue papers include recommendations to fill gaps in our scientific knowledge allowing better prediction of ecological responses. The proposed RECOVER team will play a role in interpreting empirical data obtained through the pilot projects and monitoring studies in natural areas and in independent scientific review. **ACTIONS NEEDED:** Emphasize coordinated and timely development of this strategy.

III. Review of the Performance of the D13R4 Scenario

A. Background

During the week of January 11-15, 1999, hydrologic modelers, engineers, and ecologists met to develop and evaluate a series of scenarios (referred to by some as the “New Water” scenarios) to explore the potential to capture additional volumes of fresh water, primarily intended to improve performance of Alternative D13R in the southern Everglades and Biscayne Bay. This intensive series of water model runs and evaluations was prompted mainly by comments in the Department’s draft FWCA report that stressed the need to address the most significant deficiencies of Alternative D13R prior to the Corps' completion of the final Programmatic EIS on the Restudy. This section focuses on the performance of the D13R4 scenario, which was the latest version of that week's series of model runs and was the center of discussion in the AET's review on January 20, 1999.

The D13R4 scenario captured urban and suburban runoff that had previously flowed to tide in the C-51 basin in Palm Beach County and the C-14/C-13 basins in Broward County. Modelers estimated the average annual volume of water captured from these sources at about 245,000 acre-feet. The majority of this water would be stored and treated either in the proposed Central Palm Beach County Storage Area or the proposed Site 1 Reservoir before being sent to WCA 2A. In addition to the more efficient capture of urban and suburban runoff, D13R4 included a change in distribution of flow from STA 3/4 and other operational changes within the WCAs, which would increase the total volume of "new water" potentially available for delivery to natural areas by an annual average of 271,000 acre-feet. The D13R4 scenario also altered the way water was released from the S-356 structures into northeast Shark River Slough. More details on the design of D13R4 are available on the Restudy website.

B. Evaluation of Results

No significant differences were noted relative to D13R for Lake Okeechobee, the St. Lucie River estuary, the Caloosahatchee River estuary, or the Big Cypress basin.

The reduction in freshwater flows to Lake Worth lagoon, as a result of the capture of flows that would otherwise be delivered through C-51, is considered to be a beneficial change relative to D13R. The target salinity envelope for Lake Worth Lagoon was established as between 23 ppt and 35 ppt, which is within the tolerance range of most commercially and recreationally important estuarine species. This target salinity range was correlated with freshwater inflows ranging from 0 cfs to 500 cfs. D13R4 resulted in a decrease from 96 to 22 occurrences in the simulation period of flow events greater than 500 cfs. This is expected to increase the growth of seagrass and other submerged aquatic vegetation that serves as feeding, sheltering, and breeding habitat for a variety of estuarine animals in Lake Worth Lagoon.

Significant benefits were observed under the D13R4 scenario in the areas where the intended improvements in performance were designed to occur – the southern Everglades and Biscayne Bay. Total overland flow volume into Everglades National Park would increase on an annual average by 267,000 acre-feet (from 1,159,000 acre-feet/yr. to 1,426,000 acre-feet/yr.) Average annual overland flow westward through a cross-section of Shark River Slough in Everglades National Park would increase from 1,097,000 acre-feet/yr. to 1,255,000 acre-feet/yr. The increased flows of fresh water through that cross-section are expected to enhance estuarine productivity in Whitewater Bay and the western portions of Florida Bay. Total southward flows to eastern Florida Bay via the Craighead Basin, Taylor Slough and the eastern panhandle of Everglades National Park would average 159,000 acre-feet/yr. with Alternative D13R and would rise to 175,000 under the D13R4 scenario. This added flow is expected to provide a more favorable salinity regime for coastal waters of eastern Everglades National Park and eastern Florida Bay.

The following performance measures, relating to water stages at Well P33 in central Shark River Slough, were used by the AET as an index to evaluate alternatives with respect to their effect on freshwater flows to estuaries. One measure is the number of months during the period of record when stages equal or exceed 6.3 feet msl at P33. Stages above 6.3 feet at P33 correspond to a reduced frequency of undesirable high salinity events in the coastal basins. A second measure is the number of months during the period of record when stages equal or exceed 7.3 feet msl at the P33 gage. Stages above 7.3 feet at P33 correspond to an increased frequency of desirable low salinity events in the coastal basins. Table 2 includes results for Alternative D13R, the D13R4 scenario, relative to NSM. D13R4 clearly comes closer to the NSM target for both performance measures.

Table 2. Number of months during 31-year simulation when stages exceed specified elevations at the P33 well in Shark River Slough

Performance measure	D13R	D13R4	NSM
Well P33 water level > 6.3 ft	228	235	258
Well P33 water level > 7.3 ft	18	23	30

The increased flows to the coastal basins adjacent to Florida Bay are expected to generally increase estuarine productivity. This would include an expected increase in foraging and successful nesting of wading birds in the mangroves and anticipated benefit for two federally listed endangered species – the American crocodile and the West Indian manatee.

The D13R4 scenario would increase freshwater flows to Biscayne Bay on an annual average basis by 77,000 acre-feet, to an average annual total of 851,000 acre-feet, compared to 774,000 acre-feet under D13R. Ecological benefits would be expected in wetlands and nearshore habitats in southern Biscayne Bay, including portions of Biscayne National Park. Central Biscayne Bay also would meet its recommended target of mean annual flow under the D13R4 scenario, whereas Alternative D13R fell short of the target. Overall, the performance of D13R4 in Biscayne Bay is excellent, except for flows through Snake Creek into northern Biscayne Bay, which would remain below the target under both D13R and D13R4.

The Department's draft FWCA report called for improved performance for the southern Everglades and Biscayne Bay as described above, while at the same time more closely approaching restoration targets for the WCAs. The draft FWCA cited potentially damaging high water and low water extremes in several regions of the WCAs in Alternative D13R that needed to be corrected. The following paragraphs discuss remaining difficulties in achieving restoration targets in the WCAs in the D13R4 simulation.

Simulation of the D13R4 scenario predicts mixed results for the WCAs. Loxahatchee NWR (WCA 1) would not be affected by the D13R4 scenario, relative to D13R. Some regions of WCAs 2 and 3 would not be significantly altered, others are slightly improved, and others are predicted to be adversely affected.

Increased flow through WCA 2B would improve hydroperiod and reduce the frequency of extreme low water conditions in the presently over-drained northern and eastern portions. Another example of improved performance is the predicted reduction in the frequency of extreme high water in Indicator Region 19 of WCA 3A, from 19 % in D13R to 15% in D13R4.

However, predicted performance of D13R4 in one region of WCA 2A and two regions of WCA 3B raises substantial concern about possible degradation of the current quality of fish and wildlife habitat. Performance worsened in the D13R4 scenario relative to D13R in terms of the frequency of extreme high water stages (>2.5 feet deep) in Indicator Region 24 (WCA 2A, south), Indicator Region 15 (WCA 3B, west) and Indicator Region 16 (WCA 3B, east). The percent of time during the simulation when the high water criterion was exceeded in Indicator Region 24 increased from 1% to 3%. It is not clear whether this slight increase would cause significant ecological damage, however, this is an increase in the frequency of adverse conditions relative to the performance of D13R, and is higher than the NSM, the 1995 Base, and the 2050 Base. The predictions for WCA 3B appear more likely to result in a significant increase in the period of extreme high water in the D13R4 scenario, relative to Alternative D13R. Alternative D13R4 would increase the percentage of extreme high water from 3% to 5% and from 5% to 11% in Indicator Regions 15 and 16, respectively. These percentages are equivalent to or higher than the 2050 Base, which is in turn higher than the NSM and the 1995 Base.

High water conditions would, therefore, be more frequent in the D13R4 scenario when compared to both alternative D13R and the future without project condition. This raises concern regarding balancing ecological trade-offs when restoring flow patterns and volumes versus maintaining appropriate water depths in the remnant Everglades, particularly in the WCA3B/Pennsuco Wetlands/Northeast Shark Slough areas.

Separate sections of this final FWCA report summarize the probable effects of the D13R4 scenario on federally listed threatened and endangered species and the Department's heightened concern about adequately addressing water quality in the Comprehensive Plan.

C. Summary

In summary, the D13R4 scenario was quite successful in demonstrating the ability to capture and re-route additional water to more fully achieve restoration targets for the southern Everglades and Biscayne Bay. However, D13R4 was not entirely successful in meeting those restoration targets while at the same time improving performance in the WCAs, which was one of the Department's recommendations for improvement included in the draft FWCA report. It has demonstrated the significant contribution in water volumes deliverable to natural areas through more efficient capture of urban and suburban runoff from Palm Beach and Broward counties. These features need to be explored in more detailed design of the components of the Comprehensive Plan. However, the final design of the components must ensure not only that adverse hydrologic conditions are avoided in the WCAs, but also that they more closely approach restoration targets.

D. Recommendations:

Central and Southern Everglades

1. The final plan as implemented should include the components from the D13R4 scenario that can provide an improved capability for delivery of additional water to Everglades National Park and Biscayne Bay up to the amount in the Dl3R4 scenario by capturing additional runoff from urban areas. The Implementation Plan should include a phased approach to provide for improvement and eventual full recovery of the WCAs, ENP, Biscayne Bay and those other natural areas that have been adversely affected by the C&SF Project. The ultimate amount of additional water recaptured and its distribution should be determined based on this phased approach and its ability to maximize ecological benefits in each of those areas.

2. The Corps should give high priority to examining those groups of components related to movement of water from the central Everglades to the southern Everglades, including but not limited to, L-29 and L-67 A and C. The final plan as implemented should be flexible enough to develop and substitute components during implementation that significantly reduce the operational and ecological trade-offs in balancing the restoration of flow patterns and volumes with the maintenance of appropriate water depths in the remnant Everglades, particularly in the WCA 3B/Pennsuco Wetlands/Northeast Shark Slough areas.

3. The Department recommends that the Corps not commit to the specific details of the L-67 levee component as conceived in either Alternative D13R or the D13R4 scenario. The long-term solution needs to maximize, to the extent possible, the joint restoration of both depth and flow patterns in the central/southern Everglades. For the Modified Water Deliveries/2010 Case Study time period, a set of passive features in L-67 having a combined flow capacity that does not exceed the current outlet capacity of the structures along L-29 should be designed and implemented. These initial features would avoid excessively deep water conditions in WCA 3B and would be more easily modified, depending on the final configuration of this component after removal of L-29 and the other features included in the Comprehensive Plan.

4. Both Alternative D13R and the D13R4 scenario presently use S-140 as a means to introduce water into northern WCA 3A. Although this approach has shown some positive results, detailed design through the PIR process is necessary for restoration of hydropatterns in northern WCA 3 A, which incorporates a better balance between the use of the S- 140 as a point of discharge and a series of inflow structures to spread out flow along the northern and western boundary of WCA 3A. This approach during the PIR process is intended to provide greater flexibility in distribution of inflows to the WCAs.

Biscayne Bay

1. The Comprehensive Plan is intended to provide surface water flows sufficient to meet restoration targets for Biscayne National Park and Biscayne Bay. In the meantime, surface water flows should meet or exceed the 1995 Base condition, and there should be neither any

annual or seasonal net loss in the total volume nor any reduction in the spatial and temporal distribution of combined surface and groundwater flows.

2. Every effort should be made to find sources, storage, and means of distribution of water to Biscayne Bay that (a) require minimal water treatment to reach ambient water quality in southern Biscayne Bay, (b) are likely to receive adequate funding, (c) have the greatest probability of success, (d) can achieve current and future restoration targets, and (e) for which the long-term environmental and economic consequences can be reasonably predicted (*e.g.* use reuse water as a last resort).

3. To avoid serious delay in the restoration of Biscayne Bay and Biscayne National Park, studies needed to verify restoration targets and assess the feasibility of restoration actions should be funded and conducted early in the implementation phase. The Biscayne Bay Feasibility Study, in particular, must be given a very high priority.

IV. Water Quality Concerns Raised By The D13R4 Scenario

Chapter VIII of the Department's draft FWCA Report (August 1998) discussed water quality concerns of the Interim Draft Plan, particularly the phosphorus removal capability of the proposed STAs, and the need to consider the effects of other environmental pollutants on fish and wildlife resources. The Restudy's Water Quality Team has drafted an issue paper addressing these and additional water quality issues. Among the principal areas of concern in the draft issue paper are: 1) remediation of nutrient loading in Lake Okeechobee, 2) water quality concerns in the St. Lucie Estuary, and 3) construction of an additional STA proposed by the Miccosukee Tribe of Florida to treat the anticipated increase in runoff volume that would be delivered to WCA 3A. That issue paper is being revised to include the additional water quality concerns associated with the D13R4 scenario.

The D13R4 scenario was devised and modeled mainly to increase flow volumes to Biscayne Bay and Everglades National Park (ENP). This scenario attempts to capture additional water from urban and suburban runoff and wet season flows from urbanized canals that was being lost to tide. This will improve water quality in Lake Worth Lagoon, which is the current receiving body of water for this flow. However, D13R4 represents a fundamental change in water routing relative to all previous Restudy model runs in that it sends water carrying higher pollutant loads to Biscayne Bay and Everglades National Park, which have an Outstanding Florida Waters designation. Sending this water to the Everglades increases the concern expressed in our draft FWCA report that the Comprehensive Plan does not include enough treatment capacity to handle the additional flows destined for the Everglades.

The D13R4 scenario presents a number of water quality concerns and a key factor for the re-routing is the need for additional sites to handle water treatment. The size and detention time of the proposed Site 1 STA to adequately treat nutrients and other pollutants is of particular concern. An analysis of the routing and detention times required for the additional treatment facilities will need to be completed during detailed planning. The proposed site for the buffer zone through which this water would be distributed into ENP has not yet been acquired.

Existing water quality monitoring data for the canals from which this additional water will be captured should be examined to determine the classes of pollutants and their concentrations. This may require a more advanced and detailed water quality monitoring program for these canals. Additional water quality modeling using these estimates of pollutant loads is planned to assess the implications of this new water. However, that analysis will not be finished in time to be reviewed in this FWCA report. A preliminary estimation of the flow-weighted mean concentration of phosphorus in water from the C-51, C-15, C-16, and Hillsboro basins is 166 ppb. Using this figure and the additional flow volumes needed to be treated in the Site 1 reservoir/STA in the D13R4 scenario, the South Florida Water Management District has made a preliminary determination that the Site 1 facility as described in D13R is too small. Improved evaluations of the appropriate size for this and the other proposed storage and treatment facilities must be conducted.

Recommendation:

Although the D13R4 scenario presents many challenges with respect to water quality, the Department recommends that sufficient water treatment capacity be built into the plan to handle the increased water volumes needed to achieve the hydrologic characteristics as were observed in Biscayne Bay and Everglades National Park under D13R4. Additionally, more thorough monitoring of a variety of pollutants will be required in the basins from which this water will be derived. These data will provide better estimates of the sizes of storage areas needed for initial treatment. Selection of appropriate technology for supplemental treatment (in addition to the STAs) must consider the potential ecological effects of all pollutants, not just phosphorus. The Draft Implementation Plan proposes development of a Comprehensive Integrated Water Quality Plan for the Restudy. The Department recommends that the water quality plan be given priority and that additional funding be specifically identified for this purpose in WRDA 2000 to ensure that adequate resources are expeditiously applied to this important effort.

V. Threatened and Endangered Species

A. Introduction

The August 7, 1998, preliminary programmatic biological opinion addressed Alternative D13R, which will remain the Corps'selected plan in the Final Programmatic EIS. The biological opinion determined that the Comprehensive Plan was not likely to jeopardize the continued existence of any federally listed species or adversely modify their critical habitats. Table 3 provides a summary in three categories of the determinations of likely effect.

Table 3. Summary of the Determinations in the Programmatic Biological Opinion

Species	Likely to Benefit	Likely to Benefit Overall, but Localized and/or Temporary Adverse Effects Also Likely	Likely to Adversely Affect, but not Likely to Jeopardize
West Indian manatee	ö		
American crocodile	ö		
Okeechobee gourd	ö		
Snail kite		ö	
Wood stork		ö	
Cape Sable seaside sparrow		ö	
Bald eagle			ö
Audubon's crested caracara			ö
Eastern indigo snake			ö
Florida scrub jay			ö

The preliminary biological opinion on the Restudy provided, as best can now be determined at this programmatic level, Reasonable and Prudent Measures to minimize incidental take of listed species. The opinion generally described several required actions: 1) designing and implementing a detailed monitoring and adaptive management program, 2) seeking advice from natural resource professionals to site water treatment and storage areas, 3) consulting with the FWS and other natural resource professionals during detailed planning and construction to minimize effects on listed species, and 4) sequencing the construction and operation of components in a way that will maximize benefits and minimize adverse effects on listed species.

Subsequently, we have reviewed model results for the 2010 Case Study and the D13R4 scenario. These additional model runs provide a sense of the range of flexibility in Alternative D13R. At the conceptual level of detail governing all of these simulations, we find that the findings of our preliminary biological opinion remain in effect. The following sections provide summaries of the possible implications of the additional simulations and recommendations to proceed into detailed design of components.

B. Brief Evaluation of the 2010 Case Study

Overall, the 2010 Case Study provides very little of the benefit to threatened and endangered species predicted for D13R. For the Cape Sable seaside sparrow, the 2010 Case Study provides some of the benefits expected from D13R and is a significant improvement over the 2050 Base. For the wood stork, the 2010 Case Study is not significantly different from the conditions in the 1995 Base, and does not provide any of the benefits predicted under D13R conditions. Snail kite index results show no significant difference between the 2010 Case

Study and 2050 Base foraging conditions under dry conditions. In average-to-wet years, the 2010 Case Study is a slight improvement over the 2050 Base. The 2010 Case Study does not show improvements in Shark Slough snail kite habitats that would provide additional suitable kite habitat compensating for the loss of habitat in WCA 3A during dry periods. The 2010 Case Study shows no change from the 2050 Base for the American crocodile or the West Indian manatee.

Recommendations: Our, February 18, 1999, PAL recommended that the 2010 Case Study be revisited to see if optimizing reservoir performance, reordering the implementation schedule, or phasing or breaking components down into increments might improve performance by 2010, more closely approaching the expected benefits of the final Comprehensive Plan. This approach would include consideration of the effects on threatened and endangered species summarized above. Effective monitoring of environmental responses (habitat changes, populations of listed species, and/or key life history requirements of listed species) in this phased approach will provide more useful information to assess the effects of interim actions and improve the performance by 2010 for listed species.

C. Brief Evaluation of the D13R4 Scenario

The likely effects of D13R4 on threatened and endangered species include two areas of concern and some beneficial effects. Cape Sable seaside sparrow population predictions from the ATLSS models (for the western subpopulation only) show a greater tendency for very low numbers under the D13R4 hydrologic conditions, when compared to D13R. The FWS believes that there is potential for significant adverse effects to the Cape Sable seaside sparrow within the range of flexibility demonstrated for Alternative D13R in running the D13R4 scenario. Although D13R4 appears to provide improved habitat conditions for the sparrow relative to the 2050 Base, according to the best scientific information now available, the 2050 Base would likely lead to extinction of the sparrow. For the snail kite, foraging conditions are good for both D13R4 and 2050 Base across many parts of the remaining Everglades. However, under D13R4, water levels are too high in portions of each of the WCAs to provide effective snail kite foraging. In addition, losses of snail kite nesting substrate in these areas, particularly in WCA-3B, would be expected due to the increased frequency of deep water conditions produced by D13R4. Significant improvements are expected for wood storks, American crocodiles and West Indian manatees under D13R4.

Recommendations: Our long-term recommendation is to continue the same approach recommended above for the 2010 Case Study. We are confident that with enlightened management, the various species that evolved to co-exist in south Florida can not only be saved from extinction, but also can be made more secure through recovery actions. This will require the proper balance in hydrologic conditions and other factors affecting habitat quantity and quality. We will only be able to determine and put into practice this proper balance through incremental steps in the implementation, testing, monitoring, and adjustment of the Comprehensive Plan. In addition to finding that balanced management, we must ensure that the transition from currently degraded habitat conditions to the preferred management condition involves the correct sequence of changes and a rate allowing populations of threatened and endangered species to adjust. Two of the most prominent examples (although certainly not the only ones) are:

1. Habitat for the Cape Sable seaside sparrow in northeast Shark River Slough must be enhanced and occupied prior to increasing the hydroperiod in the habitat for the subpopulation west of Shark River Slough. Hydrologic conditions expected to result from implementation of the Restudy are significantly different from hydrologic conditions under the current Experimental Water Deliveries program, which resulted in the FWS' February 19, 1999, jeopardy biological opinion. That opinion concluded that the current hydroperiod in the western habitat is contributing to jeopardy conditions for this subspecies. However, implementation of the Modified Water Deliveries project and the additional features of the Restudy would dramatically improve conditions in the sparrow's eastern habitats, providing additional flexibility for management of sparrow habitat, provided that conditions likely to result in extirpation of the western subpopulation continue to be avoided. In essence, the FWS' assessment of the short-term risk to the sparrow as expressed in the Experimental Water Deliveries biological opinion is heightened by the current scarcity of suitable habitat to the east and the limited flexibility available in the present water management system.

2. Habitat for the snail kite must be enhanced and expanded in Shark River Slough in Everglades National Park before the impounded areas of the WCAs currently used by snail kites are restored to a more hydrologically connected condition.

Careful monitoring and adjustment in management will ensure that these and other species will have adequate time to adjust and recover in the period of transition.

D. The Role of the Restudy in Implementation of the Multi-Species Recovery Plan

The FWS' February 24, 1988, letter to the Corps provided recommendations to help promote recovery of threatened and endangered species through implementation of the Restudy. This is in keeping with Federal Agencies' mandate under section 7(a)(1) of the ESA to do more than merely avoid the elimination of a protected species, but to "utilize their authorities in furtherance of the purposes of this chapter by carrying out programs for the conservation of endangered and threatened species…" 16 U.S.C. 1536(a)(1). Conservation is defined in the ESA as "the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary." 16 U.S.C. 1532(3).
That letter provided a synopsis of the general habitat management practices and species-specific management actions (for those species the FWS considered relevant to the Restudy) contained in the FWS' draft Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida (MSRP).

The FWS has strived to ensure that the Comprehensive Plan is compatible with the MSRP and vice versa. Some of the key sections of the MSRP dealing with wetland-dependent threatened and endangered species were written by the same FWS employees involved in the Restudy. We are confident that the already substantial benefits to threatened and endangered species expected to arise from implementation of the Comprehensive Plan can further promote recovery of listed species, if this plan is coupled with the Corps' commitment to carry out the positive conservation intent expressed in section 7(a)(1). Please review our February 24, 1998, letter and work with us to focus the Comprehensive Plan towards carrying out any of the recovery actions included there.

VI. The Need for Further Multi-Agency Review of the Other Project Elements (OPEs)

The Department's comments on the draft PEIS (December 23, 1998, letter from James H. Lee to Russell Reed) pointed out that the evaluation and selection of OPEs was not performed by a multi-agency team. Further, there appears to be an inconsistency between the draft PEIS and the January 25, 1999, draft Implementation Plan in their discussion of: projects already authorized as Critical Projects under WRDA 1996; projects that might be authorized under a similar programmatic authority under WRDA 2000; and those OPEs that might be authorized in WRDAs past the year 2000.

Recommendation: We recommend that the multi-agency team reconvene so that participating agencies can better understand these projects and rank them according to a mutually agreeable set of criteria. We suggest participants should include roughly equal proportions of participants who have largely an ecological perspective and those who are more involved in water supply or urban planning.

VII. Science/Research/Peer Review

The draft FWCA report recommended that all progress toward achieving ecosystem restoration be continuously evaluated in a scientific forum. We were pleased with the Corps' discussion of the adaptive assessment strategy in the draft Programmatic EIS. The Department offers some additional recommendations below.

Recommendations:

1. The Department recommends that a high priority be placed on further refinement of the Natural Systems Model early in the implementation of the Comprehensive Plan. One of the main aspects of the NSM that needs review is the assumption that the ground elevation in the SFWMM is equivalent to the NSM ground elevation south of Tamiami Trail, when evidence supports the fact that subsidence has occurred south of the Trail. The NSM ground surface elevation should be raised the appropriate amount to account for this subsidence. His correction will have implications on the appropriate comparison of alternatives relative to the NSM in future detailed design of components in the Comprehensive Plan.

2. Determination of the hydrologic conditions most conducive to accretion of peat in the WCAs should be a high priority. The Comprehensive Plan should include support for research focused on two principal objectives: 1) development and verification of a peat accretion model, and 2) development of a risk analysis for both chronic and acute loss of soil.

The effect of water depth on the expansion of cattails in areas of greater soil subsidence in northern WCA 3A is also a management concern deserving priority as a research topic.

3. Simultaneously with the research recommended above to identify the hydrologic regime that best promotes accretion of peat, the Corps and cooperating agencies should try to develop and test active management techniques (in addition to or separate from long-term changes in water management) that would accelerate recovery of damaged soils in the WCAs.

4. The Corps should support an ongoing and in-depth scientific review throughout implementation (as appropriate in adaptive assessment) to help achieve the most appropriate balance in restoration of flow patterns, flow volumes, and depths in maximizing overall ecosystem benefits. This task should be assigned to the standing scientific review panel that the Science Coordination Team has recommended to the Working Group. Although that panel would be asked to review many aspects of the entire restoration effort, this specific issue needs immediate attention. This review will be concurrent with moving ahead through detailed planning and implementation of the Comprehensive Plan, rather than delaying progress in implementation until scientific review is completed. The review panel should include both scientists familiar with the Everglades ecosystem and others who have participated in other large-scale ecosystem restoration efforts.

VIII. Conclusion

The Conceptual Plan you described in your February 19, 1999, letter creates the opportunity to provide enormous benefit to the South Florida Ecosystem. During the early stages of implementation, the Department recommends further development of the structural and operational features of the D13R4 scenario, and perhaps other scenarios, which more fully achieve the ecological restoration targets in the Water Conservation Areas, the southern Everglades and Biscayne Bay. The Corps' February 19, 1999, letter included a commitment to implement the final plan in a manner that provides improvements to the operation of the WCAs as well as providing more water for Everglades National Park and Biscayne Bay. We are also pleased that the Corps' letter concluded that the ultimate amount of additional water recaptured from urban and suburban areas and its distribution will be determined based on a phased approach to obtain the maximum ecological benefits in each of these areas. Finally, that letter included a commitment to use passive hydrologic control features to the maximum extent practicable, limiting the use of active features, such as pumps and gates, to those situations where passive controls are not adequate. Those commitments are consistent with the Department's recommendations provided above, and we express the Department's commitment to cooperate with you during detailed project design to translate those concepts to specific structural and operational features.

The Department fully supports a science-based, independent peer review process. The peer review process, coupled with an adaptive assessment strategy, must be instituted early and must work effectively to guide the implementation of the Comprehensive Plan. The multi-agency, multi-disciplinary planning approach, which has worked well to date, must be sustained as we proceed to detailed project planning and design.

We must also ensure that the water quality aspects of the Comprehensive Plan are addressed fully and early in the implementation of the Comprehensive Plan. Adequate funding, design and technical review are essential in fulfilling these water quality goals.

Finally, the C&SF Restudy has been a successful and unprecedented endeavor on a National scale. The Corps has carefully managed a broad spectrum of stakeholders, far-reaching spatial and temporal scales, and complex policy and technical issues. The Department commends the Corps and the various planning partners for their diligent efforts, and looks forward to a continued close partnership during implementation of the Comprehensive Plan.

IX. Glossary of Abbreviations and Acronyms

(For the reader's quick reference, this list includes only those abbreviations and acronyms used in the final FWCA report. The draft FWCA report includes another list for the terms used there.)

AET	Alternative Evaluation Team
ATLSS	Across Trophic Levels System Simulation
C&SF	Central and Southern Florida Project
Corps	U.S. Army Corps of Engineers
Department	U.S. Department of the Interior
EAA	Everglades Agricultural Area
ENP	Everglades National Park
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
DEP	Florida Department of Environmental Protection
FWCA	Fish and Wildlife Coordination Act
FWS	U.S. Fish and Wildlife Service
GFC	Florida Game and Fresh Water Fish Commission
MSRP	Multi-Species Recovery Plan for Threatened and Endangered Species of South Florida
NESRS	Northeast Shark River Slough
NPS	National Park Service
NSM	Natural System Model
NWR	National Wildlife Refuge
OPE(s)	Other Project Element(s)
PEIS	Programmatic Environmental Impact Statement
PIR	Project Implementation Report
RECOVER	Restoration Coordination and Verification (a proposed system-wide review team)
SFWMM	South Florida Water Management Model
STA(s)	Stormwater Treatment Area(s)
WCA	Water Conservation Area
WPAs	Water Preserve Areas
WRDA	Water Resources Development Act

Appendix A -- Everglades Issue Paper

I. Introduction

This Issue Paper has been assembled from the disparate opinions of a number of authors. It does not represent the policy of any of the individual government agencies that participated (U.S. Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, Florida Game and Fresh Water Fish Commission, South Florida Water Management District, Biological Resources Division of the U.S. Geological Survey). It also does not represent the views of the C&SF Restudy's Alternative Evaluation Team (AET), which reviewed and approved several other issue papers related to the Restudy. An earlier draft of this issue paper included detailed reviews of the performance of Alternative D13R and the D13R4 scenario in the central and southern Everglades and the southern estuaries adjacent to Florida Bay. However, due to a lack of time to adequately review those sections to ensure that they included an accurate and fully balanced treatment of the issues, the issue paper was shortened to provide only the background, conclusions, and recommendations.

The Department of Interior (DOI) identified fourteen outstanding issues in the draft Fish and Wildlife Coordination Act (FWCA) report (August 1998) on the C&SF Restudy. Two of these issues related to the Everglades basin:

> **1. Shark River Slough**
> *Total overland flow volumes to Florida Bay, through Shark River Slough, and Taylor Slough, should be increased to more fully reach Natural system Model targets.*
>
> **2.Water Conservation Areas**
> *While accomplishing the above, the hydrologic characteristics in the Water Conservation Areas (WCAs) (particularly northeastern WCA 3A, all of WCA 3B, and WCA 2B) should also more fully reach ecological targets. Alternative D13R was not able to eliminate potentially damaging high water and low water conditions in those areas. The DOI recommends that further modifications be pursued in order to achieve full restoration of hydrologic characteristics in Florida Bay, Shark River Slough and Taylor Slough without compromising full restoration of WCAs. A guiding principle should be that water flow is delivered as naturally as possible throughout all of the remaining Everglades.*

A related concern of the DOI was the deficiency in average water depth and hydroperiod in the Rocky Glades area of Everglades National Park expected with D13R. The AET evaluated the Rocky Glades as a distinct ecological landscape and determined that D13R would not improve the hydroperiod there sufficiently to restore aquatic communities characteristic of pre-drainage conditions. Although not explicitly mentioned in the draft FWCA report, hydrologic conditions in the Rocky Glades are linked to flows to Shark Slough and Taylor Slough, which were a major issue raised in the draft report.

Initial meetings to discuss resolution of these issues were held September-October, 1998. On November 30, 1998, writing teams were assigned to prepare six issue papers, including two separate issue papers for the southern Everglades and the northern/central Everglades. The present issue paper integrates concerns for both areas into a single treatment of the issues and incorporates results of the newly modeled modification to D13R, termed D13R4. Preparation of this combined paper has provided an opportunity to explore points of complete and incomplete agreement among the participants.

The authors reached broad agreement on what were the defining characteristics of the pre-drainage Everglades, but hold varying opinions on what combinations of these characteristics are necessary and sufficient for restoration of the Everglades. The relative importance of different hydrologic properties, including flow patterns, flow volumes, duration of continuous inundation, and water depths, in bringing about full restoration are at the heart of this issue. The Conceptual Model for the Everglades includes the major stressors on the system. The current version of the Conceptual Model emphasizes the importance of restoring the duration of continuous flooding in Shark River Slough, but it does not provide a formula for the relative importance of all hydrologic characteristics.

Hydrologic modeling conducted to date suggests that physical changes in the system hamper full restoration of all the defining characteristics of the Everglades described by the Science Subgroup (1993). These constraining physical changes include topographic changes due to soil loss, water supply and flood control obligations, shortage of water storage and treatment sites in key areas, and loss of the buffering capacity of upstream wetlands that are now part of the EAA. In particular, there are trade-offs between the restoration of flow patterns and volume and the restoration of water depths that have not yet been overcome. It has not yet been possible to restore natural flow lines through the Everglades and restore full flow volumes to the estuaries while at the same time eliminating or preventing unnaturally high water depths in eastern Water Conservation Area 3A and Water Conservation Area 3B.

Resolving these difficult problems will require detailed study and acquisition of new information, possibly leading to new paradigms for restoration of the Everglades ecosystem. It is therefore important that the COE and its planning partners proceed through the detailed design phase of this project with flexibility that will allow substitution of new design features that will maximize overall ecological benefits, providing balance between the restoration of flow patterns and volume and the restoration of appropriate water depths. One primary objective in design and implementation should be to advance toward long-term restoration goals (e.g., re-establishing pre-drainage flow patterns and volumes) without causing more immediate ecological harm.(e.g., increased frequency of extreme high and low water).

II. The Need for Continued Refinement of the Components

Throughout the development and evaluation of the C&SF Restudy, the COE has maintained that the Restudy would provide a flexible conceptual overview of the necessary components rather than a rigid plan. The authors of this issue paper strongly endorse the need to maintain flexibility in both the structural and operational assumptions modeled in Alternative D13R and the D13R4 scenario. Neither of those two model runs completely satisfies the requirements expressed above to increase flow to Shark River Slough while at the same time approaching more closely the restoration goals in the WCAs.

The COE and the SFWMD have recognized the need to refine the components of the conceptual plan through an adaptive assessment process, which will distinguish this effort from the original construction and operation of the present C&SF project. For example, we want to stress the need to be able to adjust the balance in the distribution of water to northern WCA 3A between the S-140 and a spreader canal along the northern edge of WCA 3A in response to observed environmental change. The construction and operation of STA 3/4 under the Everglades Construction Project (the future baseline condition for the Restudy) will provide opportunities to monitor the response of northern WCA 3A that should influence detailed design. The effect of deeper water in northern WCA 3A on the spread of cattails, the rate of peat deposition, and the susceptibility to loss of soil are among the responses that must be measured to assist in detailed design.

We believe that the general features of the D13R4 scenario allowing more efficient capture of urban and suburban runoff from Palm Beach and Broward counties should be incorporated in the conceptual plan. The structural and operational details will not be determined until detailed design, and although the detailed design will likely incorporate many of the concepts added between D13R and D13R4, changes in the specifics will most certainly be necessary.

III. Conclusions

1. The authors reached broad agreement on the **defining** characteristics of the pre-drainage Everglades, but hold varying opinions on the **necessary and sufficient** characteristics of a restored Everglades. Lack of full agreement on the relative importance of hydrologic characteristics, particularly flow patterns and water depths, in bringing about full restoration is at the heart of this issue.

2. Parker *et al*. (1955) found that the Everglades consisted of an eastern and western watershed (Figure 11 in that paper provides their interpretation of pre-drainage flow patterns.) The western watershed of the historic Everglades is still largely intact, providing a greater opportunity for full restoration than for the eastern watershed, where the outflow has been interrupted by development along the Atlantic Coastal Ridge. Some scientists now working on restoration may not be familiar with this and other early references on the pre-drainage condition of the Everglades. A modern synthesis of the previously published information is being prepared, and once this is peer reviewed and published, it may provide insights on restoration targets (particularly flow pattern) that were not fully appreciated in previous evaluations of the Restudy alternatives.

2. Even in the western watershed, soil subsidence is a physical constraint that will not allow full restoration of the flow patterns, water depths, and flow volumes of the pre-drainage Everglades. It may be physically possible to closely approach pre-drainage flow patterns and water depths, but not flow volumes. Flow patterns and flow volumes could also potentially be restored, but not without deviating from the pattern of water depths necessary for restoration.

3. Hydrologic modeling to date has not yet produced a simulation that restores natural flow lines through the Everglades, restores full flow volumes to the estuaries, and at the same time prevents unnaturally high water depths in eastern Water Conservation Area 3A and Water Conservation Area 3B.

4. Increasing accretion rates of peat and preventing conditions leading to chronic and acute loss of soils are keys to restoration, particularly in the northern portions of the present compartments of the remnant Everglades.

IV. Recommendations

1. The COE should not lock in to the specific details of the L-67 levee component as conceived in either Alternative D13R or the D13R4 scenario. The long-term solution needs to maximize, to the extent possible, the joint restoration of both depth and flow patterns. Interim solutions should concentrate on features that are more easily modified through an adaptive assessment process (such as earthen weirs), rather than permanent structures that might be constructed and later found to be less compatible with longer term solutions.

2. For the Modified Water Deliveries/Phase A time period, we recommend design and implementation of a set of passive features in L-67 having a combined flow capacity that does not exceed the current (and at any given stage of Phase A) outlet capacity of the structures along L-29. These initial features would avoid deep water conditions in WCA 3B and would be more easily modified, depending on the final configuration of this component after removal of L-29 and the other features included in the comprehensive plan.

3. The COE should give high priority to development of a Project Implementation Report (PIR) for those groups of components related to movement of water from the central Everglades to the southern Everglades, including but not limited to, L-29 and L-67 A and C. It may be possible to initiate this portion of the design of the comprehensive plan under the authorization of the Modified Water Deliveries Project.

4. Components presently included in either Alternative D13R or the D13R4 scenario should not take precedence over any substitute components that would reduce trade-off between simultaneously resolving the balance in restoration of flow patterns and restoration of appropriate water depths.

5. Both Alternative D13R and the D13R4 scenario presently use S-140 as a means to introduce water into northern WCA 3A. Although this approach has shown some positive results, we recommend that detailed design for restoration of hydropattern in northern WCA 3A incorporate a better balance between use of the S-140 as a point of discharge and a series of inflows to spread out flow along the northern and western boundary of WCA 3A. This approach is intended to provide greater flexibility in distribution of inflows.

6. Determination of the hydrologic conditions most conducive to accretion of peat in the WCAs should be a high priority. The comprehensive plan should include support for research focused on two principal objectives: 1) development and verification of a peat accretion model and 2) development of a risk analysis for both chronic and acute loss of soil. The effect of water depth on the expansion of cattails in areas of greater soil subsidence in northern WCA 3A is also a management concern deserving priority as a research topic.

7. Simultaneously with the research recommended above to identify the hydrologic regime that best promotes accretion of peat, we should also try to develop and test active management techniques (in addition to or separate from long-term changes in water management) that would accelerate recovery of damaged soils in the WCAs.

8. We support an ongoing and in-depth scientific review throughout implementation (as appropriate in adaptive assessment) to help achieve the most appropriate balance in restoration of flow patterns, flow volumes, and depths in maximizing overall ecosystem benefits. This task should be assigned to the standing scientific review panel that the Science Coordination Team has recommended to the Working Group. Although that panel would be asked to review many aspects of the entire restoration effort, this specific issue needs immediate attention. We emphasize that this review will be concurrent with moving ahead through detailed planning and implementation of the comprehensive plan, rather than delaying progress in implementation until scientific review is completed. The review panel should include both scientists familiar with the Everglades ecosystem and others who have participated in other large-scale ecosystem restoration efforts.

IV. Literature Cited

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Appendix B -- Issue Paper on Freshwater Flows to Biscayne Bay

for the
Alternative Evaluation Team
February 5, 1999

Authors: Sarah Bellmund, National Park Service; Joan Browder, National Marine Fisheries Service; Sue Alspach, Miami-Dade County Department of Environmental Resources Management

I. Introduction

Under the Central and Southern Florida Project Comprehensive Review Study (Restudy), water flows under the recommended alternative reduced the quantity of water flowing from regional and local drainage into Biscayne Bay by 25 % in the dry season and 11% in the wet season. This water was replaced with a proposed wastewater reuse facility. The expense and uncertain nature of this technology have prompted concern over the quantity, quality, distribution, and timing of water delivered to Biscayne Bay and Biscayne National Park under the Restudy. Although the quantity, quality, distribution, and timing of water delivered to Biscayne Bay and Biscayne National Park have been severely altered from historic conditions, the need to restore the Bay to more estuarine conditions is an important issue. The South Florida Restoration Task Force Working Group, the U. S. Department of the Interior (DOI), the National Marine Fisheries Service (NMFS), Miami-Dade County, and the U. S. Environmental Protection Agency (EPA) have identified the lack of correct water flows to maintain nearshore estuarine conditions in Biscayne Bay as one of the top remaining issues to be resolved related to the performance of any chosen alternative under the Central and Southern Florida Project Comprehensive Review Study (Restudy). The U. S. Department of the Interior has identified this issue as follows:

"Improve ecological conditions in Biscayne Bay by restoring more natural fresh water inflows, separate from the wastewater reuse proposed in [Alternative] D13R." (U.S.F.W.S, 1998)

The Alternative Evaluation Team (AET) was tasked with further defining this problem and identifying a solution and a process to reach the proposed solution. The purpose of this paper is to present a synopsis of what is factually known about historic and current conditions in Biscayne Bay, identify concerns, and provide recommendations for addressing them. This paper outlines the historical hydrologic and biologic conditions related to the Bay, the current conditions in the Bay, and the problems and implications of altered water flow. A series of actions are proposed to formulate performance measures, define and acquire critical missing information, and determine alternative sources of water.

Background

Biscayne Bay is located along the southeastern coast of Florida and historically served as the eastern outlet of the Everglades (Davis, 1943; Parker *et al*., 1955). The central and southern portions of Biscayne Bay comprise much of Biscayne National Park. Biscayne Bay, its tributaries and Card Sound are designated by the state of Florida as aquatic preserves, while Card and Barnes sounds are part of the Florida Keys National Marine Sanctuary. Biscayne Bay was designated under the Surface Water Management and Improvement Act of 1987 as a priority water body by the Florida Legislature. The waters of Biscayne National Park, Biscayne Bay Aquatic Preserve and the two Sounds are classified as Outstanding Florida Waters (OFWs), and as such are subject to the most stringent regulations, including Florida antidegradation policies. Card and Barnes Sounds contain one third of all American crocodile nesting in the continental United States, and the east shore of Barnes Sound is within the Crocodile Lakes National Wildlife Refuge. Parts of this area are designated as critical habitat for the American crocodile and the West Indian manatee. In addition it provides important forage habitat for Roseate Spoonbills and White Crown pigeons (SFWMD,1995). Biscayne Bay is the largest estuary on the coast of southeast Florida and is contiguous with the southern Everglades and Florida Bay system. Historically, the Everglades, Biscayne Bay, and Florida Bay were part of a larger hydrologically connected natural system of coastal lagoons and wetlands. Although the connections have been altered by surrounding development and the Central and South Florida

Flood Control Project, Biscayne Bay today still supports a diverse natural system of seagrass, hardbottom and coastal mangrove communities.

Biscayne Bay is a historically shallow subtropical estuary with average natural depths of 3-9 ft that have been altered over time by extensive dredge and fill activities (Harlem, 1979; Kohout and Kolipinski, 1967). Under existing conditions, Biscayne Bay is a healthy estuarine lagoon whose salinity, circulation, and water quality depends primarily upon freshwater inflow, wind driven circulation and ocean exchange. Dominant circulation patterns vary based on the local effects within the four major hydrodynamic regions: 1) North Bay (from Dumfoundling Bay south to Rickenbacker Causeway); 2) Central Bay (from Rickenbacker Causeway south to Black Point); and 3) South Bay (from Black Point south to Jewfish Creek) (SFWMD, 1995). South Bay is usually subdivided into two sections: a) the South Bay Section, from Black Point to Mangrove Point, which encompasses the lower portion of Biscayne National Park, and b) the Extreme Southern Bay Section from Mangrove point to Jewfish creek, encompassing Card Sound and Barnes Sound, all of which are within the Florida Keys National Marine Sanctuary (SFWMD, 1995).

Historically, freshwater flowed overland to the Bay through natural sloughs and rivers, and as groundwater through the Biscayne Aquifer (Buchanan and Klein, 1976; Kohout and Kolipinski, 1967; Parker *et al*., 1955). This pattern has been altered by regional drainage, canal construction and operation, urban development, as well as construction of roads, levees, and other hydrologic barriers to surface flow. The Bay currently receives freshwater inflow as canal flow, minor overland flow, and groundwater (SFWMD, 1995; Kohout and Kolipinski, 1967; Buchanan and Klein, 1976). Freshwater flow to the Card Sound and Barnes Sound Section is composed of intermittent canal flow from the C-111 Canal and overland runoff from adjacent wetlands, which are extensive and composed of contiguous freshwater and coastal wetlands.

The coastal wetlands adjacent to Biscayne Bay in South Miami-Dade County extend from Matheson Hammock County Park southward to where Barnes Sound and Florida Bay intersect at US Highway One (US 1) and include the largest tract of undeveloped wetlands remaining in South Florida outside of Everglades National Park, the Big Cypress, and the Water Conservation Areas. This zone of coastal wetlands includes approximately 100,000 acres of brackish and freshwater wetlands, most of which is either in public ownership or designated for acquisition by the South Florida Water Management District and Miami-Dade County. The bulk of the wetlands in this region (approximately 80,000 acres) are located on both sides of US Highway 1 south of Florida City and are part of the South Dade Wetlands Management Area. Hydropatterns, landforms, water flow, and vegetation patterns in these wetlands have been altered due to regional drainage, subsequent salt intrusion, hurricane storm surges, mosquito ditching, farming practices and the construction and presence of US 1 (Egler, 1952, Environmental Protection Agency, 1994; Meeder *et al*., 1996). Much of the land has been disturbed at some time in the past century for agriculture or other uses, but at present most of these wetlands are not disturbed by farming or development. Farming in this region has been localized north of the South Dade Wetlands Management Area in one band west of US 1 and south of State Road 9336 and in another band east of US 1 between Card Sound Road and SW 137 Avenue. Florida Power and Light operates the Everglades Mitigation Bank east of US 1 in the management area, where exotic removal and enhancement of overland flow patterns are planned.

Historic Conditions

Prior to the alteration of system by human activities, the Bay received extensive freshwater input as both overland and groundwater flow. The Bay served as the eastern outlet for freshwater from the southern Everglades and provided estuarine and freshwater nursery habitat (Davis, 1943; Smith, 1898; Buchanan and Klein, 1976; Kohout and Kolipinski, 1967). Hydrologically, freshwater inflow to the Bay was controlled by water levels in and behind the coastal ridge and overflow through the coastal ridge from the Everglades (Parker *et al*., 1955; Kohout, 1960; Kohout and Kolipinski, 1967). Freshwater flow to Biscayne Bay decreased between 1953 and 1976 by twenty percent (Buchanan and Klein, 1976), wetland hydroperiods decreased, and the patterns of freshwater discharge changed from long, slow releases over a broad front to "pulse" releases from canals following rain events.

North Bay

North and South Biscayne Bay had very different characteristics historically, a condition that persists today in spite of, and sometimes because of substantial alterations to both systems. Prior to human intervention, north Biscayne Bay was a primarily fresh or brackish water system, due to large freshwater inflows and a lack of direct connections to the ocean (Harlem, 1979). Fresh surface water entered the northern bay from Miami River, Little River, Snake Creek, and Arch Creek, which served as outlets for the Everglades. Cypress trees bordered the larger rivers and streams that flowed into North Biscayne Bay (SFWMD, 1995). The opening of Bakers Haulover cut in 1925, the widening and deepening of Government Cut, extensive dredging and filling, bulkhead construction, and the channelization of overland and groundwater flow into canals, caused irrevocable changes to the salinity regime and ecological characteristics of North Biscayne Bay (Harlem, 1979; Buchanan and Klein, 1976). Haulover cut provided a direct connection with the ocean and changed the circulation patterns in north Biscayne Bay (Harlem, 1979). The widening and deepening of Government Cut further increased the influx of saltwater into the Bay. Dredging and filling activities altered circulation patterns and contributed to increased turbidity by changing the profile of the bay bottom and replacing the sloped shoreline that absorbed wave energy with vertical bulkheads that reflected it, stirring up bottom sediments (SFWMD, 1995). Both salinity patterns and water clarity were affected by such changes, and in turn affected submerged vegetation composition and distribution patterns.

Biscayne National Park and South Bay

Central and South Biscayne Bay were historically more brackish than North Biscayne Bay, although the region still contained areas of extensive overland and groundwater flow into the Bay. Dole (1914) reports that seasonally large quantities of freshwater moved into the Bay through springs in porous rocks and sediments as well as through streams along the western shore of the bay. Water moved into Central and South Bay through broad natural flow channels that are frequently referred to as transverse glades (Davis, 1943; Buchanan and Klein, 1976). Central Biscayne Bay received enough groundwater and overland surface water flow to maintain low salinity (mesohaline) conditions even though it has the largest natural direct connection with the ocean and receives extensive ocean circulation at the area known as the Safety Valve (Figure 1). Mesohaline conditions (i.e., 5-18 ppt salinities) existed in Manatee Bay in extreme South Biscayne Bay at the beginning of the 20th century (Ishman *et al*., 1998). The western shoreline of Biscayne Bay south of the Rickenbacker Causeway received sufficient freshwater to maintain extensive freshwater swamps and marshes with only a very narrow fringe of mangroves (Harlem, 1979; Reark, 1974; Thorhaug *et al*., 1976). These coastal freshwater marshes were drained and farmed during the first half of the 20th Century (Reark, 1974), until overdrainage, salt intrusion, hurricane storm surges and new opportunities to farm in the rocky uplands resulted in wholesale abandonment of coastal farmland (Environmental Protection Agency, 1994).

Alterations to Central and South Biscayne Bay included regional drainage activities that essentially eliminated inflow from subterranean springs by the 1940's (Reark, 1974) and channelized remaining overland and groundwater flow into canals, but Central and South Biscayne Bay did not experience physical alteration of the bay bottom and shoreline to the extent found in North Biscayne Bay. The most significant impact from alteration was the regional increase in salinity, which has resulted in the slow conversion of a productive brackish estuary into a more marine and occasionally hypersaline environment (SFWMD, 1995).

Salinities in Manatee Bay and nearby waterbodies have been substantially altered by changes in freshwater inflow. Faunal records in sedimentary cores indicate an overall increase in salinity over the past 150 yrs associated with sea level rise, a change from mesohaline (5-18 ppt) to euhaline (30-35 ppt) conditions in the early 1900s, possibly associated with the original drainage of the Everglades and construction of the Flagler railway, and recent extreme fluctuations between low salinities and hypersaline conditions, probably associated with completion of the South Dade Conveyance System, which includes the C-111 Canal, in about 1980. Miami-Dade County Department of Environmental Resources Management (unpublished, cited by Ishman *et al*., 1998) reports salinities from as high as 45 ppt to as low as 14 ppt in recent years. The coastal and freshwater wetlands adjacent to Biscayne Bay have also experienced dramatic changes as a result of these regional drainage activities and the construction of roads and other barriers to water flow.

Biological Setting

Biological information supports the description of Biscayne Bay as an estuarine or brackish water system. Smith (1898), in an assessment of aquaculture potential for the Bay, cites the overabundant and ubiquitous amount of freshwater just below the ground surface as a reason for not locating a sponge hatchery on the mainland. In addition, he described Red Drum as abundant and identified oyster bars within the main portion of the Bay. Red Drum is an estuarine species requiring mesohaline (5-25ppt salinity) habitat conditions (Serafy *et al*, 1997). The primary reason for the loss of this species from the Bay and the failure of reintroductions programs has been identified as the disruption of natural freshwater flows and loss of historic habitat structured by the resulting salinity regime (D. Serafy personal communication). Oyster bars require a salinity range of between 5-25 ppt for development due to the requirements of the oysters and the inability of oyster predators, (oyster drills and flatworms) to exist in this salinity range (Davis, 1958). Optimal development of oyster eggs and larvae is 22.5 ppt, and optimal growth of larvae is between 12.5 and 17.5 ppt salinity (Davis, 1958). Further changes to south Bay may extirpate such species as pink shrimp and spotted sea trout (Serafy pers. comm.).

Vegetation patterns in the South Dade Wetlands Management Area and the eastern panhandle of Everglades National Park reflects the effects of hydropattern changes. The inland border of a zone of sparse sawgrass and spike rush, interspersed with stunted mangroves, which Egler (1952) referred to as "the white zone" because of its appearance on aerial photographs, has migrated an average of 1.5 km and as much as 3.3 km since 1940 (Meeder *et al*., 1996). Such changes were already noticeable by the 1940's, when Egler (1952) studied the Southeast Saline Everglades, which encompassed the wetlands from approximately Black Point to the wetlands of the eastern panhandle of Everglades National Park. Egler observations on the inland boundary of the white zone led him to conclude that the road interfered with the natural west-to-east flow of water and changed the balance between fresh and salt water influence in the eastern wetlands. Meeder *et al.* (1996) have documented further shifts also noted that it was greater on the east side than on the west side of US 1. From this information they concluded that the trend toward decreasing influence of fresh water approaching the coastline had continued. Meeder *et al*. (1996) also found further evidence of increasing salt water influence in fossil mollusks in sediment cores.

Hydrologic Modifications

Biscayne Bay, along with its associated coastal and freshwater wetlands, has been affected by a reduction in overland flow and groundwater seepage, caused by the construction of roads and canals as well as by the general lowering of the water table on the east coast ridge 5-6 ft. by 1945, according to (Leach *et al.* 1972). The hydraulic gradient, defined near the coast as the difference between the water table and sea level, is a major factor determining the rate of groundwater movement.

The first major event to disrupt the connection of Biscayne Bay to its water sources, the coastal ridge and the Everglades, was the completion of the Miami Canal from Lake Okeechobee to the Bay and the concomitant destruction of the waterfalls in the Miami River, which served as a natural control on outflow of freshwater and inflow of saltwater (DuPuis, 1954; Parker *et al*., 1955). The opening of the primary canal system and its connection to the Bay allowed uncontrolled freshwater movement out of the Everglades, thus draining the coastal ridge and allowing saltwater inflow during dry periods (Kohout, 1960; Parker, 1952). Cypress trees were replaced by mangroves along the larger rivers and streams of North Biscayne Bay (SFWMD, 1995). Saltwater intrusion in coastal wellfields prompted the installation of saltwater control structures in the mouths of the coastal canals between the mid 1940s and the 1960's (Kohout and Kolipinski, 1967; Buchanan and Klein, 1976; SFWMD, 1995). Increased pumpage at coastal wellfields caused decreased freshwater head in the aquifer and led to landward migration of seawater in the aquifer (Kohout, 1960). Lowering the water table on the coastal ridge profoundly reduced groundwater flows to Biscayne Bay (Parker *et al*., 1955; Buchanan and Klein, 1976).

Current Conditions

General

Water quality has been an issue of substantial concern for Biscayne Bay. Water quality in Biscayne Bay is well inventoried through 1994 in the Surface Water Improvement and Management (SWIM) Plan for Biscayne Bay (SFWMD, 1995). Land use changes and human activities led to a decline in overall water quality for the Bay when compared to historical descriptions. A water quality monitoring program was established for the Bay in 1979, which has enabled regional managers to track progress in addressing water quality concerns. Improvements have been reported in many constituents, such as coliform bacteria (derived from sewage), but others have continued to be a problem (e.g turbidity). The SWIM Plan for Biscayne Bay (SFWMD, 1995) lists many of the water quality and biotic conditions of the Bay as currently improving or recovered. Although contaminant and some water quality parameters improved, canal operations continue to produce extreme freshwater pulses that create an irregular delivery of freshwater to the bay. This was recognized as a major structuring process as early as the 1960's by Kohout and Kolipinski (1967).

North Bay

North Biscayne Bay circulation and flow is highly restricted and directly affected by causeways, barrier islands, and artificially maintained ocean inlets (Wang and van de Kreeke, 1984; van de Kreeke and Wang, 1984; Metro Dade DERM, 1985). This area of Biscayne Bay is heavily influenced by canal flows from urban areas (SFWMD, 1995). Although phytoplankton may be the principal source of primary productivity in North Bay (SFWMD 1995), the area between the 79th Street and Julia Tuttle Causeways contains a large (approximately 3000 acres), healthy seagrass bed and supports a productive fishery (SFWMD, 1995). This productive and healthy seagrass bed supports high levels of biological diversity and appears to be flourishing in a highly urbanized area of the Bay (DERM unpublished data). Large portions of the area of North Bay, between Julia Tuttle and Venetian causeways, have not been dredged and contain a mixture of sparsely to moderately vegetated seagrass communities (SFWMD 1995). The submerged communities of this portion of North Bay and would likely benefit from improved water transparency, which would promote greater benthic coverage (SFWMD 1995). Near the mouth of the Miami River, seagrass communities are impacted by reduced water quality, reduced water transparency, and nutrient enrichment from the canal water, although the effect diminishes away from the mouth, as evidenced by the presence of extensive seagrass beds west of Virginia Key. Along the margins of rivers that fed North Bay freshwater cypress trees were replaced by mangroves due to increased salinity (Harlem, 1979). Most mangroves have been lost to urban development, and only a few stands of these mangrove forests, such as the extensive stands along the Oleta River and the mainland shore of the Oleta State Recreation Area, remain.

Central-South Bay

Central Biscayne Bay, which contains the extreme northern portion of Biscayne National Park, is characterized by freshwater canal inflow, groundwater seepage, and ocean exchange. This area is well flushed and is directly and primarily influenced by exchange with the ocean across the shallow channels and embankments known as the Safety Valve (Wang and Van de Kreeke, 1984; Van de Kreeke and Wang, 1984; Metro Dade DERM, 1985). The salinity patterns in this area are dynamic due to the alternating influence of large, pulsed canal discharges and direct ocean exchange. Seagrass communities in central Biscayne Bay range from poor to excellent (SFWMD, 1995). Dense seagrass communities still occur in shallow areas between Rickenbacker Causeway and Norris Cut (DERM unpublished data). Many of these grass beds have experienced propeller scouring due to heavy boat activity. In Central Bay, mangroves line the shore of Key Biscayne. They dominate the shoreline from Matheson Hammock County Park south along the entire shoreline of Biscayne National Park, Card and Barnes Sounds (Environmental Protection Agency, 1994; SFWMD, 1995).

The southern Biscayne Bay comprises the majority of Biscayne National Park. This portion of the Bay is characterized by restricted circulation, few connections with the ocean, a high rate of evaporation, and freshwater input from canals that drain the primarily agricultural region of south Miami-Dade county (SFWMD, 1995). These characteristics result in a much higher dependence on freshwater inflow to regulate salinity and periods of hypersalinity are not uncommon (SFWMD, 1995). Biscayne National Park serves as a nursery ground for offshore gamefish and commercial fisheries (Houde and Lovdal, 1985). Currently, fisheries conditions within the National Park are generally stable, with some exceptions, such as spotted sea trout catch per unit effort which has declined in Miami-Dade County over the past 10 years (Bartone and Wilzbach, 1997). Many gamefish species, such as red fish and sea trout, have not yet recovered to their previous healthy densities, and reintroduction attempts have not met expectations. Currently, the only area known to have active breeding of spotted sea trout is North Biscayne Bay, which has more favorable salinities. The southern portion of the Bay, primarily in Biscayne National Park, is typified by an area of extensive seagrass, hardbottom, and coral communities. Biologic productivity in southern Bay is primarily benthic. The relative health of these communities is documented in the Biscayne Bay SWIM Plan (SFWMD, 1995).

Coastal Sounds

The area from Mangrove Point south, which includes Card Sound, Barnes Sound, and Manatee Bay, is the most isolated portion of the southern bay due to natural separation from the rest of South Biscayne Bay by extensive banks, and separation from the Atlantic Ocean by the barrier islands. Wind and tide are the primary mixing forces in Biscayne Bay, and wind effects are roughly twice as strong as tide effects (Swakon and Wang, 1977; Lee, 1975). Both wind and tidal effects are muted in extreme South Bay. Mixing with the Atlantic Ocean is restricted by the barrier islands and by mud banks within the Bay, and turnover time is on the order of 2.3 months in Card Sound and 3.4 months for Barnes Sound (Lee, 1975).

The area of extreme south Biscayne Bay, retains most of its natural mangrove shoreline and is distinguished by shallow waters and broad mud banks. Brook (1975), describing his study site immediately south of Long Arsenicker Key, said that a narrow (5-m wide) band of Manatee Grass (*Halodule wrightii)* occurs near the shore and is replaced by turtle grass (*Thalassia testudinum)* further offshore, where water depth was 1.5 meters. His site was part of a larger seagrass area extending to the east and west and gradually thinning out to the south as depth increased. Observations in Manatee Bay indicate that the bottom habitat varies from dense *Thalassia* cover to seagrass with open patches of coarse sand (Ishman *et al*. 1998). Based on Brook's (1975) descriptions from Card Sound, this area has a resident fish community dominated by small forage species, including the hardhead silverside, silver jenny, goldspotted killfish, two species of pipefish, and yellowfin mojarra, supported by a food web he thought to be based largely on microalgae. Great barracuda frequent and spiny lobster utilize this area (Brook, 1975). Brook (1975) considered the biomass of small fish and their food organisms in the area to be low and proposed that the hypersaline conditions experienced by the area might be limiting secondary and tertiary production.

Currently, Card and Barnes Sounds receive the majority of their freshwater flow as direct rainfall and as groundwater, except for existing canal flows to Manatee Bay in Barnes Sound. The construction and operation of the C-111 Canal, which drains much of western and southern Miami-Dade County, introduced a new source of fresh water: canal discharge. Under the existing Modwaters/C-111 Project this canal flow is eliminated. Without replacement of freshwater overland or groundwater flow impacts to these downstream receiving waterbodies may result. Since Card and Barnes Sounds are the most poorly mixed parts of Biscayne Bay, requiring 2.3 and 3.4 months for complete exchange with seawater respectively, improving overland flows to this area is a serious restoration need.

The declining influence of overland freshwater flow and groundwater seepage in the area has been a major causal factor in the change in vegetation patterns within this century (Egler, 1952; Meeder *et al*., 1996). Fish biomass is positively affected by freshwater inflow to the coastal ecotone (Lorenz, 1997). Biomass, in combination with timing and rate of dry down, influence fish densities, which determine their availability to wading birds. Coastal wetlands are an important feeding area for wading birds, including Roseate Spoonbills, Wood Storks, and White Ibis, whose South Florida breeding populations have declined substantially in the past 60 years (Ogden, 1994).

II. Define Issues in Detail

Under the Restudy process, alternatives chosen for the restoration substantially decreased the amount of freshwater moving into Biscayne Bay. To make up for the amount of local and regional water removed from the Bay, waste water reuse was added to the chosen alternative as "make up" water to achieve the 'no harm' goals set for the Bay and perhaps improve conditions to achieve some of the proposed restoration targets within the Bay. Concern over the use of this expensive and uncertain technology prompted the inclusion of a new task to identify alternative sources of freshwater for the Bay. Attempting to "find water" from the local and regional system was identified as the first component of this process. A related component was defined as the identification of biologic performance targets for restoration, which are linked to freshwater inflow. This effort is in response to the conditions within the

Bay and the fact that marine and estuarine communities are structured by the volume, delivery and timing of freshwater flow as it is moved to the Bay.

Marine and estuarine communities are affected by event related salinity changes and long term salinity shifts. Salinity affects these communities by being both too high and too low. Biscayne Bay is a fragile ecosystem that relies on a balance of freshwater delivered in the proper amounts, with the proper timing, in the proper location. Currently, water is primarily conveyed into the Bay as point source discharge through canals and through groundwater inflows. The timing, volume and method of delivery of canal discharges can cause acute and long term chronic biologic effects, which are related to timing, volume and method of delivery. Currently, water is primarily conveyed into the Bay as point source discharge through canals and through groundwater inflows. The timing, volume and method of delivery of canal discharges can cause acute and long term chronic biologic effects, which are related to timing, volume and method of delivery.

Effects of Freshwater Pulses

Canal flows result in abnormal freshwater distribution and water movement. Water moving out through canals and into the Bay acts as a coherent and discrete stable water mass of low salinity that does not immediately mix with marine water due to the density difference between freshwater and saltwater (Chin-Fatt and Wang, 1987). The extreme and rapid shifts in salinity, which result as these water masses move into the Bay can severely impact or kill attached or rooted benthic organisms and plants as well as impacting fish communities (Serafy *et al*., 1997; Irlandi *et al*, 1997; Lorenz *et al*, 1997; Montegue and Ley, 1993; Brooke *et al*., 1982). Thorhaug (1976) observed that species diversity and numbers of fish, mollusks, crustaceans and algae decreased in the vicinity of a canal in Biscayne Bay. This effect can be eliminated by shifting point source canal flow to distributed overland flow (SFWMD, 1995). Salinity changes from the movement of distributed overland flow are gradual, and are less detrimental biologically to the Bay ecosystem (Serafy *et al*., 1997; Irlandi *et al*, in press; Lorenz *et al*, 1997; Montegue and Ley, 1993; Brooke *et al*., 1982).

Effects of Reduced Flow and Loss of Seasonal Low Salinity Areas

The reduction in total freshwater flow to Biscayne Bay, along with physical modifications in North Bay, have resulted in a regional increase in the average salinity experienced in any one portion of the Bay, and periodic hypersaline conditions (>40 ppt) in some areas. Channelized flow to the Bay through canals produce periods of abnormally high salinity (>40 ppt) alternating with extremely low salinities in inshore areas due to the pulsed nature of canal flows (SFWMD, 1995). The survival of many organisms depend upon the stable seasonal availability of low salinity environments (Serafy *et al*., 1997; Montegue and Ley, 1993; Brooke *et al*., 1982; Kohout and Kolipinski, 1967), and the reduction or loss of these environments has resulted in concomitant reduction or loss of species dependent on such conditions. In Biscayne National Park some of these organisms which are dependent upon low salinity conditions include penaeid shrimp, finfish, and crocodiles (SFWMD, 1995). In North Biscayne Bay sea trout spawning is believed to be linked to the presence of stable low salinity areas which are available seasonally (Serafy, pers. comm; Bartone and Wilzback, 1997; Berkley and Campos, 1984). Historical information on the distribution of the eastern oyster indicates that this area was once a more mesohaline (5-25 ppt salinity) environment. Red Drum were once abundant (Smith 1898), but this species, which requires mesohaline (5-25ppt salinity) habitat conditions (Serafy *et al*, 1997), has been lost from Biscayne Bay because of disruption of natural freshwater flows and loss of the appropriate salinity regime (J. Serafy personal communication).

Effects of Reduced Groundwater Flows

The reduction in groundwater flows to Biscayne Bay would have likely had a larger impact in Central and South Bay, where the area is more directly and primarily influenced by exchange with the ocean, than in North Bay. Springs and seeps distributed over the bay bottom would have mixed freshwater over a wide area, which would have resulted in an extensive region of lowered salinity, in spite of the high rate of tidal exchange in Central and South Biscayne Bay. Such springs essentially ceased flowing by the 1940"s (Reark, 1974), and current information indicates that groundwater flows to South Biscayne Bay are not detectable more than 400 meters from the coastline (USGS, personal communication). Within the zone currently influenced by groundwater flows, there is a slow, but constant inflow of freshwater to the nearshore environment. This constant flow may have a substantial effect on local salinity conditions, and may act to somewhat buffer the nearshore environment by keeping local salinities consistently lower. Any impact to groundwater flows could impact this nearshore region of lowered salinity and possibly disrupt nearshore communities.

Effects of Water Quality

Watershed land use changes have resulted in concurrent changes to the water quality of the surface and groundwater flows to Biscayne Bay. Although overall water quality in Biscayne Bay has improved in recent years (SFWMD 1995), water quality is still a substantial concern in the watershed. Water quality ranges from severely degraded in the Miami River to very good near the Featherbed Banks (SFWMD, 1995). The Biscayne Bay SWIM Plan reports the trend analysis for a wide variety of constituents.. The results of these analyses vary as to whether improvement in various parameters have occurred over time. Water quality issues are different for each of the drainage basins, and depend upon the specific land uses in the basin.

Downstream communities are directly impacted by water quality changes, although the spatial extent over which a specific water quality parameter exerts influence is a function of its solubility and biological activity. The inflow of nutrients can result in shifts in benthic productivity and species composition. Contaminants may enter the bay environment and cause different impacts, depending on whether the level of exposure is acute or chronic. Major cumulative impacts to the submerged communities of Biscayne Bay may result from chronic exposure to reduced water quality.

Effects of the Proposed Alternatives

Concurrently with development of this issue paper, a modification of Alternative D13R was prepared that provides additional water to central and southern parts of the Bay, including Biscayne National Park. This alternative is termed D13R4. For comparison, Table 1 provides flow estimates to each part of the Bay without inclusion of reuse water to Central and South Bay. These figures will differ from those presented on the web page as "Simulated Mean Annual Surface Flows Discharged into Biscayne Bay for the 1965-1995 Simulation Period" because reuse inputs to the Bay have been excluded in this table in order to better evaluate D13R and D13R4 flows to the Bay without this problematic component. No flow targets were established by the AET for North Bay and the Miami River, and these flows were generally unchanged by D13R4

Snake Creek:

Target flows to Snake Creek were not achieved in Alternative D13R. Specifically, dry season flows undershot the target by 67,000 acre feet and wet season flows overshot the target by 12000 acre feet. Snake Creek is reduced by 72% in the dry season (Snake Creek is not affected by the reuse proposal). Surface water flows to the Snake Creek region in Biscayne Bay in D13R are significantly lower than current conditions. Under Alternative D13R4 Snake Creek flows are reduced by 79% in the dry season compared to the target flows and by 61% compared to existing (1995 base) dry season flows. The existing Snake Creek watershed contains extensive mangrove forests in the Oleta River corridor. Under existing conditions this is a reasonably productive nursery area and restoration efforts are ongoing to preserve and enhance the region. Adequate freshwater flows are essential to minimize impacts to this coastal wetland corridor.

Miami River:

Surface water flows to Biscayne Bay at the Miami River were significantly reduced over existing conditions in Alternative D13R. Specifically, dry season flows were reduced by 42,000 acre feet and wet season flows were reduced by 89,000 acre feet with a total reduction of 131,000 acre feet. Flow in the Miami River is reduced by 67% in the wet season and 70% in the dry season from the 1995 base. Although it remains unclear as to what impacts will result in Biscayne Bay or what impacts to water quality in the Miami River may result from this reduction in surface water flow, it is likely that reducing flow so severely may potentially have negative biologic consequences.

Biscayne National Park

The following flows were estimated without the reuse component provided in both Alternative D13R and D13R4. D13R reduces flows to Central and South Bay by 12% and 14%, respectively, in the wet season and by 7% and 24% respectively, in the dry season when compared to target flows. D13R4 approximates or slightly exceeds target flows to both Central and South Bay. The area of most severe decrease under D13R is found in southern Biscayne Bay and represents a highly restricted portion of the Bay and the main body of Biscayne National Park. This area is also currently the healthiest portion of the Bay. Decreasing freshwater flow during the dry season by this magnitude can be expected to have negative biologic impacts within the National Park. The results of alternative D13R4 indicate that it is likely that additional water may be "found" within the regional system. It is additionally important to tie restoration flows for the Bay to the regulatory process so that this water will be reliably available to the Bay.

Table 1: Target and Model-Estimated Mean Annual Surface Flows (in thousands of acre feet)

	Wet season				Dry season			
Region	Target	95base	D13R*	D13R4*	Target	95base	D13R*	D13R4*
Snake Creek	67	121	79	78	93	51	26	20
North Bay		99	97	97		41	38	37
Miami River		132	43	49		60	18	17
Central Bay	161	161	142	170	83	64	78	104
South Bay	158	158	136	149	68	52	56	69

*Estimated without reuse water to Central and South Bay.

Southernmost Coastal Wetlands and Sounds:

There are two existing projects, the Modified Water Deliveries to Everglades National Park (Modwaters) and the C-111 Project as well as the proposed Alternative D13R under the Restudy, which will decrease the total quantity of water reaching the southeast coastal wetlands and Barnes and Card Sounds through the regional conveyance system. The Modwaters/C111 Project will eliminate point-source discharges to Manatee Bay in Barnes Sound from the C-111 Canal. A spreader system will be created north of the C-111 to introduce overland flow to the coastal wetlands west of US 1. Alternative D13R proposes to extend this spreader system east of US 1 and increase the pump capacity to 500 cfs to introduce overland flow to the midway down the coastal wetlands east of US 1. Replacement of ecologically damaging point source discharges to Manatee Bay with overland flow through coastal wetlands would be expected to be beneficial. There are several complicating factors however. These factors include that the volume of water delivered to this area may not be adequate to overcome evapotranspiration in the wetlands or evaporation in the Bays and may therefore be inadequate to maintain positive salinity gradients in this poorly mixed part of the Bay.

Based on hydropattern relationships to past and present vegetation patterns, the South Miami Dade Wetlands Alternative Evaluation Team concluded that D13R would not provide adequate freshwater to drive the hydropatterns required to restore natural vegetation patterns, build high fish biomass, and provide suitable conditions for wading bird foraging in the coastal wetlands on both sides of US 1. D13R4 appears to improve hydrologic conditions, but still may not provide sufficient water to this area.

Chosen Performance Measures

Performance measures used to evaluate the alternatives were based on the current state and health of Biscayne National Park and Biscayne Bay. Flora and fauna in Biscayne National Park and Biscayne Bay reflect improvement from the severely damaged conditions in the 1950's and 60's, however, this improvement is not indicative of the Bay's biotic diversity and abundance prior to channelization. Performance measures were developed for both surface water and groundwater inputs to Biscayne Bay, and for surface water levels in the wetlands adjacent to South Bay.

The ability to develop performance measures and performance targets for alternative evaluation was limited because physical and biological characteristics in Biscayne Bay and the associated wetlands are the result of a complex interaction between input parameters, circulation in the Bay, and biological activity involving one or more of the input parameters. Computer simulation modeling is a method for working with this type of complexity. A comprehensive hydrodynamic model covering all of Biscayne Bay and able to address both groundwater and surface water issues is under development through the Biscayne Bay Feasibility Study, but was not scheduled for completion in time to assist with the development or evaluation of performance measures. Additionally, this model would not be suitable for addressing wetland restoration issues in the watershed wetlands, so another means was needed to address wetland concerns.

Performance measures for surface water flows to the Bay were developed using either existing conditions as an interim measure, or other information, as available, to set more specific targets for specific regions of the Bay. This was done in the absence of a comprehensive hydrodynamic model, detailed organismal information, or community salinity relationships. For these reasons, targets were only developed for Snake Creek, Central Bay, and South Bay, and are needed for remaining areas.

Although no specific performance targets were set for groundwater, the performance goal was to maximize groundwater levels in each region (and thus maximize flows) without compromising flood protection to that region. This goal was based on the relationship between groundwater head and groundwater flows to the Bay. The groundwater models being developed under the Biscayne Bay Feasibility Study and the water preserve studies should eventually be able to quantify the relationship between groundwater head and groundwater flows to the Bay. This information was, however, not available to support performance measure development.

No performance measures were developed for water quality in Biscayne Bay due to the uncertainty of predicting future water quality conditions and associated loading rates. In addition, the absence of information concerning the fate of compounds entering the water bodies from the watershed limits model development or determination of specific impacts to biota. The Biscayne Bay Feasibility Study proposes to develop a water quality model in Phase 2 that will permit the development and evaluation of water quality performance measures, but completion of such a model is not expected for several years. This will require additional biological information and background studies to determine fate and effects of compounds moving from this watershed into different habitats within the Bay.

Performance measures were only developed for those wetlands in the Biscayne Bay watershed within the South Dade Wetlands Management Area. This was primarily due to the coarse grid size of the South Florida Water Management Model (SFWMM) and limitations associated with this model. Performance measures for the South Dade Wetlands Management Area were defined based upon wetland communities of this region, their hydric and hydrologic requirements, and the habitat-hydrologic requirements of the wildlife communities known to use this area. It was assumed that water levels that would support vegetation patterns similar to those observed in the 1940's would provide enhanced surface and groundwater flows to Card and Barnes Sound and Northeast Florida Bay. No relationship has been established, however, between upstream water stages and downstream salinity east of US Highway 1 in the two sounds to enable such an evaluation. A Modbranch model has been developed for the area east of US 1 and south of the C-103 (Mowry) Canal, but work is still ongoing to determine whether the water provided through any of the alternatives will produce any positive effects in the downstream sounds.

III. Identify and Define Missing Pieces of Information

There are substantial gaps in supporting information that must be addressed in order to maximize the restoration of Biscayne Bay and associated natural systems in the watershed. These include refining information on groundwater flow, especially in North and South Bay but also in Card and Barnes Sounds. The relationship between groundwater and the Bay is a critical missing piece of information for this process. Groundwater models and the relationship between groundwater and salinity in the Bay must be established as quickly as feasible. Other gaps of information include establishing relationships between salinity in various parts of the Bay and canal stages and/or ground/surface water levels in the watershed, and developing comprehensive information on loading rates and the fate of target water quality constituents. There is a specific need for more detailed data collection and modeling in the nearshore environments of Biscayne Bay, in the zone where groundwater flows have been measured, to determine the relative contribution of groundwater to salinity patterns in the nearshore environment. In addition, there is a strong need for more refined topographic information to support modeling. Watershed models with more refined grids that can provide more detailed information on water movement in the watershed are also necessary. There is also a need for the development of biologic Performance Targets, biologically based hydrologic relationships, and the models or other tools to evaluate these targets and relationships with a desired degree of accuracy. The definition of biologic Performance Targets should be based upon the historic environment within the Bay and a desired biologic goal that is based on preservation and enhancement of the existing system where full restoration is not feasible. Some of this information must still be compiled or determined.

IV. Identify Solutions

In order to adequately restore and/or enhance Biscayne Bay and the coastal wetlands, freshwater inflow and water quality targets must be developed and alternative sources of water should be identified for providing the freshwater needs of the Bay. This section describes the actions necessary to develop the targets and identify alternative sources of water.

1. Develop Freshwater Inflow Targets:
Freshwater requirements must be defined and quantified in terms of the quantity, quality, timing and distribution of flows necessary to provide and maintain sustainable biological communities in Biscayne Bay, Biscayne National Park, and the coastal wetlands. The following identifies the activities needed to develop the freshwater inflow targets:

Identify Organisms in the Bay with Direct and Indirect Salinity Relationships

This task has three components a) the need to identify missing but potentially useful salinity-organism relationships, b) the need to pick specific organisms or a suite of organisms to provide salinity requirements as targets for the Bay (these may potentially be different based on the geographic location within the Bay), c) and set freshwater inflow quantity distribution and quality based on the needs of target organisms.

Identify Historic Salinity-Organism Relationships and Historic Salinity Regime

While it is intuitively obvious that if the Bay is healthy relative to pre-1970's conditions, then the existing 1995 Base flows to the Bay are beneficial. The inshore areas of the Bay (out 400-500 meters) are the areas most severely in need of restoration. Restoration in this area is intrinsically connected to lower salinities which are determined by proper volume, timing, and distributed delivery of freshwater. However, due to a lack of information in this nearshore area, it is not possible to determine or quantify additional flows of freshwater beyond 1995 base flows, which may be necessary to restore lower salinities. Since there is little or no available salinity data for the early portions of the century prior to channelization of the Everglades, drainage of the coastal ridge, and the resulting disconnection of the coastal system from Everglades, it is necessary to utilize biologic surrogates of salinity to understand historic salinity conditions within the Bay.

There are several potential means to evaluate the historic conditions within the Bay using surrogates of salinity. It is possible to utilize historic data about the distribution of organisms historically found within the bay. It is possible to examine the paleo-environment of the Bay, utilizing any coring available for the Bay. It may also be possible to examine organism distribution within dredge spoils and dredge spoil islands that were created with known sources of spoil from within the early Bay to look for organisms with known salinity relationships. It is possible to look at isotopic relationships in corals or shell of known age. It is also possible to evaluate the hydrologic conditions necessary to create the documented large outflows of freshwater in the center of the Bay. Beginning with organismal relationships, there is more historic data available for organisms at the turn of the century than hydrologic or salinity data. Distribution of salinity intolerant organisms and specific fisheries with known salinity relationships make it possible to examine these and other comparable target organisms as salinity surrogates since various organisms integrate spatial and temporal components of salinity into habitat quality.

Identify Canal Inflow/Salinity Relationship

It is essential that the relationship between downstream (nearshore) salinities and upstream water management be defined. It is necessary to investigate various methods for defining this relationship and compare the results of the various methods investigated. The methods to be compared should include but not be limited to: the process to be utilized in the development of minimum flows and levels for Biscayne Bay by the South Florida Water Management District; performing a time series analysis (such as the Box-Jenkins transfer function model); and utilizing hydrodynamic and groundwater models (as available and applicable).

Develop Biologic Community Targets and Associated Salinity Regimes

In order to identify freshwater flow requirements, nearshore salinity targets must be developed. These targets may differ according to the geographic location within the Bay. It is necessary to develop these targets by identifying the desired biologic organisms for the various zones within the Bay. The salinity regime for the chosen biologic organism will then be the target salinity regime for that particular zone in the Bay.

Develop Inflow Freshwater Requirements

Once the relationship between downstream salinities and upstream water management activities are defined and the nearshore salinity targets are developed, the freshwater inflows needed to provide salinity targets can be developed. This analysis must include determining the freshwater delivery regimes and water quality requirements for the coastal wetlands (Biscayne Bay Coastal Wetlands and South Dade Wetlands Management Area) which will be affected by delivering the needed flows to the Bay.

2. Identify Sources of Water for Providing Target Flows:

Potential sources of water for providing target flows to the Bay should be identified and evaluated based on their ability to provide the quality, quantity, timing and distribution of target inflows. The potential sources include, but should not be limited to; operational modification of the existing or proposed system, "new water" identified by the Alternative Development Team, Floridan aquifer water, and wastewater reuse. Convene a technical team specific to this area to identify and investigate sources of freshwater for Biscayne Bay. This team would work on the output from future modeling of the regional system. It would also identify other potential sources of freshwater flow for the Bay as listed above. All "new water" scenarios must include water quality assurances to the National Park and other parts of the Bay.

3. Develop and Refine Tools:

A computer model is needed which is capable of simulating surface and groundwater flows to Biscayne Bay under various proposed modifications of the C&SF Project. The ability to simulate surface and groundwater flows to Biscayne Bay is a critical step in establishing targets, determining how much water Biscayne Bay needs from the regional system, providing boundary conditions for the Biscayne Bay hydrodynamic model.

Various water management modifications have the potential to shift the location of the fresh-salt water interface by changing groundwater levels. The effect of changes in groundwater levels may be magnified by the low land elevations of South Miami-Dade county coastal areas. The ability to simulate the location of the fresh-salt interface is needed to adequately evaluate the coastal effects of various alternatives of managing the C&SF system.

4. Develop Water Quality Criteria:

Biscayne Bay is classified as an Outstanding Florida Waterbody and, therefore, waters of Biscayne Bay Aquatic Preserve and Biscayne National Park are classified as Outstanding Florida Waters (OFWs), and as such are subject to the most stringent regulations, including Florida anti-degradation standards, which prohibit permitted discharges that will degrade ambient water quality. However, it is essential that numeric criteria and pollutant loading reduction goals be developed for several critical parameters so that treatment requirements can be determined and appropriate sources of water for the target flows can be identified.

V. Identify Impacts on Other Areas

The modeling under the Alternative D13R for "new water" shows the flexibility of the system to be managed for the water needs of the natural system. Providing water for the needs of all of the natural systems has been difficult however it is unacceptable to "trade off" the needs of the natural systems against each other. More detailed attention must be focused on providing for the water needs of the two National Parks and the natural systems of Miami Dade. This ecosystem of wetlands, uplands and saltwater bodies evolved as a whole and is interdependent. It is critical to avoid the temptation to sacrifice one of the National Parks for the other or to trade off the other natural areas that are not protected by this status. It is instead necessary to identify those components, which make it possible to provide restoration flows for the entire region and incorporation these as plan components or model elements.

The water needs of the natural systems of the South Dade Wetlands, Biscayne National Park and Biscayne Bay, as well as Everglades National Park and the extended Everglade system are not in conflict with management of water for urban areas. The management of water levels for natural systems maintains water levels to prevent saltwater intrusion, provide protection for existing wellfields from saltwater intrusion and provide flexibility in the management of the region. Potentially shortfalls in water for the Bay have been identified to possibly be made up by waste water re-use or other sources of water such Floridan Aquifer water. This water must be guaranteed to the Bay as 'restoration flows' if these sources are applied. The issues associated with Re-use water are investigated under the Water for Biscayne Bay Re-Use issue paper. Floridan aquifer water must be more thoroughly investigated for water quality issues with respect to such components as sulfur, mercury, and nutrients as well as others.

VI. Resolution Status

Much work has been done or is underway in addressing the biologic and hydrologic issues in Biscayne Bay. As a component of the water quality program, the 1995 Biscayne Bay SWIM Plan recommended "shall not exceed" values for certain water quality parameters in Biscayne Bay (SFWMD 1995). A multi-agency group has been formed (the Biscayne Bay Water Quality Group) to identify background water quality concentrations in Biscayne Bay and recommend non-degradation and restoration standards for the Bay. The South Florida Water Management District is in the early stages of developing minimum flows and levels for Biscayne Bay. An interagency group is in the process of evaluating current conditions and proposing restoration targets and developing a management plan for the Model Lands-South Dade Wetlands Wetlands Management area. Under the Biscayne Bay Feasibility Study, a hydrodynamic model is under development by the U.S. Army Corps of Engineers (ACOE) and the United States Geological Survey (USGS) to evaluate hydrodynamic and salinity effects in the Bay. Various groundwater and finer scale surface water models are being developed by the ACOE and the USGS to more realistically evaluate flow into the Bay.

In the Restudy's Draft Feasibility Report and Programmatic Environmental Impact Statement, the South Miami-Dade Reuse component has been included for the purpose of improving conditions in Biscayne Bay and for mitigating effects upon the Bay resulting from other components. This component was added to the Restudy as a means to restore water to the Bay that was removed by other components of the Restudy. It is critical that the purpose of this component is fulfilled and adequate water for restoration is delivered to Biscayne Bay, Biscayne National Park, and the Florida Keys National Marine Sanctuary (Card and Barnes Sounds). The South Miami-Dade Reuse component includes the identification of all potential sources of water for Biscayne Bay, and providing superior treatment wastewater reuse if it is determined to be the best source. Additional land must be identified as a component of reuse for treatment of this water. The purpose of the Biscayne Bay Coastal Wetlands-other project element component of the Draft PEIS is to rehydrate coastal wetlands, restore overland flow, redistribute and enhance freshwater delivery by sheetflowing canal discharges over the coastal wetlands bordering Biscayne National Park, and reconnect these wetlands to the Bay.

VI. Strategy for Resolving Remaining Items

The activities discussed in the Identify Solutions section are needed to resolve the outstanding biologic and hydrologic issues in Biscayne Bay. It is anticipated that those activities would proceed simultaneously. The following is also recommended:

1. Establish Technical Team:
Establish a team of scientists (biologists and hydrologists specific to Biscayne Bay) to pursue the activities discussed in the Identify Solutions section. The appropriate resource managers and members of the research community should be represented on the team. Additionally, the Technical Team should be established immediately in order to meet the proposed schedule. Sub-teams specific to individual subject areas would be created as necessary as a component of this team. Peer review would be organized for this process and its products by the team and in conjunction with the science coordination team.

2. Expedite Development of Hydrodynamic Model:
As discussed previously, a hydrodynamic model is under development by the U.S. Army Corps of Engineers (ACOE) and the United States Geological Survey (USGS) to evaluate hydrodynamic and salinity effects in the Bay. It is imperative that this work receive an adequate amount of funding and allocation of resources in order to complete the project in as timely a manner as possible. Delays, potentially up to one year, have already occurred in the groundwater portion of the project due to limited funding and resources.

VIII. Timetable (as defined under the Implementation Plan schedule)

Biscayne Bay performance targets and alternative source evaluation
July 1999 to June 2002.

Modeling for Alternative sources of water for the Restudy is ongoing
Current to May 1999.

Waste Water Re-use Feasibility
January 2000 to 2010

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Appendix C -- Issue Paper on Flows to Biscayne National Park Utilizing Reuse
Alternative Evaluation Team
January 20, 1999

I. Introduction

The Restudy Team considered reuse in the alternative evaluation process as a means of "expanding the water pie." Wastewater reuse has the potential to provide a consistent source of fresh water which will assist in meeting the future needs of the South Florida region. Currently, wastewater is most often a loss to the water budget in that it is typically discharged to deep wells or to ocean outfalls. The Restudy Team recognized that the appropriate application of wastewater reuse can benefit natural, urban, and agricultural water supplies by adding to the water budget and reducing dependence on the regional system.

In the first several alternatives evaluated by the Restudy team, freshwater flows to central and southern Biscayne Bay fell significantly short of the target flows. The Restudy Team, therefore, developed the South Miami-Dade Reuse component which would provide superior treatment wastewater reuse to make up for the redirection of existing flows away from Biscayne Bay in previous alternatives. The Team anticipated that the reuse water would be treated to the level needed by the biologic communities in the Bay and by the wetlands over which the reuse water would discharge via overland flow. They also recognized the potential for reuse to supply a perpetual source of fresh water to the Bay that can be managed to optimally mimic target flow regimes even in the dry season.

Concerns have since been raised regarding Biscayne Bay's water quality needs, source water treatment requirements, and the timing of implementation and funding of the South Miami-Dade County Reuse component. The purpose of this paper is to identify the concerns and provide recommendations for addressing them.

II. Background

Biscayne Bay, the largest estuary on the coast of southeast Florida, is contiguous with and linked hydrologically to the southern Everglades and Florida Bay system. Historically, these three regions were part of a larger connected natural system of coastal lagoons and wetlands. Although the connections have been altered by surrounding development and the Central and Southern Florida Flood Control project, Biscayne Bay still supports a diverse natural system of seagrass, hardbottom and coastal mangrove communities.

Trend analysis on the Bay's water quality monitoring program indicates that, in many instances, efforts to restore and enhance Biscayne Bay have been successful (SFWMD 1995). The Biscayne Bay Surface Water Improvement and Management Plan (SWIM Plan) states that of 150 statistically significant trends in the data, 78% showed improvement. The parameters which showed the most improvement include turbidity, dissolved oxygen and total coliform bacteria. However, the parameters that showed the most declines in water quality were ammonia and nitrate/nitrogen. It is imperative that regional planning activities continue to bolster the ongoing water quality improvements in the Bay and, at a minimum, not exacerbate existing problem areas.

The C & SF Project Restudy provides an opportunity to protect and enhance Biscayne Bay hydrology and water quality by developing a water management strategy that more closely mimics the natural system. As mentioned previously, the South Miami-Dade Reuse component is included in the Draft Feasibility Report and Programmatic Environmental Impact Statement and proposes to investigate all potential sources of water to provide required freshwater flows to southern and central Biscayne Bay. If reuse is determined to be the best source, it would be implemented. Additionally, the Biscayne Bay Coastal Wetland component is included in order to rehydrate altered wetlands, redistribute and enhance freshwater delivery, and reduce point source impacts to the Bay by releasing canal discharges through the coastal wetlands bordering Biscayne National Park. Freshwater releases in this manner would contribute to reestablishing sheet flow of water to the Bay and provide for a broader mixing zone of fresh and salt water to buffer salinity changes.

III. Define Issues in Detail

The issue addressed in this paper is the importance of utilizing the best source of water for providing freshwater flows to southern and central Biscayne Bay due to the following concerns on Biscayne Bay's water quality needs, source water treatment requirements, and the timing of implementation and funding of the South Miami-Dade County Reuse component.

The primary Biscayne Bay issue under the C & SF Project Comprehensive Review Study is providing the quantity, quality, timing and delivery of freshwater to meet the requirements of the natural estuarine system. Because the wastewater reuse component is related to maintaining estuarine freshwater requirements, this issue is intrinsically coupled with the Issue Paper on Freshwater Flows to Biscayne Bay. The Issue Paper on Freshwater Flows to Biscayne Bay examines in more detail issues and processes necessary to more specifically define water quantity and water quality targets and alternative sources of freshwater for southeast Miami-Dade County. This paper focuses more specifically on the source of freshwater for the coastal and estuarine communities of Biscayne Bay and Biscayne National Park.

- **Water Quality and Biscayne Bay**

  As a consequence of strong tidal flushing and connection with offshore waters, open Biscayne Bay is oligotrophic and is characterized by extremely low concentrations of contaminants. Recognizing the significance of its natural values and the need to protect and restore them, almost all of Biscayne Bay and its tributaries have been designated for protection, either through inclusion within the boundaries of Biscayne National Park, within Florida aquatic preserves, or within the Florida Keys National

Marine Sanctuary. Biscayne Bay was designated a priority water body by the Florida Legislature pursuant to the Surface Water Management and Improvement Act of 1987. The area south of Biscayne National Park is included in the Florida Keys National Marine Sanctuary. Waters of Biscayne Bay Aquatic Preserve and Biscayne National Park are classified as Outstanding Florida Waters (OFWs), and as such are subject to the most stringent regulations, including Florida antidegradation standards, which prohibit permitted discharges that will degrade ambient water quality. Since the establishment of these protection measures, local, state and federal agencies have implemented monitoring, regulatory and management efforts at maintaining and enhancing biological, recreational, and aesthetic values of Biscayne Bay.

Due to the sensitivity of the Biscayne National Park ecosystem, special consideration must be given to water quality issues. An extensive long-term water quality monitoring database has been developed through cooperative efforts of local, state and federal agencies. The Biscayne Bay SWIM Plan recommended "shall not exceed" values for certain parameters based upon this database (SFWMD 1995). The database was further evaluated to define typical or background concentrations of inorganic nutrients for open waters of south Biscayne Bay by a multi-agency review group convened to develop recommendations on water quality criteria. Preliminary analysis indicates that inorganic nutrient concentrations are extremely low. Although specific performance measures and dynamic pollutant loading criteria have not yet been formally developed for Biscayne Bay, it has been suggested by the multi-agency review team that to sustain water clarity and seagrass/hardbottom benthic communities, the following nutrient concentrations must also be sustained: total ammonia, 20-50 ppb; nitrate-nitrite, 10 ppb; and total phosphorus, 5 ppb.

Since phosphorus is the limiting nutrient in Biscayne Bay, water clarity and ecological impacts are likely if nutrient levels are not adequate. Cumulative and combined (or multiple nutrients) effects are also a significant consideration, since there is evidence that ammonia and nitrate-nitrite levels are significantly elevated in the watersheds of southern and central Biscayne Bay. This is particularly a concern in the nearshore areas, which are most likely to be impacted by the quality of the source water. Low level, chronic releases of elevated nutrients in this region could fundamentally alter the type and quality of plant material available to support the food web.

In Biscayne Bay, concentrations of trace metals and organic chemicals are typically low or often below detection limits; however, such contaminants bind to particulate material and have accumulated in sediments of many canals and tributaries, particularly in more urban and industrial watersheds. Companion studies have documented that sediments in some canals and even relatively pristine areas of Biscayne National Park are toxic to aquatic organisms in standard bioassay testing (U.S. Department of Commerce NOAA 1998). Numerous past studies of occurrence and distribution of fish abnormalities in Biscayne Bay have suggested that these may be linked to contaminants in sediments. It is imperative that implementation of the Restudy Recommended Plan not increase loading of toxicants or biologically active compounds that could contribute to water and sediment quality problems. This is of critical concern in the intertidal coastal wetlands, which support a substantial food web that includes significant numbers of commercially important fish species.

- **Treatment of Water for Biscayne National Park**

Providing freshwater flows to Biscayne Bay without having to first treat the water would obviously be the most efficient and potentially most cost-effective method for meeting the water quality needs of the Bay. However, treatment may be necessary depending upon the source of water for the freshwater flows. It is important that the treatment method provided be adequate for treating the water to the appropriate levels and at the anticipated volumes without causing deleterious impacts to the coastal wetlands and Biscayne Bay.

The treatment train proposed for the South Miami-Dade reuse component assumed iron flocculation, filtration and reverse osmosis added on to advanced wastewater treatment technology. There has been limited use of this treatment combination, and therefore its effectiveness in removing contaminants to the appropriate level and at the assumed volume projected for the South Miami-Dade Reuse component must be determined. It has been assumed that this treatment train has the capability of reducing phosphorus levels to 10 ppb or less. Effectiveness for achieving acceptable concentrations of other nutrients and contaminants must also be evaluated.

Similar concerns exist for all other potential sources of water for Biscayne Bay and the coastal wetlands. Modeling and assessment of these issues is presently complicated by the lack of dynamic water quality information or pollutant loading measures. As a consequence, conservative treatment requirements must be assumed at this time based upon existing contaminant concentrations.

Additionally, the Biscayne Bay Coastal Wetland component, as it was originally designed, anticipated redirecting canal flows into the spreader system and, therefore, included treatment areas to a limited extent. A further examination of the extent of necessary treatment areas will have to be conducted in order to assess whether additional treatment areas will be needed to protect both Biscayne National Park and the healthy natural wetlands which currently comprise the Biscayne Bay Coastal Wetlands component.

- **Timing of Reuse Component Implementation**

The timeline proposed for the wastewater reuse study and pilot project is six years. It is proposed to take ten years to design and construct the treatment facility. Maintaining adequate freshwater flows to Biscayne Bay through the planning horizon for the recommended plan may conflict with achieving restoration or planning goals in surrounding systems. Therefore, this emphasizes the importance of pursuing other appropriate sources of water for Biscayne Bay which may be available sooner than the reuse component or can serve as interim sources until the reuse component is operational.

- **Reuse Alternatives and Cost**

  The wastewater reuse concept may provide another source of water, but it may be more appropriate and cost-effective to apply treated wastewater in areas where water quality requirements may not be as stringent as those for oligotrophic natural waters. For example, wastewater might be used to reduce demand for raw water from the shallow aquifer if used for irrigation in certain urban or agriculture applications elsewhere in the system. Similarly, treated wastewater might be distributed in conjunction with rehydration or hydrologic enhancement of disturbed wetlands in broader geographic buffers, rather than in limited wetlands adjoining Biscayne National Park. These alternate applications of wastewater reuse must be evaluated, along with identification of alternative sources of water for south Miami-Dade. This evaluation must include a cost-effectiveness analysis.

IV. Identify and Define Missing Information

Water quantity and quality targets or performance measures for Biscayne Bay need to be refined in order to more accurately evaluate freshwater requirements and alternative sources. While this need is discussed in detail in the Issue Paper on Freshwater Flows to Biscayne Bay, the following water quantity information is relevant to this issue paper also. In particular, adequate data on groundwater flow to Biscayne Bay, finer scale models with more accurate capabilities for assessing impacts upon Biscayne Bay, and accurate estimates on existing and simulated surface water discharge is needed.

Additionally, water quality targets and pollutant load reduction goals must be established so that sources can be evaluated and treatment requirements can be determined. There is extensive surface water quality and sediment chemistry data for Biscayne Bay, as well as descriptive information on distribution and productivity of benthic communities, but it needs to be linked to hydrologic models to assist in establishing dynamic targets. In order to expand the scope of hydrologic models to perform as comprehensive water quality models, additional data on atmospheric loading, groundwater quality, and sediment/water column dynamics will be required.

Additional characterization of toxicants and biologically active components of source water is required if it is to be discharged to Biscayne Bay surface waters or wetlands. The fate of these components under different treatment regimes and in receiving water bodies must be evaluated. Wildlife and habitat impacts should be examined to understand and address concerns about the potential for long-term water and sediment contamination. Biological effects data, such as toxicity or bioaccumulation testing may be required. Potential receptors depend upon treatment and conveyance methods selected. For example, if wetland treatment areas are used to reduce nutrient levels or otherwise enhance water quality, birds and other wildlife may be attracted to the area. Benefits, such as improved habitat may result, but risk associated with contaminant exposure will also have to be assessed.

Additional technical information is required to determine treatment requirements, where and how much water can be discharged, and size of wetland areas needed for water enhancement and conveyance. This will be necessary to protect both Biscayne Natural Park and existing wetlands. The south Miami-Dade reuse component is intended to replace the decrease in freshwater for the entire Bay occurring as a result of other components of the Restudy. Due to limitations imposed by the scale of the regional South Florida Water Management Model, the effluent generated by reuse was modeled as direct canal flows. Due to the projected nature and quality of this water, it is likely to require some type of wetland polishing treatment or detention. The intended purpose of the Biscayne Bay Coastal Wetland component as it was originally conceived is to rehydrate coastal wetlands, redistribute and enhance delivery, and reduce point source impacts by sheetflowing canal discharges over the coastal wetlands bordering Biscayne National Park. Although there are some treatment areas as components of the Biscayne Bay Coastal Wetlands, the size and design of these may have to be refined to accommodate the volume and level of treatment needed for wastewater.

V. Identify Solutions

1. As discussed in the Issue Paper on Freshwater Flows to Biscayne Bay, the refinement and finalization of the targets for the quantity, quality, timing and distribution of freshwater flows to the estuaries is the critical first step in resolving the source water issue. This will include, at a minimum, 1) the development of the analytical tools necessary to evaluate the effects of hydrologic modifications on Biscayne Bay (i.e. the hydrodynamic model currently under development, an associated water quality model, and hydrologic models capable of providing boundary conditions for the hydrodynamic model); 2) resolution on the Bay's water quality criteria and pollutant loading reduction requirements; and 3) collection of the data needed to support this process (i.e. surface and groundwater flow data, surface and groundwater quality data, biological effects from current water management operations, and delineation of the Bay's existing estuarine zone).

2. A thorough analysis of all potential sources of water to provide freshwater flows to Biscayne Bay must be conducted. This analysis should evaluate the capability of each source to provide the quality, quantity, timing and distribution of freshwater flows needed by Biscayne Bay. A parallel analysis should evaluate the potential for reusing or discharging treated wastewater elsewhere in the region. This analysis must consider the full geographic range of the C & SF Project.

3. A cost-effectiveness analysis should be conducted to compare the sources of water identified in the previous process.

4.   Adequate flexibility must be provided in the final Feasibility Report in order to implement alternative options which achieve similar purposes. For example, the Feasibility Report should allow for the provision of alternative sources of water, if identified, and redirecting wastewater reuse to meet other demands, if appropriate.

VI.   Identify Impacts on Other Areas

Potential benefits may result from identifying other sources of water for Biscayne Bay such as, overall Plan costs may be significantly reduced and/or wastewater reuse could alternatively be used to reduce or offset urban or agriculture water demands. One potential drawback is that reallocating freshwater to meet Biscayne Bay water quality and quantity requirements may reduce the availability of freshwater for other components of the system.

VII.   Resolution Status

Several of the solutions discussed above have been addressed in the Restudy Draft Feasibility Report. For instance, the current description of the South Miami-Dade County Reuse component provides for the identification of alternative sources of water for Biscayne Bay and that if other more appropriate sources are not identified, reuse water would be pursued for providing the Bay's freshwater needs. The Restudy Draft Feasibility Report also provides for conducting a pilot study to address the water quality issues associated with discharging reclaimed water into Biscayne National Park and to determine the level of superior treatment needed along with the appropriate methodologies for that treatment.

VIII.   Strategy for Resolving Remaining Issues

The refinement and finalization of Biscayne Bay estuary targets and the identification of alternative sources of water for Biscayne Bay should be identified as early action items in the final Feasibility Report. Science/technical committees should be used to establish the targets.

The process of identifying alternative sources of water for Biscayne Bay should be adequately characterized in the Restudy final Feasibility Report to fit into U.S. Army Corps of Engineers procedures.

The South Miami-Dade County Reuse component should be flexible enough to allow for redirecting costs for the design and implementation of a system for providing alternative sources of water for Biscayne Bay without having to pursue a reauthorization. The component should also be flexible to allow the redirecting of wastewater reuse to meet other demands.

Adequate costs should be allocated in the Final Restudy Feasibility Report for the refinement and finalization of Biscayne Bay estuary targets and for the alternative water source identification process.

IX. Timetable

The following timelines were taken from the draft sequencing schedule for the Feasibility Report's Implementation Plan.

Jan. 1999 to June 2002	Refine Biscayne Bay performance targets and identify and evaluate potential sources of water, including reuse, to provide needed freshwater flows
Jan. 2000 to Jan. 2014	Determine ecological effects of reuse, and design, construct and monitor the reuse pilot project

X. Conclusions

Providing the appropriate quantity, quality, timing and delivery of freshwater is critical for an ecologically viable Biscayne Bay. Concerns have been raised regarding Biscayne Bay's water quality needs, source water treatment requirements, and the timing of implementation and funding of the South Miami-Dade County Reuse component. Due to these concerns, all potential sources for providing fresh water to central and southern Biscayne Bay should be investigated. The decision on the appropriate source should be made in conjunction with the determination on the water quality, quantity, timing and duration of flows needed by the Bay.

XI. References

South Florida Water Management District, November 1995, Biscayne Bay Surface Water Improvement and Management Plan.

Appendix D -- St. Lucie Estuary Issue Paper

Robert Pace, U.S. Fish and Wildlife Service
Steve Traxler, U.S. Army Corps of Engineers
16 December 1998

1. Background

The Department of the Interior (DOI) identified the incomplete attainment of the high flow restoration targets in the St. Lucie Estuary (SLE) as an issue needing resolution in an August 1998, Draft Fish and Wildlife Coordination Act (FWCA) report. The South Florida Ecosystem Restoration Task Force also recognized this as an issue needing more analysis in its review of the performance of the Initial Draft Plan (Beneke 1998). In this paper, we have used the word "issue" in reference to the concerns expressed above about whether or not the Initial Draft Plan presented in the C&SF Restudy is sufficiently close to the restoration targets. We have used the word "problem" in reference to the ecologically damaging conditions in the SLE that need to be corrected. This issue paper was written to briefly describe the fundamental ecological problems in SLE, the issue of certainty within the limits of error in the C&SF Restudy's analysis, and to outline a process to resolve this uncertainty.

The SLE is highly altered from its original condition. Around 1892, the St. Lucie Inlet was excavated to provide navigational access to the ocean, and a primarily freshwater system was converted to an estuary. The South Fork of the estuary was connected to Lake Okeechobee in 1924 through construction of the St. Lucie Canal (C-44). Much of the western portions of Martin County and St. Lucie County historically were covered with pine flatwoods containing scattered wetland depressions that could locally contain normal rainfall; extreme rainfall events most likely drained partially to the coast and partially to Lake Okeechobee or the northern Everglades. The SLE's watershed was greatly enlarged during the 1950s through connection of the C-23 and C-24 system of canals that now drain northern and western portions of St. Lucie County.

The restoration goals for the SLE recognize that it is impossible to return the system to its original freshwater condition. The goal is to allow the SLE to function as a productive estuarine system supporting a diverse assemblage of fish and wildlife. The Indian River Lagoon (IRL), a portion of which lies between the SLE and the Atlantic Ocean, is recognized as unique among estuaries in the United States in its mixture of temperate and subtropical flora and fauna. Swain et al. (1994) listed approximately 2,500 species of plants and animals directly associated with the Indian River Lagoon. Gilmore *et al.* (1981) documented over 800 species of fish in the IRL and associated waters. The IRL is among the most diverse estuaries in the United States (Indian River Lagoon National Estuary Program 1996).

The principal focus in setting restoration goals for the SLE in the Restudy has been establishment of a more favorable salinity regime. The target salinity gradient in the SLE was determined by a hydrodynamic model (Morris 1987), combined with estimates of the salinity requirements of two indicator species in the estuary, shoal grass (*Halodule wrightii*) and American oyster (*Crassostrea virginica*) (Haunert and Chamberlain 1994). We continue to support the selection of these as indicators of ecological conditions within the estuary. Although fish are economically important in the SLE, and although fish are clearly affected by adverse hydrologic events in the SLE, the mobility of many species of fish allows them to adjust their distribution in response to salinity changes. We believe that sessile organisms will provide a more responsive measure of the variation in salinity, turbidity, and nutrients at particular monitoring stations in the estuary. Because submerged aquatic vegetation and oyster reefs provide productive fish habitat in the estuary, we find that these are appropriate indicators of overall estuarine health.

Mere survival of remnant patches of shoal grass or oysters following an adverse hydrologic event (flood or drought) would not be considered to be successful restoration of the estuary. Sustainability of shoal grass and oysters as viable habitats is the goal. This helps explain why the predicted significant reduction in adverse events for Alternative D-13R relative to the 1995 Base and the 2050 Base is not be considered by some ecologists to be close enough to the restoration goals to provide adequate protection. The substantial reduction in the frequency of these adverse conditions may or may not prove adequate to sustain these indicator species across significant areas of the SLE. Only long-term monitoring of these resources will indicate how their area of coverage and density fluctuate relative to these stressors. Continued collection of baseline data must serve as reference for any gradual improvement of conditions in response to steps in implementing the features of the Restudy.

During the 1997-1998 winter-spring El Niño event, releases of fresh water from the S-80 structure on the St. Lucie Canal began in December, with peak discharges between March 1 and April 20 averaging 7000 cfs. The North Fork of the St. Lucie River, which normally averages 18 ppt salinity decreased to 0 ppt during peak flows. Portions of the SLE that normally average 24 ppt decreased to 5 ppt, and the IRL, which normally averages 30 ppt, decreased to approximately 20 ppt. The high volume fresh water discharges coincided with a high incidence of fish with lesions. Soon after this ecologically damaging event, the South Florida Ecosystem Working Group called for establishment of the St. Lucie Issue Team to immediately accelerate progress toward improving water and habitat quality in the SLE. Their Interim Report (October 1998) provides an excellent summary of the environmental problems affecting water and habitat quality in the SLE, provides details on the effects of the 1997-1998 El Niño rainfall events, and recommends short-term actions to alleviate the problem.

2. Define the Issues

Although the St. Lucie River Issue Team was formed immediately following a period of high volume discharges from Lake Okeechobee to both the SLE and the Caloosahatchee River, that team maintained proper perspective in not limiting discussion of ecologically damaging water management practices to regulatory discharges from Lake Okeechobee through C-44. We believe it is important to continue to educate the public that runoff generated within the drainage basins is as serious an ecological problem as regulatory releases from Lake Okeechobee. The St. Lucie River Issue Team properly described two ecological problems:

Problem 1 Excess fresh water entering the estuary from regulatory releases from Lake Okeechobee have direct and powerful adverse impacts on the water, sediment, and habitat quality of the estuary by not only reducing salinity but also carrying silts, sediments and other pollutants to the estuary.

Problem 2 Due to stormwater releases and water use from agricultural and urban development, even in the absence of Lake Okeechobee discharges, the desirable salinity envelope goal of the estuary is often violated by too much, or too little, fresh water entering the estuary from its own 827 square mile watershed.

The strategy to address these ecological problems throughout the iterative process of alternative development for the Restudy has centered on provision of storage areas distributed appropriately along the C-44, C-23, C-24, and C-25 drainage basins.

Haunert and Chamberlain (1994) originally devised the performance measures used in the Restudy. The performance measures for the SLE were not calculated directly by the South Florida Water Management Model (SFWMM). The calculations involved post-processing the output of the SFWMM for an alternative. This post-processing is performed through the estimation of basin runoff using the CREAMS-WT model, and the use of an optimization model (OPTI-2) intended to test operational rules for the storage reservoirs and to suggest optimum locations and sizes for the storage areas. The authors of this issue paper are not qualified to judge whether the additional step of linking these models to the SFWMM increases the level of uncertainty surrounding our predictions of ecological conditions, but we recommend that additional calibration and estimation of the confidence levels in these models should be included in the scope of the Indian River Lagoon Feasibility Study.

Alternative D-13R of the Restudy met the goals for providing low flows to the SLE. The performance measures called for no more 50 months in the 31-year simulation when mean monthly flow was less than 350 cfs. Alternative D-13R had only 50 months, as opposed to 163 months in the 2050 Base. However, the issue raised by the DOI's draft FWCA report and the Working Group is that D-13R did not fully reach the goal of eliminating the high flow violations in the SLE. The model predicted 15 months of mean monthly flow greater than 1600 cfs, as opposed to the target of no more than 9 months. The simulation also predicted 8 months of mean monthly flow greater than 2500 cfs, as opposed to the target of no more than 3 months.

The SFWMD performed a sensitivity analysis on the effects of varying the total amount of storage in the drainage basins of the SLE (Table 1). This analysis was performed in June 1998, and led to formulation of the components proposed in Alternative D-13R for the SLE.

Justification that the performance of Alt D-13R satisfies the performance targets of the Restudy (Konyha and Conboy 1998):
For low flows the critical period is spring (i.e. March, April, May). During these months the target data set had 28 months of low flows (<350 cfs) while D-13R had only 13 months. For

high flow months (>1,600 cfs), there is a good reason to count months of sequential exceedences as a single "event" rather than two months. Utilizing this method, the count drops to eight events greater than 1,600 cfs (vs. seven for the target) and five events greater than 2,500 cfs (vs. three for the target). In addition, three of the higher flow events (those > 2,500 cfs) exceed the target by less than 150 cfs (> 2,500 and < 2,650 cfs).

Table 1: Targets for the SLE and the number of months the simulations exceed the high and low flow criteria under various amounts of total storage volume. The targets are from the performance measures originally devised by Haunert and Chamberlain (1994).

Storage (Acre/feet)	Months <350cfs	Months >1,600cfs	Months >2,500cfs
Target	50	9	3
2050 base	163	71	36
1995 base	154	77	40
190,000 (Alt D)	56	24	9
232,000 (Alt D-13R)	50	15	8
285,500	46	12	5
380,000	46	10	6

Hydrologic and ecological modeling are tools with a number of assumptions built into them. When a model generates a number or "prediction", there is a certain confidence interval around that number within which the actual observation may (i.e. if the model output prediction is 9, the confidence limits around it could be 8 to 10 or 1-19 depending on how accurate are the model's assumptions and data). The same types of confidence intervals apply to the targets. Often these confidence values are difficult to determine. Some people misinterpret the targets and model predictions as if these were observed values with a high level of accuracy. One should remember is that these numbers are relative and should be used only for comparisons with other simulated alternatives. The model predictions will become more accurate as additional data are collected and incorporated into the models. The models do predict that Alt. D-13R is significantly better than Alt D and that both alternatives are greatly improved over the 1995 base and 2050 base conditions. For these reasons, the estuary subteam of the Alternative Evaluation Team colored the SLE as green (meaning that they thought restoration would be successful).

3. Define Additional Information Needed to Resolve Issues

During the Alternative formulation process for the Restudy, the best available ecological and modeling data was utilized. In conjunction with the Restudy, the IRL Feasibility Study was proceeding along. Whereas the Restudy is primarily a broad conceptual plan, the IRL Feasibility Study is focusing in on the actual project features for the components selected by the Restudy in D-13R.

The following tasks need to be performed to meet the restoration targets for the SLE and to complete the Indian River Lagoon Feasibility Study:

1. Continue optimization modeling **(underway)**.
2. Incorporate the HPSF runoff coefficients into the optimization model **(should be completed by December 1998**).
3. Further calibration and validation of the hydrologic model and the optimization model should be performed to reduce the uncertainty in each. Estimation of the remaining potential error in the models should be calculated and considered in detailed planning **(needs to be started in 1999 and reviewed periodically until completion of detailed design)**.
4. Continue a Land Suitability Analysis to identify more potential storage sites **(underway)**.
5. Use the recently completed St. Lucie Salinity model to determine regions where oysters and shoal grass potentially could recolonize.
6. Perform a screening analysis on the alternatives and on the various storage areas scenarios **(planned for spring 1999)**.
7. Continue analysis of the sensitivity of the indicator organisms (oysters and shoal grass) to salinity and other water quality stressors.
8. Develop a system wide monitoring plan to review the effects of the components on the ecosystem and guide the adaptive assessment **(underway, with oyster and shoal grass data being collected)**.
9. Develop a method to quantify ecological benefits to the estuary. The data from the salinity model and monitoring will be used in this process **(planned for February 1999)**.
10. Develop an operational plan for the storage sites **(planned for 1999)**.

4. Identify Potential Solutions

Currently, the Indian River Lagoon (IRL) Feasibility Study is conducting optimization and other types of modeling to determine the size and location of storage sites. Although increasing the total capacity for storage in the SLE's drainage basins above that used in Alternative D13R is a strategy that must be further analyzed, the sensitivity analysis cited above suggests that Alternative D13R may have reached a point of diminishing returns with respect to increased storage capacity. The ongoing IRL Feasibility Study utilizes the concepts outlined in the Restudy and further refines the plan formulation process initiated under the Restudy to seek solutions to the problems of the SLE. The practicality and feasibility of other components, such as ASR and back pumping to Lake Okeechobee, will be reviewed during the upcoming screening process. Additionally, operational alternatives, such as elevating normal water stage in C-44, will be modeled to determine if that feature produces any additional reduction of months of high flow.

5. Effects on Performance in Other Areas

Storage and release of runoff generated within the drainage basins of the SLE should not affect any other portions of the C&SF system. We recommend that planning and implementation of the IRL Feasibility Study proceed as quickly as possible to provide the needed storage facilities.

However, capturing regulatory releases from Lake Okeechobee in the C-44 basin has implications throughout the C&SF system. The linkage between ecological conditions in the littoral zone of Lake Okeechobee, the SLE, and the Caloosahatchee Estuary is recognized in the present C&SF system. The intent of the Restudy is to provide more capacity for storage in and around Lake Okeechobee to alleviate the constraints in the present water management system. The design and functioning of the additional components proposed by the Restudy will have an effect on the SLE, and conversely, the storage available in the C-44 basin to accept regulatory releases from Lake Okeechobee may affect the need for storage capacity elsewhere in the system. The most direct connections include:

1. Component GG4 – The ASR wells around Lake Okeechobee are needed to not only improve conditions within the lake's littoral zone, but also to reduce the need for regulatory releases to the SLE and the Caloosahatchee.

2. Component D4 – The C-43 Basin Storage Reservoir will provide some additional capacity to receive regulatory releases that might otherwise remain in the lake. Without this feature, high lake stages would be more frequent than those predicted under Alternative D-13R, and the remaining adverse effects would likely continue to be shared among the lake's littoral zone, the SLE and the Caloosahatchee.

3. Component A6 – The North of Lake Okeechobee Storage Reservoir is needed to reduce the impact of high rainfall events upstream of Lake Okeechobee and thereby, reduces the need for regulatory releases to the SLE and the Caloosahatchee.

If it is determined in detailed planning that any of these components cannot be built or that their efficiency is reduced, either the storage of regulatory releases along C-44 would have to be increased, or the performance predicted for Alternative D-13R would be degraded.

6. Strategy for Resolving Remaining Issues

The SLE has had a number of studies performed on it. Currently, the IRL Feasibility Study is working to integrate the data collected in these studies. The multi-agency team working to develop the feasibility study is screening the components to arrive at the best configuration to reach the targets for the SLE. These components will then need to be implemented in a method to yield the benefits as quickly as possible. A robust monitoring plan needs to be developed to determine how the system is responding to the project components and ultimately guide the adaptive assessment of the system. Development and implementation of the monitoring plan and the adaptive assessment strategy are high priority task for the participating agencies in following through with the Comprehensive Plan.

During the IRL Feasibility Study and the Restudy the NEPA process dictates public and agency input into both plans. From the projects beginnings (i.e. the first scoping letter) until the implementation of the project features, the public can make comments and influence the development of the plan. The Restudy team has just completed a series of public meetings and these comments will be incorporated into the Comprehensive Plan. Concurrently, public and agency comments are being solicited until the end of December 1998. Upon completion of the Draft IRL Feasibility Study, a similar public meeting and comment period will occur. Any remaining issues can be resolved during this process.

7. Timetable

Completion of the Restudy Final report:	July 1999
Completion of the Final IRL Feasibility Study	May 2001

The problems in the SLE have been developing over a number of years. Recently, with the unusually large amounts of rainfall, the damage to the estuary was very visible. Public support for restoration of this part of the C&SF system is extremely high. The conceptual plan D-13R of the C&SF Restudy has made progress toward meeting the SLE targets, especially when compared against the 1995 and 2050 base cases (Table 1).

The tasks outlined in section 3 of this paper will be included in the IRL Feasibility Study. That study will eliminate any uncertainty about the adequacy of the proposed facilities in solving the ecological problems of the SLE. Continued public support and involvement is critical throughout the whole restoration process.

8. References

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APPENDIX E

PLANNING AID LETTER
DATED FEBRUARY 18, 1999

United States Department of the Interior

National Park Service
Everglades National Park
4001 State Road 9336
Homestead, FL 33034

Fish and Wildlife Service
State Supervisor-Ecological Services
P.O. Box 2676
Vero Beach, FL 32962

February 18, 1999

Colonel Joe R. Miller
District Commander, Jacksonville District
U.S. Army Corps of Engineers
400 West Bay Street
Jacksonville, Florida 32232

Attention: Planning Division

RE: Draft Implementation Plan for the Central and Southern Florida Project Comprehensive Review Study

Dear Colonel Miller:

This is our response to the January 25, 1999, Draft Implementation Plan for the Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy). We appreciate our recent discussions on the draft plan and your agreeing to allow the Department of the Interior (the Department) sufficient opportunity to have meaningful input into this significant effort.

The Department has prepared this Planning Aid Letter (PAL) for the Army Corps of Engineers: (the Corps) Draft Implementation Plan for the C&SF Restudy authorized by section 309(I) of the Water Resources Development Act (WRDA) of 1992 (P.L. 102-580). This PAL is intended to provide input for the Final Implementation Plan scheduled to be released on February 25, 1999. This PAL is provided in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) and represents the views and recommendations of the Department.

The Corps and South Florida Water Management District (SFWMD) are to be commended for their collaborative and innovative approach to the project management for Restudy implementation. Considerable flexibility has been built into the plan (monitoring, feedback and adaptive assessment) that will allow the plan to move forward in a way that should maximize ecosystem restoration. We agree with the overall Guidelines and Sequencing Rules contained in the plan. Additionally, the plan recognizes that technical and cost uncertainties may greatly affect the restoration effort (e.g., ASR, seepage control). Contingency plans have been formulated to address the need to seek viable alternatives should these technologies be infeasible, or cost-ineffective. Pilot Projects are proposed for authorization in WRDA 2000 to test these technologies. This is a good strategy.

Following are the primary comments and recommendations the Department considers important to consider for inclusion in the Final Implementation Plan:

- o **ENVIRONMENTAL BENEFITS**: Based on our analysis of the 2010 Case Study, the Department believes the Draft Plan needs to provide greater environmental benefits during the first 10 years of implementation. We understand that the Corps has committed to making improvements to the Draft Plan to provide additional benefits, including assurances that fresh water flows will not be reduced to Biscayne Bay and that flows into the southern Everglades will be enhanced. These improvements are important in view of the examples in the Draft Plan showing SFWMD=s Minimum Flows and Levels are not met in many locations within Everglades National Park and that the 2010 Case Study does not perform as well as the 2050 base condition, during drier than average conditions, in much of the southern Everglades and its estuaries. Further, it is essential that the minimal ecological improvements shown in the Case Study for the WCAs and the southern Everglades be substantially improved.

  As the Corps proceeds with these improvements, a high priority should be given to examining those groups of components related to movement of water from the central Everglades to the southern Everglades, including but not limited to, L-29 and L-67 A and C. Particular consideration should be given to phasing or advancing elements of these components to improve benefits without causing harm to any part of the system. The Plan should commit to being flexible enough to develop and substitute components during implementation that significantly reduce the operational and ecological trade-offs in balancing the restoration of flow patterns and volumes with the maintenance of appropriate water depths in the remnant Everglades, particularly in the WCA 3B/Pennsuco Wetlands/Northeast Shark Slough areas.

  The Department recommends that over the next several months, the 2010 Case Study be revisited by the interdisciplinary team to revise and refine the project sequence. Special emphasis should be placed on not merely avoiding adverse effects on natural areas, but to produce conditions significantly better than today and approaching the benefits of the final Plan. The performance of the Implementation Plan could be improved by optimizing reservoir performance, reordering the implementation schedule, or phasing or breaking components down into increments. For example, water storage in the EAA was operated in the 2010 Case Study as it was in Alternative D13R (the 2050 condition). We suggest exploring interim operational plans for EAA storage that would maximize environmental benefits by 2010 (e.g., restoring the volume, timing and distributions of inflows to the WCAs and Shark River Slough).

- o **WRDA 2000 AUTHORIZATION**: The Department is pleased that several environmental restoration components such as AQQ@ (raising Tamiami Trail), AWW@ (C-111 spreader canal), and the OPE to protect wetlands adjacent to the Loxahatchee National Wildlife Refuge are included in the Initial Authorization Package. However, we recommend that a multi-agency team convene to review the list of projects already authorized as Critical Projects under WRDA 1996, projects that might be authorized under a similar programmatic authority under WRDA 2000, and those Other Project Elements that might be authorized in WRDAs past 2000 for the purpose of maximizing ecological restoration early in the implementation phase. The Department is committed to working with the Corps to rank these projects in this manner.

o **LAND ACQUISITION**: It is imperative that the necessary lands are purchased in order to realize our long-term restoration goals. With the rapid pace of development in south Florida, restoration opportunities will be lost if action is not taken quickly. This is particularly true for the Water Preserve Areas, where there is an eminent threat of development along the urbanized Atlantic Coastal Ridge. Routinely, it is a local, non-federal sponsor that must expeditiously act to acquire needed lands. In order to incur commitments necessary to acquire these lands, they must have assurances that lands acquired will be credited by the Corps as part of the federal project.

In light of the above, the Department requests the Corps implement the authorizing language in WRDA 1996, at section 528(d)(4) which provides for credit to non-federal interests for the Avalue of lands or interests in land acquired@ for activities which restore, preserve and protect the south Florida ecosystem.

o **WATER QUALITY**: The Draft Implementation Plan rightfully recognizes the need for an overall water quality strategy. Considerable work is needed to formulate the proposed Comprehensive Integrated Water Quality Plan. We recommend that the water quality plan be given priority and that additional funding be specifically identified now to ensure that adequate resources are expeditiously applied to this important effort. The Department recommends that those agencies responsible for water quality improvements necessary to implement the Comprehensive Plan be identified in WRDA 2000 and be held accountable for assuring that those water quality improvements are accomplished. We also recommend that these water quality features be scheduled to coincide with the construction schedule of the various project components to ensure that water deliveries are adequately treated before being released into the natural system.

o **ASSURANCES TO WATER USERS**: The discussion on assurances quotes from the Assurances Plan of the Governor=s Commission for a Sustainable South Florida. The Assurances Plan raises significant issues respecting the continued applicability of federal statutes and regulations to the C&SF Project operations and design, and to natural resource protection issues, generally. The Assurances Plan may also be construed to convert inadvertent project benefits, such as flood control benefits, into legal entitlements. Accordingly, the Department recommends a more general discussion of the assurances issue be included in the Final Implementation Plan instead of adoption of the Assurances Plan of the Governor=s Commission for a Sustainable South Florida, absent further review.

o **PROJECT IMPLEMENTATION REPORT (PIR) PROCESS**: As drafted, the roles and responsibilities of the Restoration, Coordination and Verification (RECOVER) team are not clearly defined. To avoid duplication of effort and confusion with agency statutory responsibilities, we recommend that the RECOVER strategy be clarified. The roles and responsibilities, scope of RECOVER review and involvement in the PIR process are the three primary areas needing clarification.

We envision a priority role for the RECOVER process to assist in the future planning to restore the remaining central and southern Everglades. There is a need for additional refinement of ecological performance measures, outside peer review, adaptive assessment, and a need for overall consistency. A multi-agency/interdisciplinary approach will be needed to accomplish these goals. This should be highlighted in the Final Plan.

To avoid serious delay in the ecosystem restoration of Biscayne Bay and Biscayne National Park, studies needed to verify restoration targets and assess the feasibility of restoration actions should be funded and conducted early in the implementation phase. Thus, the Department recommends that the Biscayne Bay Feasibility Study be accelerated and given a high priority. In the meantime, surface water flows to Biscayne Bay must meet or exceed the 95 Base condition, and there should be neither any annual or seasonal net loss in the total volume, nor any reduction in the spatial and temporal distribution of combined surface and groundwater flows to Biscayne Bay.

The Corps should also give high priority to examining those groups of components related to movement of water from the central Everglades to the southern Everglades, including but not limited to, L-29 and L-67 A and C. The final Comprehensive Plan should be flexible enough to develop and substitute components during implementation that significantly reduce the operational and ecological trade-offs in balancing the restoration of flow patterns and volumes with the maintenance of appropriate water depths in the remnant Everglades, particularly in the WCA 3B/Pennsuco Wetlands/Northeast Shark Slough areas.

Finally, both Alternative D13R and the D13R4 scenario presently use S-140 as a means to introduce Water into northern WCA 3A. Although this approach has shown some positive results, detailed design through the PIR process is necessary for restoration of hydropatterns in northern WCA 3A, which incorporates a better balance between the use of the S-140 as a point of discharge and a series of inflow structures to spread out flow along the northern and western boundary of WCA 3A. This approach during the PIR process is intended to provide greater flexibility in the distribution of inflows to the WCAs.

o **SCIENTIFIC PEER REVIEW**: The Department recommends that the Draft Implementation Plan include an independent scientific peer review process to provide continuing review throughout implementation of the Comprehensive Plan. This process should closely follow the implementation schedule and provide the assurance that the best science available is integrated into each step of project implementation. The Department looks forward to working with the Corps, Task Force members and others in establishing this peer review process.

o **<u>COORDINATION WITH THE SOUTHERN EVERGLADES RESOURCE ALLIANCE</u> (SERA)**: Specific consideration needs to be given to how RECOVER would coordinate with SERA. SERA is responsible for coordinating the Modified Water Deliveries Project and the C-111 Project. Both projects have Congressional authorization and are critical to restoration of the Southern Everglades. Recommendations made by SERA effect RECOVER and vice versa. For example, current implementation plans for the Modified Water Deliveries Project call for raising sections of Tamiami Trail several years earlier than proposed in the Draft Implementation Plan. Resolution of these conflicting schedules and timely implementation of these projects will be crucial to the Service=s= evaluation of endangered species impacts resulting from current operations.

The Corps has done a good job of bringing forward several of the Restudy components needed to support the Modified Water Deliveries and C-111 Projects (components O, QQ1/2, AA, V, FF, and WW); however, the DEPARTMENT requests that the scheduling of the following components also be moved forward. As currently drafted, the 2010 Case Study projects with delayed implementation include: WCA 3A/3B Levee Seepage Management (construction dates 2005-2009), Raising the East Portion of Tamiami Trail (2006-2011), WCA 3 Decompartmentalization (2018-2021), Additional S-345 Structures (2006- 2009), L-31N Levee Improvements and the S-356 Structures (2005-2010), and the C-111 Spreader Canal (2005-2008). In each case, the late dates for project design and construction would make it extremely difficult to link these components with the established project management plans for the Modified Water Deliveries and C-111 Projects. Accordingly, the Department recommends the SERA coordination process, including a discussion of potential scheduling conflicts, be discussed and clarified in the Final Implementation Plan.

The Department also recommends that the Corps not commit to the specific details of the L-67 component as conceived in either Alternative D13R or the D13R4 scenario. The long-term solution needs to maximize, to the extent possible, the joint restoration of both depth and flow patterns in the central/southern Everglades. For the Modified Water Deliveries/2010 Case Study time period, a set of passive features in L-67 (such as earthen weirs) having a combined flow capacity that does not exceed the current capacity of the structures along L-29 should be designed and implemented. These initial features would avoid deep water conditions in WCA 3B and would be more easily modified, depending on the final configuration of this component after removal of L-29 and other features included in the Comprehensive Plan.

o **<u>CRITICAL RESTORATION PROJECTS</u>**: Critical Restoration Projects (CP), previously authorized by WRDA 1996 (eg. C-4 East Coast Canal Structures, Southern Crew, Golden Gate Estates, etc.) appear on Table 5.3-1: AProgrammatic Authority@ in the

Draft Implementation Plan. We understand the dilemma faced by the Corps in regard to meeting rigid WRDA deadlines for CPs. The Department concurs that it is appropriate and in the best interest of Everglades restoration to place those CPs which did not meet Project Cooperation Agreement deadlines (September 30, 1999), in the Programmatic Restudy authority to assure that these projects are planned and built.

However, the Department also recognizes that these rigid CP deadlines have created a planning and interagency coordination environment which lacks the thoroughness of Congressionally authorized Civil Works studies which usually accompany efforts such as the proposed CPs. Specifically, CPs planned to date are conceptual in nature and typically would benefit from additional scientific data analysis necessary to improve both engineering and environmental design.

As the Corps and its partners move forward with the CPs, the Department recommends that the current list of CPs be thoroughly reviewed and re-prioritized, as necessary, to maximize both the environmental review and engineering analyzes necessary to ensure that ecological restoration goals are attained. The Department looks forward to working closely with the Corps in this regard.

We appreciate the opportunity to provide our comments on the Draft Restudy Implementation Plan. Please feel free to contact us if you would like to further discuss our comments and/or recommendations.

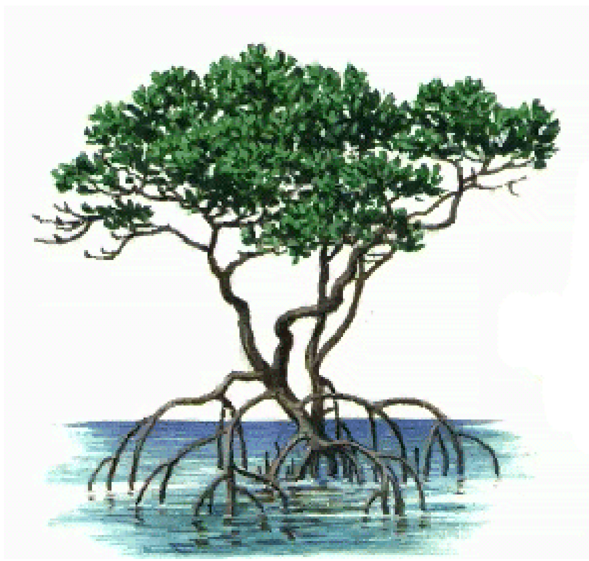
Sincerely,

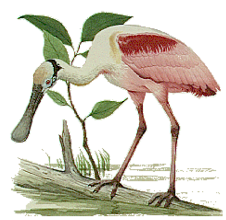
Stephen W. Forsythe
State Supervisor
Ecological Services
Fish and Wildlife Service

Richard G. Ring
Superintendent
Everglades National Park
National Park Service

cc: South Florida Water Management District-West Palm Beach
Environmental Protection Agency-West Palm Beach
Governor=s Commission for a Sustainable South Florida
South Florida Ecosystem Restoration Task Force
Florida Game & Fresh Water Fish Commission-Tallahassee
Florida Department of Environmental Protection-Tallahassee
Miccosukee Tribe of Florida-Miami
Seminole Tribe of Florida-Hollywood
William Leary, Office of the Assistant Secretary - Fish and Wildlife and Parks
Geographic Assistant Regional Director, Area III, Fish and Wildlife Service

DRAFT
FISH AND WILDLIFE COORDINATION ACT REPORT





CENTRAL AND SOUTHERN FLORIDA COMPREHENSIVE REVIEW STUDY

Prepared by:
South Florida Restoration Office
Vero Beach, Florida
U.S. Fish and Wildlife Service

Submitted to:
Jacksonville District
U.S. Army Corps of Engineers

United States Department of the Interior

National Park Service
Everglades National Park
40001 State Road 9336
Homestead, Fl. 33034

U.S. Fish & Wildlife Service
South Florida Ecosystem Office
P.O. Box 2676
Vero Beach, Fl. 3296

IN REPLY REFER 10

AUG 7 1998

Colonel Joe R. Miller
District Commander, Jacksonville District
U.S. Army Corps of Engineers
400 West Bay Street
Jacksonville, Florida 32232

Attention: Planning Division

RE: Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement for the Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy)

Dear Colonel Miller

The Department of the Interior (DOI) has prepared the enclosed Draft Fish and Wildlife Coordination Act (FWCA) report for the U.S. Army Corps of Engineers' (COE) Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement for the Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy) authorized by section 309(I) of the Water Resources Development Act (WRDA) of 1992 (P.L. 102-580). The Final FWCA report, anticipated for release in the spring of 1999, will fulfill the requirements of section 2(b) of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661*et seq.)* and will represent the Secretary of the Interior's report to Congress on the C&SF Restudy. This Draft FWCA report fulfills DOI's obligation pursuant to our 1997 Transfer Fund Agreement for the C&SF Restudy.

A summary of effects of the COE's Initial Draft Plan on federally threatened and endangered species is included in the Draft FWCA report. The Preliminary Programmatic Biological Opinion, dated August 7, 1998, for this conceptual plan is appended to this report. The Final Biological Opinion, also anticipated for release in the spring of 1999, will satisfy the consultation requirements of section 7 of the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 *et seq.)*.

The DO I commends the COE on efforts to date to develop a conceptual strategy to restore ecological function and structure in south Florida, particularly in the remaining central and southern Everglades. The Initial Draft Plan as represented in Alternative D13R, if fully implemented, would do much towards accomplishing this objective. Added modifications to improve ecological performance in Northeast Shark River Slough, the WCAs Biscayne Bay and the St. Lucie Estuary, as well as measures to protect water quality system-wide, are still needed. Further, the DO I looks forward to working with the COE to address other issues critical to the Initial Draft Plan, particularly those of plan implementation and technological uncertainty.

The DOI has every confidence that these issues can be satisfactorily addressed, resulting in a feasible conceptual strategy for south Florida ecosystem restoration that the DOI can fully endorse. The DOI commits to working with the COE to continue improvement and refinement of the ecological aspects of the Initial Draft Plan as the plan is finalized in the spring of 1999. Further, as the components of this conceptual plan proceed to more detailed design, the DOI looks forward to assisting the COE in further analysis under the National Environmental Policy Act. Additional coordination under the FWCA and consultation under the ESA will be conducted at the appropriate stages of detailed planning.

Finally, the DOI views the C&SF Restudy as a precedent-setting milestone in the Federal Government's and State of Florida's commitment to protect and restore the south Florida ecosystem.

Joe. we commend the efforts of both you and your staff in this extraordinary effort.

Sincerely,

Stephen W. Forsythe
State Supervisor
U.S. Fish and Wildlife Service

Sincerely,

Richard G. Ring
Superintendent
Everglades National Park

cc:
Assistant Secretary for Water and Science, DOI, Washington, DC
Assistant Secretary for Fish and Wildlife and Parks, DOI, Washington, DC
Director, FWS, Washington, DC
Director, NPS, Washington, DC
Regional Director, FWS, Atlanta, GA
Regional Director, NPS, Atlanta, GA
Executive Director, South Florida Ecosystem Restoration Task Force, Miami, FL
Executive Director, SFWMD, West Palm Beach, FL
Executive Director, GFC, Tallahassee, FL
Environmental Services, GFC, Vero Beach, FL
Governor's Commission for a Sustainable South Florida, Coral Gables, FL
Biscayne National Park, Homestead, FL
Big Cypress National Preserve, Ochopee, FL
Loxahatchee NWR, Boynton Beach, FL
Ding Darling NWR, Sanibel Island, FL
Florida Panther NWR, Naples, FL
Biological Resources Division, USGS, Miami, FL
SuperintendenMiccosukee Tribe of Florida, Miami, FL
Seminole Tribe of Florida, Hollywood, FL

DRAFT FISH AND WILDLIFE COORDINATION ACT REPORT

For the:

CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW STUDY

Prepared by:

South Florida Restoration Office
Vero Beach, Florida
U.S. Fish and Wildlife Service

Submitted to:

U.S. Army Corps of Engineers
Jacksonville District
Jacksonville, Florida

FOREWORD

The Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy) is unprecedented in its scope and complexity. It has truly been a multi-agency and multi-disciplinary effort. Detailed documentation of the evaluation and alternative design process is available on the Worldwide Web, and the U.S. Army Corps of Engineers will also provide extensive documentation in the Draft Integrated Feasibility Report and the Programmatic Environmental Impact Statement for the C&SF Restudy. We find it unnecessary to repeat those details in this report.

Due to the DOI's direct involvement in the design and evaluation of the Initial Draft Plan, we have departed from previous formats for the Fish and Wildlife Coordination Act Report. We have organized this report largely as a series of issue papers providing the DOI's observations on the Restudy process and the challenges remaining to be fully resolved. We have provided, wherever the level of specificity in this conceptual plan allows, recommendations to assist the U.S. Army Corps of Engineers and the South Florida Water Management District in meeting these challenges.

Due to the large number of people who assisted in this endeavor, we elected to not individually list participants that merit acknowledgment. Therefore, rather than list individual acknowledgments, we express gratitude to all the participants from the Fish and Wildlife Service, the National Park Service, the Florida Game and Fresh Water Fish Commission, the Biological Resources Division and Water Resources Division of the U.S. Geological Survey, the National Marine Fisheries Service, the South Florida Water Management District, the U.S. Army Corps of Engineers, and several environmental organizations, especially the National Audubon Society, the World Wildlife Fund, and The Nature Conservancy.

EXECUTIVE SUMMARY

INTRODUCTION

Scope of Authorities

The Department of the Interior (DOI) has prepared this Draft Fish and Wildlife Coordination Act (FWCA) report for the U.S. Army Corps of Engineers' (COE) Draft Programmatic Environmental Impact Statement for the Central and Southern Florida Comprehensive Review Study (C&SF Restudy) authorized by section 309(I) of the Water Resources Development Act (WRDA) of 1992 (P.L. 102-580). The Final FWCA report, anticipated for release in the spring of 1999, will fulfill the requirements of section 2(b) of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) and will represent the Secretary of the Interior's report to Congress on the C&SF Restudy.

A summary of effects of the COE's Initial Draft Plan on federally threatened and endangered species is included in the Draft FWCA report. The Preliminary Programmatic Biological Opinion, dated August 7, 1998, for this conceptual plan is appended to this report. The Final Biological Opinion, also anticipated for release in the spring of 1999, will satisfy the consultation requirements of section 7 of the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 *et seq.*).

An analysis of the Critical Projects authorized under section 528 of the WRDA of 1996 and Other Project Elements identified as crucial to overall ecosystem restoration are discussed in this report, but will require future coordination under the FWCA and ESA as more detailed plans are developed.

Ecosystem Decline

Originally authorized by Congress in 1948, the C&SF Project has resulted in the channelization, compartmentalization and drainage of vast areas of the south Florida ecosystem for the stated purposes of meeting water supply and flood control needs. Considered to be the most complex waterworks in the United States, the project consists of more than 1,400 miles of canals and levees, more than 2,000 water control structures and pump stations, and approximately 256,000 acres of water conservation areas. The originally authorized C&SF Project has not been fully constructed to date.

The recently authorized C&SF Restudy is a subset of the larger C&SF Project. The C&SF Restudy includes approximately 18,000 square miles of south Florida extending from Orlando to Florida Bay. The entire Kissimmee/Lake Okeechobee/Everglades watershed was considered in this ecosystem planning effort.

Construction of the C&SF Project over the past 50 years has resulted in extensive urban and agricultural development which now shapes the south Florida landscape. It is fair to conclude that the south Florida landscape has been extensively altered and damaged and that ecosystem health and stability have declined as a consequence.

Today, it is recognized and documented that there will be a continued decline of the south Florida ecosystem if nothing is done to stabilize ecological integrity. The current condition of the ecosystem demonstrates the decline to date: wading bird populations in the southern Everglades have declined by 90 percent, 68 species have been listed as threatened or endangered, exotic invasive plant and animal species have infested large areas of the ecosystem, coastal estuaries continue to be damaged by discharges of large volumes of fresh water, and the overall spatial extent of the Everglades wetland ecosystem has declined by 50 percent and continues to decline at an alarming rate. At the same time, it is recognized that south Florida will experience accelerated development pressure due to a projected population increase in south Florida from five million people today to an anticipated 12 million people by the year 2050. Subsequent increases in water demand for urban and agricultural development will be felt system-wide.

Consistent with the Governor's Commission for a Sustainable South Florida, the DOI considers the implementation of ecosystem restoration an "investment" in the future of both the human and natural environments of south Florida. Thus, the DOI finds that the status quo is unacceptable, and that a comprehensive and scientifically sound ecosystem-based strategy to begin the process of ecosystem restoration is imperative and is the most prudent course of action. Ecosystem restoration is of particular concern and priority to the DOI as the major steward of federal lands (parks, wildlife refuges and preserves) and DOI trust resources (threatened and endangered species, migratory birds and wetland resources) in south Florida.

The Secretary of the Interior established the South Florida Ecosystem Restoration Task Force in 1992 to partner federal, state, tribal, academic, local and private resources to develop a long-term strategy to restore south Florida. Subsequently, the COE, South Florida Water Management District, and other interested agencies and parties developed a consensus-building process involving considerable multi-agency resources over the past five years through the C&SF Restudy Team. The Plan Formulation stage began in earnest in October 1997 with the establishment of the Alternative Development Team (ADT) and the Alternative Evaluation Team (AET). Both teams eventually included representatives of all interested agencies, local governments, agricultural interests, and Native American Tribes. Through an iterative process involving alternative plan development and evaluation based on hydrologic modeling and establishment of ecological restoration targets, the AET and ADT developed Alternative D13R. As a result of these extraordinary planning efforts, the COE now recommends Alternative D13R as the Initial Draft Plan.

In addition to preparing this Draft FWCA report, the DOI has participated in numerous planning meetings and workshops with the concerned planning partners and provided the COE with three Planning Aid Letters (PAL) identifying important issues to be addressed during the planning process. These PALs assisted the COE in developing a restoration plan which more fully meets the DOI's ecosystem restoration goals and objectives in south Florida.

ANALYSIS OF THE INITIAL DRAFT PLAN

Alternative D13R, if fully implemented, would make significant progress toward achieving ecological restoration throughout the C&SF Project, and the DOI endorses most of the elements contained in the Initial Draft Plan. However, Alternative D13R needs further improvements to more fully reach the restoration goals and targets established by the C&SF Restudy Team. Therefore, the DOI recommends further Initial Draft Plan modification prior to the development of the Final FWCA report and subsequent release of the Final PEIS in the spring of 1999.

The Draft FWCA report contains a detailed discussion of issues that the South Florida Ecosystem Restoration Task Force highlighted as most in need of continued analysis and development in the C&SF Restudy. The DOI concurs with the Task Force's issues, as well as others, and elaborates as follows:

Northeast Shark River Slough

Total overland flow volumes to Florida Bay, through Shark River Slough, and Taylor Slough, should be increased to more fully reach Natural System Model targets.

Water Conservation Areas

While accomplishing the above, the hydrologic characteristics in the Water Conservation Areas (WCAs) (particularly northeastern WCA 3A, all of WCA 3B, and WCA 2B) should also more fully reach ecological targets. Alternative D13R was not able to eliminate potentially damaging high water and low water conditions in those areas. The DOI recommends that further modifications be pursued in order to achieve full restoration of hydrologic characteristics in Florida Bay, Shark River Slough and Taylor Slough without compromising full restoration of WCAs. A guiding principle should be that water flow is delivered as naturally as possible throughout all of the remaining Everglades.

Biscayne Bay

Whether or not wastewater reuse on the scale proposed by the C&SF Restudy is feasible for Dade County, the COE should continue to seek opportunities that are not dependent on this technology in order to restore more natural flows to Biscayne Bay. Chapter VI of this report describes two Other Project Elements (OPEs) that would benefit Biscayne Bay with or without the additional water that may be available through reuse facilities. These two OPEs are entitled: South Dade Agriculture Rural Land Use and Water Management

Plan and Biscayne Bay Coastal Wetlands. The DOI believes that these projects and any others developed to improve ecological conditions in Biscayne Bay should be given priority. Under any future circumstances, total flow volumes to Biscayne Bay should be no less than those simulated in the 1995 Base.

St. Lucie Estuary

Restoration goals for minimum flows of fresh water to the St. Lucie Estuary and the elimination of regulatory releases to the estuary from Lake Okeechobee would be generally met in the Initial Draft Plan. However, the runoff generated within the St. Lucie drainage basin is still significantly greater than the restoration target. The DOI recommends that further hydrologic modeling efforts be undertaken to restore the St. Lucie Estuary prior to release of the Draft PEIS in the spring of 1999, and that this important restoration effort be highlighted as a priority for future analysis and refinement under the authority of the COE's Indian River Feasibility Study.

Water Quality

The DOI recognizes that the Water Resources Development Act of 1996 authorizes the protection of water quality as a project purpose of the C&SF Project. As such, water quality protection must be addressed throughout the entire Kissimmee/Okeechobee/Everglades watershed. The DOI remains concerned that the C&SF Restudy does not include an adequate plan for treatment of water destined to be returned to the natural system. The DOI recommends that specific pollutant loading targets be established and an implementation plan developed to reach defined targets within the watershed. Finally, planning should not be limited to nutrient loading; a variety of water quality parameters and pollutants also need to be addressed (e.g., pesticides and mercury contamination).

SUMMARY OF FWCA REPORT FINDINGS AND RECOMMENDATIONS

Detailed findings and recommendations can be found throughout various chapters of the FWCA report. The following is a summary of each chapter discussion:

Ecosystem Sustainability

The hydrologically restored wetland habitats of central and south Florida will not have the same distribution, abundance, and diversity of fish and wildlife as the pre-drainage Everglades. Provided the Initial Draft Plan is refined as described above, the DOI is reasonably certain that the restored wetland habitats of the remaining central and southern Florida Everglades ecosystem will have the necessary structure and function to be sustainable in the long-term.

Other Project Elements

The DOI has provided a review of the ecological benefits expected from implementation of the Other Project Elements (OPEs). These projects lie either outside of the South Florida Water Management Model assessment area, or at a scale not readily usable by the model, but are included in the report as important components of overall south Florida ecosystem restoration. Many of these projects provide ecosystem benefits on a regional scale. The DOI recommends that those OPEs which provide the most significant ecological benefit receive the highest priority for future detailed planning and implementation.

Water Supply

The DOI believes that water supply for all users (urban, agricultural, natural system) cannot be met in the year 2050, unless unconstrained water demands by urban and agricultural users is reevaluated. This is particularly important considering the projected human population increase in south Florida. For the natural system, on the other hand, an adequate water supply is a matter of ecosystem survival or collapse. The C&SF Restudy must maintain this perspective, otherwise, the ever-growing, highly specific demands of the urban and agricultural sectors are likely to take priority over the unchanging, less well-defined needs of the natural system. The DOI recommends that a guaranteed water allocation to the natural system be developed and instituted as soon as possible.

Exotic Plants and Animals

Control of non-indigenous species of plants and animals is an important aspect of ecosystem restoration in south Florida. Existing control measures should be accelerated, more effective techniques should be developed, and regulations should be revised and better enforced to prevent additional introductions of exotic species. The South Florida Ecosystem Restoration Task Force and Working Group Exotic Pest Plant Task Team are developing a statewide strategic plan for managing and controlling exotic pest plants. This effort should be vigorously supported and implemented. The DOI recommends that an equivalent Task Team for invasive exotic animals be established.

Wetland Mitigation

Policies governing Clean Water Act authorization of wetland mitigation within the study area must be consistent with the goals of the C&SF Restudy. Enhancement of wetland function attributable to the C&SF Restudy should not be credited to other interests who are required to mitigate for wetland functional losses. As a policy, using lands inside the C&SF Restudy boundary to replace *wetland functional losses occurring outside the C&SF Restudy boundary should be prohibited. To meet the stated goal of "increasing the spatial extent of wetlands" wetland mitigation should supplement, not supplant, ecosystem restoration benefits attributable to the C&SF Restudy. Information on the location of features proposed in the C&SF Restudy must be made accessible to reviewers of permit applications, and all permit decisions must be compatible with the design and purposes of the C&SF Restudy*

Land Acquisition

Land acquisition requirements, particularly for the Water Preserve Areas and other Water Storage Areas, are substantial in the Initial Draft Plan. The DOI has provided a review of our current understanding of these issues. Land acquisition funding should receive priority before restoration opportunities are lost. Although current activity is largely dependent on willing sellers, the DOI finds that eminent domain procedures will likely be required to complete the plan.

Water Preserve Areas

The Water Preserve Areas of Palm Beach, Broward and Dade counties are an essential feature of the C&SF Restudy that should proceed rapidly to detailed design, while preserving areas of existing high habitat value and providing fish and wildlife habitat enhancement features in others. The DOI recommends that land acquisition in this critical area be accelerated and that the COE begin an expedited Feasibility Study of the area as soon as possible before restoration opportunities are supplanted by continued urban and agricultural development.

Water Storage and Treatment Areas

Water storage and treatment in other portions of the C&SF Restudy area should also minimize impacts on a fish and wildlife habitat. The DOI has provided recommendations for the relocation of the currently proposed storage location in the Caloosahatchee River Basin and for siting of storage and treatment areas in the Taylor Creek/Nubbin Slough Basin.

Adaptive Management

The DOI recommends that all progress toward achieving ecosystem restoration be continuously evaluated in a scientific forum. A peer-reviewed science-based adaptive management strategy, coupled with a sound monitoring program, is the recommended means for integrating all the past knowledge of the south Florida ecosystem with recent findings of the scientific community. Based on the monitoring information, the interagency adaptive management team will prepare annual reports and provide *recommendations to decision-makers on how to proceed. This strategy will ensure that refinements to the Initial Draft Plan will be based on the best and most recent information. The annual reports will also be an avenue for keeping the general public fully informed.*

Scheduling, Sequencing and Priorities

Proper sequencing of presently authorized projects and the components to be authorized in the C&SF Restudy must be determined and followed. The DOI provides restoration planning priorities to integrate authorized projects in the Kissimmee River Basin (Headwater Lakes Revitalization and Kissimmee River Restoration Projects) and in the Southern Everglades (Modified Water Deliveries and C-111 Projects), as well as proposed project components (Water Preserve Areas, Water Conservation Areas, Indian River Lagoon Restoration, Lake Okeechobee Re-regulation, and others). Effective sequencing of actions proposed by the C&SF Restudy (relative to each other and to existing authorized projects) must be thoroughly analyzed and integrated in construction schedules.

Future Feasibility Studies

The DOI strongly supports the completion of the Water Preserve Areas, the Indian River Lagoon, and the Southwest Florida Feasibility Studies and recommends that a new feasibility study be initiated for Biscayne Bay.

Threatened and Endangered Species

The FWS concludes that the C&SF Restudy will promote recovery of several federally-listed threatened and endangered species. Other listed species will either not be affected, or will be adversely affected, but not jeopardized, by implementation of the Initial Draft Plan. Due to the conceptual nature of the Initial Draft Plan, the FWS anticipates an indeterminable amount of incidental take for several listed species as a result of the construction and hydrologic operation activities associated with the plan. Reasonable and Prudent Measures, coupled with required Terms and Conditions, are provided in the Preliminary Biological Opinion to minimize incidental take. In addition, affirmative conservation measures are provided to the COE to further overall listed species recovery in accordance with section 7(a)(1) of the ESA and the Memorandum of Understanding on Implementation of the ESA between the federal agencies.

Wildlife-Related Recreation

Recreational opportunities in the natural areas of south Florida must be considered in detailed project design and in policy development. Issues involved with access for hunting and fishing, management of fish and wildlife resources in *the Water Conservation Areas, and the perception that federal lands are receiving restoration priority over state lands are issues that must be addressed with the Florida Game and Fresh Water Fish Commission.*

Aquifer Storage and Hydrologic Models

The DOI provides technical recommendations regarding necessary studies on aquifer storage and recovery and on improvements to hydrologic models.

Decompartmentalization

Opportunities for removal of structures that impede restoration should be a guiding principle; addition of structures must be clearly demonstrated to be unavoidable before being included in designs.

Technological Uncertainty and Trade-Offs

As the COE proceeds to detailed planning of project components, there may be some components that are not feasible from a technical, regulatory, or a financial standpoint. Tradeoffs will become more prominent in decision-making and fall back positions will need to be devised to address ecological problems that would be compromised by these tradeoffs. Detailed design of all components should continually consider approaches that will promote passive systems over intensely active management.

CONCLUSION

The DOI commends the COE on efforts to date to develop a conceptual strategy to restore ecological function and structure in south Florida, particularly in the remaining central and southern Everglades. The Initial Draft Plan as represented in Alternative D13R, if fully implemented, would do much toward accomplishing this objective. Added modifications to improve ecological performance in Northeast Shark River Slough, the WCAs, Biscayne Bay and the St. Lucie Estuary, as well as measures to protect water quality system-wide, are still needed. Further, the DOI looks forward to working with the COE to address other issues critical to the Initial Draft Plan, particularly those of plan implementation and technological uncertainty. The DOI has every confidence that these issues can be satisfactorily addressed, resulting in a feasible conceptual strategy for south Florida ecosystem restoration that the DOI can fully endorse.

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List of Acronyms

ASR	Aquifer Storage and Recovery
ATLSS	Across Trophic Levels System Simulation
BICY	Big Cypress National Preserve
BMPs	Best Management Practices
BRD	Biological Resources Division (of the USGS)
CARL	Conservation and Recreation Lands Program
COE	U.S. Army Corps of Engineers
CP(s)	Critical Project(s)
CREW	Corkscrew Regional Ecosystem Watershed
C&SF	Central and Southern Florida Project
DOI	U.S. Department of the Interior
EAA	Everglades Agricultural Area
ECP	Everglades Construction Project
EFA	Everglades Forever Act
ELM	Everglades Landscape Model
ENP	Everglades National Park
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
EWQM	Everglades Water Quality Model
DEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use, Cover and Forms Classification System
FWCA	Fish and Wildlife Coordination Act
FWS	U.S. Fish and Wildlife Service
GFC	Florida Game and Fresh Water Fish Commission
NEPA	National Environmental Policy Act
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NSM	Natural System Model
OPE(s)	Other Project Element(s)
P2000	Preservation 2000
PEIS	Programmatic Environmental Impact Statement
ROGEM	River of Grass Evaluation Methodology
SERA	Southern Everglades Restoration Alliance
SHCAs	Strategic Habitat Conservation Areas
SFWMD	South Florida Water Management District
SFWMM	South Florida Water Management Model
SGGE	Southern Golden Gate Estates
SOR	Save Our Rivers
STA(s)	Stormwater Treatment Area(s)
SWFWMM	Southwest Florida Water Management Model (proposed)
USGS	U.S. Geological Survey
WCA	Water Conservation Area
WMA	Wildlife Management Area
WPA	Water Preserve Area
WRD	Water Resources Division (of the USGS)
WRDA	Water Resources Development Act

CHAPTER I -- IDENTIFICATION OF PURPOSE, SCOPE, AND AUTHORITY

Cheryl Buckingham and Robert Pace, FWS

A. Introduction

The Central and Southern Florida Project is a multi-purpose project, which was first authorized in 1948 to provide flood control, water control, and water supply to the area extending from Orlando to Florida Bay. While the project performed its intended purposes well, people soon noticed a number of unintended effects that pointed to a system-wide decline in environmental quality. Wading bird populations suffered steep declines, water quality problems emerged, and exotic and nuisance plants and animals rapidly expanded. By the mid-1980's, it became apparent that the alteration of flows through the Kissimmee River and the changes to depths, hydroperiods, and flow patterns in the Everglades were linked to the decline of commercial fisheries in Lake Okeechobee and Florida Bay. As ecological conditions worsened, the public realized that much of south Florida's economy is dependent on a healthy ecosystem and that this economy would decline with deteriorating environmental conditions. From an agency perspective, the thought process has shifted from a piecemeal approach to trying to fix the problems to the realization that a comprehensive ecosystem restoration strategy was needed. Public will and agency awareness resulted in the Central and Southern Florida Project Comprehensive Review Study (Restudy).

B. Purpose

The original Congressional authorization (WRDA 1992) described the purpose for the Restudy as follows: "to determine the feasibility of structural modifications to the project essential to the restoration of the Everglades and Florida Bay ecosystems, while providing for other water related needs" and "for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation." The DOI determined that the sequence of these purposes, as stated, implies that the primary intent of Congress was to provide a process for the restoration of south Florida's ecosystems.

In 1994, the COE's Reconnaissance Report acknowledged this Congressional intent by stating that, "the focus of this study is restoration of the ecosystem that was affected by construction of the Central and Southern Florida Project." (COE 1994)

In 1996, the COE's perspective on the purposes for the Restudy appeared to change as the COE started to compile a wide range of components or options (primarily developed from the C&SF Restudy Reconnaissance Report , the Governor's Commission for a Sustainable South Florida, and the South Florida Water Management District's Lower East Coast Regional Water Supply Plan) that could be included in the Restudy. These objectives and initial project components were reviewed by the Governor's Commission for a Sustainable South Florida, resulting in "A

Conceptual Plan for the C&SF Project Restudy" (Governor's Commission for a Sustainable South Florida 1996). As a result, a new set of "broader" Restudy goals and objectives emerged to "enhance ecological values and enhance economic values and social well being" (COE 1997). Minimizing the loss of existing services (water supply, flood protection, navigation) had been originally characterized as a constraint to achieving ecosystem restoration. Increased urban and agricultural water supply, enhanced flood protection, and improved opportunities for navigation now appear to be equivalent to ecosystem restoration as goals for the Restudy. WRDA 1996 reflected this shift in the emphasis of the purpose of the Restudy.

> "The Secretary shall develop, as expeditiously as practicable, a proposed comprehensive plan for the purpose of restoring, preserving, and protecting the South Florida ecosystem. The comprehensive plan shall provide for the protection of water quality in, and the reduction of the loss of fresh water from, the Everglades. The comprehensive plan shall include such features as are necessary to provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project."

Although WRDA 1996 seemed to provide greater emphasis on "enhancement of water supplies" than WRDA 1992, its inclusion of authority for the COE to consider water quality issues was a significant step toward a comprehensive view of ecosystem restoration.

The South Florida Ecosystem now suffers the effects of over 100 years of human alterations and large portions of the ecosystem are showing signs of acute ecological stress. Because of the interdependence between the people of south Florida and the natural system, we believe the health and well-being of future generations depends on restoring the natural system and we must, within reason, remove the causes of that ecological stress. To achieve this outcome, we recommend a return to the original emphasis for purposes of the Restudy, as prescribed by Congress in the WRDA of 1992 and the COE in its 1994 Reconnaissance Report.

A Programmatic Environmental Impact Statement (PEIS) is being prepared for this Initial Draft Plan, which includes an adaptive, incremental process for implementing the plan, and identification of cost-effective increments. It serves as the basis for obtaining Congressional authorization for the Water Preserve Areas and other plan components determined to be feasible and cost effective. As subsequent feasibility studies are completed, the comprehensive plan will be reviewed and refined.

C. Scope

The study area encompasses approximately 18,000 square miles from Orlando to Florida Bay with at least 11 major physiographic provinces: Everglades, Big Cypress, Lake Okeechobee, Florida Bay, Biscayne Bay, Florida Reef Tract, nearshore coastal waters, Atlantic Coastal Ridge, Florida Keys, Immokalee Rise, and the Kissimmee River Valley. The Kissimmee River, Lake Okeechobee and the Everglades are the dominant watersheds that connect the remaining mosaic of wetlands, uplands, coastal areas, and marine areas.

The pre-drainage wetlands of southern Florida covered an area estimated at approximately 8.9 million acres. This region was a complex system of hydrologically interrelated landscapes, including expansive areas of sawgrass sloughs, wet prairies, cypress swamps, mangrove swamps, and coastal lagoons and bays. The pre-drainage wetland ecosystems of southern Florida had three essential characteristics:

- Large spatial scale
- Habitat heterogeneity
- A hydrologic regime that featured dynamic storage and sheetflow

As a result of land use and water management practices during the past 100 years in southern Florida, spatial scale has been reduced, habitat heterogeneity has been impacted, and the dynamic storage and sheetflow features have been greatly reduced. Understanding the role these characteristics played in the healthy ecosystem and the factors that impacted them has been the focus for setting restoration goals and priorities for the Restudy. While it is true that the pre-drainage wetlands cannot be fully restored, a successful restoration program will be one that recovers to the extent possible these defining characteristics of the former system. Achievement of this goal should result in the recovery of ecologically viable systems that functionally resemble the pre-drainage Everglades and its interrelated wetland systems.

The fundamental tenet of south Florida ecosystem restoration is that hydrologic restoration is a necessary starting point for ecological restoration. Water management changes have been the chief cause of the problems in this ecosystem and it is believed that restoration begins with the reinstatement of the natural distribution of water in space and time over a sufficiently large area. The water must also meet ecologically-based water quality standards, what is commonly referred to as “marsh-ready water.” It should be noted that the definition of these water quality requirements is constantly being modified as we learn more about the stressors on the system, and the definition will likely need to be tailored for the particular ecological structure and function of different parts of the remaining natural system.

The ecological goal for south Florida ecosystem restoration is to recreate, on a somewhat smaller scale, a healthy ecosystem large enough and diverse enough to survive the natural cycles of droughts, floods, and hurricanes and to support large and sustainable communities of native vegetation and animals. A successful restoration plan must encompass the whole regional system (the Kissimmee-Okeechobee-Everglades watershed), not smaller portions of the C&SF project in isolation.

D. Authority

The reconnaissance phase of the C&SF Restudy was authorized by Section 309(l) of the WRDA 1992 (P.L.102-580) and two resolutions of the Committee on Public Works and Transportation, United States House of Representatives, dated September 24, 1992. The Reconnaissance Report, completed in November 1994 by an interagency, interdisciplinary team, identified the hydrologic and ecological problems in southern Florida and opportunities that existed for solving them. Preliminary alternative plans were formulated that showed promise and the Corps of Engineers recommended the study move into the feasibility phase.

The feasibility phase was authorized by the WRDA of 1996 (P.L. 104-303) and is cost-shared between the federal government and the non-Federal sponsor, the South Florida Water Management District. The overall feasibility effort will be a series of feasibility studies, similar to the way the original 1948 C&SF Project plan led to a series of specific projects. The underpinning of the effort is the development of the Initial Draft Plan, which is intended to ensure that components work together as a comprehensive plan.

As required by WRDA, 1996, this Initial Draft Plan has been prepared in cooperation with the non-Federal project sponsor and the Interagency South Florida Ecosystem Restoration Task Force. It also has considered the conceptual framework presented in the report entitled "Conceptual Plan for the Central and Southern Florida Project Restudy", published by the Governor's Commission for a Sustainable South Florida in July, 1995, and approved by Governor Lawton Chiles.

E. Conclusion

Arthur R. Marshall's (1971) plea for restoration of the Everglades basin still rings true nearly 30 years later:

> The stresses of overloading the south Florida environment reflect on the general populace. For this reason the principal criteria for adjudging and instituting solutions must be in the public's interests.
>
> We must change direction. Our exploitive and technological orientation must be re-directed in favor of more considerate uses of natural systems. They have an efficiency of their own as well as finite limits which we can no longer disregard. We do not control nature. Our intrusions into natural systems merely bring into play other sets of natural laws -- some favorable to man, some not.
>
> The environmental problems of the Everglades are of such precipitous nature and so relevant to the broad public interest that no single agency of government has the perspective and authority to resolve them. If any is able to do so, that ability is not evident. Strong executive scrutiny, led by the Cabinet of Florida, is in order.

At the request of the COE, the DOI has been a full participant in the formulation and evaluation of alternative plans and in selection of the Initial Draft Plan (Alternative D13R). Throughout this process, the DOI has provided formal and informal assessments of the benefits and impacts of the Initial Draft Plan. Points of reference for the Initial Draft Plan in these assessments have included other analyzed alternatives (Alternatives A through D), an approximate simulation of the present condition (1995 Base), the future without project condition (2050 Base), and restoration targets (including, but not limited to, the Natural System Model). These analyses have generally been in keeping with the level of detail of the conceptual plans. A tiered approach is being used and more detailed analyses will be performed at the appropriate time.

This report constitutes the report of the Secretary of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act at the conceptual level of detail. Additional 2(b) reports will be required for feasibility studies arising from this conceptual plan (e.g. the Indian River Lagoon, Water Preserve Area, and Southwest Florida feasibility studies) and the detailed design of all components in the Initial Draft Plan, including those identified as Critical Projects for immediate implementation.

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CHAPTER II -- DEFINING EVERGLADES RESTORATION -- "THE FIELD OF DREAMS"

Robert Doren, ENP; Robert Pace, FWS

Everglades Restoration has been described and defined in several ways and in several plans. Each plan has a slightly different twist or nuance but all are essentially the same. Each recognizes that the original Everglades (ca. 1850) is the theoretical restoration target, and each recognizes that this target is no longer realistic. They recognize that the pre-existing Everglades can never be recovered given the dramatic changes that have occurred and continue to occur. However, each definition also recognizes that restoration today relates more to stopping further damage and "fixing" or reversing as many of the changes as possible.

Restoration definitions have therefore included the following concepts: 1) preventing additional deterioration, 2) undoing or reversing as many of the changes as possible, 3) allowing natural processes to reestablish, and 4) provide persistence and predictability to the "new" system in such a way that the reestablishment of natural processes take place within the ecological functioning of the ecosystem that is understood to be characteristic of the Everglades.

All ecosystems, especially at the landscape level, are self-regulating and self-organizing. This point is critical to understand in order to realize that, by returning a more natural hydrologic regime to the Everglades, there is sufficient expectation that the Everglades will then restore "itself." What this means is, that as the problems of water quantity, quality, timing and distribution, the impact of exotics, fire management, lack of connectivity, etc. are corrected or reversed, the natural system will respond in an ecologically positive manner. Resource managers can only reinstate those physical ecological parameters that they manage. The ecosystem is then allowed to respond. Since Everglades restoration is being attempted at the landscape level, restoration cannot pretend to restore form and must by necessity attempt to restore function and process with the assumption that form will follow function. However, even if everything possible is done to "put things right," the Everglades of the future will be a different Everglades than the past, or of today. With restoration, the Everglades of the future will exist in an alternative stable state relevant to the setting of the restoration goals inherent in maintaining an ecologically sustainable Everglades.

Although the literature on restoration ecology suggests that successful restoration of wetlands is largely dependent on establishing the desired hydrologic regime over suitable soils (Palmer *et al.* 1997), we should not assume that, if the future hydrologic regime approaches historic patterns, that the flora and fauna of the pre-drainage Everglades will entirely return to historic composition, distribution, and abundance. Too many potentially confounding variables have intervened in the system. We are aware of some of these -- existing species of exotic plants and animals and the threat of new introductions, soil loss and the resulting topographic changes, and the influence of soil-bound nutrients on the spread of cattails (even if surface waters contain target concentrations of nutrients). Presently unknown factors may also arise in unexpected ways to influence success in achieving restoration of fish and wildlife abundance and diversity. Although we have a reasonable expectation that the essence of what constitutes the Everglades can be recovered through re-establishment of improved hydrologic conditions, we must guard against carrying too far the "Field of Dreams hypothesis;" that is, "if you build it, they will come." (Palmer *et al.* 1997)

In the end, one cannot know *a priori* precisely what the restored Everglades will look like - whether all the species one expects in the Everglades will remain or return, or exist in the same numbers, distribution, or diversity. To quote Hobbs and Norton (1996), "...there is the potential for systems to follow alternative pathways depending on the precise combination of management, climatic, and biotic factors experienced. The stochastic nature of the environment means the outcome of a particular restoration measure may differ when carried out at different locations or different times." However, given the current unpredictable alterations consistently inflicted on the Everglades (flooding, draining, decompartmentalization into parcels by levees and canals, addition of fire out of season, addition of pollutants and exotics, etc.) and the responses the system has made regarding loss of species diversity and richness, community structure, and ecological function, further decline of the ecosystem is inevitable without intervention. Therefore, intervention by reversing the ills caused to the ecosystem - if reversed well enough so that the changes are persistent and within the natural patterns of variation that evolved with the ecosystem - will allow the ecosystem to reestablish sustainable functions characteristic of the Everglades.

As Don Boesch, Chair of the Florida Bay Science Oversight Panel, said; "...restoring the Everglades is not rocket science or brain surgery, it's much more complicated than that."

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CHAPTER III -- BRIEF DESCRIPTION OF THE ALTERNATIVES

Robert Pace, FWS

The number of components and their design are too complex to easily summarize. The C&SF Restudy Web site (http://141.232.1.11/org/pld/restudy/hpm/index.html) contains both general and detailed descriptions of the alternatives. The detailed descriptions are lengthy documents, ranging from 85 pages for Alternative A to 95 pages for Alternative D. Alternative D contained the greatest number of components, totaling 60. The components range in complexity, in terms of the simulations and also as they might be designed and built in reality. For example, water supply provisions for the City of West Palm Beach were designed in detail, with corresponding detailed modifications to the South Florida Water Management Model (SFWMM). Other components, such as water storage and treatment in the Taylor Creek/Nubbin Slough basin, were simply added to the SFWMM as hypothetical storage for water from Lake Okeechobee, without definition of their location in the real world.

The revisions leading to formulation of Alternatives A through D from their precursors, Alternatives 3 through 6, resulted in less distinct differences among the alternatives because they shared many components.

The decompartmentalization of WCA 3 is one of the principal ways the alternatives differed. Alternative A retained most of the existing levees and structures around WCA 3, with dependence on large pumps along Tamiami Trail to deliver an increased volume of water to northeast Shark River Slough. This approach was not in keeping with the tenet of removing structures whenever possible from the remaining Everglades to achieve restoration. Alternative B involved removal of the Miami Canal, both the L-67A and L-67C and their associated canals, all of L-29 along Tamiami Trail and all of L-28. Alternative C also removed the Miami Canal, but left in place the western portion of L-29 and the L-28. A series of weirs were placed along the present location of the L-67A. Alternative D was similar in its approach to decompart-mentalization, except that it involved removal of the L-28 tieback, which was present in Alternative C. Alternative D13R involved complete removal of the L-29 and L-28, similar to Alternative B, but included refinement of the design of the weirs along the location of the L-67A. Alternative D13R also modified rules at selected water gage locations in the WCAs governing the importing and exporting of water. The northern two-thirds of the canal along L-67A would remain in place in Alterative D13R. Figure III-1 is a schematic representation of the components of D13R in the central Everglades, with notations as to how they differ from Alternative D

Other significant differences among the alternatives included the following:

1. Alternatives C and D extended the C-111 spreader canal east of Card Sound Road. The spreader canal extended only up to Card Sound Road in Alternative B and was absent in Alternative A.

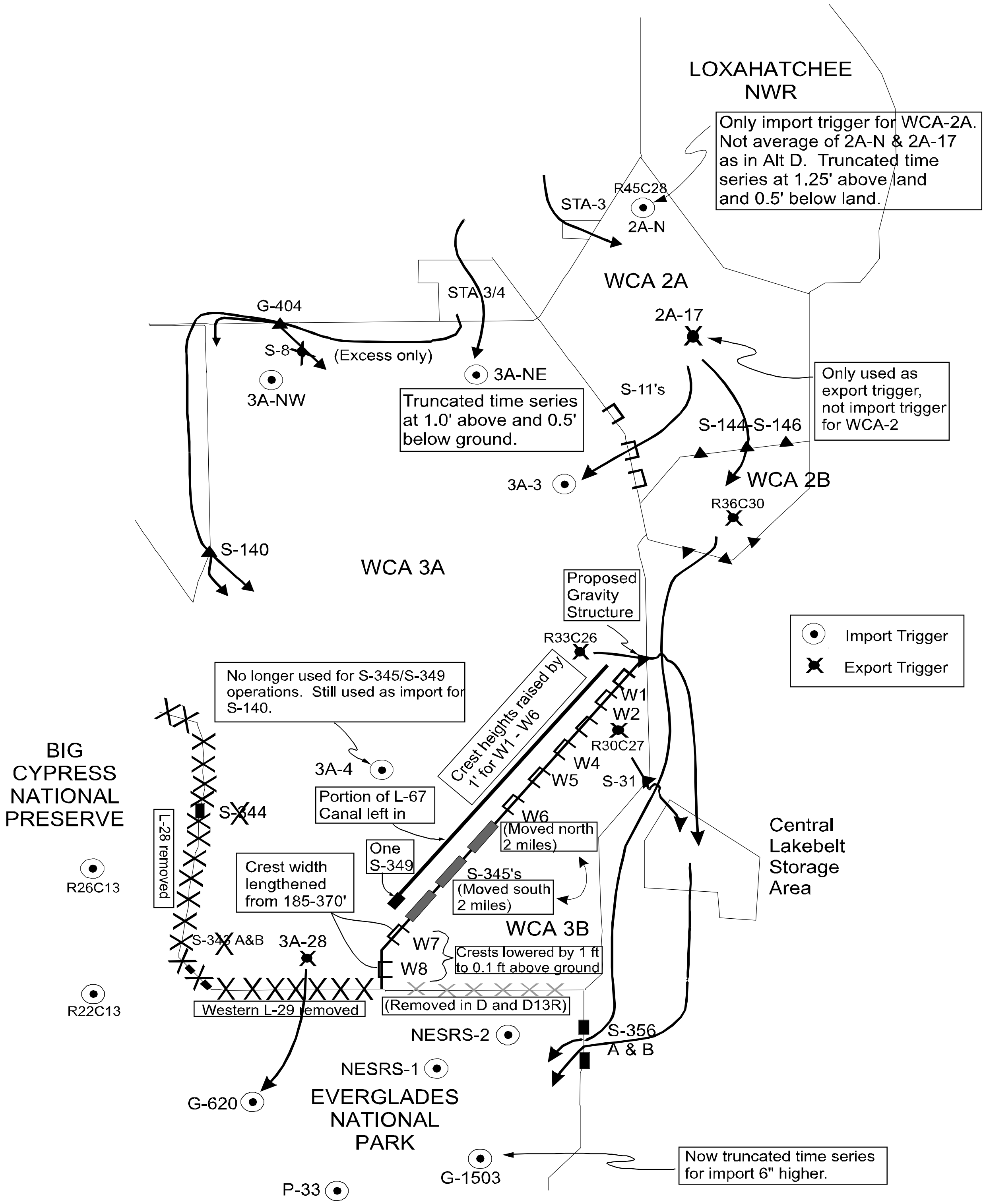
2. Alternatives C and D added South Dade County water reuse program.

3. Alternatives C and D modified the use of Central Lake Belt storage, relative to operation criteria for WCA 3 and South Dade County water reuse program.

4. Alternatives C and D modified the L-28 Interceptor.

5. Alternative D13R increased water storage in the Upper East Coast, including the C-23 and C-24 basins and the North Fork and South Fork of the St. Lucie River.

Figure III-1. Schematic representation of the conceptual design changes between Alternative D and Alternative D13R within the Water Conservation Areas.



CHAPTER IV -- EVALUATION METHODOLOGY

Cheryl Buckingham and Robert Pace, FWS

A. Plan Formulation and Evaluation

The plan formulation stage of the C&SF Comprehensive Review Study began in earnest in October, 1997 with the formulation of the Alternative Development Team (ADT) and the Alternative Evaluation Team (AET). Both teams included representatives of a number of interested agencies, local governments, agricultural interests, and Native American tribes. The ADT began the planning process by developing a set of components that were modeled using the South Florida Water Management Model (SFWMM). The results of the "Starting Point" model were posted on the C&SF Restudy Web site-http://141.232.1.11/org/pld/restudy/hpm/index.html-where members of both teams and the public could comment. The AET met, analyzed the comments, and suggested improvements to the ADT. The ADT met, incorporated the AET's suggestions into the next model run, Alternative 1. This iterative process between the AET and the ADT was repeated over the following nine months as Alternatives 1-5 were formulated. At the end of the nine month period, enough information had been gained on certain components that optimized versions of them were available. At about the same time, a number of underlying assumptions in the 2050 plan had been reevaluated and the final version of the Natural System Model (NSMv4.5 Final) had become available. The Restudy Team decided to re-visit the base conditions and re-evaluate the best performing of the alternative plans (Alternatives 3-5) to incorporate the new information. This ensured that both base conditions and the alternatives contained the latest, best information available. It also guaranteed that the earlier alternatives were not unduly handicapped simply because they contained preliminary, imperfect versions of components that had since been optimized. At this same time, the newest alternative was modeled. This plan would have been Alternative 6, but the "re-scaled" alternatives were renamed A through D to avoid confusing them with the earlier versions.

Extensive evaluations of the benefits and impacts of each alternative on the natural resources of the south Florida ecosystem were conducted by sub-region teams of the AET. The entire AET then met to review the sub-region team conclusions and to suggest improvements and priorities for the ADT to include in the formulation of the next alternative. Representatives from all of the resource agencies, including FWS, NPS, GFC, USGS, and NOAA/NMFS were fully integrated into the AET. Ample opportunity was made available to review, evaluate, comment upon, and to suggest improvements at each step in the plan formulation and plan selection process. For this reason, FWS determined that it was unnecessary to develop a separate evaluation of the alternatives to satisfy the requirements of the Fish and Wildlife Coordination Act Report. This evaluation, therefore, consists of a review of the tools used by the AET to analyze the alternatives (this chapter) and a summary of the AET's findings (Chapter V). The strengths and weaknesses of the selected alternative that FWS and the other agencies, particularly within the DOI, believe are important are included in Chapter V.

B. The Development of Evaluation Tools

A number of evaluation tools were used by the AET and ADT to communicate with each other and to evaluate the outputs of the SFWMM runs. These included the Natural System Model (NSMv4.5 Final), Conceptual Models, Performance Indicators, Performance Measures, River of Grass Evaluation Methodology (ROGEM), Across Trophic Level System Simulation (ATLSS), water quality tools, the Multi-Species Recovery Plan, scientific literature, and individual expertise. Each alternative was examined by the AET in light of the Existing Condition (1995 Base), and the Future Without Project condition (2050 Base) to ensure that progress was being made in the direction of restoration.

1. Natural System Model (NSMv4.5 Final). The NSMv4.5 Final simulates the hydrology of the Everglades under a more natural landscape. This model is based on the SFWMM with the man-made modifications to the landscape (including canals, structures, pumps, etc.) removed. All of the dominant hydrologic processes are included in this two-dimensional, integrated ground and surface water model. It covers many but not all of the areas of interest, the exceptions being the St. Lucie and Caloosahatchee basins, parts of western basin (west of State Road 29), Florida Bay, and Biscayne Bay. The NSMv4.5 Final runs on a daily time step using historical meteorological conditions for the period from 1965-1996 and illustrates the differences between the pre-drainage and the current, highly-managed systems. Greater spatial and temporal extent of surface water depths occurred under natural conditions and some of the deeper pools have relocated from the west side of the coastal ridge to the present-day Water Conservation Areas. Both ground and surface water flow volumes in all parts of the modeled area show significant differences in quantity and timing of flows throughout the Everglades basin. The NSM is useful as a conceptual goal, as a way to visualize the historic distribution patterns of flows, depths, and hydroperiods. Because the natural area is greatly reduced from historic conditions and has, in several ways, been irreparably altered, matching NSMv4.5 Final grid-for-grid in each location is neither practical nor advisable. Creating a system that mimics a scaled-down version of NSMv4.5 Final is also ill-advised because it is unlikely that a reduced version of the natural system would function the same way. During the formulation of alternatives 1-5, the provisional version of the NSMv4.5 was used in the SFWMM as the basis for the targets for many performance measures. When the final version of NSMv4.5 became available, Alternatives 3 through 6 and the two base conditions were rerun using NSMv4.5 Final and the alternatives were renamed Alternatives A through D.

2. Conceptual Models. Identifying targets for restoration for the south Florida ecosystem required many years of effort by a number of people associated with private organizations, government agencies and universities. In 1996, the Governor's Commission for a Sustainable South Florida completed a Conceptual Plan for the C&SF Project Restudy. This conceptual plan recognized the need for increased storage in the system, improved continuity in natural areas, adequate water quality, increased spatial extent, conservation of soils, protection and restoration of coastal estuarine and marine ecosystems, and control of invasive plants. In 1997, the Science Subgroup of the Working Group of the South Florida Ecosystem Restoration Task Force published a list of specific, measurable success criteria (Science Subgroup 1997). The group identified them to help design modeling and monitoring programs and to aid in the evaluation and reporting process. Some success indicators were considered to be “precursors” to restoration. These included hydropatterns, organic soil, nutrients, estuarine salinity patterns, and water clarity. The rest were considered “ecologic” indicators. These included landscape patterns and spatial extent (considered to be a precursor, as well), periphyton communities, coral reefs, contaminant body burdens, fish abnormalities, keystone and imperiled species, wading birds, fish populations and communities, and fish species.

Members of the Everglades Partnership conducted a Workshop on Ecological Sustainability Criteria for South Florida on April 25-26, 1996, at the University of Miami, with participation by natural and social scientists, representatives of public interest groups, and managers of government agencies. They reviewed the scientific basis for the selection of the Science Sub-Group’s indicators and broadened public and academic participation in the process. To implement the success criteria, they identified modeling, research, and monitoring needs and identified critical research issues that were impeding their evaluation. Although the Everglades partnership generally endorsed the Science Sub-Group’s selection of precursor and ecological indicators, the group recommended that clearer goals be established and that those goals eventually should form the basis for environmental “report cards,” which are considered the heart of annual reports of restoration success. They discussed the need for indicators to operate at different temporal and spatial scales to reflect the range of response times and levels of complexity within the C&SF Project. The group also addressed issues of societal preferences in the selection of important attributes of the system.

The group agreed on the need to form hypotheses around the system’s interactions that should be expressed in Conceptual Models to clarify the causal links between management options, precursor indices, and changes in ecosystem structure and function as expressed in ecological indices. Conceptual models, they believed, also would be an effective tool for describing and communicating these linkages to the public.

After the workshop, the group agreed to prepare a strategic plan to identify the roles of science in the planning, implementation, and evaluation phases of the restoration process. This strategic plan became the basis for the Adaptive Management strategy (Figure XIV-1)

Following the recommendations of the Sustainability Criteria Workshop, the Natural Systems Team (NST) subgroup of the Southern Everglades Restoration Alliance (SERA) and other *ad hoc* groups drafted a number of conceptual ecological models. A conceptual model as defined by the NST is a simple, non-quantitative model developed to build consensus on the most important ecological elements and linkages that characterize a stressed ecosystem. A conceptual model was drafted for most of the landscape types in the south Florida ecosystem, that defined the stressors, the effects of those stressors, and the attributes of the system that are important in illustrating the impacts of the stressors on the landscape. Conceptual models also identify performance criteria, also called performance indicators. For example, "low water levels (<11 ft)" are one of the stressors in the Lake Okeechobee conceptual model (Figure IV-1). The "effects" of low water levels include "exposure and drying of interior marsh, exposure and drying of shoreline vegetation, expansions of exotic and nuisance plants, loss of native plants and periphyton, and loss of desired invertebrates and forage fish. The "attributes" that exhibit the effects of low water levels are “fish and wildlife.”

Draft conceptual models were developed by the NST for Everglades Sloughs, Marl Prairies/Rocky Glades, Mangroves, and Florida Bay. Other *ad hoc* teams developed conceptual models for Lake Okeechobee, St. Lucie and Caloosahatchee Estuaries, Biscayne Bay, and the Big Cypress region. These conceptual models and their performance indicators were heavily relied upon by the AET team to develop performance measures to evaluate the set of base cases and alternative plans. Figures IV-1 and IV-2 illustrate the structure of two portions of the larger conceptual model for Lake Okeechobee-- those areas dealing with the extreme high water and extreme low water stressors, which were among the criteria for evaluation of the effects of the Restudy alternatives on Lake Okeechobee.

3. Performance indicators. Performance criteria and performance indicators, unlike performance measures described below, are usually recommendations for directional improvement and do not include quantitative targets. Performance indicators are means of measuring impacts of hydrologic conditions on different attributes of the system.

4. Performance measures. Performance measures were developed from performance indicators by identifying a specific target that defines the optimum condition. Hydrologic performance measures were based on the following: Outputs from the Natural Systems Model (NSMv4.5 Final) or other hydrologic modeling, information on optimizing the ecological attributes from the conceptual models, or best scientific evidence. Of the several hundred hydrologic performance indicators and measures developed to illustrate outputs of the SFWMM for each model run, a subset of performance measures was eventually selected that best represented the AET’s goals. Ecological performance measures were also developed for a number of species, guilds, and habitat types. Results of the AET’s analyses of these performance measures was posted on the Web site and formed the basis for: 1) the AET’s evaluation of alternatives in each iterative cycle of plan development, 2) the ultimate selection of the Initial Draft Plan (Alterative D13R), and 3) the DOI’s continual involvement in the process, leading to the findings of this report.

5. River of Grass Evaluation Methodology (ROGEM). ROGEM is a landscape-scale, habitat-based methodology, which yields outputs representing relative responses of wetland habitats to Restudy alternatives. ROGEM's methods and a preliminary set of equations were developed during the C&SF Reconnaissance Study and presented in the Reconnaissance Report (COE 1994). ROGEM uses a system-wide approach appropriate for a large, diverse study area. It focuses on hydrologic conditions within the study area and indicates relative habitat responses to changing hydrologic conditions resulting from project alternatives. ROGEM yields numeric output indicating relative habitat quality for each area and uses input from SFWMM and other models as available or appropriate (e.g. water quality). ROGEM, as used during the reconnaissance study, has been peer-reviewed through the SFWMD’s Expert Assistance Program. Because it operates at the landscape scale, ROGEM cannot be used to evaluate impacts at the species level (e.g. threatened and endangered species).

The classification of the different south Florida landscapes used in ROGEM was revised to be consistent with the Conceptual Models described above. A ROGEM analysis was prepared for each of the AET's sub-region teams. Each team developed hydrologic performance measures based on either their Conceptual Models, or, lacking them, on best professional judgement. Near the end of the iterative plan formulation process, sub-teams developed index variables based on the performance measures and combined them, weighting the elements they believed were most important or most indicative of restoration success. Most variables used spatial or temporal hydrologic data taken directly or post-processed from the South Florida Water Management Model (SFWMM). Equations also include some water quality and other appropriate variables. ROGEM outputs represent **quality** of fish and wildlife habitat on a 0 to 1 scale. The outputs are ordinal data with 1(one) representing optimum quality habitat and 0 representing worst quality habitat. Outputs show relative system-wide habitat responses to restoration plans. ROGEM was among the evaluation tools used by the AET to rank the relative performance of each alternative relative to the 2050 Base condition and to assess how closely each alternative approached its goals in each of the sub-regions.

ROGEM analyses were completed for Lake Okeechobee, freshwater marshes (Everglades), Big Cypress, Florida Bay, Southern Mangroves, Biscayne Bay, St. Lucie estuary, and the Caloosahatchee estuary.

The documentation for the ROGEM model used to evaluate effects of Restudy alternatives on Lake Okeechobee is provided at the end of this chapter.

6. Across Trophic Level System Simulation (ATLSS). Not every AET sub-region team represented a geographical landscape--the sub-teams for water quality and endangered/indicator species are examples. The endangered/indicator species subgroup reviewed the results of the Across Trophic Level System Simulation **(**ATLSS) model to gauge the effects of different restoration scenarios on biotic components of the south Florida ecosystem. ATLSS uses pseudo-topography to step down the 2-mile-by-2-mile grid scale of the SFWMM to 500 m or finer resolution. At this finer scale, a number of models are being developed at different trophic levels to capture the different scales that reactions to hydrologic changes can occur. Eventually, individual-based models and population-level models will be available for a wider, more representative set of animals. Currently, structured population-scale models exist for fish, macroinvertebrates, reptiles and amphibians. Individual-based, breeding potential or foraging potential models exist for the Cape Sable seaside sparrow, snail kite, wood stork, white-tailed deer and Florida panther. Model results for each alternative were compared to the results of the 1995 Base and to the 2050 Base to determine the effect of an alternative on a selected native species in south Florida. ATLSS has not been run using the NSMv4.5 Final due to the amount of uncertainty associated with defining pre-drainage vegetation patterns, but the results of such a model run would be welcomed by ecologists.

7. Water Quality Evaluation Tools. Other evaluations used the SFWMM output to assess potential effects of the Restudy alternatives on water quality. These include: 1) Lake Okeechobee Water Quality Model, 2) Everglades Water Quality Model, and 3) Dr. William W. Walker's water quality performance measures. Complete descriptions of these evaluation methods are available at the following Web sites:

Name of Evaluation Method	World Wide Web Address
Lake Okeechobee Water Quality Model	http://141.232.1.11/org/erd/osr/projects/lowqmweb/indexwq.html
Everglades Water Quality Model	http://141.232.1.11/org/erd/esr/projects/ewqm/restudy/java
Dr. William W. Walker's water quality performance measures	www2.shore.net/~wwwalker/restudy/index.htm

8. Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida. Recovery plans are prepared by the U.S. Fish and Wildlife Service. They delineate reasonable actions that are believed to be required to recover and/or protect listed species. The Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida (1998) identifies the recovery needs of 68 species that are listed as threatened or endangered pursuant to the Endangered Species Act of 1973, as amended (16 U.S. C. 1531 *et seq)*. Of these 68 species, 59 depend on the success of the South Florida Ecosystem Restoration Initiative. Each alternative plan was evaluated to determine not only its possible impacts to listed species, but its potential to recover them.

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Editorial Note: The following pages provide examples of a ROGEM analysis using hydrology-based performance measures for Lake Okeechobee. The figures that follow illustrate those portions of the Conceptual Model for Lake Okeechobee that relate to the extreme high water and extreme low water stressors.

Priority Hydrologic Performance Measures for Lake Okeechobee
Authors: K. Havens (SFWMD), L. Manners (COE), R. Pace (FWS)

Five priority performance measures are calculated, weighted and summed using the River of Grass Evaluation Model (ROGEM) for Lake Okeechobee. The Lake Okeechobee ROGEM is comprised of metrics (Suitability Index Variables, or SIVs) that concern the fluctuation and timing of lake stages. These variables exert major controls over ecosystem structure and function. Fluctuation and timing of lake stages affect the distribution of native and exotic plant communities, and in turn the habitat quality (cover, nesting sites, foraging habitat) for fish, birds, and other wildlife (Aumen 1995). The ROGEM assumes that restoration of a more natural (within the constraints of the dike system) hydroperiod would result in positive biotic responses of the lake community.

Each SIV ranges from 0 (worst score) to 1.0 (best score). Relationships between hydrologic attributes and SIVs in this model are not linear, but reflect expert opinion that the degree of ecosystem stress is exacerbated by an increasing occurrence of undesirable events. This gives rise to a curvilinear relationship between hydrologic attributes and their SIVs. At a certain point (considered here to be 4 events or more per decade), the degree of stress is so severe that the ecosystem cannot recover its ecological and societal values.

An extreme low lake stage (<11 ft) performance measure ($\mathbf{SIV_{MINX}}$) indicates the frequency of events that result in a loss of over 95% of the littoral zone as habitat for aquatic biota, and promote expansion of exotic plants into pristine native-plant dominated regions of the lake. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

Lake stage never falls below 11 ft = 1.0
Lake stage falls below 11 ft on 1 occasion per 10 yrs = 0.9
Lake stage falls below 11 ft on 2 occasions per 10 yrs = 0.7
Lake stage falls below 11 ft on 3 occasions per 10 yrs = 0.4
Lake stage falls below 11 ft on 4 or more occasions per 10 yrs = 0

A moderate low lake stage (<12 ft) performance measure ($\mathbf{SIV_{MINM}}$) indicates the frequency of prolonged (>12 continuous month) events that substantially reduce the littoral area available as wildlife habitat, and promote exotic plant expansion. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

Lake stage never falls below the 12 ft / 12 month criterion = 1.0
Lake stage falls below the 12 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
Lake stage falls below the 12 ft / 12 month criterion on 2 occasions per 10 yrs = 0.7
Lake stage falls below the 12 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
Lake stage falls below the 12 ft / 12 month criterion on 4 or more occasions per 10 yrs =0

An extreme high lake stage (>17 ft) performance measure (**SIV$_{MAXX}$**) indicates the frequency of events that may cause wind and wave damage to the shoreline plant communities, and transport phosphorus-laden pelagic water into pristine interior regions of the littoral zone. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

Lake stage never exceeds 17 ft = 1.0
Lake stage exceeds 17 ft on 1 occasion per 10 yrs = 0.9
Lake stage exceeds 17 ft on 2 occasions per 10 yrs = 0.7
Lake stage exceeds 17 ft on 3 occasions per 10 yrs = 0.4
Lake stage exceeds 17 ft on 4 occasions per 10 yrs = 0

A moderate high lake stage (>15 ft) performance measure (**SIV$_{MAXM}$**) indicates the frequency of prolonged (>12 continuous months) events that may: limit light penetration to the lake bottom, resulting in a loss of the benthic plants and algae that stabilize sediments and provide habitat for invertebrates and fish; and promote greater circulation of phosphorus-rich turbid waters from mid-lake to less eutrophic near-littoral regions, where phosphorus inputs stimulate algal blooms. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

Lake stage never exceeds the 15 ft / 12 month criterion = 1.0
Lake stage exceeds the 15 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
Lake stage exceeds the 15 ft / 12 month criterion on 2 occasions per 10 yrs = 0.7
Lake stage exceeds the 15 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
Lake stage exceeds the 15 ft / 12 month criterion on 4 occasions per 10 yrs = 0

A spring recession performance measure (**SIV$_{VAR}$**) indicates the number of years during which January to May lake levels decline from near 15 ft to 12 ft, without any reversals greater than 0.5 ft. These conditions appear to be favorable to nesting birds and other wildlife in the marsh. They also may allow for re-invigoration of willow stands, and permit fires to burn away cattail thatch. The goal is to have a substantial number of events. The performance measure score is calculated as follows:

Stage recession between January and March from ~15 ft to ~12 ft NGVD, with no reversal greater than 0.5 ft NGVD, occurring every yr = 1.0
Stage recession occurring only in 9 out of 10 yrs = 0.9
Stage recession occurring only in 8 out of 10 yrs = 0.7
Stage recession occurring only in 7 out of 10 yrs = 0.4
Stage recession occurring only in 6 or fewer out of 10 yrs = 0

SIV Priority Weights

The five SIVs address important aspects of how water level and its seasonal variation affects the intrinsic ecological (e.g. habitat for wading birds and federally endangered species) and societal (e.g. recreational fisheries) values of Lake Okeechobee. However, the five SIVs are not considered of equal importance in regard to indicating an absolute level of stress (or benefit). A weighting scheme was developed, on the basis of best professional judgement, to reflect the relative importance of each SIV as an index of lake ecosystem health. For simplicity, a weighting scale of 1 to 5 (1 being least important, and 5 being most important) is used.

The SIVs associated with the >17 ft and >15 ft / 12 month criteria are given priority weights of 5. Extreme or prolonged high water levels have been documented to affect numerous ecosystem attributes, including: littoral plant and periphyton communities; benthic plants and periphyton; fisheries habitat; and water quality (including turbidity, phosphorus, and algal blooms). These effects are well documented by scientific research (Sheng and Lee 1991, Havens 1997, Steinman *et al.* 1997).

The SIVs associated with the <11 ft and <12 ft / 12 month criteria are given priority weights of 4. Extreme or prolonged low lake stages also may cause harm to the ecosystem, but the impacts are less documented and are not considered as serious on a lake-wide basis, that is, the effects primarily are restricted to the littoral zone proper, and negative impacts (e.g., loss of fisheries habitat) may in part be compensated for by enhanced growth of submerged plants in the southern near-shore pelagic region.

The SIV for spring lake level recession describes a seasonally-variable hydro-pattern that is considered by experts to benefit a variety of littoral zone values, including wading birds and certain native plant communities (Smith *et al.* 1995). It is the only SIV that relates to seasonal variation in lake levels and that variation is considered by experts (Havens and Rosen 1997) to be critical for a healthy ecosystem. However, there is a high degree of uncertainty in scoring the spring recession attribute. For example, do recession events that occur slightly earlier or later than the designated optimal (January-May) period have equal or lesser benefit to the community? Do recession events that occur over higher or lower ranges of water depth than the designated optimum (15 to 12 ft) have equal or lesser benefit to the community? There are no clear answers to these questions, and therefore, until further research results are available, the SIV associated with this attribute is given a weighting of 3.

Integrated Scoring

A Community Suitability Index (CSI) integrates the scores of five hydrologic SIVs and their respective weighting factors, and has an overall range of 0 to 1.0. The weighted CSI model is:

$$\mathbf{CSI} = (4*SIV_{MINX} + 4*SIV_{MINM} + 5*SIV_{MAXX} + 5*SIV_{MAXM} + 3*SIV_{VAR}) / 21$$

Table IV-1. Example of the results of the ROGEM analysis for Lake Okeechobee. Evaluation of Alternatives A through D, D13R, and the revised 1995 and 2050 base conditions.

Variables	95Base		50Base		ALT A		ALT B		ALT C		ALT D		ALT D13R		WEIGHT
	#	Value	#	Value	#	Value	#	Value	#	Value	#	Value	#	Value	
SIV min-x (Extreme Low Stage, <11')	3	0.4	4	0	2	0.7	2	0.7	1	0.9	1	0.9	1	0.9	4
SIV min-m (Prolonged Low,< 12' for 12 mo.)	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	0	1	0	1	4
SIV max-x (Extreme High Stage, > 17')	2	0.7	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	5
SIV max-m (Mod.Stage, > 15' for 12 mo.)	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	5
SIV var (Spring Lake Level Recession)	2	0	2	0	3	0.7	3	0.7	4	0.7	4	0.7	4	0.7	3
Weighted CSI	0.6		0.6		0.8		0.8		0.9		0.9		0.9		

CSI = ((SIV min-x * 4) + (SIV min-m * 4) + (SIV max-x * 5) + (SIV max-m * 5) + (SIV var * 3)) / 21

K.Havens (SFWMD), L. Manners (COE), R. Pace (FWS) - June 1998

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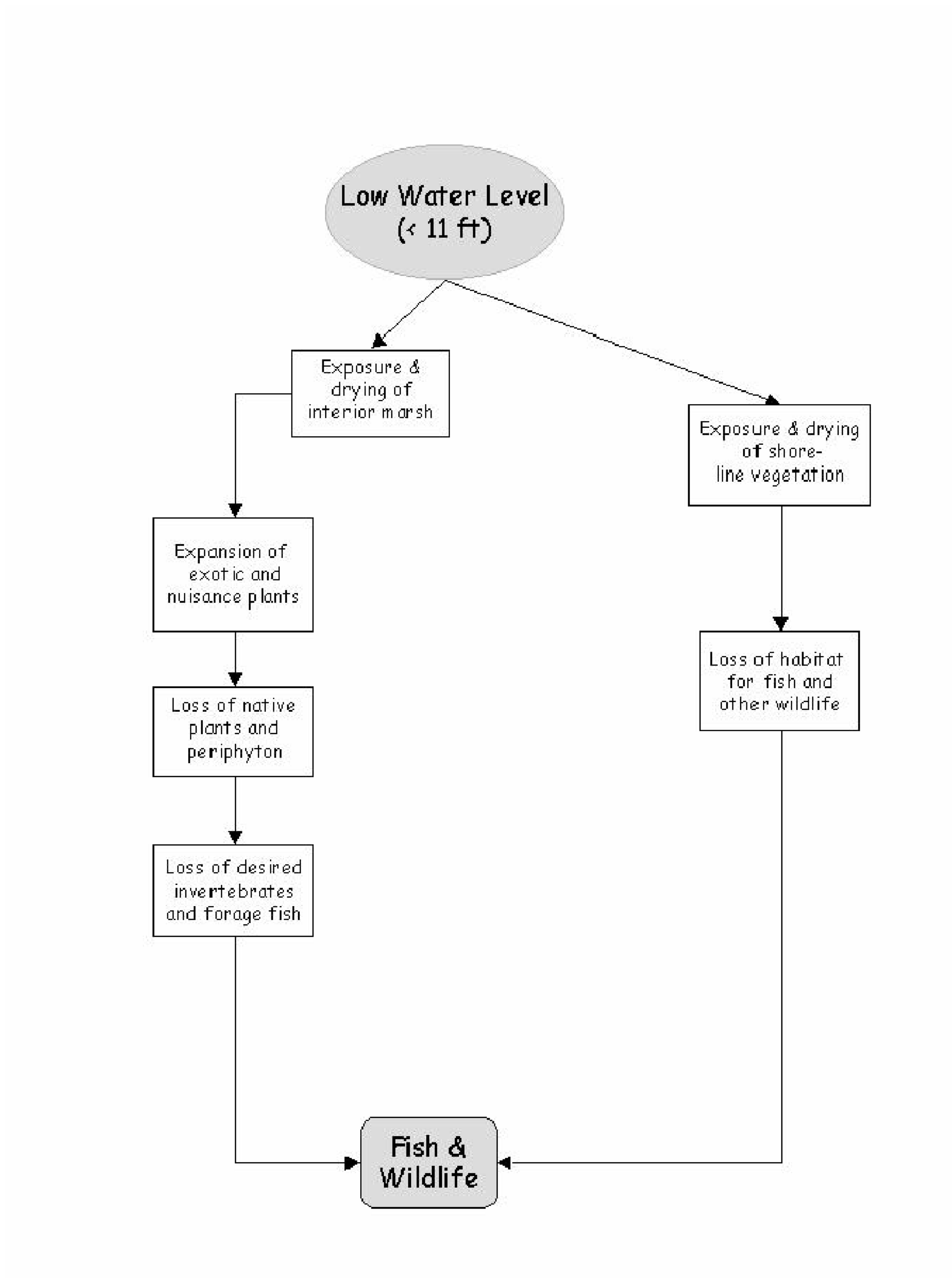

Figure IV-1. A portion of the conceptual model for Lake Okeechobee dealing with the effects of low water levels on fish and wildlife (from Karl Havens, SFWMD).

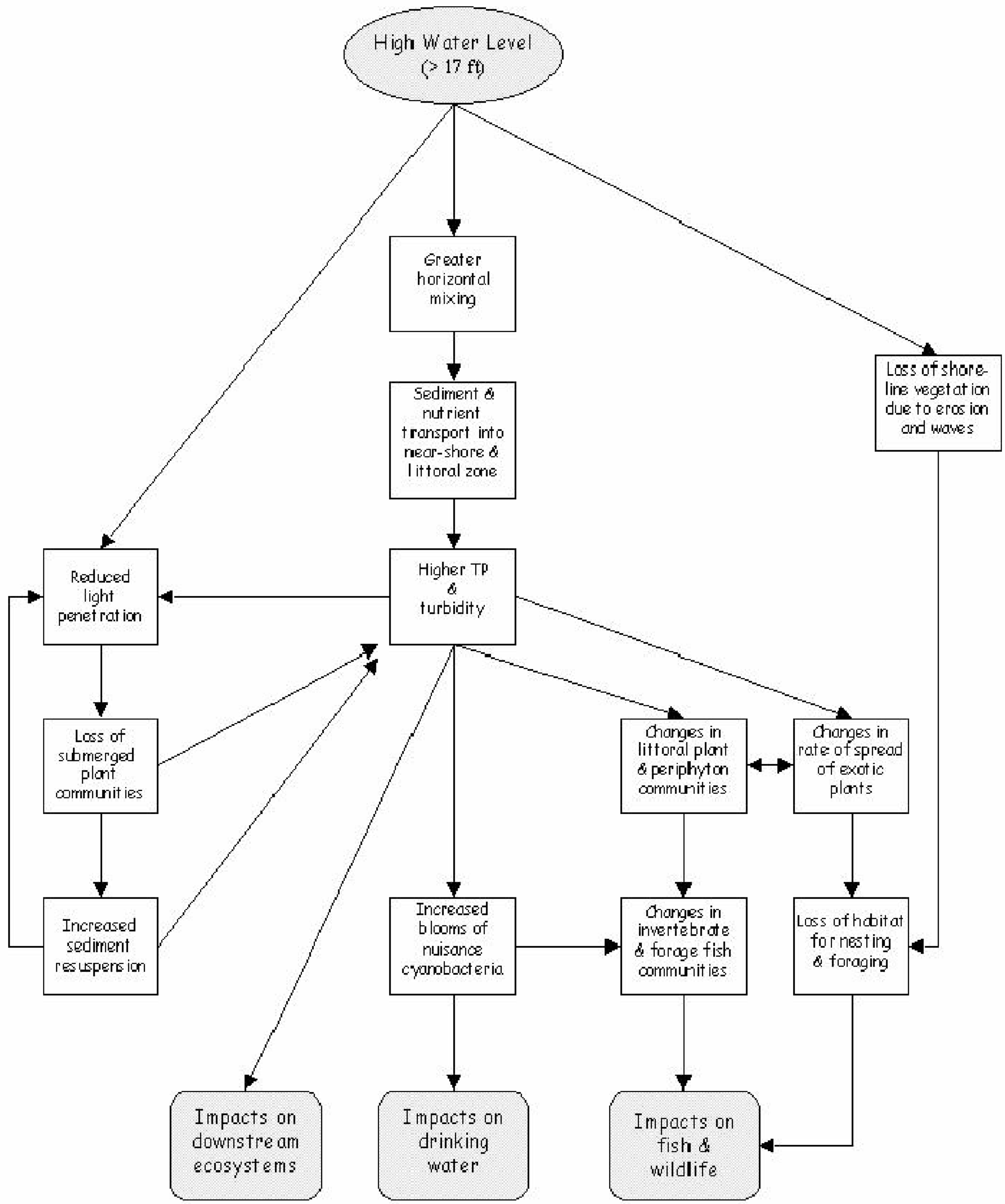

Figure IV-2. A portion of the conceptual model for Lake Okeechobee dealing with the effects of high water on fish and wildlife (from Karl Havens, SFWMD).

CHAPTER V -- ANALYSIS OF ALTERNATIVES

Summarized from the reports of the AET Sub-region Chairs

A. Threatened, Endangered, and Indicator Species (ATLSS Model Results)

Information on threatened and endangered species is presented in Chapter XVI of this report. Indicator species analyzed through the ATLSS modeling included a fish, white-tailed deer, and wading bird models. The following information summarizes impacts the C&SF Restudy will have on these indicator species.

1. Fish The ATLSS fish model results have consistently predicted higher overall fish abundances as flow volume and inundation duration have moved closer to NSM conditions. Based on these previous results, we can make some general predictions for Alternative D13R. Alternative D13R hydrologic conditions should produce average fish abundances higher than those expected for 2050 Base as expected hydroperiods increase consistent with NSM. In particular, increased hydroperiods in northeast Shark River Slough, Taylor Slough, WCA 3B, northeast WCA 3A, and Loxahatchee NWR should lead to greater fish abundance. This should also be true when only prey-sized fish at appropriate wading bird foraging depths are counted except for the deepest parts of Shark River Slough and WCA 3B.

2. White-tailed Deer Since ATLSS white-tailed deer results are not available for Alternative D13R, predicted effects on deer must be inferred from the ATLSS high resolution hydrology results and other sources. A review of performance measures for WCA 3A and 3B indicator regions shows that Alternative D13R reduces many of the excessive high water conditions and excessive inundation durations that had caused concern for eastern WCA 3A, southern WCA 3A and WCA 3B in several previous alternatives. These improvements should provide slightly better foraging conditions and reduced drowning losses for white-tailed deer in WCA 3 under Alternative D13R as compared to Alternative D. Overall, increased hydroperiods in most of the WCAs and northeastern Big Cypress under Alternative D13R as compared to the 2050 Base would likely slightly decrease habitat quality in these marginal deer habitats. Small areas of northeastern and southern WCA 3A and the Big Cypress-ENP border area are exceptions. Alternative D13R continues progress towards NSM-like conditions in most of ENP and would be expected to continue to produce reduced white-tailed deer habitat suitability in many already poor deer habitats for this region. For those few areas with high deer breeding potential (Long Pine Key and surrounding short hydroperiod marsh and northwest Big Cypress), there is little difference between Alternative D13R and the 2050 Base.

3. Wading Birds Since ATLSS wading bird results are not available for Alternative D13R, predicted effects to wading birds must be inferred from the ATLSS high resolution hydrology results and other sources. A review of performance measures for WCA 3A and 3B shows that Alternative D13R reduces many of the excessive high water conditions and excessive inundation durations that had caused concern for eastern WCA 3A, southern WCA 3A and WCA 3B in several previous alternatives. These improvements should provide relatively larger areas suitable for wading bird foraging and decreased flood-induced losses of wading bird nesting substrates in WCA 3 under Alternative D13R as compared to Alternative D. When compared to the 2050 Base, Alternative D13R provides mixed results for wading birds in WCA 3, with improvements in southern WCA 3A (due to reduced high water) and in northern WCA 3A (due to reduced drydowns), and losses in northeastern WCA 3A and WCA 3B (due to increased high water).

Hydrologic performance measures for the southern Everglades and for Florida Bay also indicate that Alternative D13R better matches natural conditions in these areas than other Alternatives. The improvement in the timing and duration of freshwater flows to Florida Bay estuaries and improved timing of fish-concentrating drydowns should lead to better wading bird foraging and breeding conditions in the southern Everglades under Alternative D13R relative to both base cases. Greater fish abundances expected under Alternative D13R, as compared to the 2050 Base, also suggest improved foraging conditions for wading birds.

B. Lake Okeechobee

Chapter IV provided the ROGEM equations for Lake Okeechobee as an example of an evaluation used by the AET.

The Initial Draft Plan appears to improvements conditions in Lake Okeechobee and its littoral zone. Both the 1995 Base and the 2050 Base had summary scores of 0.6 in the ROGEM analysis. These scores would be characterized as fair to poor in overall performance. All of the Restudy alternatives improved on these scores. Alternatives A and B had identical scores for all variables in the ROGEM equations; summary scores for these simulations improved to 0.8, through reduction in the number of extreme low water stages and an increase in the number of years when the water recession in spring is considered to be favorable to foraging by wading birds. Alternatives C, D, and D13R had identical scores for all of the ROGEM variables, with 3 of the 5 indices as high as those for Alternatives A and B, and with the remaining 2 indices higher. The two improved indices were those for avoidance of extreme low water and avoidance of moderately low water lasting more than 2 years. The summary ROGEM scores for Alternatives C, D, and D13R were 0.9, which we believe would achieve very favorable hydrologic conditions for fish and wildlife habitat in the lake's littoral zone. However, based on results from a model scenario in which the ASR component around Lake Okeechobee was removed, we believe that this level of success in reaching ecological targets is partially dependent on the feasibility of that feature. Should ASR at this scale prove to be infeasible, we expect that the ecological benefits would be significantly reduced. The COE has not completed sensitivity analyses on the Initial Draft Plan, which should include an evaluation of the effect of the inability to use large-scale ASR around Lake Okeechobee.

C. Estuaries - Caloosahatchee and St. Lucie Estuaries; Lake Worth Lagoon

The estuaries, bays, and lagoons of south Florida are the ultimate receiving waters for the flows retained and rerouted by the C&SF Project. Currently, groundwater and surface water flows to coastal waters are generally reduced with altered hydroperiods. To a large degree, surface water input is currently intercepted and delivered through regulated canals that are characterized by high amplitude and short duration storm flows during the wet season; and low base flow during the dry season. Abnormally high flows contribute to poor water quality with increased turbidity, color, and altered salinity levels that directly affect estuarine seagrasses by reducing light penetration necessary for photosynthesis and destroying wildlife, fish, and invertebrate habitat. Minimum levels of inflow and nutrients usually occur in April and May, at the end of the dry season, when juvenile fish depend on an abundant food supply of phytoplankton and zooplankton, which requires a minimum level of freshwater and nutrients.

1. Caloosahatchee Estuary The Restudy project alternatives were evaluated with performance measures based on flow needed to support optimum hydrologic conditions conducive to optimum quality habitat for fish, wildlife, and other aquatic resources in the Caloosahatchee estuary. The targets are based on model outputs of natural variation that would have occurred during the period 1965-1995 as well as on desirable salinity conditions for existing and potential aquatic resources within the estuary. A summary of the measures evaluated, the results, and recommendations are provided below.

Performance Measure- number of dry season months (November-May) that the mean monthly flow was less than 300 cfs from C-43 and Lake Okeechobee at S-79: The target number of months not to be exceeded, and considered better for estuarine aquatic biota, is 60 times for the 1965-1995 period. This should maintain sufficient minimum mean monthly flows from the lake in order to maintain favorable salinities and water quality within the estuary. Insufficient fresh water discharges contribute to poor estuarine water quality including inadequate fresh water to maintain desirable salinity envelopes. Allowing the estuary to become too saline has produced adverse effects on estuarine seagrasses, fish and invertebrates, including critical indicator species, e.g. *Vallisneria.*

Performance Measure- number of months of mean monthly flow greater than 2,800 cfs as measured at S-79. High volume discharges to the estuary contribute to poor estuarine water quality including increased turbidity, color and violation of favorable salinity envelopes. High flow events have direct effects on estuarine seagrasses by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat, and contributing to unfavorable salinities for aquatic vegetation, fish and invertebrates, including critical indicator species, e.g. the American oyster, turtle grass, and *Vallisneria*. The optimum scenario would have no more than 22 months of mean monthly flows of greater than 2,800 cfs during the simulation period. This should reduce high volume discharge events to the estuary and improve estuarine water quality to benefit estuarine vegetation, invertebrates, and fish communities.

Performance Measure- number of months mean monthly flows were greater than 4,500 cfs at S-79 for the 1965-1995 period. This is to reduce the occurrence of extreme discharge events and improve water quality in the lower estuary, including San Carlos Bay, in order to protect estuarine resources. Mean monthly flows above 4,500 cfs result in freshwater conditions throughout the estuary causing impacts to biota. This volume of flow also degrades water quality and adversely impact biota in San Carlos Bay. The total allowable number of monthly violations indicate that the optimum condition is to have no more than 6 months of mean monthly flows of greater than 4,500 cfs during the simulation period.

Performance Measure- number of days Lake Okeechobee Regulated Discharges from Zone A greater than 7,800 cfs. Zone A discharges have rapid and serious effects on estuarine seagrasses in the Caloosahatchee estuary and San Carlos Bay by reducing light penetration necessary for photosynthesis. Zone A discharges destroy fish and invertebrate habitat and contribute to unfavorable salinities for estuarine biota, including critical indicator species, e.g. the American oyster, *Vallisneria*, and other vegetation. The target is zero violations in order to reduce the occurrence of extreme discharge events from the lake to the estuary, improve estuarine water quality, and protect estuarine aquatic biota. Furthermore, the results of hydrologic modeling of the period 1965-1995 indicate that no daily flows greater than 7,800 cfs would have occurred.

An evaluation of the performance measures for each project alternative indicated that Alternatives A through D13R all score 1.0 on a scale of 0.0 to 1.0. Any of the alternatives would be considered very good for the Caloosahatchee Estuary. All the alternatives greatly exceed the target values set in the performance measures (except for regulatory releases which meets the target). Furthermore, Alternatives A through D13R show major improvements over the 1995, which scored 0.0, and the 2050 Base, which scored 0.1. One footnote is that D13 predicted better flows overall for the estuaries in southwest Florida than did D13R. The flow dynamics should be modeled to determine the cause of the apparent flow decrease.

2. St. Lucie Estuary The Restudy alternatives were assessed with performance measures based on the flow needed to provide optimum hydrologic conditions for optimum quality habitat for fish, wildlife, and other aquatic resources. Flow targets are based on natural variation that occurred during the period 1965-1995 as well as on desirable salinity conditions for existing and potential aquatic resources within the estuary. The St. Lucie estuary receives fresh water both through inter-basin transfer from Lake Okeechobee and from local watershed contributions. Inflow problems can be divided into two categories: 1) high inflow events, when large regulatory releases from the lake and/or the watershed cause poor estuarine water quality and 2) maintaining dry season base flows. Minimum levels of inflow and nutrients usually occur in April and May, at the end of the dry season, when juvenile fish depend on an abundant food supply of phytoplankton and zooplankton, which require a minimum level of fresh water and nutrients.

With regard to the first type of inflow problem, fish with tumors, lesions, and scale and other deformities have historically been present in the St. Lucie River and at least four fish disease events have been noted since 1979 that appear to correlate to high discharges from Lake Okeechobee. In early 1998, when the wet winter caused releases out the C-44 canal to reach a peak of 8,500 cfs, a disease event occurred with lesioned fish concentrated around the St. Lucie estuary. About 28 species of fish were reported with lesions, including mullet (*Mugil cephalus*), shark (subclass Elasmobranchii), bluegill (*Lepomis macrochirus*), gray snapper (*Lutjanus grisues*), bluefish (*Pomatomus saltatrix*), tuna (*Thunnus sp.*), snook (*Centropomus undecimalis*), red drum, spotted sea trout (*Cynoscion nebulosus*), and channel catfish (*Ictalurus punctatus*). No extensive fish kills were recorded, but rather a chronic disease situation appeared related to a toxic dinoflagellate, *Cryptoperidiniopsis.* The exact relationship between the dinoflagellate and discharges and water quality is not proven at this time. To address the second type of inflow problem, appropriate inflows to the estuary which produce a favorable salinity range were determined based on the requirements of submerged aquatic vegetation (SAV) and oysters. Surface water flows coming from the watershed and ground water should be in the range of 350 cfs to 1,600 cfs. Performance measures are described below.

Performance Measure- number of months with mean monthly flow less than 350 cfs for the 1965-1995 period. The objective is to maintain adequate mean monthly flows in order to maintain favorable conditions for estuarine organisms. This includes the importance of fresh water and nutrient input into the system in the appropriate quantity and timing to support primary and secondary productivity. Insufficient freshwater discharges during the dry season contribute to reduced estuarine productivity. For the estuary to act as a nursery for juvenile fish, plankton populations should be at a high enough density for fish to easily feed. The optimum scenario would have no more than 50 months of mean monthly flows of less than 350 cfs during the simulation period..

Performance Measure- number of months with mean monthly flows greater than 1,600 cfs as measured from the lake and the watershed for the 1965-1995 period of record. This is to reduce high volume discharge events to the estuary and improve estuarine water quality to protect and enhance estuarine habitat and biota. Recent analysis has determined that mean monthly flow should not frequently exceed 1,600 cfs. As flows exceed this limit, the salinity is reduced below desirable levels for some estuarine resources. These events have direct effects on SAV by reducing light penetration necessary for photosynthesis, degrading fish and invertebrate habitat, and contributing to unfavorable salinity concentrations for aquatic vegetation, fish and invertebrates. The optimum scenario would have no more than 9 months of mean monthly flows greater than 1,600 cfs.

Performance Measure- number of months with mean monthly flows greater than 2,500 cfs for the 1965-1995 period. The objective is to reduce the occurrence of extreme discharge events and improve water and sediment quality in the estuary to protect estuarine vegetation, invertebrates, and fish communities. Mean monthly flows above 2,500 cfs result in freshwater conditions throughout the estuary, producing severe impacts to estuarine biota. This volume of flow begins to impact the Indian River Lagoon to the north and south of the St. Lucie inlet. The optimum condition is to have no more than 3 months of mean monthly flows greater than 2,500 cfs.

Performance Measure- number of days with Lake Okeechobee Zone A discharges greater than 7,200 cfs per day at S-80 for the period 1965-1995. Zone A discharges transport large amounts of sediment and result in freshwater conditions within the entire estuary. These events can have rapid and serious effects on estuarine SAV by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat. They contribute to unfavorable salinity concentrations for most aquatic life, including the American oyster and SAV, as well as contributing to the occurrence and severity of fish diseases. These large volume discharges also cause adverse effects on large areas of the Indian River Lagoon surrounding the St. Lucie inlet and possibly influence nearshore ocean habitats adjacent to the inlet. Prolonged Zone A discharges result in even greater damage to the various ecosystems and more widespread adverse effects. Because of the magnitude of Zone A releases on the environment, this variable is the highest priority of the four performance measures. The objective is to eliminate extreme discharge events from the lake to the estuary, and improve estuarine water quality in order to protect existing and potential habitat for estuarine vegetation, invertebrates, and fish communities. No Zone A discharges of this magnitude are desirable. Furthermore, the results of hydrologic modeling of the period 1965-1995 indicate that no daily flows of greater than 7,200 cfs would have occurred during this period.

Alternatives A through D13R each scored 0.8 on a scale of 0.0 to 1.0. There is very little difference between Alternatives A through D13R for the St. Lucie estuary, although Alternative D13R performed slightly better due to the increased storage in the basin which will attenuate more flood flows. The basin runoff results in all alternatives are still about four times greater than their targets but regulatory release and low-flow targets were almost met.

3. Lake Worth Lagoon The performance measure used to evaluate Restudy project alternatives to Lake Worth Lagoon was wet/dry season average flows discharged through S-40, S-41, and S-155 for the 31 year simulation. The restoration target is to create estuarine conditions, to the extent possible, in the Lake Worth Lagoon. An estuarine salinity envelope of 23 ppt to 35 ppt was chosen as the target salinity range as it is a viable range for a number of organisms, many of which are commercially and important for recreation. To attain these salinities, a maximum flow of 500 cfs was predicted from hydrodynamic modeling to create a salinity of 23 ppt. To achieve a 35 ppt salinity, 0 cfs is the target because enough ground water enters the estuary to still allow these estuarine conditions.

Alternatives A, B, C, D were ranked with Alternative B best, followed by Alternative C, then Alternative D and Alternative A, with the 2050 Base coming in last. After closely examining the model output, the minimum flow performance criteria for Alternative D has a number of small releases that are above 0 cfs, but small enough so that they do not affect the salinity. So in actuality Alternative D is probably tied with Alternative C in the ranking. Alternative B was given a grade of "B", Alternatives C and D were graded a "C", Alternative A received a "D", and the 2050 and 1995 Bases were both graded "F." After reviewing the model output, it appears that Alternative D is probably very close to receiving a grade of "B". Alternative D13R has the same numbers as Alternative D and so would be ranked and graded the same.

D. Northern and Central Everglades Region

1. Evaluation Methods Model results for each alternative were evaluated at the level of individual indicator regions. Scores were then aggregated into spatially- and hydrologically-distinct groups. The final evaluation classified these indicator regions into ten sub-regions that correspond areas with distinct hydrologic performance. These are described in the AET's final report.

Initially, evaluations were based on five performance measures, with each measure containing one or two component variables. However, after inspection of initial scores, two of these were dropped resulting in the following performance measures and variables: 1) inundation pattern (variables - number and mean duration of inundation periods), 2) extreme high water (variables - number and mean duration of high water events), and 3) extreme low events (variables - number and mean duration of low water events).

Target variable values for the performance measures were those predicted by NSMv4.5 Final, with the following exceptions: 1) in Indicator Region 17, performance was evaluated by comparing values to the average of NSM values for Indicator Regions 14 and 18, 2) in Loxahatchee NWR, the targets were defined as the 1995 Base values, in keeping with the Refuge's current regulation schedule, 3) for high water extremes, the performance target was modified to be consistent with the number and duration of events less than or equal to NSM values, and 4) for low water extremes, the performance target was the minimization of the frequencies and duration of events.

Index values were developed for each performance measure and indicator region in order to simplify comparison of the alternatives. Indices were used as a basis for ranking Alternatives A through D relative to each other and the 2050 Base. For each performance measure and indicator region, indices were rounded to the nearest tenth and then ranked from 1 to 5, with ties given the mean of the tied ranks. These ranks were averaged across indicator regions (using spatial weights) and were also averaged across the three performance measures. Ranks for each alternative and the 2050 Base are presented in the AET's final report.

It was determined that the indices and ranks described above do not allow for a ecological interpretation of each alternative due to the largely arbitrary numeric scale. A separate evaluation was prepared for this purpose. Each performance measure for each indicator region was evaluated using best professional judgement of sub-team members as to the ecological consequences of the predicted performance. The sub-team then assigned each indicator region a color score of green, yellow, or red for each performance measure, with green assigned to a model performance if it predicted conditions expected to promote a sustainable Everglades marsh community. This color scheme is described in more detail in the AET's final report.

2. Sub-region Evaluations for Alternatives A through D13R

a) Loxahatchee NWR (Indicator Regions 26 & 27) (green). Loxahatchee performs well in Alternatives A through D13R, matching targets defined by the 1995 Base. The number and duration of extreme low water is reduced in each case, an improvement over the drier conditions predicted for the 2050 Base. The number and duration of high water events are also reduced compared to the 2050 Base, in fact, the alternatives meet performance targets for extreme high water. . There is some uncertainty about the effect of high water on tree islands in southern LOXAHATCHEE NWR, however, overall, the alternatives conform to current hydrologic management objectives for the refuge.

b) Holey Land and Rotenberger WMAs (Indicator Regions 28& 29) (green). These areas perform nearly identically in Alternatives A through D13R. The regulation schedule for Rotenberger WMA appears to eliminate high water extremes effectively while maintaining suitable inundation patterns. In Holey Land, extreme depths over 1.75 ft occur only rarely and the frequencies and durations of extreme low water are less than those predicted by NSM. There is uncertainty about the minimum conditions needed to protect peat soils but as long as the alternative provides dry season deliveries via the STAs, it should be possible to adjust operational details so as to avoid further soil loss in these areas.

It should be noted that in Holey Land WMA, differences in performance relative to the 1995 and 2050 Bases do not provide a realistic comparison with the alternatives because the bases assumed a 0-2' regulation schedule that is not currently in use, nor is it likely to be implemented in the future. Hence, the sub-team evaluation in this area was restricted to comparisons with target values.

c) WCA 2A (Indicator Regions 24 & 25) (yellow). In general, Alternatives A through D13R exhibit problematic performance in WCA 2A compared to the 2050 Base and it is uncertain whether these conditions would lead to a sustainable healthy marsh in the future. Generally, model results are poor in northern WCA 2A (Indicator Region 25) and mixed in southern WCA 2A (Indicator Region 24).

Inundation patterns in northern WCA 2A were much longer. NSMv4.5 Final predicts that northern WCA 2A dried out approximately every year, yet Alternatives B through D13R predicted dry-outs to occur less than once every three years on average. In southern WCA 2A they were similar to NSM in all four alternatives.

Both southern and northern WCA 2A failed to meet target values for extreme high water conditions. In all of the alternatives, high water conditions in the north were similar to the 2050 Base, but in the south, conditions were slightly worse. Although extreme high water events occurred only 1% of the time in the alternatives, the duration of those events was greater than NSMv.4.5 predictions. Alternatives A and D13R were less extreme than Alternatives B through D and the differences may or may not be significant, but they cannot be said to be an improvement over the 2050 Base.

Extreme low water events were also reduced in Alternatives A through D compared to the 1995 Base and the 2050 Base. Alternative D13R showed four additional low water events over the period of record in the southern part of WCA 2A, a situation that would not protect peat soils. Overall, northern WCA 2A has a very non-NSM-like hydropattern and southern WCA 2A has exaggerated extreme high water conditions and lengthy hydroperiods. Together, they create uncertainty about future marsh conditions in this area. It appears that there are trade-offs between the northern and southern parts of WCA 2A that may be solved by operations. In one interim scenario that preceded Alternative D13R, operations of WCA 2 were tailored to improve innundation patterns in the south. It worsened extreme high water conditions in the north. In another scenario, WCA 2A, was operated to improve conditions in the north. It worsened high water problems in the south. More detailed design is needed to determine if a balance can be achieved that promotes sustainable marsh conditions in both the north and the south.

d) WCA 2B (Indicator Region 23) (red). Although this area had good NSM-like innundation patterns as a result of the alternatives, problems with extreme high water, extreme low water, or both, caused it to fail to meet the targets. Alternatives B through D13R reduced high water extremes over both the 1995 and 2050 Bases but depths greater than 2.5 ft still occurred 10-11% of the time, far from the NSM value of 1%. The subteam concluded that although Alternatives B, C, D and D13R show significant improvement relative to both the 1995 and 2050 Bases, the frequent occurrence and long duration of extreme high and low water make it unlikely that this area would function in a sustainable manner as either a shorter- or longer-hydroperiod Everglades wetland. More attention needs to be given to this area during detailed design.

e) Northwestern WCA 3A (Indicator Regions 20 & 22) (green). Although Alternative C performed slightly better, Alternatives A through D13R performed better than the 2050 Base and much better than the 1995 Base on all performance measures. In Alternative D13R, inundation patterns match NSM planning targets, high water extremes are minimal and low water extreme events are much improved over the 95 and 2050 Bases. There remains some concern that the area represented by Indicator Region 20 may still be likely to experience more extreme low water than will be sufficient to protect peat soils. However, it may not be possible to further reduce low water events without causing trade-offs such as increased risk of cattail proliferation in ponded areas.

f) Northeastern WCA 3A (Indicator Region 21) (yellow). This area has a problem with a tendency toward both too much high and low water, a problem none of the alternatives completely solved. For inundation pattern, Alternatives B, C, D and D13R were close to NSM, with Alternative D13R most closely matching target values.

The frequency of high water events is greater in all alternatives, except for Alternative A, than in the 1995 and 2050 Bases. This increase raises concerns about potential negative effects on wading bird nesting habitat in this region. Changes in STA operations, additional storage, or re-routing of flood waters might alleviate or reverse this negative impact for some rookery sites.

Low water events are a problem whenever protection of peat soils is desired and the best target for this area is the one with the fewest extreme low water events. For extreme low water events, the 2050 Base has fewer events than NSM, although the duration of the events is same. While all alternatives were improvements over the 1995 Base, only Alternative A was better than both the NSM and 2050 Base. Alternative B was worse than both the 2050 Base and NSM. The rest of the alternatives, Alternatives C, D and D13R, were in between: they did better than NSM targets but had a few more events than the 2050 Base. While Alternatives A and D13R performed the best of the alternatives in reducing low water extremes relative to both base cases, the predicted frequency and duration of low water events still seems large and may not insure protection of peat soils.

g) Eastern WCA 3A (Indicator Region 19) (yellow). None of the alternatives approached NSM targets in this region. The area east of the Miami Canal and south of Alligator Alley is deeply ponded in both 1995 and 2050 Bases and remains so in all four alternatives. High water extremes are most notable in this area. All alternatives show substantial improvements over the 1995 Base but not necessarily over the 2050 Base. Alternative A predicts an improvement over the 2050 Base. Alternative B was similar to the 2050 Base and Alternatives C and D showed greater depths for longer periods than the 2050 Base. High water extremes, however, are dramatically reduced in Alternative D13R relative to Alternative D although the target is still far from matching the NSM target of 0% high water. This may be the result of changes in operations and retention of a portion of L-67A canal, which allows more rapid removal of water from this area. Overall, the eastern WCA 3A is far from reaching its target values. However, unlike the predictions for WCA 2B, extreme high water is not combined with an increased frequency of extreme low water events. Therefore the sub-team scored this area as yellow rather than red.

g) Central and Southern WCA 3A (Indicator Regions 14, 17, & 18) (green/yellow). In the southern and central WCA 3A, Alternatives A, B, and D13R performed reasonably well and Alternatives C and D performed poorly. Alternative A best matched target inundation patterns throughout this region, with performance very similar to the 2050 Base, however the frequency of high water events in Indicator Region 14 was slightly elevated. Alternatives B and D13R, by reducing the frequency of high water events, eliminated flooding of tree islands during high rainfall years. While Alternatives B and D13R show increased inundation durations, with fewer marsh dry-outs than NSM, especially within Indicator Regions 17 and 18, these plans meet the important target for tree island communities because of the greatly reduced frequency of extreme high water events.

h) WCA 3B (Indicator Regions 15 & 16) (yellow). In this area, only Alternative A approaches the inundation pattern predicted by NSMv4.5 Final. The other alternatives predict fewer drydowns and longer periods of inundation than the 2050 Base. The effect of very lengthy periods of inundation on WCA 3B is uncertain.

Alternative A met the targets for high water extremes and Alternative D13R significantly reduced the frequency of events enough to prevent damage to higher hammock tree islands; impacts on less-elevated tree islands still may occur in Alternative D13R. For extreme low water events, all the alternatives were better than 2050 Base, the best being Alternative D13R, but all had either a few more events or events of slightly longer duration than the NSM targets. Given the removal of the eastern L-29 levee in Alternatives C, D, and D13R, combined with the restoration of long hydroperiods and deeper water in northeast Shark River Slough, it appears inevitable that water depths and inundation durations in WCA 3B will increase.

i) Pennsuco Wetlands (Indicator Regions 52& 53) (green). Inundation durations are significantly increased relative to both the 95 and 2050 Bases although the overall inundation pattern in Alternative D13R differs from NSM predictions. High water extremes are also rare and occur much less frequently than under NSM. In general, Alternative D13R predicts "NSM-like" ridge and slough conditions with reduced drought frequencies. This would be expected to protect marsh soils and provide for a sustainable marsh for this area. Extreme low water occurs infrequently in Alternative D13R, which represents an improvement over Alternatives A through C and a dramatic improvement over both the 95 and 2050 Bases.

3. Summary of Evaluation

Alternative D13R appears to provide the best overall performance for the WCA system. While all the alternatives perform well with respect to alleviating excessive drought conditions that have damaged peat soils, Alternative D13R provides the best overall reduction in extreme high water conditions that would flood out tree island vegetation communities, especially in southern WCA 3A and WCA 3B. Thus, Alternative D13R appears to make substantial progress toward solving the two most significant problems that have resulted from the C&SF Project in this region of the Everglades.

Two notable areas of uncertainty remain, however. One of these is the effect on wading bird populations of changes in depth patterns in northeastern WCA 3A. Although overall restoration of the Everglades watershed is expected to improve wading bird nesting habitat regionally, the timing of development of suitable breeding sites to the south, relative to changes in current nesting sites, could have significant effects on regional wading bird populations. A more detailed analysis of anticipated effects of Alternative D13R on wading bird breeding and foraging habitat, combined with a plan for system-wide monitoring, will be important components in implementing the plan.

The second major area of uncertainty is the effect of a shift in the overall hydrologic pattern toward longer periods of inundation with fewer drying events than those predicted by NSM. The best overall match to NSM inundation patterns is Alternative A, where it appears that maintenance of the WCAs as compartments provides more control over water depths in different sections of the Everglades. With partial decompartmentalization such as that in Alternatives B and D13R, exact matches to local NSM predictions for the Indicator Regions in WCA 3 no longer appear to be possible, given the reduced overall extent of the Everglades watershed north of Tamiami Trail. Hence, the benefits of decompartmentalization in promoting sheetflow and reducing the frequency and duration of flooding appear to conflict with the ability of water management to match local NSM targets. In considering this apparent trade-off, the sub-team concluded that the long-term sustainability of the northern and central Everglades marshes probably depended more on the avoidance of extremes of drought and flood than on exact restoration of local pre-drainage hydroperiods. Only Alternatives B and D13R manage to avoid extreme high water in southern and central WCA 3A, and only Alternative D13R accomplishes this in WCA 3B as well.

In conclusion, Alternative D13R provides inundation patterns that are "NSM-like" and that seem likely to promote a sustainable Everglades ecosystem. There nonetheless remain many uncertainties about the biological response that will occur, and these uncertainties can only be overcome by a suitable plan for adaptive management that will allow timely and informed changes in water management as deemed necessary to promoting biological restoration goals.

E. Southern Everglades Region including Florida Bay Coastal Basins

1. Shark River Slough

The NSMv4.5 Final characterized Shark River Slough as a predominately aquatic system that was continually flooded and flowing during wet and dry seasons for wet years and in all but the most extreme dry years. The Everglades Slough Conceptual Model used the following performance measures for ecological restoration: 1) duration of uninterrupted flooding, 2) drought severity as measured by the duration of dry conditions, and 3) water depth during periods of flooding. Two additional performance measures that were also considered are the total annual flow volume and the seasonal distribution of that flow in Mid-Shark River Slough.

Alternatives A through D showed improvement compared to the over-drained base conditions in Shark River Slough, with Alternative D demonstrating a markedly higher level of achievement of performance measures. However, Alternative D fell short of the performance targets for the Slough when performance was averaged over the three indicator regions (northeast, middle, and southwest). The extended duration of dry conditions lowered the achievement index for that performance measure to 36% for the slough as a whole. As an example, the dry periods in northeast and middle Shark River Slough averaged three weeks longer in Alternative D than the three- to four-week duration indicated by NSMv4.5 Final. The overall achievement index for the performance measures for Shark River Slough under Alternative D was 64%. The AET determined that a 60% achievement of hydrologic performance measures does not provide adequate assurance that the ecological values identified would be restored under an alternative plan. This represents the case for Alternative D for Shark River Slough. In addition, Alternative D only partially restores hydrological and ecological conductivity of the Slough to its upstream reaches in WCA 3A due to the presence of western levee L-29.

Performance measures for the evaluation of Alternative D13R in the southern Everglades were the same as those used to evaluate Alternative D with one exception. The mean duration of dry conditions, which was used as a measure of drought severity in Shark River Slough, was replaced by the number of dry events during the period of record to compare Alternative D to Alternative D13R.

For Shark River Slough, Alternative D13R was successful in reducing the number of dry events during the period of record in order to closely approach the frequency indicated by NSMv4.5 Final. This reduction represented an 89% achievement of this restoration target for the Slough as a whole. However, the mean duration of uninterrupted flooding in Alternative D13R fell short of the NSMv4.5 Final values, resulting in an 76% achievement of this restoration target for the slough. This compares to a 25% achievement under the 1995 Base and 29% under the 2050 Base.

Alternative D13R also increased the mean water depth during periods of flooding in northeast, middle and southwest Shark River Slough, which allowed it to achieve 79% of the NSMv4.5 Final restoration target compared to 58% achievement under the 1995 Base and 67% under the 2050 Base.

The overall achievement index for the performance measures in Shark River Slough under Alternative D13R was 82% compared to 28% under the 1995 Base and 38% the 2050 Base. A 0.8 achievement of the hydrologic performance measures is considered to provide **reasonable assurance** that the ecological values identified in the Everglades Sloughs Conceptual Model would be restored under Alternative D13R in Shark River Slough. Additional confidence in Alternative D13R is gained for reaching these restoration goals due to the increased connectivity between the slough in Everglades National Park and its upper reaches in WCA 3 as a result of the removal of L-29.

2. Rockland Marl Marsh

NSMv4.5 Final characterized the Rockland Marl Marsh as a seasonally flooded system where water levels typically dropped below the ground surface during most years, except during prolonged high rainfall periods when the marsh remain flooded for multiple years. The Marl Prairie/Rocky Glades Conceptual Model identified three priority hydrologic performance measures for the ecological restoration of the Rockland Marl Marsh. These include: 1) duration of uninterrupted flooding, 2) drought severity as measured by the duration of dry conditions and depth below ground surface, and 3) the number of wet season water level reversals in which the depth drops to less than 0.2 feet during a period of flooding.

Alternatives A-D all showed improvement over the over-drained base conditions, with Alternative D more successful in achieving restoration targets. The average duration of uninterrupted flooding increased to 32 weeks, compared to 12 weeks under the 1995 Base and 23 weeks under the 2050 Base. The number of wet season water level reversals was reduced to three in 31 years. Dry conditions lasted an average of 24 weeks. These targets are very close to NSMv4.5 Final conditions. Overall achievement index for the performance measures in the Rockland Marl Marsh under Alternative D was 83% compared to 22% for the 1995 Base and 60% for the 2050 Base.

Alternative D13R prolonged the mean duration of uninterrupted flooding in the Rockland Marl Marsh to 30 weeks as compared to the NSMv4.5 Final duration of 44 weeks. This represented an achievement of 68% of the NSMv4.5 Final target. The number of wet season water level reversals was reduced to four under D13R. Dry conditions in the Marsh lasted an average of 21 weeks as compared to 26 weeks under NSMv4.5 Final.

The overall achievement index for the performance measures in the Rockland Marl Marsh was 76%. A 0.8 achievement of the hydrologic performance measures is considered to provide **reasonable assurance** that ecological values in the Marl Prairie/Rocky Glades Conceptual Model would be restored under Alternative D13R in the Rockland Marl Marsh.

3. Florida Bay Coastal Basins

The performance measures for recovery/enhancement of ecological conditions in Florida Bay are represented by the 5 coastal basins in or near Florida Bay as mentioned above. These performance measures use output from the SFWMD Model's predicted mean monthly salinity for the various basins in Florida Bay based on P-33 Stage/salinity relationships. The high and low salinity targets for these basins have been documented in the conceptual models. Two time periods were evaluated: the dry to wet transition period (March-June) and the wet season (August-October). The dry-wet transition is critical for the health of many organisms in Florida Bay including spotted seatrout, snook, red drum, tarpon and pink shrimp. Salinity changes/variation at this time of the year are considered much more important than salinity fluctuations during the wet season because salinities are at their highest and can change most rapidly as the wet season begins. Cumulative salinity differences were calculated for the Dry/Wet transition and wet season and compared to their departure from NSM and ranked. The method of calculating coastal salinities from P-33 stage needs to be integrated with rainfall in future, detailed analyses. Additional salinity transfer studies to address inland hydrology are planned during fall 1998.

NSMv4.5 Final characterized the Florida Bay coastal basins as estuarine environments that experience low to moderate salinity well below seawater concentrations the majority of the time. Four priority performance measures for the ecological restoration of the Florida Bay coastal basins are identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model. All of these performance measures are based on relationships between mean monthly salinity in five coastal basins. The performance targets are to reduce cumulative salinity differences to values that do not exceed the cumulative differences produced by NSMv4.5 Final.

The 1995 Base indicated primarily high salinity conditions and very few low salinity events, which produced a shift in the estuarine environments of the coastal basins to more marine conditions. The 2050 Base revealed only a slight improvement over the 1995 Base. High salinity events were less frequent, but low salinity events were also less frequent under the 2050 Base.

Alternatives A through D all substantially improved salinity regimes in the Florida Bay coastal basins with each alternative nearly equal effective in overall performance. The performance of Alternative D approached restoration targets for the coastal basins for three of the four performance measures. The overall achievement index for the performance measures under

Alternative D was 78% compared to 20% for 1995 Base and 30% under the 2050 Base. However, a similar index, rounded off to 0.8 was also attained for Alternatives A through C.

Under Alternative D13R, the reduction in the number of high salinity events achieved 88% of the NSMv4.5 Final restoration target compared to 48% achievement under the 1995 Base and 69% under the 2050 Base. For low salinity events, Alternative D13R was successful during 18 months of the period of record (when P33 stages rose to 7.3 msl). Although this increase in the number of low salinity events resulted in a 60% achievement of the NSMv4.5 Final target under Alternative D13R, this is much improved as compared to 23% under the 1995 Base and only 7% under 2050 Base. The **cumulative** salinity difference from concentrations that marked high salinity events during March-June decreased to 660 under Alternative D13R as compared to the NSMv4.5 Final target of 440. However, the cumulative salinity differences from concentrations that marked low salinity events during August-October under Alternative D13R was 1025 as compared to the NSMv4.5 Final target of 525, representing a 60% achievement.

The overall achievement index for the performance measures in the Florida Bay coastal basins under Alternative D13R was 80% compared to 20% under the 1995 Base and 50% for the 2050 Base. A 0.8 achievement of the hydrology/salinity performance measures is consider to provide **reasonable assurance** that the ecological values identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model would be restored under Alternative D13R in the Florida Bay coastal basins.

F. Big Cypress

1. Discussion

Given the poor topographic data in this region and the problems with the western part of the area being too near the boundary of the models, outputs of the NSMv4.5 Final and SFWMM, particularly depth estimates, should be viewed with caution. In order to best analyze the impacts of Restudy alternatives the Big Cypress subregion was divided into three major geographic areas which include North Big Cypress, South Big Cypress and Southeast Big Cypress. These three areas have distinct responses to the various Restudy alternatives.

All of the effects on the North Big Cypress occurred in Alternatives C and D, and were retained in D13 and D13R. The effects resulted from filling the L-28 Interceptor Canal and removing its western levee, creating openings for water to move south along the Western Feeder Canal, and replacing S-190 with a pump station to maintain upstream drainage. This scenario also required some sort of water treatment capability to assure that all water moving south and southwest from the upstream canal system would provide only clean water. These components converted an area about two cells wide for most of the length of the L-28 Interceptor along its western side to approximately NSMv4.5 Final conditions.

The most significant changes to South Big Cypress, occurred in Alternative D, with the removal of the L-28 Tieback Levee. With this structure removed, hydrologic conditions showed almost complete restoration to NSMv4.5 Final conditions, including restored hydroperiods and increased flows across the eastern portion of the Big Cypress. The model results for D13 and D13R were almost identical to one another, and both showed generally small but distinct increased deviations from NSMv4.5 Final. When looking at the hydrologic responses to these alternatives for individual performance measures and indicator regions, the geographic area where the deviations were greatest was in the vicinity and downstream of the Dade-Collier Transition and Training Airport (Jetport). We have not evaluated how the Jetport is modeled in the SFWMM, and it is possible that the fill associated with it may be extensive enough such that flows through this area are blocked under the hydrologic conditions that exist in Alternative D13.

In southeastern Big Cypress, along its border with the Everglades and below Tamiami Trail, the most significant changes occurred in Alternative B, when the L-28 and L-29 levees and canals were removed. According to the model, there were larger areas showing reduced hydroperiods and the reductions in hydroperiods and flows were greater than in Alternatives A, C, or D, all of which were close to NSMv4.5 Final condition. In Alternative C, the L-28 and only the western portion of L-29 were restored, which was sufficient to return conditions in this area close to NSMv4.5 Final. The removal of the L-28 Tieback in Alternative D did not seem to affect this portion of the Big Cypress. Alternatives D13 and D13R produced generally small and variable responses among the various performance measures.

2. Summary

The combination of components in Alternative D produced the greatest benefits in terms of restoring the largest amount of area in the Big Cypress to approximately NSMv4.5 Final conditions. It also seems that several of the most beneficial components could be implemented in any of the Alternatives, since they operate almost independently from the rest of the Everglades ecosystem. This would be the situation for the L-28 Interceptor and L-28 Tieback components. Changes to the L-28 South and L-29 have more extensive and complex interactions with other parts of the Everglades.

G. Biscayne Bay

1. Analysis of model outputs For the Restudy, Biscayne Bay is bounded by Snake Creek to the north (Oleta River State Park) and Biscayne National Park to the south. The influence of proposed water management alternatives on Card and Barnes sounds to the south of Biscayne Bay is considered as part of the Model Lands. Biscayne Bay has been classed as a shallow, tidal, bar-built estuary (Kohout and Kolipinski 1967). The salinity gradient that established estuarine habitat in Biscayne Bay is dependent on both surface and groundwater flows (Fatt and Wang 1987). Before 1910, freshwater input came through numerous coastal streams, sloughs, and springs and from wet season sheetflow to the tidal zone. Currently, groundwater and surface water flow to the bay is reduced and hydroperiods have been altered. Surface water input to the bay is now intercepted and delivered through 14 regulated canals that are characterized by high amplitude, short duration storm flows during the wet season and low base flow during the dry season when hypersalinity has been observed as a result of evaporation, retention of canal flow, and bay circulation (Lee 1975).

The effects of salinity changes have been documented for fish (e.g. Davenport & Vahl 1975, Provencher *et al.* 1993, Serafy *et al.* 1997) and for invertebrates (e.g. Brook 1982, Montague and Ley 1993, Irlandi *et al.* in press). The presence and operation of the canals and construction of permanent oceanic inlets has resulted in a loss of estuarine function and shifted Biscayne Bay to more of a lagoon system, adversely impacted from freshwater pulses and highly variable salinities. These conditions have been at least partly responsible for the loss of historically abundant estuarine species, such as red drum (*Sciaenops ocellata*), black drum (*Pogonias cromis*), and eastern oyster (*Crassostrea virginica*), the loss of juvenile fish habitat, and the significant increase in stress-tolerant fish species such as the gulf toadfish (*Opsanus beta*) (Serafy *et al.* 1997). In addition to loss of species, many fishes in the bay exhibit tumors and deformities which may result from water and/or sediment quality factors.

Biscayne Bay ecosystem restoration plans were initially considered by the South Florida Water Management District in a planning process that resulted in a water management plan, Surface Water Improvement and Management Plan for Biscayne Bay (SWIM Plan, Alleman 1995). This document clearly outlines the rational for: 1) reducing excessive canal discharges by flow management, 2) providing a stable brackish water habitat during the wet season, and 3) providing more water during dry periods to prevent hypersaline conditions from impacting important marginal wetlands and nearshore habitats. Based on this plan and the consensus of government resource managers and university researchers, performance measures that would promote restoration of the Biscayne Bay ecosystem were established to permit evaluation of Restudy water management alternatives.

Performance measures were developed based on the potential effect of water management alternatives on surface water reaching Biscayne Bay which was divided into five regions from north to south. The regions were Snake Creek, North Bay, Miami River, Central Bay, and South Bay. The flow targets consist primarily of the existing average annual inflow to Biscayne Bay as defined by the 1995 Base, with a 2% increase in total inflow budget to be applied in the dry season to the Central and South Bay regions. A separate target for Snake Creek was also developed based on canal discharge that would maintain salinities for oyster survival.

The ranking of alternatives in terms of supplying surface water to Biscayne Bay assumes all components, especially the use of ‘re-use’water in Alternatives C and D, are present. This refers to ‘re-used’water or tertiary-treated domestic wastewater to replace water that will be withdrawn from the existing water management plan. The assumption that is implicit is that ‘re-used’water will be available and appropriate for use in a valuable, pristine, marine environment that sustains Biscayne National Park. The subteam recommends that additional feasibility studies be pursued and completed before evaluating the proposed alternatives.

Biscayne Bay currently receives surface water in amounts that will, when properly distributed, permit partial restoration of the coastal ecosystem. Scores that are less than 1.0, as occurs in all the alternatives, indicate that performance measures are not meeting the targets established for Biscayne Bay. Alternative D13R performs the best in terms of available water, but in terms of total bay inflow, Alternative D13R does not improve conditions for restoration compared to 1995 Base conditions. As such, none alternatives as they are currently proposed appear to achieve restoration of Biscayne Bay.

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H. Model Lands/C-111 Area

Alternative scenarios for the Model Lands were evaluated using six performance indices as follows.

High water index: The proportion of time that water levels are below the high water threshold when water levels are so high that they may stress the vegetation communities naturally characteristic of these areas.

Low water index: The proportion of time that water levels are above the specified low water threshold so that the period of time that water levels are below a specified low water level are minimized.

Extreme low water index: The proportion of time that water levels less than 1 ft below the specified low water threshold.

Relative dry period slope index: Relative measure of the steepness of the slope of the stage duration curve during dry periods.

Wet Season Inundation Pattern Index: Proportional measure of how many times during the 31-yr simulation that water levels drop below surface elevation during the July-October portion of the wet season.

Late Wet Season Inundation Index: Proportional measure of how many times during the 31-year simulation that autumn periods of inundation ended during the months of November and December. This index was applied only to Model Lands South, which includes habitat critical for roseate spoonbill (*Ajaia ajaja*) feeding. A good year for wading bird feeding would be characterized by water standing well into January. Premature drydowns in the early dry season in this region may severely reduce available food to support roseate spoonbill nesting.

Overall, alternatives that added water to this region yielded higher scores than alternatives that did not. Alternatives B, C, and D consistently scored higher than the base conditions or Alternative A. There were differences among the indicator regions, however, in which alternative produced the best results. Alternatives C and D were the configurations resulting in the greatest benefits to the region as a whole and are preferred to Alternative B for that region. A design that benefits the entire region is preferred to one that benefits only a part of it. Furthermore, should an additional source of high quality water be identified in the future, Alternatives C or D will provide the infrastructure necessary to distribute this water throughout the Model Lands area. Regional managers are already attempting to reduce artificial hydrological barriers between these indicator regions and manage the entire area as a connected system.

Although Alternatives C and D improved conditions in the region as a whole, these alternatives still did not reach stated targets. Water levels were below the low water thresholds more than half the time in all four indicator regions of the Model Lands.

The configuration and operation changes from Alternative D to D13 to D13R made no difference to hydrologic conditions in the Model Lands-C111 Area. There were no changes in any of the performance indices from D to D13 or D13R. According to the performance indices, the water needs of the Model Lands-C111 Area still are not met, although conditions will be improved if either Alternative D, D13, or D13R are implemented.

Many concerns should be addressed in the detailed design phase. Additional water is needed for the Model Lands-C111 Area. Furthermore, the quality and quantity of some of the water provided to the South Dade area in Alternative D13R must be confirmed. Some of the benefits in Indicator Regions 5 and 6 may have originated from the regional use of advanced treatment wastewater to maintain canal stages in South Dade, but this option may prove too costly or too impractical to implement.

The benefits of having higher water levels in the Model Lands-C111 Area are clear. Alternative sources of water should, therefore, be identified and investigated as part of the design process. The specific location and design for the water delivery system need to be carefully considered to minimize impacts to existing high quality wetlands and avoid disrupting the natural system with excessive infrastructure. To maximize benefits, an effort should be made to improve the design to ensure that the best configuration of components has been achieved.

I. Water Quality Team

The water quality team evaluated eight sub-regions in south Florida for its water quality ranking matrix contained within the AET's final report. Alternatives A, B, C, D, D13R along with the 1995 and 2050 Bases were evaluated from a water quality perspective. Due to a lack of model results (particularly the Everglades Landscape Model), alternative plans could not be ranked based upon an empirical evaluation of water quality impacts or benefits in Big Cypress National Preserve and the Holey Land and Rotenberger Wildlife Management Areas.

The limited availability of modeling tools, by default, restricts the number of pollutants that can be evaluated for water quality concerns. Performance measures for the sub-regions primarily included hydraulic/phosphorus loads and total flows. Chlorophyll *a* was also evaluated for Lake Okeechobee (median and maximum concentrations).

The water quality team determined that the base conditions and alternative plans should not be ranked using EPA's preliminary mercury model results since the model requires further development. It is believed that atmospheric deposition is the dominant contributor of mercury in the Everglades Protection Area and alternative plans are not expected to significantly affect mercury levels for this region.

The matrix presented in water quality team's report contains several important footnotes. For example, for many of the performance indicators evaluated for Lake Okeechobee, the **differences** between simulated conditions for the alternatives is within the uncertainty of the model and are

not statistically significant. However, the water quality team felt it was important to rank the alternative plans for Lake Okeechobee from a water quality perspective.

The cumulative score presented in the matrix indicates that Alternative D13R received the highest score and represents the preferred alternative plan from a water quality perspective. The changes made to Alternative D to create Alternative D13R provided significant improvements to the ENP and St. Lucie watershed sub-regions. The scores within the matrix indicate these improvements. The Water Conservation Areas (WCAs) received a higher ranking for the 2050 Base and in Alternative A due to the increases in flow volumes to the WCAs for the other alternative plans. This increase in flow will increase loads of any potential pollutants. However, the overall score for the WCAs was not statistically different between the alternatives for WCA 2A, WCA 2B, and WCA 3B. For WCA 2A, Alternatives B through D13R ranked equally and were improved over both the 2050 Base and Alternative A. For WCA 3A, structural loads of total phosphorus were reduced in Alternatives D and D13R, which produced a higher overall score for both of these alternatives.

Both the Lower East Coast sub-region and the Caloosahatchee watershed were ranked equally between Alternatives D and D13R, both of which are preferred over the other alternatives. Loxahatchee National Wildlife Refuge received equal scores for all of the alternative plans but all were preferred over both the 1995 and 2050 Bases.

J. Total System

There are three total system performance measures that look at large-scale attributes of the natural system. Because many of the barriers to flow were removed in Alternative D13R, performance in all three measures was improved significantly over the 2050 Base condition.

1. Continuity This performance measure addresses the differences in water surface elevations on either side of major artificial barriers in the remaining. Artificial barriers tend to create markedly different water regimes on their upstream and downstream sides. Water usually pools on the upstream side causing the area downstream to become drier. Water quality parameters also may differ widely. Smaller species that do manage to cross a barrier may find inhospitable conditions on the other side. Larger species such as wading birds that feed at particular depths for example, may have to travel much further to feed. The target condition is water elevation differences across each barrier similar to that predicted by the NSMv4.5 Final. Differences of more than one depth class from NSM predictions are considered poor.

Performance was improved in Alt D13R over the 2050 Base for two reasons: 1) upstream pooling effects disappeared when barriers like Miami Canal, Tamiami Trail and L-28 were removed and, 2) water flows more evenly throughout the system than it did in the 2050 Base.

2. Sheetflow Vast expanses of sheet flow characterized the pre-drainage system. The slow-moving water ensured water quality and stored water in the wet season for gradual during the dry season. In the managed system, both the directions of flow and the flow volumes were altered significantly. Gradual flows through WCAs were replaced by large areas of ponded water, often with increased depths. Other areas received less than their due, for example, flow volumes through major sloughs decreased. The direction of flow is known to given tree-islands in interior marshes their tear-drop shape. In some areas, the direction of flow in the managed system runs perpendicular to those islands.

The sheetflow performance measure looked at flow volumes across a number of transects situated throughout the remaining natural area. Both flow volumes and general directions of flow were improved in Alternative D13R over the 2050 Base. Flows volumes across Tamiami Trail increased 92% over 2050 Base. The proportion of flows crossing the Tamiami Trail line east of the L-67 vs. west of L-67 improved as well. In the NSMv4.5 Final, the proportion of flows east/west was 62%. The proportion improved from only 11% in 2050 Base to 55% in Alternative D13R. In addition, flows through southern WCA 3A increased from only 62% of NSMv4.5 Final volumes in the 2050 Base to 110% of NSMv4.5 Final in Alternative D13R **without** causing excessive high water events. Lastly, flows in western WCA 3A were spread more evenly into the dry season in Alternative D13R, preventing the premature dry season drydowns seen in the 2050 Base.

3. Fragmentation In its effort to control flood waters and provide water supply, the C&SF Project created miles of canals and levees that fragment the natural landscape. Canals and levees usually coexist; construction of a canal usually means a spoil levee exists alongside it just as a levee requires a borrow canal. Roadways usually involve combinations of levees and canals, sometimes with culverts to allow water to flow underneath. In some places, multiple canals, levees and water control structure form intricate patterns and prove formidable barriers to wildlife.

When levees block the flow of water, they also restrict the movement of aquatic and semi-aquatic life forms in the water. Land-based predators use the levees to invade the marsh interior, preying upon animals that attempt to cross the intrusive fingers of terrestrial habitat. Canals act as corridors particularly for non-native animals and plants that can extend their ranges rapidly from points of introduction and can move into wetlands where they can alter habitats and affect food webs (Loftus and Kushlan 1987, Loftus 1986). Artificial, deep-water habitats provide thermal and spatial refuge to large numbers of both non-native and native aquatic predators in the dry season, enhancing their survival and ultimate population sizes. During the dry season, these predators prey heavily on small marsh fishes and invertebrates moving in from the adjacent wetlands (Howard *et al.* 1995).

This performance measure compared the number of miles of canals and levees in the different plans to those in the base condition. In Alternative D13R, which represents a significant decompartmentalization scenario, the number of miles of canals was reduced by 40% and levees by 20% compared to the 2050 Base.

4. Summary Alternative D13R improves some important landscape-scale parameters of particular interest to ecologists. Improving hydrologic connectivity should create more natural interspersion of habitat types by equalizing the depth patterns in areas now characterized by high contrasts in depths. Improving sheetflow is expected to ensure high water quality and normalize the distribution of water and depth patterns throughout the system. Reducing fragmentation should reduce the ease with which exotic species invade the inner marshes and expand the ranges of a number of native species.

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CHAPTER VI -- OTHER PROJECT ELEMENTS

Betty Grizzle, Steve Peacock, Robert Pace, and others, FWS

A. Introduction

Other Project Elements (OPEs) are defined by the following criteria: 1) the project must be a component or feature that cannot be evaluated using the SFWMD Model, 2) the project must support and be consistent with the C&SF Restudy objectives, 3) the project must have federal interest, and 4) the project should not be a stand-alone research or data collection project. The COE has also identified Critical Projects within this OPE list. Critical projects have been identified as those projects that are essential to the success of the Restudy. Once these projects are evaluated, they are authorized for approval and funding through COE Headquarters after which an abbreviated one-year feasibility study is conducted. A NEPA review and design study is then initiated. Once the NEPA process is completed, the project undergoes a detailed plan and specification phase, leading to contract award and construction.

This chapter presents a description of OPEs and evaluations for benefits to trust resources that have been proposed for the C&SF Restudy. The list of projects was provided by the COE and was compiled from three sources: the Governor's Commission for a Sustainable South Florida Conceptual Plan, the Critical Project nomination list, and the Restudy Team. The narratives are organized by regions of southern and southwest Florida as described in previous sections of this report. During this evaluation process, it was discovered that some projects on the original OPE list had no contact or reference information available. Therefore, it was determined that there was insufficient information to provide an evaluation of some projects. In addition, some originally proposed projects were found to be contained within either the 2050 Base or in all of the alternative plans under consideration for the Restudy (e.g. East Coast Canal Structures which is Restudy Component T6) and therefore will not be evaluated as OPEs.

Two documents that were frequently consulted for this evaluation, the Governor's Commission for a Sustainable South Florida conceptual plan for the C&SF Project Restudy (1996) and the Science Subgroup Report (1993) will be referenced in this introductory section rather that repeatedly throughout the narrative section.

Governor's Commission for a Sustainable South Florida. 1996. A conceptual plan for the C&SF Project Restudy. Governor's Commission; Coral Gables, Florida.

Science Sub-Group of The South Florida Management and Coordination Working Group. 1993. Federal objectives for the south Florida restoration.

An evaluation matrix, Table VI-1, was developed for the OPEs discussed in this section of the report and can be found at the end of the OPE discussion. Figure VI-1 represents a general location map for these OPEs. As stated previously, the FWS felt it was necessary for each of the OPEs to be assessed based on benefits to trust resources. The matrix represents a short-hand evaluation of the narrative discussion of each project. It should be noted that the original list of Critical Projects received from the COE was previously ranked during a South Florida Ecosystem Restoration Working Group meeting and does not necessarily reflect the assessment of the FWS.

The FWS has chosen to complete the matrix based upon the "best professional judgement" of each investigator. Benefits to habitat, hydrology, and improvements to water quality represent some of the parameters evaluated for each OPE. Each OPE was rated within these parameters by a low, moderate, or high score based upon a subjective determination as to the benefits of the projects components and/or design. The subjectivity of our evaluation was necessitated both by the short time given to compile this information and the great differences in the level of specificity of the proposals.

B. Discussion of Other Project Elements (OPEs)

KISSIMMEE RIVER WATERSHED

1. Increase Storage in the Kissimmee Chain of Lakes

Background, Scope, and Objectives

The Science Subgroup (1993) recommended modification of the regulation schedules for only the lower portion of the Chain of Lakes--Lake Kissimmee, Lake Hatchineha, and Cypress Lake to provide for seasonal lake stages up to 54 feet. Raising lake stages in this manner would re-flood an estimated 18,500 to 23,500 acres of wetlands. Subsequent project planning indicated that although the SFWMD has purchased lands around these lakes to the 54-foot contour, flood control concerns have limited the designed high pool stage to about 52.5 feet. The FWS (1994) estimated that the proposed new regulation schedule would restore approximately 7,200 acres of wetlands if three levees at specific locations along the lakes' shorelines were breached, and continued project planning is likely to include acquisition and restoration of all of these wetlands, including those beyond the three levees. The Science Subgroup report did not mention increased storage in the Chain of Lakes upstream of Cypress Lake. The Governor's Commission for a Sustainable South Florida (1996) stated the following:

> Additional storage within the Kissimmee River Basin could reduce the amount of runoff entering Lake Okeechobee during the wet season when the lake typically approaches high levels. This could shorten the duration of high water levels within the lake that damage its littoral zone and could reduce the frequency of high volume discharges to the east and west coast estuaries. The

> increase in water levels within the Upper Chain of Lakes could be restricted to avoid natural system impacts of high water levels and the need to maintain flood protection to lakeside residential development throughout the area. In support of the Commission's sociological and economic goals, this concept must be designed to balance the need for storage with the need to maintain flood protection to lakeside developments and should not result in the relocation of communities and agricultural areas.

We agree with the Governor's Commission regarding the potential benefits of this action if it could be accomplished without affecting flood control, but we do not believe this is possible. North of Cypress Lake in the Kissimmee Chain of Lakes, housing has encroached to levels around the shoreline that severely limit any attempts to store more water. The two largest lakes, Lake Tohopekaliga and East Lake Tohopekaliga, have two large population centers - Kissimmee and St. Cloud - close to their respective shorelines, and additional suburban housing is being constructed along the lakes' shorelines. Osceola County regulators require that new developments conform to floor elevation specifications, but this regulation was most likely based on the existing lake regulation schedule, and in any case, older homes not subject to regulation would likely be more vulnerable to flooding with a higher lake regulation schedule.

In addition to the potential downstream benefits of increased water storage in the lakes (benefits to Kissimmee River restoration and improved hydrologic conditions in Lake Okeechobee), greater fluctuation in lake stages would have an intrinsic benefit to the ecology of the Chain of Lakes. Flood control measures have reduced the historic high water levels, while water supply and navigation concerns attempt to minimize the severity of droughts. Short hydroperiod marshes which used to be inundated periodically by flood waters have been displaced by pasture grasses and invaded by shrubs. Deposition of a band of organic material around the lakes' shorelines is exacerbated by narrow restriction of lake levels. These conditions promote proliferation of dense tussocks of undesirable native species and exotic species of vegetation, which causes deterioration of habitat conditions for fish and wildlife. Due to the water supply and flood control constraints, natural year-to-year fluctuations in water levels is not feasible. Instead, extreme drawdowns of several months duration can be scheduled every seven to ten years to dry the built-up sediment load. Other management practices often included during the drydown are mechanical removal of the sediment and dense vegetation, discing, burning, and herbicide treatments.

Status of Project

Water managers have remained open to discussing changes to the regulation schedule for the upper end of the Kissimmee Chain of Lakes (above Lake Cypress). However, flood risk concerns have constrained opportunities. In fact, the 1997-1998 El Niño weather event prompted St. Cloud residents to call for consideration of lowering the maximum allowable pool stage in East Lake Tohopekaliga (J. Carnes, SFWMD, personal communication 1998). Such action would be contrary to the intent to remedy the adverse ecological effects of overly static water levels in the Kissimmee Chain of Lakes.

Recommendations

Lacking the ability to broadly fluctuate lake levels at both the high and low ends of the mean, extreme drawdowns must be planned and carried out on a seven- to ten-year cycle for all the lakes above Cypress Lake (Carnes 1997). The FWS (1994) recommended possible inclusion of an additional feature (not included in the authorization for the Kissimmee Headwater Lakes Revitalization Project) to further increase storage at Lake Cypress, where housing does not intrude around the lake's shoreline. Cypress Lake historically had a higher lake stage than Lake Hatchineha and Lake Kissimmee, but all three lakes are now held at roughly the same elevation. We recommend additional investigation of constructing a new water control structure at the northern end of C-36, allowing a higher maximum pool stage and greater water level fluctuation in Cypress Lake. It is uncertain whether the volume of boat traffic between Cypress Lake and Lake Hatchineha would require installation of a lock at this proposed water control structure.

Points of Contact

South Florida Water Management District (West Palm Beach and Kissimmee Field Station); Florida Game and Fresh Water Fish Commission (Kissimmee).

References

Carnes, J. Telephone communication, May 21, 1998.

Carnes, J. 1997. Management plan for the Kissimmee Chain of Lakes (Draft). South Florida Water Management District. August 1997.

U.S. Fish and Wildlife Service. 1994. Fish and Wildlife Coordination Act Report, Kissimmee Headwater Lakes Revitalization. U.S. Fish and Wildlife Service; Vero Beach, Florida.

2. Additions to the Authorized Kissimmee River Restoration

Background, Scope, and Objectives

Restoration of the Kissimmee River represents the largest riverine restoration project ever conceived. Prior to channelization, the Kissimmee River meandered 103 miles within a one to two mile-wide floodplain. The C-38 channel cut a straight line through the bends in the natural riverbed, reducing the run of the river to 56 miles. The floodplain contained approximately 41,000 acres of wetlands (Pruitt and Gatewood 1976). Following channelization, water flow was restricted to the confines of the channel and regulated in a series of impounded "pools" (Koebel 1995). The floodplain remained inundated at the lower end of each pool, but the remaining wetlands were affected by elimination of water level fluctuations and altered flow. Approximately 30,000-35,0000 acres of wetlands were either drained, covered with spoil, or converted into canal (Toth 1993).

Historical records and aerial photographs indicate three dominant wetland habitats existed along the Kissimmee River floodplain. The most extensive community was broadleaf marsh, covering over 56% of the floodplains. Common plant species included pickerelweed (*Pontederia cordata*), arrowhead (*Sagittaria lancifolia*), cutgrass (*Leersia hexandra*), and maidencane (*Panicum hemitomon*). Willow (*Salix caroliniana*), buttonbush (*Cephalanthus occidentalis*), and other shrub communities were often interspersed within the broadleaf marshes or found along the river channels, and covered approximately 14% of the floodplain (predominately in the north-central section of the basin). Wet-prairie communities comprised about 26% of the wetlands present. Habitats, found on the floodplain periphery, experienced significant wet-dry cycling, and were dominated by maidencane (*Panicum hemitomon*) cutgrass (*Leersia hexandra*), and horned beakrush (*Rhynchospora inundata*). Lower elevation communities experienced short drawdown periods, and were comprised of a diverse group of forbs, grasses, and sedges, including water-hyssop (*Bacopa caroliniana*), watergrass (*Hydrochloa caroliniensis*), flatsedge (*Cyperus spp.*), netted nutrush (*Scleria reticularis*), and short-beak baldrush (*Psilocarya nitens*). Cypress swamps, and ash/oak forests were also somewhat common along abandoned tributaries and oxbows (Toth *et al.* 1995).

The currently authorized Kissimmee River Restoration, known as the Level II Backfilling Plan, extends from the middle of Pool B to the bottom of Pool D (Figure VI-2), and would restore approximately 24,000 acres of wetlands. The 1991 FWCA Report on the Kissimmee River Restoration, Level II Backfilling, included the upper end of Pool E, but this was deleted from the federally authorized project approved in 1992 (FWS 1991).

The 1991 FWCA Report predicted substantial benefits to fish and wildlife resources, particularly fisheries, waterfowl, and wading birds. The projected benefits to wading birds included greatly improved foraging conditions for the endangered wood stork (*Mycteria americana*). The bald eagle (*Haliaeetus leucocephalus*) also would find expanded opportunities for feeding in the restored ecosystem and would likely establish additional nesting territories. It was anticipated that the restoration project would likely have minor adverse impact on the threatened Audubon's crested caracara (*Polyborus plancus audubonii*). Impacts are not expected to jeopardize the species, and the FWS provided recommendations for maintaining suitable habitat conditions along the edge of the restored floodplain. Habitat management recommendations to protect the caracara include prescribed burning and continued sustainable levels of cattle grazing along the edge of the restored floodplain (FWS 1991). Appropriate management guidelines for cattle grazing on public lands along the Kissimmee River should be carefully considered, ensuring that the intensity of grazing pressure is compatible with restoration goals. Pruitt and Gatewood (1976) provide a historical perspective on cattle carrying capacity in the area.

The projects recommended below for further consideration as part of the Restudy are complementary additions to the Level II Backfilling Plan.

Status of Projects

a. Pool A

Pool A is the northern-most reach of the C-38 Canal, just south of the S-65 outlet structure at Lake Kissimmee (Figure V-1). This portion of the river was not included in the Level II Backfilling Plan due to concerns about the ability to effectively release flood waters from the upstream Kissimmee Chain of Lakes. One of the earlier restoration proposals for this reach of the river included shallowing of the C-38 canal. However, shallowing of the existing canal would provide limited restoration benefits to the floodplain. An existing 560-acre impoundment near Rattlesnake Hammock provides a model for additional impoundments in the upper portions of Pool A that would enhance, but not fully restore, the surrounding floodplain. Construction of the additional impoundments would involve removal of portions of the spoil banks of C-38, and this material would be used to enclose the adjacent floodplain, allowing enhanced hydroperiod in the floodplain. The majority of the area to be enhanced has already been acquired by the SFWMD and most of the floodplain could be enhanced, except for the River Ranch Resort. The downstream portion of Pool A would be enhanced by allowing greater pool stage fluctuation. The FWS' 1991 FWCA Report estimated that an additional 3,200 acres of wetlands could be restored in Pool A, but the exact area of wetlands to be restored depends on the detailed plans that will arise for impoundments and pool stage fluctuation in Pool A.

b. Pool E

The upper portion of Pool E was originally included in the Level II Backfilling Plan, but the Water Resources Development Act (WRDA) of 1992 removed it from the federally authorized plan. Pool E is considered a "locally preferred option" under WRDA 1992. The deletion of Pool E from the plan was based on concerns about flooding of homes along that stretch of the Kissimmee River. It was previously estimated that approximately 2,700 acres of floodplain was available for restoration by extending the Level II Backfilling Plan throughout Pool E (FWS 1991). How much of the floodplain will be enhanced by other proposals depends on their design and operation. The enhancement of conditions on the floodplain would be conceptually similar to the proposal for Pool A, except that additional land acquisition would most likely be required.

c. Paradise Run

Paradise Run is the southern-most segment of the Kissimmee River, and the highly convoluted natural river channel runs entirely west of the C-38 canal south of the confluence of C-41A and C-38. Allen *et al.* (1981) reviewed information then available for restoration of the isolated portions of the original river channel and the marshes that once were present in the floodplain. In addition to the loss of marsh habitat value, Allen *et al.* (1981) documented the absence of certain fish species, such as black crappie (*Pomoxis nigromaculatus*), largemouth bass (*Micropterus salmoides*), and channel catfish (*Ictalurus punctatus*) from Paradise Run, which normally would be expected to occur. The authors cited a combination of reduced flows, siltation, accumulation of organic matter, and nutrient enrichment from surrounding pastures as causing degradation in water quality, leading to restriction of the fish fauna to those species more tolerant to such conditions. Allen *et al.* (1991) proposed construction of an additional water control structure along C-41A downstream (east) of the existing S-84, with the intent of creating a water receiving area in the southern part of Pool E, which could then be delivered from C-41A through a culvert to the northern end of Paradise Run. The report also considered leaving the existing L-59 in place, in which case the Paradise Run restoration would be operated as a northern and southern compartment. The report mentions the accumulation of organic matter (seven to nine feet thick in some locations) in the natural river channel since construction of the C-38, and suggests that sediments may need to be dredged from the natural river channel before restoring flow. Flushing of sediments from the river channel through increased flow would be beneficial to the water quality and fisheries habitat in Paradise Run, but would add to the already high nutrient loading to Lake Okeechobee. Portions of Paradise Run have already been acquired by the SFWMD; these tracts are mainly located between the original river channel and C-38 (SFWMD 1998). To carry out restoration of Paradise Run, however, additional land must be acquired west of the original river channel. Although the remaining tracts west of the original river channel are presently included in acquisition plans for Save our Rivers (SFWMD 1998), the SFWMD may eliminate these from further consideration (F. Davis, SFWMD, personal communication 1998). This decision may be based on lessened recent attention by the GFC in promoting the habitat benefits to be gained and on the current lack of Federal involvement in the project. The Restudy provides an opportunity to increase State and Federal attention to restoring Paradise Run, which should increase the priority for acquisition of the remaining lands through the Save Our Rivers program.

Recommendations

i. Detailed planning of wetlands enhancement should proceed in those portions of the Kissimmee River not included in the Level II Backfilling Plan.

ii. Development and implementation of detailed plans should start with Pool A, where it appears enhancement can occur on lands already acquired by the SFWMD. Enhancement could then proceed to Paradise Run, where some land has been acquired, and finally include Pool E, where land acquisition needs must be determined in accordance with the design of an enhancement plan.

iii. We recommend that the remainder of the Save Our Rivers tracts identified for Paradise Run be acquired.

All of these projects are highly related both hydrologically and biologically. For example, consideration of storing water north of C-41A to drive restoration of Paradise Run must consider both the effects on current habitat conditions in Pool E and how this action may fit into future wetland enhancement goals for Pool E. Planning for all areas should consider the feasibility of dredging accumulated sediments from portions of the historic river channel prior to increasing flows, thereby reducing the threat of increased nutrient loading to Lake Okeechobee.

References

Allen, M.J., L.S. Perrin, L.A. Rowse, and R.A. Krause. 1981. Management proposal for river/marsh restoration of Paradise Run. Office of Environmental Services, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Davis, F. Telephone communication, May 7, 1998.

Koebel, J.W. 1995. An historical perspective on the Kissimmee River restoration project. Restoration Ecology 3(3):149-159.

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Toth, L.A. 1993. The ecological basis of the Kissimmee River restoration plan. Florida Scientist 56(1):25-51.

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U.S. Fish and Wildlife Service. 1991. Kissimmee River Restoration Project. Revised draft Fish and Wildlife Coordination Act Report. U.S. Fish and Wildlife Service; Vero Beach, Florida.

3. Lake Istokpoga Restoration

Background, Scope, and Objectives

Lake Istokpoga is located within the Kissimmee River Basin in Highlands County. Water levels in the lake were stabilized for flood control and water supply in the 1960s as part of the C&SF Project. This stabilization, in conjunction with development within the watershed and invasion of exotic plants, has led to degradation of fish and wildlife habitat. Tussock islands, composed primarily of water hyacinth (*Eichhornia crassipes*) and *Scirpus cubensis*, are estimated by GFC to occupy approximately 2,500 acres of the 27,692 acre lake. These dense, unnatural vegetation communities have increased dramatically over the last several years due to the stabilized water levels. The tussock islands displace natural habitat and create noxious conditions in the littoral zone for fish species. These islands also create navigational problems within the lake. Aquatic macrophytes, particularly cattails (*Typha* spp.), dominate much of the lake's historic sandy shoreline, inhibiting the continued survival of cypress swamps. Hydrilla (*Hydrilla verticillata*) also represents an important control issue for maintaining Lake Istokpoga's ecosystem. In addition, when hydrilla is not controlled, the lake serves as a continuous source for hydrilla throughout the downstream portions of the Kissimmee River Basin.

Restoration of natural water level fluctuations is essential to the long-term restoration of the lake. Creating a lake-level regulation schedule for Lake Istokpoga that more closely resembles a natural system rather than regulating the lake solely for water supply and flood control purposes would be an optimal goal. However, there is no storage available north or south of the lake and homes surrounding the lake eliminate any potential for increasing lake water levels.

The proposed restoration project would include the removal of tussock islands and shoreline cattails, and provide a control program for hydrilla. A partial drawdown of the lake would permit the removal of shoreline cattails and hydrilla and begin the recovery of historic cypress swamp habitat. In a broader sense, the project will design a management plan for Lake Istokpoga in order to provide a more natural water level regulation that will prevent the growth of tussock islands while promoting establishment of more desirable fish and wildlife habitat. The project will also provide more capacity for water storage as well as restore flood control capabilities for the lake. Lake Istokpoga water is used for agricultural irrigation and cattle operations.

Status of Project

The SFWMD, Lake Okeechobee Service Center, has been conducting interagency meetings to investigate the potential for establishing a more natural operation of the Lake Istokpoga system. The GFC, in cooperation with the SFWMD, has begun harvesting operations for the tussocks. The GFC has proposed two alternatives for the dredged material. Because it is extremely costly to transport this material out of the lake, one idea would be create 4-5 foot tall, "wildlife islands" within the lake and establish more compatible wildlife habitat on these islands. Another proposal would be to store the dredged material in upland, agricultural habitats along the northeast and western shoreline. The GFC is working with private landowners to locate areas that will allow for storage of this dredged material (K. Denson, GFC, personal communication 1998). The GFC, in conjunction with the SFWMD, is seeking funding sources for additional harvesting operations.

Recommendations

The restoration of Lake Istokpoga has been an ongoing issue for resource managers. This project is timely in the context of several other restoration projects either proposed or in-progress within the Kissimmee River watershed. The project also offers the opportunity to restore a portion of the water storage that has been lost within the Lake Okeechobee/Kissimmee River Basin in recent years. The DOI supports restoration efforts of natural systems, particularly those that are regional in scope. Because of the severe degradation of this lake, this project offers tremendous potential for enhancing fish and wildlife habitat and restoring an impacted fishery. The DOI would like to see a management plan that would provide a long-term solution to restoring a more natural lake regulation schedule, but we are uncertain how this can be accomplished without acquisition of properties that lie close to the present water elevation.

Points of Contact

Loris Asmussen, SFWMD, Lake Okeechobee Service Center

References

Denson, K. Telephone communication. June 24, 1998.

LAKE OKEECHOBEE

1. Restoration of Torry, Kreamer, and Ritta Islands, Lake Okeechobee

Background, Scope, and Objectives

The Science Subgroup Report (1993) did not provide specific guidance on restoration goals for this area, recommending only to “integrate the islands at the southern end of the Lake into an overall management plan for the Lake.” The Governor’s Commission report (1996) stated that “restoration of these islands would involve degrading selected levees to allow more natural water levels and transplanting native vegetation. These actions would not affect existing private properties. They could result in additional habitat for water birds, fish, and other wildlife. Contaminant studies need to be completed prior to restoration design.”

We find that although restoration of these islands may be valuable, and although several ideas have been considered, this project element currently lacks a clear vision of goals. Our investigation suggests that the generalized goal of filling agricultural drainage ditches and removing of abandoned levees should be part of a coordinated multi-purpose plan. These purposes would likely include: 1) provision of public access to wildlife observation trails and platforms, 2) waterbird management, and 3) planting of native trees and shrubs, which will promote recovery of the endangered Okeechobee gourd (*Cucurbita okeechobeensis* ssp. *okeechobeensis*).

Lake Okeechobee has a developing eco-tourism industry, primarily involving airboat tours. Although birding tour groups visit Lake Okeechobee, they have inadequate access to observation sites. Repair of the existing Torry Island Road, construction of parking, and an elevated wildlife observation deck would promote tourism and would foster public support for preservation and restoration of the wildlife values of the lake's littoral zone.

Soil samples from Torry and Kreamer islands in 1977 contained DDT, DDD, and DDE levels ranging from 2,200 to 110,000, 580 to 10,000, and 1,300 to 9,300 µg/kg, respectively (Pfeuffer 1985). A single sample was collected from southern Torry Island in 1985; this contained DDD and DDE residues at 4,900 and 300 µg/kg, respectively (Pfeuffer 1991). None of the parent compound, DDT, was found, suggesting that degradation or biotransformation of the pesticides may be occurring. Samples collected in 1992 from six sites on Ritta Island showed all analyzed pesticide compounds below the detection limit of 5 µg/kg (Pfeuffer, unpublished data 1998).

If contaminants are at acceptable levels, detailed planning of a waterbird management impoundment should proceed. A location should be selected where existing habitat values are minimal. The size and operation of this management area must be designed.

Status of Project

Although restoration of these islands has received some attention, the goals are still poorly defined. We recommend development of an integrated multiple-purpose design, as outlined above. Other than limited sampling of chlorinated hydrocarbons and some sporadic surveys for the Okeechobee gourd, little baseline information is available.

Future Needs for Information or Design

The resource inventories that will be required for effective planning include the following:

i. Vegetation map, topographic map, and analysis of a series of aerial photographs
ii. More extensive sampling of chlorinated hydrocarbons (DDT and DDE residues)
iii. Continued monitoring of the distribution of the Okeechobee gourd
iv. Inventory of breeding sites for wildlife, particularly any wading bird colonies or concentrations of alligator nests.

Recommendations

Other Project Elements (OPEs) must support and be consistent with C&SF Restudy objectives for achieving ecological restoration. The DOI would not support a plan that focused exclusively on waterfowl management. However, we could support use of a limited area for this purpose, provided that larger areas of the islands are opened to improved sheetflow through removal of remnant agricultural ditches and levees.

After the required resource inventories are completed, detailed planning should be initiated for improvement of access (limited to wildlife tours) along a portion of Torry Island Road and construction of boardwalks and an observation platform for viewing of wildlife. Results of the resource inventories would also be used to plan and carry out the control of *Melaleuca* and Brazilian pepper (*Schinus terebinthifolius*) and the planting of native trees and shrubs, such as pond apple (*Annona glabra*) and willow (*Salix caroliniana*). Because the endangered Okeechobee gourd now uses both exotic and native species to support its vines, planting of native trees and shrubs while exotic species are being removed would promote recovery of the Okeechobee gourd..

Because Ritta Island has extensive native wetland vegetation around its periphery, and because no road access is available for earth moving equipment, the ecological impact of reaching and working at this relatively remote site must be carefully weighed against the benefits of restoring drainage ditches and levees. Torry and Kreamer islands are more readily accessible, and the resource inventories might support a decision to restore drainage ditches and levees in all but the most environmentally sensitive areas.

All planning for these islands must consider present and probable future water regulation policies.

Points of Contact

Waterfowl Management, GFC, Fellsmere; Contaminants Sampling, Aquatic Weed Control, SFWMD, West Palm Beach; FWS, Vero Beach.

References

Pfeuffer, R.J. 1985. Pesticide residue monitoring in sediment and surface water within the South Florida Water Management District. Technical Publication 85-2. South Florida Water Management District; West Palm Beach, Florida.

Pfeuffer, R.J. 1991. Pesticide residue monitoring in sediment and surface water within the South Florida Water Management District, Volume 2. Technical Publication 91-01. South Florida Water Management District; West Palm Beach, Florida.

Pfeuffer, R.J. 1998. Unpublished data. South Florida Water Management District; West Palm Beach, Florida.

2. Lake Okeechobee Water Retention/Phosphorus Removal

Background, Scope, and Objectives

The proposed scope of this project includes four drainage basins, three of which are tributaries to the Kissimmee River (S-65D, S-65E, and S-154). The fourth basin is within the Taylor Creek/Nubbin Slough (S-191). These basins are known to contribute the greatest concentrations of phosphorus to Lake Okeechobee (SFWMD 1997). Initial projects are being tested at two parcels-the Palaez wetland in the S-154 basin and at Grassy Island Ranch, adjacent to Taylor Creek.

The Kissimmee prairie contains a highly complex mosaic of herbaceous and forested wetlands, many of which were historically in the form of small scattered depressions. These somewhat isolated wetlands historically trapped organic matter and dissolved nutrients. Conversion of native prairie to improved pasture, sod farms, or vegetable farms increased nutrient loading to the wetlands. Habitat conversion, when combined with ditching through the prairie and among previously isolated wetlands, transported nutrients via major drainage canals to Lake Okeechobee. In addition to the adverse impact of accelerated eutrophication of Lake Okeechobee, more direct and rapid drainage of these lands contributes to rapid inflows to Lake Okeechobee. Higher water levels in Lake Okeechobee also increase the suspension of nutrient-laden sediments in the lake (Havens 1997).

This project will include plugging the connections among remaining wetlands to drainage ditches and diversion of canal flows to wetlands. The enhanced retention of water in these scattered wetlands will promote natural retention of phosphorus and will reduce peak flows to Lake Okeechobee. In addition to reducing ecological damage to the lake, these actions are expected to extend hydroperiods in the prairie wetlands, which provide habitat for a variety of wildlife, including waterfowl such as the Florida duck (*Anas fulvigula fulvigula*), the Florida sandhill crane (*Grus canadensis pratensis*), and several species of wading birds.

Status of Project

Substantial planning efforts have been initiated for this project, including assessment of the two pilot projects and identification of additional sites in the basins. The project is consistent with the goals of the SWIM Plan for Lake Okeechobee and will supplement efforts to establish best management practices (BMPs) on dairy farms in the area. This proposal has received support from the SFWMD, NRCS, DEP, and the South Florida Ecosystem Restoration Working Group.

Recommendations

The DOI strongly supports implementation of this project. The pilot sites should be carefully monitored to provide information on how best to design facilities at other sites throughout the selected basins. Planting appropriate species of herbaceous and woody wetland plants would further enhance habitat values for fish and wildlife. Information on types of vegetation, availability of plants at native nurseries, and successful techniques should be provided to landowners cooperating in the program. The NRCS has expressed interest in providing technical assistance in this program, and because of their expertise, it is recommended that they assist in disseminating information on wildlife habitat enhancement.

References

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3. Lake Okeechobee Tributary Sediment Dredging

Background, Scope, and Objectives

This project will remove sediment from eight sites that were identified within the study as containing the highest concentrations of phosphorus. It is estimated that 60 tons of phosphorus can be removed from the system by dredging these eight sites (B. Rosen, SFWMD, personal communication 1998). Two sites are located in the Taylor Slough/Nubbin Creek Basin on the L-

63N Canal where 45 tons of phosphorus will be removed. The other six sites are located in the S-65D, S-65E, and S-133 basins where a total of 15 tons of phosphorus will be removed (R. Sosnowski, SFWMD, personal communication 1998).

A two-year study conducted by Mack, Roos and Associates investigated phosphorus content and transport potential to northern Lake Okeechobee This study, completed in 1997, analyzed sediment from 84 sites within the tributaries for phosphorus content and determined that approximately 550 tons of phosphorus is contained in tributaries within an eight-basin area. (R. Sosnowski, SFWMD, personal communication 1998). The study also found the highest concentration of phosphorus occurs within the top twelve inches of sediment and that the phosphorus is bound to organic sediments.

Status of Project

A demonstration project has been proposed in a section of the L-63 canal, but its extent has not been determined. Permits from the COE and the DEP have not been filed as yet and it is anticipated that it will take seven months to obtain those permits. The demonstration project is scheduled to begin in the spring/summer of 1999. Success of the demonstration project will be evaluated in part by review of the phosphorus budgets for Lake Okeechobee which are currently in place (R. Sosnowski, SFWMD, personal communication 1998).

Recommendations

The DOI supports the removal of phosphorus from the tributaries to Lake Okeechobee. However, the project is in the preliminary stages and many questions need to be answered. A disposal site for the dredged material has not been determined or how it will be stabilized. The primary benefit of this project is to reduce phosphorus loading to Lake Okeechobee, which in turn will enhance water quality to all water users south of the lake, as well as the estuaries receiving water from the lake.

Points of Contact

SFWMD, West Palm Beach (Rob Sosnowski or Barry Rosen).

References

Rosen, B. Telephone communication, April 23, 1998.

Sosnowski, R. Telephone communication, May 1 and June 8, 1998.

CALOOSAHATCHEE RIVER

1. Removal of the Sanibel Island Causeway

Background, Scope, and Objectives

In 1960, during review of the original permit for the Sanibel Island bridge, the FWS had recommended a completely elevated bridge, rather than the construction of the two islands forming the causeway. The FWS predicted that in addition to the direct effects of the project on seagrasses, the scallop fishery in San Carlos Bay would be adversely affected. The scallop fishery did collapse soon after, but it is uncertain to what degree this was caused by construction of the causeway since the Intracoastal Waterway channel and the Franklin Lock on the Caloosahatchee River were also completed in the mid-1960s.

In 1989, Lee County commissioned a hydrologic model of the Sanibel bridge and causeway. That study found that construction of the causeway affected velocities in Redfish and Captiva Passes by less than 1 percent, and that the construction resulted in a change in velocity over 1,620 acres immediately adjacent to the bridges and islands (Hydrosystems Associates, Inc. 1989). It was also found that removal of the eastern island would be more effective in increasing tidal circulation in nearby portions of San Carlos Bay than removal of the western island. Goodwin (1996), using a calibrated two-dimensional circulation and constituent-transport model, found that removal of the Sanibel Causeway did not significantly affect flushing of upper and lower Charlotte Harbor, but it had a slight effect on flushing of Pine Island Sound and San Carlos Bay.

We could find no specific reference to this project element in the Science Subgroup report (1993) or in the Governor's Commission report (1996). The FWS proposed consideration of this project element during the Restudy's focus group meeting with the FWS' refuge managers. The J.N. "Ding" Darling NWR has a strong interest in improving tidal flushing through the area. Productivity of seagrasses and other estuarine/marine habitats is directly related to fish and wildlife values on the Refuge.

Removal of the Sanibel Causeway islands is justified even if the positive effects are limited to southern Pine Island Sound and San Carlos Bay. Excessive freshwater pulses from the

Caloosahatchee River have been exacerbated by construction of bulkheads along the river, thereby eliminating the buffering capacity of wetlands and floodplains upstream of the estuaries. Coupled with measures to capture regulatory releases from Lake Okeechobee and to store excessive runoff from the Caloosahatchee drainage basin, removal of the Sanibel Causeway would promote restoration of Pine Island Sound and San Carlos Bay. In addition to the loss of the scallop fishery, portions of the former predominately marine ecosystems in these bays have been altered by depressed salinity, and loss of seagrasses (McNulty *et al.* 1972, Harris *et al.* 1983) and other benthic organisms, such as soft corals.

Status of Project

The Lee County Department of Transportation has proposed to replace the existing drawbridge with a high span, and their current plan includes removal of the easternmost causeway island. However, removal of the island has met some local opposition, because the island is used for recreation. Lee County DOT has considered dredging the eastern island and using the material to widen the remaining western island (B. McAuliffe, Lee County DOT, personal communication 1998) to replace area lost for recreational use.

Recommendations

The DOI strongly supports removal of at least the eastern of the two Sanibel Causeway islands. Although this project is currently proposed to be funded by a Lee County bond issue, Federal agencies should stress the regional benefits to be gained by this project to overcome opposition based on local concerns about the recreational use of the islands. We do not recommend disposal of dredged material to widen the remaining island, even if it can be demonstrated that this would not further impede tidal circulation. The direct impact of disposal of the material on productive bay bottom should be avoided. If only the eastern island is removed, we recommend that the suitable portions of the dredged material be used for beach renourishment. Any material determined unsuitable for disposal on beaches should be hauled away and deposited in an upland site; this could include adding to the elevation, but not the area, of the remaining island. We understand the current proposal by Lee County does not include funding for the additional expense to haul the dredged material away. If Lee County cannot fund this additional expense, supplementary Federal financial assistance should be provided.

References

Goodwin, C.R. 1996. Simulation of tidal-flow, circulation, and flushing of the Charlotte Harbor Estuarine System, Florida. Water Resources Report 93-4153. U.S. Geological Survey; Tallahassee, Florida.

Harris, B.A., K.D. Haddad, K.A. Steidinger, and J.A. Huff. 1983. Assessment of fisheries habitat: Charlotte Harbor and Lake Worth, Florida. Final Report, Florida Department of Natural Resources, Bureau of Marine Research; St. Petersburg, Florida.

Hydrosystems Associates, Inc. 1989. The Sanibel Bridge study. Consultant's report prepared for Lee County. Hydrosystems Associates, Inc.; Tampa, Florida.

McAuliffe, B. Telephone communication, March 1998.

McNulty, J.K., W.N. Lindall, and J.E. Sykes. 1972. Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase 1, Area description. NOAA Technical Report. NMFS Circular 368.

2. Caloosahatchee River Remnant Oxbow Rehabilitation

Background, Scope, and Objectives

The Caloosahatchee River was first channelized in 1937 to improve navigation and provide flood control. During 1945, and again in the 1960s, the channel was widened and deepened to increase runoff within the basin and to provide greater discharge capacity from Lake Okeechobee. During that same period, two combination lock and dam structures were constructed, and the final lock and dam was added in the mid-1960s.

No fewer than 35 oxbows, remnants of the pre-channelized river, are present along the C-43 Canal between the city of LaBelle and the Franklin Locks (S-79) (FWS 1984). Oxbow lakes are shallow (maximum depth 1.5 to 3.0 m) and small (less than 1.0 acre to 11.6 acres). They range in length from 118 m (390 ft) to 720 m (2,370 ft). The majority are openly connected to the main channel, several are clogged by floating or emergent vegetation, and a few are blocked from the C-43 Canal by fill or sediment. The oxbow banks are generally steep. Drew and Schomer (1984) provided a list [adapted from Milleson (1980)] of vegetation found in the oxbows, and found that the abundance of floating mats of vegetation indicated lack of water current. They listed the presence of a number of exotic or nuisance species, but did not provide a measure of percent cover. Accumulation of organic sediments and nearly anoxic conditions were also noted in some of the oxbows. It is likely that additional degradation of habitat conditions has occurred since that report, including increased density of vegetation and abundance of exotic species, increased sediment loading, and a further decline in water quality.

The objective of the project is to improve flow through the oxbows and enhance habitat conditions. Habitat for fish and wildlife will be improved within the oxbows, and water quality improvements will likely be experienced in the adjacent portions of the canal and in the downstream estuary. Although some of the oxbows exhibit degraded habitat conditions, others are now in relatively good condition. Sport fishing along the Caloosahatchee River between LaBelle and the Franklin Locks occurs largely within the remaining oxbows; rehabilitation of the more degraded oxbows would promote recreational values in this stretch of the river. There are potential benefits to threatened and endangered species including the wood stork (*Mycteria americana*) and the West Indian manatee (*Trichechus manatus*), which occasionally migrates through the locks along the Caloosahatchee Waterway between the Gulf of Mexico and Lake Okeechobee.

Status of Project

This proposal has not entered the detailed design phase. Initial efforts, already underway, involve baseline studies in 10 of the 35 oxbows, which will contribute to the specific design of the rehabilitation projects and will provide a comparison for continued monitoring following rehabilitation (K.W. Cummins, SFWMD, personal communication 1998). A broad range of parameters are being evaluated in the baseline studies, including vegetation, fish, invertebrates, and a number of water quality measurements.

Recommendations

We recommend that this project proceed rapidly from the collection of ecological baseline data, to detailed design, and to implementation of the enhancement. Because the present ecological conditions in the oxbows and the problems and opportunities for enhancement vary among the oxbows, specific measures for rehabilitation should be determined on a case-by-case basis (K.W. Cummins, SFWMD, personal communication 1998). We are concerned about the potential short-term impacts on water quality if the remnant oxbows are opened to increased flow without stabilizing any remaining sediments in the oxbow. If rehabilitation includes dredging of sediments from the oxbows, proper stabilization of the dredged material must be ensured to prevent it from redepositing in the oxbows or the C-43.

In addition to exploring the potential for improved flow through the oxbows, we recommend that any drainage into the oxbows from adjacent properties be examined for opportunities to create filtration marshes. These marshes should reduce the loading of sediments into the oxbows and will buffer the inflow of runoff from the surrounding watershed. Land adjacent to the oxbows may need to be acquired to establish filtration marshes where local drainage enters the oxbows.

In addition to removing exotic vegetation and planting native emergent wetland plants, project planning should seek opportunities to re-establish growth of submerged aquatic vegetation. The submerged exotic *Hydrilla verticillata* is well established in the oxbows. This species provides productive habitat for fish and wildlife when it is present in moderate density, but high density beds become "topped out," and can cause choking of the waterway with poor water flow. We recommend establishment of native submerged species such as tapegrass (*Vallisneria americana*), and musk-grass (*Chara* spp.) wherever possible. Both of these species provide excellent habitat conditions for invertebrates that serve as food for fish, wading birds, and waterfowl. Water in this portion of the Caloosahatchee River is laden with tannin and suspended particulate matter, which limits light penetration in the water column. Because the banks of the oxbows are often relatively steep, suitable water depths with adequate light penetration to support *Chara* and *Vallisneria* are limited. We recommend that project planners investigate opportunities to create shallow shelves along suitable portions of the oxbows to allow planting of native species of submerged aquatic vegetation. Areas presently dominated by exotic species, such as *Melaleuca* or *Schinus*, are potential candidate sites for this type of enhancement.

Points of Contact

Kenneth W. Cummins, SFWMD, Tarpon Bay Environmental Laboratory, Sanibel, Florida.

References

Cummins, K.W. Telephone communication. June 11, 1998.

Milleson, J. 1980. Caloosahatchee River oxbow studies. Pages 275-312 *in* Water use and supply development plan, Vol. IIIC - lower west coast. South Florida Water Management District; West Palm Beach, Florida.

Drew, R.D. and N.S. Schomer. 1984. An ecological characterization of the Caloosahatchee River/Big Cypress watershed. U.S. Fish and Wildlife Service. FWS/OBS-82/58.2. 225 pp.

UPPER EAST COAST

The upper east coast geographic area that encompasses the Indian River Lagoon and the Ten Mile Creek section of the St. Lucie River is considered hydrologically removed from the Everglades and Florida Bay ecosystems. Presently, the only connection is the C-44 or St. Lucie Canal that discharges water from Lake Okeechobee to the St. Lucie Estuary. However, the Restudy will evaluate alternative regulation schedules for Lake Okeechobee on a system-wide basis with consideration given to the environmental needs of the Indian River Lagoon and the St. Lucie Estuary.

Water Preserve Areas (also called Regional Attenuation Facilities) are designed to provide for the diversion of surplus rainfall runoff from drainage basins to storage areas where the water can be treated prior to discharge for environmental base flows and water supply purposes.

1. Ten Mile Creek Water Preserve Area

Background, Scope, and Objectives

Ten Mile Creek is the largest sub-basin delivering water to the North Fork of the St. Lucie River estuary, which discharges into the Indian River Lagoon. The St. Lucie River estuary and the Indian River Lagoon are each classified as Outstanding Florida Waters. The proposed project includes the acquisition of approximately 1,559 acres in the Ten Mile Creek basin and construction of an above ground water detention area. The proposed site is located southwest of Ft. Pierce in St. Lucie County, situated immediately west of the crossing of the Florida Turnpike and I-95, south of Highway 70 and north of Midway Road. The site is currently in two ownerships. Ten Mile Creek flows west to east across the north portion of the proposed site.

The project is designed to promote restoration of the North Fork of the St. Lucie River by reducing excessive stormwater flows into this section of the river. The Water Preserve Area proposed for this project will be used for seasonal or temporary storage of stormwater from the Ten Mile Creek basin. Storage of excess stormwater will allow for measured releases into Ten Mile Creek and allow for a more natural salinity regime within the estuary. Stored water can also be released during the dry season to augment insufficient flows. Sediment loads to the estuary should be reduced as a result of the settling of suspended solids in the storage reservoir. The project also proposes that the captured stormwater be passed through a polishing cell for additional water quality treatment before being released into the North Fork.

Ten Mile Creek is an important component of the St. Lucie River estuary and Indian River Lagoon Restoration Projects. The Indian River Lagoon Surface Water Improvement and Management Plan (SWIM Plan), Appendix B (SJRWMD and SFWMD 1989), provided a summary of the water quality conditions for the lagoon system. The water quality assessment for Ten Mile Creek was described as “fair” with relatively high levels of pesticides as a result of runoff from surrounding citrus groves. The SWIM Plan also noted that high rates of floodwater discharge from this drainage area appeared to transport excessive amounts of sediments into the North Fork of the St. Lucie River, which directly affects downstream estuarine environments. The proposed detention area would be important in reducing the amount of pesticide contamination and sediment load in Ten Mile Creek and would provide improved water quality in the North Fork.

The conceptual design proposed for the Ten Mile Creek Water Preserve Area includes the construction and operation of an above-ground reservoir with a pump station for filling the reservoir from Ten Mile Creek and a gated water level control structure for the release of water back to the creek. The "footprint" of the reservoir is estimated at approximately 550 acres with the remaining acreage to be used as a polishing cell and a natural preserve area. Based upon existing topography, stored water depths will average ten feet.

Status of Project

Preliminary siting studies have been conducted for this project with a preferred site and an alternative site selected. In cooperation with the COE, the SFWMD is the project sponsor; however, several agencies (e.g. DEP, FWS, and EPA) will be participating in the project design and environmental assessment.

Recommendations

The DOI supports restoration projects which would enhance Florida's estuarine environments such as seagrass beds and other important habitats that provide nursery grounds for juvenile fishes and invertebrates. Commercial and recreational fishing represent particularly important activities in this region and should be benefitted by improvements to the estuary. The Ten Mile Creek critical project described above represents a viable alternative to the present problems associated with undesirable discharges to the North Fork of the St. Lucie River. The primary concern for the DOI is the location of the Water Preserve Area. The site should be selected so that adverse impacts to the environment are reduced. Particular attention should be paid to avoid conversion or destruction of important upland habitat (e.g. scrub).

References

St. Johns River and South Florida Water Management District. 1989. Surface Water Improvement and Management (SWIM) Plan for Indian River Lagoon.

2. C-25 Basin Water Preserve Area

Background, Scope, and Objectives

The C-25 drainage basin consists of 134,500 acres located west of Ft. Pierce. Discharges from this basin occur via Taylor Creek into the Indian River Lagoon. To date, there have been no comprehensive studies of the basin's impact on the lagoon. Discharges from the basin are untreated and therefore water deliveries result in an unabated pollutant load directly into the lagoon system. The section currently impacted by C-25 basin discharges encompasses important segments of the lagoon including an area that contains the only open shellfish harvesting area (Big Starvation Cove) in the southern Indian River Lagoon. Based on information from water quality monitoring programs being conducted by the DEP and the SFWMD, the C-25 basin has been shown to transport significant sediment loads, nutrient loads, pesticides, polyaromatic hydrocarbons, and heavy metals into the estuary and offshore waters (G. Graves and D. Strom, DEP, written communication 1998). Twelve violations of state water quality standards have been documented between 1992 and 1997 for the pesticides malathion and ethion (MacDonald *et al*. 1996).

The proposed project would incorporate basin modifications to attenuate peak flows and provide storage to treat water prior to discharge, recharge ground water, provide storage for agricultural and urban demands during drought, and provide for dry weather minimum estuarine discharges. The C-25 basin design elements may also enhance the Ten Mile Creek sub-basin as discussed previously.

Status of Project

At the present time, this project is unfunded and has not proceeded beyond the nomination stage. The SFWMD currently provides limited monitoring of this basin and the canal as part of its region-wide water quality monitoring network.

Recommendations

Elements of the proposed project may assist in the restoration of reservoirs and wetland flow-ways, which can be beneficial to a variety of wildlife. Improvements in the timing and quality of water discharged by C-25 basin should improve water quality within the lagoon and may result in greater expanses of seagrass beds, less stress to resident fauna as a result of reduced levels of toxins, and enhanced protection of offshore reef systems. Benefits to both commercial and recreational fisheries would be expected as well. As with the Ten Mile Creek project, the DOI is supportive of estuarine enhancement projects but would like additional information concerning the site selection of the water preserve area in order to evaluate the impacts to existing wetland and adjacent upland habitats.

References

Graves, G. and D. Strom. Written communication, OPE Fact Sheet, April 27, 1998.

MacDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology 5: 253-278.

LOWER EAST COAST: PALM BEACH COUNTY

1. Pal-Mar/Corbett Land Acquisition Project

Background, Scope, and Objectives

Pal-Mar is a large pine flatwood/wet prairie/depression marsh complex located in Palm Beach and Martin Counties, northeast of the J.W. Corbett Wildlife Management Area (WMA). The project includes some of the highest quality pine flatwoods in southern Florida in an ecotone between pine flatwoods and the treeless Everglades (CARL 1997). The total proposed project area for Pal-Mar is 35,435 acres of which 2,552 acres have been acquired as of 1997 (SFWMD 1998). In addition to the Pal-Mar land acquisitions, the project may also include a privately owned parcel of land consisting of approximately 3,000 acres between Pal-Mar and J.W. Corbett WMA. If acquired, the project area would produce an unbroken 125,000-acre greenbelt extending from the DuPuis Reserve near Lake Okeechobee across the J.W. Corbett Wildlife Management Area and connecting with Jonathan Dickinson State Park (H. Trammall, SFWMD, personal communication 1998).

Status of Project

The acquisition of land at Pal-Mar is on-going. The acquisition of the parcel of land between Pal-Mar and Corbett (approximately 3,000 acres) is proposed.

Recommendations

The DOI supports the acquisition of the 3,000 acres which would provide a contiguous wildlife corridor from DuPuis Reserve to Jonathan Dickinson State Park. This would provide vital habitat connectivity for those species that require large unfragmented tracts of land for survival.

Points of Contact

GFC, West Palm Beach (Jim Schuette)

References

Conservation and Recreational Lands (CARL) Annual Report. 1997.

South Florida Water Management District. 1997. Save Our Rivers 1998 land acquisition and management plan. South Florida Water Management District; West Palm Beach, Florida..

Trammell, H. Telephone communication, May 1, 1998.

2. Winsberg Farms Wetland Restoration

Background, Scope, and Objectives

The project involves the acquisition of approximately 175 acres of land that are currently farmed in row crops and a nursery. Following acquisition, the area would be converted into a wetland. The purpose of this project is to provide indirect use of treated wastewater and cost effective effluent disposal through irrigation of agricultural crops and recharge of local ground water. Secondary benefits that may result include reduced dependence on water from Lake Okeechobee, creation of wildlife habitat and open space, and providing a link to the county-wide greenway system. Acquisition of lands for the project will begin in 1998 and continue over a three-year period. The proposal is to purchase approximately 60 acres annually for the next three years, while allowing the current owner to farm the area until 2001 (H. Hadjimiry, Palm Beach County Water Utilities Department, personal communication 1998).

The Wakodahatchee wetland, a pilot project for this proposal, was constructed in 1996. This project involved the construction of wetland cells, planting native wetland vegetation to promote removal of nutrients and construction of a boardwalk throughout the wetland complex for environmental education/bird-watching. The Wakodahatchee wetland pilot project is well managed by Palm Beach County and 119 species of birds have been recorded in the area. Because the Wakodahatchee wetland has proven to be an extremely well-received project, it is anticipated that Winsberg Farms will also receive strong public support. The operation and management plans for the proposed project will be identical to the Wakodahatchee wetland. Pollutant removal performance by the Winsberg Wetland will be estimated through the application of empirical treatment models and by analysis of the Wakodahatchee wetland data.

When constructed, a research and monitoring plan will be developed and implemented to provide detailed descriptions of the water budget and water quality enhancement performance of the wetland. Wildlife utilization of the Winsberg wetlands will be quantitatively assessed through monitoring similar to surveys currently being conducted by Palm Beach Department of Environmental Resources Management for the Wakodahatchee wetlands.

Status of Project

Acquisition of the first parcel of 60 acres will be presented before the Palm Beach County Commission in June 1998. Some conceptual drawings and design work have been completed (R. Liberti, Palm Beach County Water Utilities Department, personal communication 1998).

Recommendations

The 175-acre wetland proposed for this project will increase the spatial extent of wetland habitat and provide a geographic link with other local natural systems. Intense development pressure in south Florida continues to fragment remaining natural areas. The DOI supports this acquisition and restoration project for the habitat it will provide to wading bird populations, snail kites, and other wildlife that currently utilized adjacent natural areas. The DOI is also supportive of projects that incorporate water conservation and reuse since it will reduce dependence on critical water supplies in the Everglades ecosystem.

References

Hadjimiry, H. Telephone communication, April 21, 1998.

Liberti, R. Telephone communication, April 30, 1998.

3. Wetlands-Based Water Reclamation Project

Background, Scope, and Objectives

The City of West Palm Beach, Florida has developed a wetlands-based water reuse program to maximize water conservation, an innovative approach for the reuse of treated wastewater and augmentation of the drinking water supply.

The sources of drinking water for the City of West Palm Beach are Lake Mangonia and Clear Lake. These lakes are recharged with water from the city's 20-square-mile Wetland Catchment Area (WCA) via the M-Canal, which is augmented with water pumped from Lake Okeechobee via the L-8 Canal. To meet emergency drinking water needs, the city uses a standby wellfield which consists of ten wells. In order to reduce the amount of water needed to be pumped from Clear Lake and Lake Mangonia during peak usage, the city is developing an Aquifer Storage and Recovery (ASR) program. Wastewater is currently treated at the East Central Regional Wastewater Treatment Plant (ECRWWTP) and discharged via deep well injection to the Floridan aquifer which contains non-potable water in southeast Florida. The proposed approach is to tie these two systems together to meet the conservation goals of the city (Camp Dresser & McKee Inc. (CDM) , no date)

Treated wastewater will be sent from the ECRWWTP to existing wetlands adjacent to the treatment plant. These wetlands are in a state of decline as a result of alteration of the hydrologic regime in the area and the subsequent infestation of melaleuca (*Melaleuca quinquenervia*). The water will flow through the wetlands thereby maintaining a more natural hydroperiod (P. Gleason, CDM, personal communication 1998). Water from the wetlands will be piped to the aquifer near the standby wellfield where it will be recovered and pumped to the M-Canal and into Clear Lake and Lake Mangonia and from there to the city's water treatment plant.

The City of West Palm Beach has applied to the COE for use of this area as a mitigation bank. The proposal involves removal of melaleuca and the creation, restoration and enhancement of approximately 1,500 acres of wetlands in the project area. The bank would be established so that money from the sale of mitigation credits would fund the restoration and maintenance of the 1,500 acres of wetlands (E. Olson, City of West Palm Beach, personal communication 1998).

A threatened and endangered species survey was conducted by Ecosystem Research Corporation to determine which threatened and endangered species occur within the Wetland Reuse Site. Threatened or endangered species that were observed within the project site included the Florida snail kite (*Rostrhamus sociabilis*), American alligator (*Alligator mississippiensis*), wood stork (*Mycteria americana*), eastern indigo snake (*Drymarchon corais couperi*), limpkin (*Aramus* *guarauna*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), and the gopher tortoise (*Gopherus polyphemus*). In addition, ten listed plant species occurred within the project site (City of West Palm Beach and Palm Beach County Utilities 1998).

Status of Project

A small-scale demonstration project has been completed through a cooperative cost-share agreement between the City of West Palm Beach and the South Florida Water Management District. This pilot project was used to evaluate chemical combinations and levels which optimize the process. An application will be submitted to the COE and the Florida Department of Environmental Quality in May 1998 to include the addition of the Advanced Water Treatment Facility, distribution lines, and the mitigation banking proposal.

Recommendations

The DOI supports the idea of water reuse since it will reduce dependence on critical water supplies to the Everglades ecosystem. This project will provide a more natural hydroperiod to the project area especially along the eastern perimeter where major hydrologic alteration has occurred. The increased hydroperiod will help reduce the spread of melaleuca, which has already invaded the area, and will enhance existing wetlands.

Any construction activity in the area will require initiation of consultation under the ESA. The request to the COE for creation of a wetland mitigation bank for removing melaleuca from the project site needs to be reviewed. The FWS concurs with the SFWMD's Environmental Advisory Committee (EAC) that "removing exotic plants from wetlands is essential for the health of those systems, however, removing exotic plants for mitigation credit is inappropriate because exotic removal alone does not replace lost wetland functions" (EAC 1997). However, the mitigation banking project appears to have elements of creation and restoration of wetlands as part of the proposal and not merely removal of melaleuca as the basis for the bank. Areas in the proposed bank which only involve removal of melaleuca would not be considered as appropriate mitigation.

Points of Contact

City of West Palm Beach (Erik Olson); Camp Dresser & McKee Inc. (Pat Gleason).

References

Camp Dresser & McKee Inc. No date. Wetlands-based water reclamation program, Brochure.

City of West Palm Beach and Palm Beach County Utilities. 1998. Baseline monitoring report - wetlands based water reclamation project. Camp Dresser & McKee Inc.

Environmental Advisory Committee. 1997. Exotic Plant Removal: A non-viable mitigation alternative. South Florida Water Management District; West Palm Beach, Florida.

Gleason, P. Telephone communication, April 24, 1998.

Olson, E. Telephone communication, April 13, 1998.

4. Hillsboro Pilot Aquifer

Background, Scope, and Objectives

This project represents a regional Aquifer Storage and Recovery (ASR) demonstration project in the Hillsboro canal region to capture and store excess flows from local drainage and Loxahatchee NWR, that are currently being released to tide, for use during dry periods. The project involves construction of six, five-million-gallon-day (mgd) wells to the upper Floridan Aquifer. Four of the wells will be operated by the SFWMD and two of the wells will be on a cost-share and operational contractual agreement with Palm Beach County. The purpose of the demonstration project is to determine recovery rates and cycling necessary for a future larger project. Proposed cost for the project is approximately $15 million (L. Devillon, SFWMD, personal communication 1998).

Status of Project

A feasibility study for the project will begin in 1999. Filing for permits from the Florida Department of Environmental Protection will begin in 1999. The SFWMD is developing its contractual agreement with Palm Beach County for two of the wells.

Recommendations

The DOI supports the storage of water to prevent saltwater intrusion and to reduce direct dependence of utilities on surface water recharge from Lake Okeechobee or the Water Conservation Areas. If ASR is implemented, we recommend that all Federal and State rules and regulations pertaining to ASR be complied with. However, we recommend that other alternatives (back-pumping or water preserve areas) for water storage be reviewed, which may provide more benefit to fish and wildlife resources.

Points of Contact

South Florida Water Management District, West Palm Beach (Lou Devillon); Palm Beach County Water Utilities (Ray Liberti)

References

Devillon R. Telephone communication, April 20, 1998 and May 12, 1998.

5. L-8 Water Catchment Area-Loxahatchee Slough Infrastructure Improvement

Background, Scope, and Objectives

The land surrounding the L-8 Canal primarily consists of rural and suburban residential homes on acre-and-a-quarter lots. The canal and remnant wetlands provide foraging opportunities for snail kites and wading birds such as the tri-colored heron and wood stork that nest in the City of West Palm Beach's Water Catchment Area. The L-8 Canal delivers water from Lake Okeechobee to the M-Canal and on to the West Palm Beach Water Catchment Area. It also delivers water to the C-51 Canal, which discharges to tide in Lake Worth Lagoon. The southern L-8 sub-basin drains south through L-8 to C-51 or to the Loxahatchee NWR. Stormwater Treatment Areas under construction to help purify Loxahatchee NWR water are not designed to handle the L-8 water. In conjunction with this concern, there is an effort to treat and reduce C-51 discharges to the Lagoon. The objective is to divert runoff from the southern L-8 basin away from Loxahatchee NWR and the C-51 and into the West Palm Beach Water Catchment Area and perhaps the Loxahatchee Slough (Slough). Agricultural and urban runoff from the southern L-8 sub-basin can be treated and used as urban water supply for West Palm Beach, and might also be used to fill environmental water demands for the Water Catchment Area and Slough. However, it has yet to be determined that the Slough requires this extra water.

The current project plan as presented is to dredge the L-8 Canal and add pump capacity to take water from L-8 and route it to West Palm Beach into the Water Catchment Area. Several other pieces of an L-8 project have been considered including: extending the M-Canal two miles east and north; building a new water storage and treatment area near the west leg of the C-18 Canal; adding a pumping station at the north end of the M-Canal; placing a water control structure between the new reservoir and C-18; and constructing a new ten-mile-long canal to connect the Town of Jupiter's surface water recharge system with the North Palm Beach Water Control District.

Status of Project

This project is on hold until planning dollars become available.

Future Needs for Information or Design

The Loxahatchee Basin Hydrology model should be run to determine if and when the Slough might require excess L-8 flows. If it is determined that these flows are not required within the Slough, then the West Palm Beach Water Catchment Area may be considered for storage of this extra water, especially in wetter than normal years.

Other information needs include sampling of sediments and water for contaminants and locating an upland dredge spoil disposal site to handle potentially toxic material.

Recommendations

The DOI recommends that this project be further planned and constructed only if it is determined to be primarily positive for fish and wildlife resources of the L-8 area, Loxahatchee NWR, and the Loxahatchee Slough. We request that the COE certify that project hydrology will not worsen environmental conditions for the Loxahatchee NWR, or other conservation lands in the J.W. Corbett Wildlife Management Area, West Palm Beach Water Catchment Area, or Loxahatchee Slough.

The Department also recommends that best management practices be established and implemented for agriculture and for suburban residents of the L-8 Basin.

Earlier in the Restudy process, mention was made of constructing a 10-mile long Jupiter Seacoast Utility Water Supply Canal as part of the L-8 Loxahatchee Restoration Project. The DOI does not believe this concept appears consistent with the Restudy's focus on environmental enhancement and we suggest that other alternatives be considered.

Points of Contact

City of West Palm Beach (Erik Olson).

6. Loxahatchee Slough Restoration

Background, Scope, and Objectives

Since the construction of the C-18 Canal, the Loxahatchee Slough (Slough) has received less water. The C-18 redirects historic Slough flows into the Northwest Fork of the Loxahatchee River into the Southwest Fork (DEP 1997). The landscape can be described as a central, herbaceous freshwater slough with mesic pine flatwoods around the drier edges and dry prairie interspersed among the pines. The Slough is a swale system of herbaceous marsh and transverse ridges of cypress strands and some hammock tree islands (S. Farnsworth, Palm Beach County Environmental Resources Management, personal communication 1998). Palm Beach County Environmental Resources Management staff have recorded many Federal- and State-listed species including snail kite, wood stork, Florida sandhill crane, least tern, limpkin, little blue heron, tri-colored heron, alligator, gopher tortoise, eastern indigo snake, and Sherman's fox squirrel.

Plans to restore the Slough have been considered since the 1970's but have been constrained by land availability. In 1985, the Northwest Fork of the Loxahatchee River was under consideration for Federal Wild and Scenic Designation (which it achieved) and the environmental community requested the COE to initiate Slough restoration. The Fish and Wildlife Service prepared a Habitat Evaluation Procedure analysis in the mid-80's and proposed a target hydrograph to assist in this restoration process. The FWS proposed reflooding the slough predicated on 5,000 acres of land available for restoration in the mid-80's. In 1997, Palm Beach County purchased those 5,000 acres and 7,000 additional acres through their Environmentally Sensitive Lands Program. This Loxahatchee Slough Restoration critical project is designed to rehydrate the 11,000 acres while protecting existing urban areas. Overall project objectives are to restore the Slough and to ensure appropriate flows for the Northwest Fork of the Loxahatchee River.

Specific components of the project include placing a weir structure with a sliding concrete gate within the C-18 Canal to raise water levels from 14.8 feet to 17.5 feet and allow overbank flooding to rewater the County's land in the Slough. Also, because the Slough was historically contained within the West Palm Beach Water Catchment Area, the connection under the Beeline Highway will be enhanced with the new C-18 structure as water from the catchment area will rehydrate additional wetlands. Palm Beach County has committed to remove exotics from 1,600 acres of the Slough before it is reflooded.

As a side note, one problem within the Slough's general drainage basin area is the Indian Trails Development. This community has inadequate stormwater drainage and rights on the drainage canals are completely allocated. There has been concern about environmental effects of the development's flows. GKK mining approached the Water Management District for a 20-year permit for shellrock or limestone mining and offered to provide a storage reservoir for the Indian Trails Development. The proposed mining/reservoir area has already been rock-and-muck mined and GKK's reservoir could store water in the wet season and send it to the Slough during the dry season.

Status of Project

The Loxahatchee Slough Restoration project is currently under review by the COE. The SFWMD has provided a letter of intent to the COE who then drafted a letter report for the project. Details of project costs are being worked out.

Palm Beach County has provided a cost share for the exotic vegetation removal project component and intends to begin contracting as soon as possible. Exotic vegetation such as *Melaleuca*, *Lygodium*, and some Brazilian pepper will be removed over the course of three years.

The SFWMD and the City of West Palm Beach have developed a hydrologic model of the Loxahatchee basin and are testing possible hydrographs for the Slough against water users, rainfall, and baseflow required for the Northwest Fork of the Loxahatchee River (currently there is a 50 cfs minimum set).

Future Needs for Information or Design

The hydrologic model of the Slough should be run and calibrated to match actual events and then used to determine how much water can be used by the Slough and when and where and how likely the water is to be available. There is a need to determine the biologically appropriate flows and water levels and historic ranges within the Slough.

Recommendations

The restoration will lengthen the hydroperiod of the wetlands and stabilize the Slough. Fish and wildlife needs should received the highest priority of the restoration with irrigation and water supply withdrawals receiving secondary attention. The DOI recommends that water stored in the Slough should stay within the historic range of levels. We recommend setting wet-year flows/levels and dry-year flows/levels in such as way as to not over-inundate the Slough nor produce “draw-down” conditions. The Slough should not also become a stormwater dumping flow-way to the estuary. Neither the Slough nor the estuary will benefit from excessive or untimely discharges.

The Palm Beach Water Catchment Area and C-18 water are considered Class I waters. Other water sources are not. To prevent the degradation of Class I waters, we recommend the Slough waters be reclassified at least from its current Class III to Class II. Once the restoration project is complete, the area should be protected from point and non-point source runoff.

The freshwater marsh and other habitat components should be managed as a total system with a goal of increasing and maintaining heterogeneity (FWS 1998). The FWS recommends considering fire and drawdowns as management tools and managing for early successional stages to give more diverse habitat niches. Also, performing management measures on different areas at different times will sustain and improve habitat heterogeneity.

Points of Contact

SFWMD, (Frank Lund); COE (Vern Gwin); Palm Beach County Environmental Resource Management (David Nemi or Steve Farnsworth).

References

Farnsworth, S., Telephone communication, June 3, 1998.

Florida Department of Environmental Protection. 1997. Loxahatchee River National Wild and Scenic River management plan, September, 1997 Draft Plan Update. West Palm Beach, Florida.

U.S. Fish and Wildlife Service. 1998. Freshwater marsh ecological community account. Multi-species recovery plan for the threatened and endangered species of south Florida. Volume II of II, The communities. Technical/Agency Draft. Vero Beach, Florida.

7. Lake Worth Lagoon

Lake Worth Lagoon (Lagoon) is located along the coast of Palm Beach County. The Lagoon functioned as a freshwater system as recently as 100 years ago, but became a marine environment with the construction of permanent inlets to the Atlantic Ocean. The estuary provides spawning, nursery, and foraging habitat for many fish and invertebrate species, which sustain and mature into important inshore/offshore recreational and commercial resources. It is believed that fishery resources have declined within the past forty years as a result of loss of habitat and water quality degradation. Between 1940 and 1975, approximately 87% of mangrove habitat and emergent, aquatic vegetation along the Lagoon's shoreline disappeared (Harris *et al.* 1983). In addition to non-point source runoff from surrounding urban areas, excess fresh water and sediment loads from the C-16, C-17, and C-51 canals have contributed to the decline in the Lagoon ecosystem. These alterations and impacts to the Lagoon have seriously diminished its ability to function as a healthy estuarine ecosystem. Management of the Lagoon system is needed for the protection and enhancement of this coastal resource. A draft management plan for the Lagoon has been prepared by the Palm Beach County Department of Environmental Resources Management and the DEP and Palm Beach County has also developed a Draft Surface Water Improvement and Management (SWIM) Plan for the Lagoon.

References

Harris, B.A., K.D. Haddad, K.A. Steidinger, and J.A. Huff. 1983. Assessment of fisheries habitat: Charlotte Harbor and Lake Worth, Florida. Final Report, Florida Department of Natural Resources, Bureau of Marine Research; St. Petersburg, Florida.

a. Lake Worth Lagoon Water Quality Restoration - Sediment Removal

Background, Scope, and Objectives

The C-51 Canal extends from the north end of Loxahatchee NWR eastward into the Lagoon and represents one of three primary drainages entering the Lagoon. The Palm Beach County SWIM Plan (Palm Beach County 1997) identified this basin as the most critical area for reversing water quality and ecological degradation in the Lagoon.

Plans are being developed for diverting western C-51 basin waters to STA-1 East, providing treatment for this water, and routing the treated water to Loxahatcheee NWR. However, a solution for "de-mucking" eastern C-51 basin waters has also been identified. Because undeveloped land represents a scarce commodity in the eastern C-51 basin, no site is available for constructing a Stormwater Treatment Area (STA). Therefore, Palm Beach County has proposed to dredge existing sediments out of the C-51 Canal and to remove and dispose of sediments so that they do not flow through the S-156 structure into the Lagoon.

Status of Project

Palm Beach County has proposed this pilot project jointly with the SFWMD, who is assisting in identifying sources of revenue. Details of the project that have yet to be determined include the method and extent of the dredging. Planning will continue as funding sources are secured.

Future Needs for Information or Design

Information needs for effective planning include sampling of sediments and water for contaminants and developing disposal site vegetation and topographic maps using aerial photography.

Recommendations

The DOI supports this project if it can be demonstrated to be ecologically viable and not contribute additional contamination to the Lagoon or local ground water. A full assessment of contaminants in the sediments must be conducted for determining appropriate dredging methods and disposal of spoil. Spoil disposal must be located at suitable upland locations and remediation/mitigation may be required for habitat losses. Monitoring of the dredging and disposal operations and Lagoon turbidity trends should be included in the project.

After the removal of sediment from the C-51 Canal, aquatic vegetation should be re-established within the Lagoon in close proximity to the C-51 discharge point. Species should be selected according to salinity conditions (24 to 35 ppt for seagrass) and bottom contours (FWS 1998). Established vegetation can enhance water quality within the Lagoon and provide much needed nearshore habitat for estuarine organisms.

Points of Contact

Palm Beach County Department of Environmental Resource Management (Jim Barry); SFWMD (Tommy Stroud).

References

Palm Beach County Department of Environmental Resources Management. 1997. Draft Surface Water Improvement and Management Plan for the Lake Worth Lagoon. West Palm Beach, Florida.

U.S. Fish and Wildlife Service. 1998. Seagrass Community. Multi-species recovery plan for the threatened and endangered species of south Florida. Volume II of II. The communities. Technical/Agency Draft. Vero Beach, Florida.

b. Lake Worth Lagoon Water Quality Improvements

Background, Scope, and Objectives

A draft management plan for the Lake Worth Lagoon prepared by Palm Beach County Department of Environmental Resource Management and DEP identified several basins as either critical, high, or medium priority for restoration efforts. The C-51 watershed and the middle and north Lake Worth Lagoon segments are critical for water quality and ecological degradation and for the environmental significance of the north Lagoon segment. The C-16 watershed, the south Lake Worth Lagoon segment, and Intracoastal Waterway watershed are considered high priority restoration areas due to the extent of water quality and ecological degradation and the environmental significance of the Intracoastal Waterway watershed. The C-17 watershed is identified as a medium priority area for restoration.

Project objectives include: 1) establish baseline information on general water quality, turbidity and salinity levels, 2) determine the optimum minimum and maximum flows of fresh water to the Lagoon, 3) manage excessive freshwater inflows from point and nonpoint sources, 4) decrease inputs of nutrients, toxic substances, and suspended materials, 5) identify anthropogenic loadings of fecal coliform bacteria in the Lagoon and reduce loads to below state standards or to natural background levels.

Status of Project

Some project needs for the restoration of water and sediment quality appeared in the draft management plan for the Lake Worth Lagoon prepared by Palm Beach County Department of Environmental Resource Management and the DEP (DEP 1998). The plan is expected to be approved and adopted by an interdisciplinary, multi-agency Lake Worth Lagoon Ecosystem Management Area Steering Committee. Funding for planning and implementing water and sediment quality restoration is needed.

Future Needs for Information or Design

The resource inventories and modeling efforts that will be required for effective planning include:

i. Baseline information on general water quality, turbidity, and salinity levels with protocols determined for sampling water quality parameters including, but not limited to, temperature, salinity, dissolved oxygen, nitrogen, phosphorous, suspended solids, chlorophyll, turbidity, fecal coliform, and color.

ii. Defining the relationship between light, water quality, and presence of seagrasses.

iii. Model and establish optimum minimum and maximum inflows of fresh water for the Lagoon.

iv. Develop predictive models that link light attenuation and water quality to nutrient loadings and epiphyte abundance.

Recommendations

The DOI recommends implementing management actions that will improve or maintain water quality conditions necessary for seagrass growth in the Lagoon. It is also recommended that mangrove communities and nearshore reef and hard-bottom habitat be protected from point and non-point source pollution. We recommend identifying sources and developing pollutant load reduction goals for sediments, nutrients, and toxic substances for the Lagoon using stormwater treatment, wastewater reuse, best management practices for uplands, etc.

Points of Contact

Palm Beach County Department of Environmental Resource Management (Jim Barry); SFWMD (Pat Walker).

References

Florida Department of Environmental Protection. 1998. Lake Worth Lagoon management plan (draft). West Palm Beach, Florida.

c. Lake Worth Lagoon Habitat Restoration

Background, Scope, and Objectives

Thirty-six project sites have been targeted within the Lagoon for this habitat restoration project. Components identified for this project are designed to: 1) restore, enhance, and create emergent mangrove and cordgrass wetlands, coastal hammock habitat, and protective upland buffer zones where feasible; 2) restore, preserve, and create seagrass beds, oyster bars, and other submerged benthic habitat; 3) construct artificial reef habitat, which will provide important intermediate and adult habitat required for estuarine- and marine-dependent fish and invertebrate species; 4) protect the Florida manatee, and other endangered, threatened and rare species, and species of special concern.

Status of Project

The DEP and the Palm Beach County Environmental Resources Management agency have drafted a restoration plan for the Lagoon (DEP 1998). The plan is anticipated to be approved and adopted by an interdisciplinary, multi-agency steering committee for the Lagoon. Funding is needed for planning and implementation components of the project.

Future Needs for Information or Design

The resource inventories that will be required for effective planning include the following:

i. Identify and map current extent of seagrass habitat in the Lagoon and assess status and condition, including species composition.

ii .Determine the relationship between light and water quality to growth of seagrasses in the Lagoon.

iii. Identify the extent of mangrove habitat in the Lagoon and identify areas that can be linked together.

Recommendations

The DOI strongly recommends funding all or part of this habitat restoration project. Specific habitat recommendations for the Lagoon include: 1) stabilize and increase seagrass habitat by preserving existing seagrass habitat and restoring additional seagrass where feasible, 2) stabilize and increase mangrove habitat, 3) where feasible, support mangrove restoration by restoring natural landscape contours and therefore restoring sheetflow hydrology, and 4) prevent burial and degradation of existing nearshore reefs and hard-bottom habitats in the Lagoon and re-establish impacted areas.

Points of Contact

Palm Beach County Department of Environmental Resource Management (Jim Barry or Harvey Rudolph); SFWMD (Frank Lund or Joel Van Arman).

References

Florida Department of Environmental Protection. 1998. Lake Worth Lagoon management plan (draft). West Palm Beach, Florida.

LOWER EAST COAST: BROWARD COUNTY

1. Restoration of the North Fork of the New River

Background, Scope, and Objectives

The North Fork of the New River, in the City of Fort Lauderdale, is the only remaining natural section of the New River. There is minimal tidal flow in this section of the river and large amounts of sediment and debris (tree trunks, tires, appliances, etc.) are distributed throughout the riverbed, creating unattractive areas and health hazards (K. Carter, Broward County Department of Natural Resource Protection, personal communication 1998). The existing riparian zones of the North Fork are actively eroding in some places and exotics have replaced native species in some areas.

North Fork water quality is characterized by high bacterial and nutrient concentrations and low dissolved oxygen levels. It is believed that contamination from nearby septic tanks and sewage lines has degraded water quality and concentrations of fecal bacteria are consistently high. Sediment samples collected and analyzed throughout the North Fork are virtually void of benthic macroinvertebrate communities. A portion of the sediment bed load consists of sludge previously deposited into the North Fork by a now decommissioned wastewater treatment plant (Broward County 1994a). The presence of heavy metals in sediment was measured at seven collection sites in the North Fork by Broward County Department of Natural Resources. Cadmium and lead levels were greater than the probable effect level (PEL) at six of the seven sites and mercury levels were above the PEL at one site (Broward County 1994b).

This project consists of: 1) spot dredging to improve water quality and water circulation; 2) removal of exotic plant species and revegetation with native plants; 3) implementation of a water quality monitoring program; 4) development of a master plan to promote revegetation and shoreline restoration, including shoreline re-contouring.

Status of Project

A grant agreement between the Florida Department of Environmental Protection and Broward County Commission to secure $50,000 in funding was executed on May 5, 1997. This grant was used to purchase equipment related to water quality testing and a pilot revegetation project, which has been completed. Approximately 80% of the dry season water quality sampling has been completed and the wet season sampling began in May 1998. A recent matching fund grant from the Florida Inland Navigation District and Broward County of $37,500 was implemented to conduct preliminary dredging tests.

Recommendations

The DOI supports the efforts to improve water quality and circulation in the New River. Spot dredging will increase circulation of water in the river, reducing occurrences of stagnation and improve water quality. However, proper disposal of spoil material represents a concern for this project. Disposal sites should be identified so that impacts to sensitive environments are avoided and sediments are not re-transported into the river.

The removal of exotic vegetation and restoration of aquatic and littoral vegetation in conjunction with planting of native species will enhance the biological diversity of the area. Native vegetation along the shoreline will protect against erosion and filter runoff entering the river. An increase in species abundance, richness, and diversity of migratory birds and other wildlife may occur.

Based on the location information provided in the critical letter report for this project, the FWS, Vero Beach office, conducted a GIS and Florida Natural Areas Inventory database check to determine potential species locations. This was done in conjunction with discussions with other Federal and State agency personnel in an effort to develop a sensitive species and critical habitats list for this project. Results of this search have determined that three instances of West Indian manatee (*Trichechus manatus latirostris*) mortality have occurred within approximately one mile of the project area. The West Indian manatee is both a Federal- and State-listed endangered species. One mortality was associated with a floodgate, another mortality was perinatal, and the cause of the third mortality was not determined. Should this project be funded, the FWS recommends initiating informal consultation under section 7 of the Endangered Species Act. Dredging in this area may result in direct or indirect impacts and may affect the Florida manatee.

Implementation of the Standard Manatee Protection Precautions will be required. These stipulations are essential to the protection of the manatee in this area and should be included as special conditions to any permit issued for the proposed project.

References

Broward County Department of Natural Resource Protection. 1994a. New River restoration plan. Technical Report 94:04.

Broward County Department of Natural Resources Protection. 1994b. Toxicological screenings of the hard-head catfish (*Arius felis*) and the blue crab (*Callinectes sapidus*) in the North Fork of the New River, Broward County, Florida. Technical report 94:08.

Carter, K. Telephone communication. April 1998.

2. Western C-11 Basin Water Quality Improvement Project

Background, Scope, and Objectives

The western C-11 basin consists of 51,840 acres located in south-central Broward County, Florida. Stormwater runoff from this basin flows into the South New River Canal (C-11) where it is pumped into the Everglades Protection Area, Water Conservation Area (WCA) 3A, through the S-9 pump station.

In the past, untreated agricultural and urban runoff being pumped into WCA 3A through the S-9 pump station has created water quality concerns. The purpose of this project is to improve the timing and quality of the stormwater discharges from the western C-11 basin into the Everglades Protection Area.

The project involves changes to the pump operation schedule to reduce sump drawdown extremes; use of additional smaller electric pumps to pump seepage and reduce the frequency of high pumping rates that disturb bottom sediments; construction of a gated control structure in the western C-11 canal, west of US Hwy 27, to isolate seepage from stormwater runoff and maintain more consistent canal stages; changes in canal geometry; and rerouting of flows during peak storm events (COE 1998).

Status of Project

This critical restoration project was ranked fifth in importance by the South Florida Ecosystem Restoration Working Group. The project has been approved by Corps of Engineers Headquarters to proceed with the NEPA and preliminary design phase (M. Dollar, COE, personal communication 1998).

Recommendations

The DOI supports the idea of providing a cleaner water supply to the Everglades Protection Area.

Results from a Breeding Bird Survey conducted in 1985 identified an abandoned great blue heron colony adjacent to the project area (B. Stys, GFC, personal communication 1998). Although the components of this project are localized within the canal, the FWS recommends that impacts to wading birds resulting from construction operations be considered for this project if it is determined that sensitive species occur within the area.

Points of Contact

Southern Everglades Restoration Alliance (Louis Hornung).

References

Dollar, M. Telephone communication. April 1998.

Stys, B. Written (fax) communication. April 13, 1998

U.S. Army Corps of Engineers. 1998. Draft project letter report, Western C-11 basin water quality improvement. Jacksonville District; Jacksonville, Florida.

LOWER EAST COAST: SOUTH DADE COUNTY

The Lower East Coast Urban Area (metropolitan and agricultural areas) as defined by the Science Subgroup Report (1993) contains a mosaic of developed and undeveloped lands. The remaining natural habitats are described as fragmented and are composed of tidal marsh/mangroves, freshwater wetlands, pine rocklands, and remnant coastal scrub. Those areas that adjoin the historical freshwater Everglades wetland habitat, east of the east coast protective levee system, are generally degraded as a result of over-drainage practices, the invasion of exotic plant species, and urban expansion.

Restoration efforts must achieve a balance of natural, urban, and agricultural landscapes. Hydrological restoration objectives identified by the Science Subgroup Report (1993) for this region include reducing the dependence of the urban metropolitan and agricultural areas on the Everglades/WCA water and managing the water budgets of the natural urban and agricultural areas for their mutual benefit. To this end, the COE has identified several critical projects (CPs) and other project elements (OPEs) for South Dade County in the Restudy.

1. WCA 3B Seepage Reduction

Background, Scope, and Objectives

This infrastructure project was proposed as an attempt to manage water seepage at the east coast protective levee on the east side of WCA 3B. This is an area where there are large documented seepage losses out of WCA 3B into the South Dade canal system. Due to the extremely high transmissivity of the aquifer at this site, water losses are high. The project is designed to reduce losses out of WCA 3B and improve water deliveries across L-29 to the eastern portion of the ENP. The project would install an underground seepage barrier, using grout technology, to a depth of 100 feet. The barrier would be located between two control structures, S-334 and S-335. An upstream collector canal connected to a downstream spreader canal by a pipe would allow water to pass through the system with the gate open and the barrier in place. The concept is to manage and control the seepage, not prevent it from occurring.

Status

The project was postponed indefinitely at a Governor's Commission Technical Advisory Committee meeting, at which time the proposal received much opposition. In addition, the rockminer's group in South Dade have withdrawn their support for this project.

Recommendations

If one of the primary restoration goals is to create more flow through the Everglades system, then the process of achieving a more natural flow by increasing water levels into the system will have the effect of increasing the groundwater gradient in some areas. This increase in the gradient will result in increased seepage losses in some locations. This project offers an approach to reduce these types of water losses, which can be very high for those aquifers with high transmissivities.

The design of the various alternative plans for the Restudy does not provide for the construction of extensive curtain walls. The alternative plans do address seepage at one location (L-31N) with a shallower 30-foot barrier and there are some provisions for backpumping to alleviate excess ponding. The WCA 3B project represents a type of “demonstration” project for seepage for those aquifers which have high transmissivity rates.

This project does pose the question as to whether hydrological mathematical models developed for the Restudy adequately address areas such as the east coast levee in an effort to better understand the hydrodynamics associated with levee construction and connections to the underlying aquifer. If more accurate models are developed that address seepage losses, then the impacts and/or benefits to trust resources as a result of these types of projects can be better be evaluated. Therefore, the DOI is unable to provide an evaluation of this project at this time.

Points of Contact

Larsen and Associates, Miami (Paul Larsen).

2. South Dade Agriculture: Rural Land Use and Water Management Plan

Background, Scope, and Objectives

The Governor’s Commission for a Sustainable South Florida (1996) addressed the issue of sustainable agriculture in its conceptual plan. This plan states that, for South Florida, the future of agriculture is dependent on several factors such as restoration measures, urban development, readjustment of water table levels, the long term availability of water, and, for many areas, the oxidation of organic peat soils.

The South Dade Agriculture and Rural Land Use and Water Management Plan is being developed by the Department of Planning, Development, and Regulation of Metropolitan Dade County to be included in the county’s Comprehensive Master Plan. This critical project actually consists of two separate projects, the first of which is entitled South Miami-Dade County Agricultural and Rural Area Retention Plan. The second plan will focus on lands within the watershed of South Biscayne Bay, including Biscayne National Park, and is identified as the South Biscayne Bay Watershed Management Plan. The intent and scope of this second project are still being defined at the present time.

The South Miami-Dade County Agricultural and Rural Area Retention Plan is described as an agriculture and rural character retention initiative for the South Miami-Dade County area and will identify the major components of agricultural production and agribusiness, primarily through the use of microeconomic and analytical techniques. Agriculture industry practices associated with each major crop (or commodity) within South Miami-Dade County will be inventoried and studied in conjunction with existing surface water and groundwater hydrologic data. Information will also be collected and analyzed to establish economic strategies and incentives that may be used to strengthen and retain the agricultural industry in this region. The results of this study will be used to determine operating conditions that would optimize water supply and flood protection to these agricultural areas while minimizing adverse impacts to water quality.

As it currently stands, the South Biscayne Bay Watershed Management Plan can be described as a study to develop a plan to direct the comprehensive management of the South Biscayne Bay watershed's land and water resources. Primary components of the study will include: the calculation of pollutant loading into receiving water bodies; analyzing and improving the quantity of distributors and timing of freshwater discharges into Biscayne Bay; identifying pollutant loading reduction levels and canal conveyance capacities, determining best management practices for existing land uses; and developing watershed management strategies. The results of the hydrological and pollutant models developed during the study will allow for the evaluation of various land-use scenarios in an effort to achieve a long-term land use and water management plan for South Miami-Dade County.

Recommendations

The South Miami-Dade County Agricultural and Rural Area Retention Plan, as currently defined, represents a land use-planning document for Dade County and as such is difficult to evaluate for effects on trust resources. The proposed South Biscayne Bay Watershed Management Plan, although still in draft form, may yield useful information concerning water quality issues for Biscayne Bay.

3. South Dade/C-111 Basin Hydrological/Water Quality and Sustainable Agricultural Program

Background, Scope, and Objectives

Proposed structural and operational changes to the C&SF Project are being evaluated to assess gross changes in regional hydrology. There are some concerns as to whether these models will adequately predict and assess changes in the water table and localized flooding in the South Dade agricultural area. For example, raising and lowering water levels in L-31N, C-111, and the rehydration of Taylor slough may effect agricultural land uses in South Dade. This project will evaluate and enhance the available regional hydrological and water quality data. It will also field calibrate, formulate, and develop a model that is capable of simulating the hydrology in the South Dade agricultural area. This will be accomplished by using a spatial and temporal scale that will allow prediction of localized impacts from proposed changes in the C&SF Project. The development and implementation of technologies guided by a localized model's predictions will be used to reduce not only the vulnerability of crops to the effects of extended high water tables, but also impacts to Everglades National Park (ENP), Biscayne Bay, and Florida Bay by minimizing ground and surface water pollution.

Status of Project

At the present time, this project is unfunded and has not proceeded beyond the nomination stage.

Recommendations

The finer resolution hydrological model produced from this project should provide a way to quantify fluctuations in water levels in the field and therefore improve the ability to assess the effects of various water management scenarios on agricultural activities in South Dade. The DOI would be supportive of this critical project if the model would also be used to assist in increasing water efficiency for this sub-region as well as reducing ground and surface water pollution that currently impacts ENP, Biscayne Bay, and Florida Bay.

4. Water Quality Treatment and/or Urban and Agricultural Best Management Practices (BMPs)

Background, Scope, and Objectives

The goal of the project is to ensure that agriculture in the South Dade County basin remains economically viable as well as a good and sustainable neighbor to both Everglades and Biscayne National Parks, both of which are adjacent to farmed lands. The project is designed to help increase water and fertilizer efficiency and reduce the amount of nutrients seeping into the Biscayne aquifer from these South Dade agricultural areas by developing best management practices (BMPs).

The University of Florida's Institute of Food and Agricultural Science (IFAS), Tropical Research and Education Center in Homestead is conducting this study in collaboration with South Dade farmers. Other project partners include the Florida Department of Agriculture and Consumer Services, the EPA, and the DEP.

The poor retention properties for both water and nutrients of the hard, porous oolitic limestone soil in the South Dade agricultural areas results in the tendency of farmers to use more fertilizer and water than necessary to promote new plantings and increase crop yields. Nutrients from leached fertilizers flow from the fields through the aquifer and into Biscayne Bay resulting in increased levels of nutrients to nearshore waters (B. Schaffer, IFAS, personal communication 1998). Research personnel from the Tropical Research and Education Center will be investigating systems to monitor soil moisture using a process called EnviroScan that can be used to determine the most efficient irrigation rates for the highest crop yields with the least amount of nutrients leaching into ground water. The study also includes the use of groundwater monitoring wells as well as monitoring of pesticides. The Tropical Research and Education Center staff will compare the use of EnviroScan technology with traditional methods of monitoring and scheduling irrigation to determine which method is most efficient, reliable, and cost effective. Once the three-year study is completed, the SFWMD may adapt the technology to other areas throughout South Florida.

Status of Project

This study is currently underway under the guidance of the Tropical Research and Education Center. Field demonstration tests for using Enviroscan technology have been initiated as well as tests to validate the fertilization rates developed by IFAS for South Dade soils and crop types.

Recommendations

This project provides an opportunity to improve water quality in south Florida agricultural areas by reducing non-point source pollution and excess water flows. The study is also designed as an educational/demonstration project to assist farmers in voluntarily implementing BMPs. These types of projects, while on a small scale, have the potential to provide valuable information that can be used to reduce adverse impacts from non-point source pollution, a water quality concern for many watersheds in south Florida. The DOI supports these studies for their inherent restoration effects to Biscayne Bay and nearshore waters.

Points of Contact

University of Florida, Institute of Food and Agricultural Science (IFAS), Tropical Research and Education Center, Homestead (Dr. Bruce Schaffer); SFWMD, West Palm Beach (Lisa Smith).

References

Schaffer, B. Telephone communication, May 13, 1998.

5. Restoration of Pineland and Tropical Hardwood Hammocks on previously Rock-plowed Land in C-111 Basin in Dade County

Background, Scope, and Objectives

Tropical hardwood hammocks are defined as evergreen, broad-leaved forests composed of shrub and tree species that are common to the Bahamas and Greater Antilles (Snyder *et al*. 1990). Along with rockland pine forests, these vegetative communities form the rockland ecosystems of south Florida. Rockland tropical hammocks occupy elevated, rarely inundated, and relatively fire-free areas in three major rockland areas of south Florida - the Miami rock ridge, the eastern Big Cypress Swamp, and the Florida Keys (Snyder *et al*. 1990). Rockland plant ecosystems can be considered as just one component of the diverse mosaic of plant communities that contribute to habitat heterogeneity and ultimately to the biological diversity of south Florida's natural environment.

This critical project is designed to demonstrate the techniques for re-establishing native conifer and hardwood forests on those lands that have previously been rock-plowed. The restoration project will consist of restoring native south Florida slash pine and hammock species within a 200-foot-wide strip on each side of two miles of State Road 9336 from the C-111 canal to the L-31W canal. Two one-acre hammock sites will be established in low lying areas on each side of the road. Native species initially proposed for the site include dahoon holly (*Ilex cassine*), gumbo limbo (*Bursera simaruba*), live oak (*Quercus virginiana*), sweet bay (*Magnolia virginiana*), paradise tree (*Simarouba glauca*) as well as a variety of shrub plants. Once the overstory has become established, the project will add additional shade species to provide an understory within the hammocks. Monitoring efforts will be included in the project design in order to demonstrate the progressive reduction in vulnerability to encroachment of exotics as the native plants mature.

Status of Project

At the present time, this project is unfunded and has not proceeded beyond the nomination stage.

Recommendations

Tropical hammocks that comprise the rockland plant ecosystems support the largest number (59 taxa) of rare and threatened plants (Gunderson 1994) and therefore represent important habitat for consideration in restoration efforts. This project is important if only for the valuable monitoring information it will provide relative to re-establishment of native species on rock-plowed lands. Other locations within the Everglades ecosystem that have been disturbed by past land use practices may also provide an opportunity to implement similar revegetation efforts and thus provide important habitat for sensitive plant and wildlife species. The DOI supports the implementation of this project.

References

Gunderson, L.H. 1994. Vegetation of the Everglades: determinants of community composition. Pp.323-340 *in* S.M. Davis and J.C. Ogden (eds.) Everglades: The ecosystem and its restoration. St. Lucie Press; Delray Beach, Florida.

Snyder, J.R., A.K. Herndon, and W.B. Robertson, Jr. 1990. South Florida rockland. Pp. 230-277 *in* R.L. Myers and J.J. Ewel (eds.) Ecosystems of Florida. University Presses of Florida; Gainesville, Florida.

6. L-31E Flow Redistribution Project

Background, Scope, and Objectives

This critical project consists of reworking and constructing a freshwater distribution system along a 3.5-mile length of L-31E levee and borrow canal from S-20G to S-21A. This work will include moving the levee toward the borrow canal on top of an existing road, creating a new ditch and berm along the east side of the canal, and constructing a series of culverts to convey water from the borrow canal along the west side of the levee to the new ditch along the east side.

The intent of the L-31E Flow Redistribution Project is to facilitate the restoration of the ecological integrity of Biscayne Bay by re-establishing the sheetflow of fresh water through coastal wetlands in Biscayne National Park. Historically, fresh water entered the southern Biscayne Bay estuary through a series of creeks and sloughs. This flow pattern was disrupted by the L-31E levee system constructed in the 1960s for flood control. Currently, freshwater flows discharge from a few control structures into the estuary resulting in frequent and wide swings in salinity at the canal discharges. Studies have documented disrupted benthic communities near the canal discharge zones as well as destruction of seagrass beds as a result of these pulses of freshwater.

Restoration benefits to the estuary are expected to include: (1) reduction in the frequency of damaging wide swings in salinity at water control structure locations, (2) delivery of fresh water to wetland communities and subsequent availability to the estuary, and (3) reduction in pollutant loading to Biscayne Bay by removal of contaminants. Freshwater flow will be restored into mangrove wetlands at appropriate locations. Point source discharges of freshwater, which may contain contaminants, into Biscayne Bay will be greatly restricted or eliminated. The project is expected to facilitate the restoration of essential fish and mangrove fringe habitat and thereby enhancing habitat for the endangered American crocodile (*Crocodylus acutus*).

Status of Project

Currently, the technical issues relative to the L-31E Flow Redistribution Project are being reviewed by the project's sponsor (SFWMD). The geographic scope of the project has been modified from the original proposal to one-half the area to reduce the cost. Measures of benefits will also be added to the project's scope.

Recommendations

Unrelated, but nearshore, ongoing projects sponsored by SFWMD are currently providing valuable monitoring information for the estuarine community in Biscayne Bay and should prove useful in redefining the scope of the L-31E Flow Redistribution Project. Because this critical project is still undergoing design change, at this time, it is difficult to provide a comprehensive evaluation or evaluation as to the benefits to fish and wildlife resources. This project may provide benefits to the natural resources described above for Biscayne Bay and the DOI is supportive of projects that assist in the restoration of the bay.

7. Biscayne Bay Coastal Wetlands

Background, Scope, and Objectives

Freshwater marshes, coastal wetlands, and nearshore estuarine ecosystems of western South Biscayne Bay have been seriously impacted by diversion of overland freshwater flow into canals and by a reduction in groundwater seepage along the shoreline due to the drawdown of the water table as a result of development along the east coast. This loss of groundwater seepage is believed to have seriously reduced the total flow of fresh water into Biscayne Bay during the dry season. This project is expected to create conditions that will be conducive to re-establishing oyster beds and other components of the oyster reef community. The diversion of the current canal discharges into coastal wetlands is expected to reestablish productive nursery habitat along the shoreline as well as reduce the severe freshwater discharges at the canal outlets that are physiologically stressful to fish and benthic invertebrates in the bay. The reduction or elimination of large pulses of fresh water to the estuary will also result in improved water quality for the nearshore environment.

The project is located in southeast Dade County, from the Deering Estate at C-100C, south to the Florida Power and Light Turkey Point Power Plant. This project has five sub-components that are designed to rehydrate the Biscayne Coastal Wetlands by creating sheetflow through the wetlands and reducing point source discharges to Biscayne Bay. These are described as follows (B.Perry, Biscayne National Park, personal communication 1998):

a) Deering Estate Flow-way - this sub-component will pump water from the SW 160th Street ditch (a tributary to C-100C) through property adjacent to the Deering Estate and into Cutler Drain, which runs through the Deering Estate. This feature is designed to rehydrate the coastal Deering Estate and reduce point source discharges to Biscayne Bay.

b) Cutler Wetlands - operation of this sub-component is designed to route water south from C-100A through a Stormwater Treatment Area (STA) (to be constructed adjacent to C-100B) to the Cutler Wetlands proposal area via a shallow distribution swale to C-100B. Water will be pumped from C-100B through the STA to the spreader swale and from C-100A south into the spreader swale to allow sheetflow to the east and Biscayne Bay. This will redistribute flow along the shoreline with a timing and volume schedule that will allow re-establishment of nearshore oyster bars, reduction of point source discharges into the bay, and restoration of coastal mangrove habitat.

c) L-31E Flow-way - A flow redistribution system will be designed west of L-31E, allowing for the restoration of existing wetlands in the area between L-31E and the western boundary of the redistribution system. A distributional swale, containing a western levee, will be constructed along this boundary. The wetland area west of L-31E is intended to be used for short-term, shallow ponding of water to maintain wetland habitat and distribute freshwater flow to Biscayne Bay, which will aid in re-establishing conditions for living oyster bars along the shoreline. This sub-component also includes design features that hydrologically isolate the Dade County landfill and backfill the Military Canal.

d) North Canal Flow-way - Two 200 cfs pumps will pump water from both the C-103 and the Florida City Canal to proposed STAs, when water is available, and reestablish sheetflow across freshwater and coastal wetlands to Biscayne Bay. This feature will distribute freshwater outflow to Biscayne Bay along the shoreline to help reestablish conditions for living oyster bars and to reduce point source discharges to the bay.

e) Barnes Sound Wetlands - Water, when available, will be pumped from Florida City Canal, to a shallower east-west spreader canal to be constructed south of a proposed 500-acre STA for spreading water to wetlands within Barnes Sound. The purpose of this sub-component is to restore coastal freshwater and mangrove wetland habitat and reduce point source discharges to Biscayne Bay.

Several general considerations for this project include: 1) the presence of existing ditches, which interfere with historic flow patterns, 2) the presence of exotic plants and animals, 3) water quality concerns, and 4) land ownership constraints. The project will therefore consider filling ditches and adopting an invasive exotic removal program. Most of the lands to be acquired are currently under acquisition efforts by the State and Dade County.

The proposed project will also include a variety of studies to verify and validate the effectiveness of the structures and operations of the project. Programs to be implemented include: 1) water quality monitoring (both surface and ground water), 2) estuarine habitat evaluation, and 3) benthic community and fish responses.

Status of Project

The Biscayne Bay Coastal Wetland Project is sponsored by the South Dade Wetlands group that is composed of representatives from Biscayne National Park, Everglades National Park, NOAA-NMFS, Miami-Dade Department of Environmental Resources Management, the SFWMD, and the COE.

Recommendations

The DOI strongly supports this project because of the potential to substantially improve the biological integrity and stability of this coastal ecosystem. Additional wetland and estuarine habitat will be restored for the bay and within Biscayne National Park as a result of restoring the natural hydrologic regime. A general increase in species diversity and abundance of estuarine fish and invertebrates is expected in response to implementation of this project as well as improvements to seagrass bed communities in nearshore waters.

References

Perry, B. 1998. Written communication (OPE Fact Sheet), May 1998.

WESTERN BASIN AND BIG CYPRESS

This subregion of southwest Florida presents an immensely varied landscape, dominated by seasonally flooded cypress savannahs and freshwater marshes, with interspersed hydric pine wetlands and pine-dominated uplands. The area also includes an extensive coastal fringe of mangroves, beaches, and numerous estuaries. Restoration of predrainage hydroperiods and water flow is an important goal for large areas of southwest Florida including Big Cypress National Preserve, the Fakahatchee Strand State Preserve, the Florida Panther NWR, Southern Golden Gate Estates, Corkscrew Swamp Sanctuary, the Ten Thousand Islands NWR, and the Rookery Bay National Estuarine Research Reserve (NERR). Some of these areas are linked hydrologically. Many changes are underway to watersheds in southwest Florida to accommodate both agricultural and rapidly growing urban land use. These changes may affect the neighboring and downstream natural areas listed above. As a result, several critical projects, some of which are extensive in size and scope, have been identified for this region and are described below.

Existing hydrological models used by the SFWMD, Big Cypress Basin, and others are inadequate in providing essential information regarding how changes in the hydrologic regime will effect the ecosystem. The Southwest Florida Project Coordination Team has proposed a Southwest Florida Water Management Model (SWFWMM) for those areas within southwest Florida that are not contained within the SFWMM. In addition, the COE, with sponsorship of the SFWMD, has proposed a separate feasibility study for southwest Florida as a part of the C&SF Restudy. In fiscal year 1999, a reconnaissance study will be initiated to identify water resource problems and opportunities, leading to the initiation of a full feasibility study in fiscal year 2000. Chapter XV provides an additional discussion of the Southwest Florida Feasibility Study and recommendations from the FWS.

1. Henderson Creek/Belle Meade Drainage Basin Restoration

Background, Scope, and Objectives

This critical restoration project is located in southwest Florida within Collier County, a region of Florida that is experiencing a tremendous increase in urban growth. Roads, canals, planned unit developments, commercial projects, and agriculture represent land uses within the Belle Meade watershed that pose adverse impacts to the coastal habitats and hydrology of Collier County. The impacts from these land use patterns and the subsequent channelization of natural systems has greatly modified the volume, timing, and quality of freshwater flows that drain into the Rookery Bay estuary and adjacent estuarine waters. These estuarine areas provide critical nursery habitat for commercially and recreationally important finfish and shellfish. In addition, the channelized flow in this watershed has severely restricted the ability of associated wetlands to filter pollutants.

The area known locally as Belle Meade Drainage Basin represents the primary drainage basin for the Rookery Bay NERR and is currently targeted for acquisition by the DEP, Division of State Lands, through the Conservation and Recreation Lands (CARL) Program. Historically, fresh water flowed across the land surface of the Belle Meade Drainage Basin, percolating through wetland flow-ways before entering Rookery Bay NERR. Acquisition and restoration of the remaining undeveloped lands surrounding Henderson Creek (which links the watershed basin with the estuary) is proposed with this project in an attempt to prevent further hydrologic and habitat degradation.

The project has five components: a) installation of culverts under State Road 951, b) construction of a filter marsh stormwater management system, c) Manatee Basin hydrologic restoration, d) construction of swale and spreader systems, and e) removal of the Road-to-Nowhere roadbed. Two of these components include land acquisition actions.

a. The installation of four additional culverts under SR 951 is proposed to help increase the surface water flow from the east side of the road to the west side. The four existing culverts recently constructed have improved flows but become overloaded during peak flow conditions.

b. The DEP Carl Program is pursuing the purchase of two parcels of land (approx. 25 acres) adjacent to the Henderson Creek canal. A proposed stormwater management system in the form of a filter marsh on these lands would allow water from the Henderson Creek canal to flow through this filter marsh, which would assist in removing pollutants from the water before it reaches the estuary. The water levels in the canal and the stormwater management system would be managed through the development of an operational plan for the Henderson Creek weir. In addition, invasive, exotic plants would be removed from this site, providing an enhancement benefit to the vegetation community.

c. The Manatee Basin hydrologic restoration consists of both acquisition and restoration activities. Four parcels (approx. 100 acres) of land that drain into the Manatee Basin have been targeted for acquisition by three different funding sources: the CARL Program, Collier County, and a combined FWS grant and Farm Bill funds. Restoration activities would involve: installation of additional culverts under US Route 41, filling of existing drainage ditches to the adjacent grade, returning a power line access road to an at-grade level and installation of GeoWeb materials to allow access for maintenance crews, removal of exotic plants, and creation of a berm along the southern boundary of these parcels to prevent downstream flooding of residential areas.

A public access point and interpretive boardwalk has been proposed, which would lead through the natural plant communities and provide a public viewing areas for manatees.

d. Two overflow swale and spreader systems are proposed from the US Route 41 canal to reintroduce freshwater into McIlvane Marsh and the Ten Thousand Islands NWR in place of the current canal and culvert system now in place under US Route 41. The two broad swale and spreader systems would direct freshwater overflows from the US Route 41 canal to the south. Residential and agricultural development south of US Route 41 currently limits the conveyance of freshwater sheetflow.

e. The Road-to-Nowhere was placed in the McIlvane marsh in the late 1960s as part of a development project. This area was then deeded to the state as part of a settlement agreement. Southern States Utilities currently has an outfall pipe for gray water that runs from its sewage treatment plant to the marsh system. Although not currently used, this pipe has been used for high-volume flows on an irregular basis. The goal of this aspect of the project is to remove the pipe and then the old roadbed. Recent surveys of the area have documented a nesting population of the endangered American crocodile. The removal of the road, or portions thereof, will be coordinated with the FWS and the GFC so that this listed species would not be adversely impacted.

Status of Project

Portions of the Henderson Creek/Belle Meade Restoration project are proceeding with grant monies received from the NMFS and the SFWMD. Work is currently underway by Collier County personnel to implement the swale/spreader system, primarily the acquisition of easements. Studies of nesting populations of the endangered American crocodile are being conducted by biologists associated with the University of Florida, Gainesville. Although eggs were laid in nests during 1997 and 1996, no hatchlings occurred in either year (Paul Moler, GFC, personal communication 1998). Researchers will be collecting eggs in 1998 and incubating them *ex situ* in an effort to determine egg viability and fertility. These biologists are also planning to conduct additional surveys of the southwest coast for populations of this endangered species.

Recommendations

This critical project as well as the Southern Golden Gate Estates Restoration Project and the Southern CREW Project Addition described below represent extensive habitat restoration projects for the Western Basin of south Florida. Some of the ecological improvements for the Henderson Creek/Belle Meade project include: 1) restoration of historic surface water flow patterns to estuarine and marsh habitats, 2) removal of invasive exotic plants, 3) improvement of water quality for flows to the estuary, and 4) improvements to habitat important for supporting sensitive species such as the American crocodile and the West Indian manatee. To the extent possible, historic overland flow-ways to Manatee Basin should be restored. The DOI strongly supports restoration in the Western Basin of southwest Florida, particulary those which can provide restoration of historic fish and wildlife habitats.

References

Moler. P. Telephone communication, May 18, 1998.

2. Southern Golden Gate Estates Hydrologic Restoration

Background, Scope, and Objectives

The Southern Golden Gate Estates (SGGE) study area encompasses approximately 94 square miles of important lands in southwestern Collier County, between the Fakahatchee Strand and Belle Meade watersheds. The Picayune Strand State Forest (previously the Golden Gate State Forest) encompasses the southern blocks of the Golden Gate Estates land area. The SGGE project area has been identified as an important surface storage and aquifer recharge area with unique plant communities and wildlife habitat. It also includes three major flow-ways that contribute fresh water to the Ten Thousand Islands estuary of the western Everglades watershed. Much of the area was logged for cypress in the 1940s and 1950s, after which the area was purchased for development of the Golden Gate Estates subdivision. Construction of road and drainage modifications in the 1960s and 1970s have resulted in reduction of aquifer storage, increased fresh water shock load discharges to the estuaries, invasion of upland vegetation, and increased frequency of forest fires. A study was commissioned in 1975 to study the feasibility of restoring the area south of Interstate 75. Since then, numerous studies have been conducted to develop methods of restoring the area to its former condition. In 1985, SGGE was included in the "Save Our Everglades" portion of the Conservation and Recreational Lands (CARL) program. The primary objective of this critical project is to restore the environment of the area to its natural state by re-establishing the historic flow-ways and reducing the shock load of fresh water discharges to the estuary.

Status of Project

An Interagency Technical Committee, with representatives from SFWMD, COE, Florida Department of Forestry, NRCS, GFC, Big Cypress Basin, DEP, and the FWS, has been meeting on a regular basis in an effort to evaluate the SGGE Hydrologic Restoration Project. Active acquisition of private lands is still ongoing through a willing seller program (CARL) administered by the DEP. The implementation of this project is entirely contingent upon acquisition of lands. Of the 55,200 acres of land proposed for acquisition, 37,312 acres have yet to be acquired, of which approximately 7,500 acres are controlled by nearly 4,200 land owners. The Federal Farm Bill grant has allocated monies in non-matching funds to assist in the acquisition of the project site. Active land acquisition is presently ongoing for the adjacent Fakahatchee Strand State Preserve on the east and the Belle Meade CARL project located on the western side of the project site.

Recommendations

The Picayune Strand State Forest Resource Management Plan (1996) presents a list of fish, wildlife, and plant resources for the area; however, a comprehensive plant and animal survey has not been conducted for the forest due to lack of funding. The proposed area is located almost entirely within the Florida Panther Preservation Area and within Florida panther (*Felis concolor coryi*) telemetry locations and therefore is considered to be within potential Florida panther habitat. Because the panther prefers upland habitats, the project planning process must include protection of upland areas that may be impacted by increase flows to the preservation area as well as evaluation of extended hydroperiods for these areas. Biologists from the Florida Panther NWR (which is located immediately adjacent to SGGE) have suggested that wildlife inventories be conducted for this area to include monitoring of movements for both the endangered Florida panther and Florida black bear (*Ursus americanus floridanus*), which is a candidate for Federal listing. Additionally, to the immediate southwest of this study area, there are nesting locations for the federally-endangered red-cockaded woodpecker (*Picoides borealis*) and one bald eagle (*Haliaeetus leucocephalus*) (a federally-threatened species) nest within the study region. Other species of concern that have been identified as occurring within the project region include the endangered wood stork (*Mycteria americana*) and the threatened eastern indigo snake *(Drymarchon corais couperi*). State-listed species that are known to inhabit this area include the Big Cypress(=mangrove) fox squirrel (*Sciurus niger avicennia*) and the southeastern American kestrel (*Falco sparverius paulus*). The status of each of the above described species should be determined and the potential impacts resulting from re-establishment of historic flow-ways in this region assessed.

Since the proposed project will most likely change freshwater discharges to the Ten Thousand Islands NWR, which contains habitat for the endangered West Indian manatee and endangered American crocodile, impacts to these listed species should be considered in the planning process. West Indian manatee critical habitat has been designated for all connected bays and estuaries for this portion of Collier County. The FWS would be interested in any proposed alteration of flows of fresh water to Faka Union Canal as a result of this project, since this canal is known to be an aggregation site for the manatee and has contributed to boat-related manatee mortality. Increasing sheetflow as opposed to canal flow may reduce the risk of manatee mortality.

Coordination with the COE, the SFWMD, GFC, and the SGGE Interagency Technical Committee is essential to this project. The Big Cypress Basin (Basin) office of the SFWMD has been tasked with developing a Watershed Management Plan for the Basin, which includes the SGGE area. The SFWMD requested watershed planning assistance from the NRCS. The scope of work in developing a Basin Watershed Management Plan has been reviewed by the Interagency Technical Committee. The NRCS will acquire and analyze topographic, soil, and vegetation data and perform hydrologic modeling analyzes for the SGGE area to be used in developing the plan. This information will be important for guiding the hydrologic restoration critical project for SGGE. The Basin office has earmarked $40,000 in additional funds to extend the Watershed Management Plan project to September 1999. This will ensure that the work is funded until fiscal year 2000 WRDA monies can be allocated to continue the biological and hydrological monitoring in the SGGE area.

The DOI believes that the SGGE Hydrologic Restoration project represents an important critical project for southwest Florida. The biological surveys and hydrological information gathered for the SGGE area for developing the Watershed Management Plan for the Basin will be essential for the design and implementation of this project.

References

Florida Department of Agriculture and Consumer Services, Division of Forestry. 1996. Forest resource management plan for the Picayune Strand State Forest, Collier County, Florida.

3. Southern Corkscrew Regional Ecosystem Watershed (CREW) Project Addition/Imperial River Flow-way

Background, Scope, and Objectives

This project will involve acquisition of 4,670 acres of land in the southern Flint Pen Strand region of Lee County and the historical Imperial River flow-way to Estero Bay. After restoration of historical flows, this land area will be added to the Corkscrew Regional Ecosystem Watershed which lies on the eastern border of the proposed project. The project area has been significantly altered by construction of roads, house pads, agricultural berms, and ditches. This has resulted in restriction of historical sheetflow, unnatural water impoundments and flooding, increased pollutant loading to the Imperial River and Estero River, and disruption of natural wetland functions. The lands proposed for acquisition have been divided into five and ten acre tracts that are being developed into single family home sites. This critical project will include purchase of lands in the impacted region before additional homes are constructed. The area has a history of flooding problems that have required the evacuation of residents. If the land continues to be developed for housing, additional roads, house pads, septic tanks, and drain fields will increase the blockage of the surface water flow and contribute to the degradation of water quality in adjacent environmentally sensitive areas.

Hydrologic restoration will include the following activities: removal of existing road beds, removal of single family homes, removal of debris, filling of ditches, and removal of agricultural berms and canals. Other project components include modifications of the Kehl Canal weir and replacement of the Imperial Bonita Estates (IBE) bridge. The Kehl Canal weir will be raised in order to provide more storage capacity and gates will be added to allow better water management and control of the canal which flows through the land proposed for acquisition. The IBE bridge located over the Imperial River downstream from the Kehl Canal weir will be replaced so that it will allow a more direct flow path and eliminate a constriction that currently exists within the natural stream channel as a result of the current bridge design. The project sponsor will be responsible for acquiring any authorizations under Section 10 of the River and Harbors Act and Section 404 of the Clean Water Act, as required.

This acquisition project will not only mitigate future impacts, but also should provide long-term benefits to a watershed of over 300 square miles. The removal of structures and filled areas in the project site will restore the historical flow-way of the Imperial River and reduce the depth and duration of stormwater impacting natural areas. Additionally, the re-establishment of historical flows across the project site will reduce the potential that currently exists for forcing water eastward through the CREW Project and the Corkscrew Swamp Sanctuary, causing harm to natural wetlands by increasing the depth and duration of hydroperiods in these areas. The Kehl Canal weir modifications are designed to reduce the dry season flows (overdrainage) to the Imperial River by acting as a natural storage area. As stated earlier, the project will eventually be added to the CREW with perpetual management to maintain natural system qualities.

Status of Project

In a combined effort, Lee County and the SFWMD have already purchased 2,000 of the total project's 4,760 acres of land. The urgency of this proposed acquisition is high due to the ongoing residential development in the area and the potential impacts of this development to the water quality of the Imperial River as well as to the environmentally sensitive lands of the CREW and Corkscrew Swamp Sanctuary.

Recommendations

The above described critical project represents one piece of an important watershed in southwestern Florida, a region of Florida that is currently experiencing tremendous urban growth pressures. The project land acreage is contained within the identified Florida Panther Preservation Area and within panther telemetry locations. Specifically, the lands within this project that are located east of Bonita Grand Road and north of Bonita Beach Road are classified as Priority 2 panther habitat based upon the less frequent use of this area by the endangered panther (Logan, *et al*. 1994). These lands are composed primarily of wetland habitat adjacent to agricultural lands and have been impacted to some extent by housing development. The acquisition, restoration, and management of this land acreage would provide benefits to the panther by: 1) providing a buffer area from urban use, 2) providing habitat on the periphery of the range that is suitable for dispersing subadult populations, and 3) to a lesser extent, providing habitat for a panther with an established home range (such as one female that currently utilizes Corkscrew Swamp (A. Eller, FWS, personal communication 1998). Two additional federally- listed species that are expected to occur within the Southern CREW project addition are the threatened eastern indigo snake and endangered wood stork. Biological surveys to document population distribution and abundance should be conducted for these species.

The proposed Southwest Florida Water Management Model and an expanded NSM model would be beneficial in understanding the altered hydrologic system for this region. Model outputs would provide important design information for this restoration project and others proposed for southwest Florida.

References

Eller, Jr., A.C. Tele-communication (E-mail), May 15, 1998.

Logan, T.J., A.C. Eller, Jr., R. Morrell, D. Ruffner, and J. Sewell. 1994. Florida panther habitat preservation plan - south Florida population. Florida Panther Interagency Committee; Atlanta, Georgia and Tallahassee, Florida. 44 pp.

4. Seminole Tribe Big Cypress Water Conservation Plan

Background, Scope, and Objectives

The Big Cypress Seminole Reservation (Reservation) is the largest of the federal reservations held in trust by the United States government for use by the Seminole Tribe of Florida (Tribe) and is located in Hendry and Broward Counties, Florida. The Reservation has a hydrologic connection to the C-139 Basin, the EAA, the L-28 Basin, WCA 3A, Feeder Canal Basin, L-28 Tie Back Basin, the Miccosukee Reservation, Big Cypress National Preserve, and, ultimately, to Everglades National Park (ENP).

The C&SF Project, primarily the construction of major canals, levees, and control structures, continues to have a major impact on central and southern Florida natural systems, including those within the Big Cypress Reservation. Continued deterioration of the wetland habitats on the Reservation, increase in spatial extent of exotic species, and continued decline in water quality can be expected without changes to the current hydrological system.

A Conceptual Water Conservation System Design (Conceptual System Design) prepared by AMS Engineering and Environmental (1995) has been presented by the Tribe in an effort to: 1) utilize available, native wetland resources to reduce the total phosphorus concentration in accumulated surface water runoff prior to discharge, 2) store surface water for irrigation, 3) attenuate peak storm runoff discharges, and 4) provide the opportunity to rehydrate a portion of the Big Cypress National Preserve Addition. The Tribe has proposed that it will integrate the use of field applied best management practices, “on-line” surface water storage cells, and existing swamp and marsh wetlands as effective treatment areas within the proposed Water Resource Areas (WRAs) to reduce total phosphorus concentrations in surface waters leaving the Reservation.

The Big Cypress Water Conservation Plan (Plan) is a water conservation project that would implement the Conceptual System Design proposed by the Tribe. The Plan is designed to improve the quality, quantity, timing, and distribution of water on the Reservation. The western portion of the project consists of 2,092 acres and is being considered as a critical project for the Restudy with work being performed by the COE. The eastern portion of the project consists of 5,043 acres and is being proposed under programs to be funded in part by the NRCS.

The proposed critical project will provide for the design and construction of water control, management, and treatment facilities in Basins 1, 2, 3, and 4 and the major conveyance systems necessary to bring the Tribe’s water entitlement into these four basins. The project is designed to improve the water quality and runoff from phosphorus generating agricultural sources within the Reservation. The phosphorus goal has been set at 50 ppb. However, the project will be designed to allow for additional treatment technology to meet stricter phosphorus levels, if required.

Status of Project

The Tribe has filed for a Section 404 permit with the COE for the **eastern** portion of the water conservation project. The FWS evaluated the public notice and provided recommendations to the COE requesting the following information: 1) provide any available wildlife survey information for the Reservation, 2) provide a description of the vegetative communities that will be affected by the project, and 3) conduct a wetland assessment to quantify lost wetland functions and values as well as the benefits of wetland creation, enhancement, and preservation that may mitigate lost functions and values. An interagency Wetland Rapid Assessment Procedure (WRAP) has been recommended for this task.

Although the critical project addresses the **western** portion of the Conceptual System Design, the FWS believes that the above concerns should be addressed for the critical project as well. The FWS requested that the COE combine both projects into one NEPA review to facilitate an analysis of total project effects.

Recommendations

The DOI is supportive of restoration projects within the western basin of southwest Florida. The Tribe's proposed Water Conservation Plan (**which includes all seven basins within the Reservation**) presents a conceptual design to address such issues as flood attenuation, water quality, water supply, and environmental enhancement goals on the Reservation. However, there are a number of unresolved concerns related to this project that must be addressed before the project can proceed. These include: 1) determining the extent of wetland impacts, 2) mitigation measures to be taken for wetland impacts, 3) preservation of adjacent wetland habitat, 4) establishing a monitoring program for the project, 5) the redirection of water to Big Cypress National Preserve (e.g. water quantity), 6) details on how the irrigation cells will function, especially during storm events, 7) operational design of the WRAs, 8) treatment of other pollutants other than phosphorus, and 9) objections expressed by the Miccosukee Tribe relative to the 50 ppb phosphorus target for the project. The need for wildlife surveys must be addressed for the project area. It is anticipated that the COE, the FWS, the EPA, and SFWMD will work with the Tribe to resolve these and other issues.

References

AMS Engineering and Environmental. 1995. Conceptual water conservation system design for Big Cypress Reservation. Prepared for Seminole Tribe of Florida.

5. Town of Fort Myers Beach

Background, Scope, and Objectives

The Town of Fort Myers Beach in southwest Florida (Lee County) has identified the need for the protection of adjacent Estero Bay and local beaches from pollutants transported via stormwater runoff from the island on which the town is located. Most of the town is urbanized and has an inadequate stormwater management system. Components identified for this critical project include: inventory of stormwater systems, sediment sampling, screening of illicit connections, and implementation of an urban retrofit project. The project is designed to enhance Estero Bay and has received full support of local government and residents of the community. Apparently, the town has no other alternative for stormwater treatment, such as creating a filter marsh, due to lack of space. The town has already begun to identify stormwater "hot spots" through inventory and sampling procedures and has converted 48,000 square feet of asphalt to pervious paving materials. Pores in the asphalt of these materials allow runoff from parking lots to flow through the pavement into an underground reservoir of small stones, and then gradually filter into the surrounding soil. Other options for controlling urban runoff that are under consideration include installation of "water quality inlets," which are baffled concrete tanks for solids and oil separation, as well as numerous other best management practices (e.g. encouraging the use of slow-release fertilizers, etc.) The project is expected to provide immediate water quality and ecological benefits to the Estero Bay Aquatic Preserve by reducing pollutant loading to receiving waters.

Status of Project

At the present time, the town is seeking revenue sources to implement components of this project. A private consultant planning group, is presently working with local land owners to initiate volunteer efforts to repave their parking lots with pervious paving materials. The Town of Fort Myers Beach is developing a comprehensive plan that will include a stormwater management element.

Recommendations

This critical project does have the potential for improving the water quality of Estero Bay and nearshore waters by reducing the effects of stormwater runoff and subsequent pollutant transport. However, the DOI would expect this very localized project to be resolved by the city with monies from grants or through a levy on local utility bills. We are uncertain as to whether this project is of adequate scope to generate Federal interests. The project may be significant for providing a model stormwater management program for other coastal communities throughout Florida.

6. Lake Trafford Restoration

Background, Scope, and Objectives

Lake Trafford, located approximately three miles west of the city of Immokalee (Collier County), is the largest lake south of Lake Okeechobee with a surface area of 1,494 acres. The lake represents the headwaters of the Corkscrew Swamp Sanctuary to the southwest, the Corkscrew Regional Ecosystem Watershed (CREW) to the west, and the Fakahatchee Strand system to the south. Lake Trafford is an integral contributor to the sheetflow that traverses the CREW and Southern Golden Gate Estates. As the only major lake in southwest Florida, Lake Trafford represents an important resource for wildlife, including migratory birds.

Approximately 8.5 million cubic yards of unconsolidated muck (loose, flocculent organic material) has accumulated on the bottom of the lake as a result of deposition of organic matter over time and herbicidal treatments of the lake in the 1970s for hydrilla (*Hydrilla verticillata*). Hydrilla is a particularly troublesome exotic weed that outcompetes both native and other exotic plant species. During storm events, bottom sediments are disturbed resulting in an increase in suspended solids, dissolved nutrients, and an increase in biological oxygen demand. The decrease in water clarity and low dissolved oxygen levels has resulted in a severely depressed fishery for the lake.

The objective of this critical project is to restore water quality and habitat functions for the lake. A multi-agency task force evaluated the muck removal aspect of the restoration project and determined that a one-time dredge event would provide lake restoration. Sediment analysis of the muck determined that the spoil material was suitable for disposal on farmland. The material will be pumped to an upland disposal site on existing farmland less than one mile from the lake. The disposal area consists of a 449-acre, diked, agricultural facility, which will be divided into three cells. Recurrence of the muck layer is not anticipated due, in part, to improved aquatic plant control methods. Surrounding agricultural lands, which are expected to receive enhanced productivity benefits from the muck disposal, are expected to commit to using best management practices to reduce pollutant loading into the lake. In summary, the long-range goal for this restoration project is to 1) restore native aquatic plant communities and fish spawning habitat for the enhancement of fish and wildlife populations, 2) provide enhancement of the quantity and diversity of benthic organisms, 3) control nonpoint source pollution through BMPs, and 4) develop a long-term management plan for the lake.

Status of Project

This critical project is currently under review by the COE Jacksonville District Office. Request for funding is expected by the end of this fiscal year. The project sponsors (DEP, GFC, and SFWMD) will provide all lands, easements, rights-of-way, relocations, and disposal area requirements.

Recommendations

The DOI strongly supports ecological restoration projects that are designed to improve lake habitat, particularly those which contain components that address muck removal and disposal. The dredging activity would need to be coordinated with the FWS in order to address potential impacts to threatened or endangered species that may be present at this site. The timing of these activities may need to be adjusted so as to avoid the nesting/breeding seasons for avian species. Benefits to the Lake Trafford fishery will occur as a result of implementation of this project. It would be useful to include monitoring components within the scope of this project in order to document changes in the abundance and distribution of fish species as well as other aquatic species (e.g. invertebrates, periphyton, macrophytes). The importance of containment of the deposited material on farm lands cannot be underestimated for this type of project. The proposed BMPs to control erosion on the receiving farms must be agreed upon in advance and closely monitored.

7. Tamiami Trail Culverts

Background, Scope, and Objectives

U.S. Highway 41, also known as Tamiami Trail, is a two-lane highway in south Florida that connects Miami to Naples. The project area is located within Big Cypress National Preserve, Collier County, between State Route 92 (Collier Seminole State Park) to the west and 50-Mile Bend to the east. Modified Water Deliveries to Everglades National Park project will address the hydrological impacts of the highway east of the 40-Mile Bend. The elevated roadbed of the Tamiami Trail currently acts as a barrier to the north-south sheetflow to Ten Thousand Islands NWR, Southern Golden Gate Estates, Fakahatchee Strand State Preserve, southeast Big Cypress National Preserve, and Everglades National Park. This sheetflow is important for the support of these regional wetland ecosystems. A borrow canal immediately north of the Tamiami Trail intercepts the south-southwest flow and transfers it to an east-west direction until it is intercepted by bridges or water control structures at which point it exits to the south. Due to this channelization of flow-ways, seasonal hydropattern characteristics (distribution, timing, and water quality) of this surface water flow are disrupted and some wetland habitats receive too much freshwater, while other areas receive too little.

The project is designed to help restore a more natural hydropattern to both the Big Cypress Basin and coastal areas. Initial design features involve placing 87 additional culverts under Tamiami Trail at 30 separate sites along with construction of 29 blocking plugs within the existing borrow canal. The exact locations for these sites would be determined after field inspection to determine the best location in the natural drainage swales to isolate the culvert structures. This would help to block the east-west flow of the borrow canal. The project will be completed in three phases: Phase I - conduct a comprehensive assessment of the hydrological impacts from the Tamiami Trail (currently being initiated by USGS and Florida Department of Transportation); Phase II - identification of locations for additional water conveyance structures (i.e. bridges, culverts); and Phase III - installation of additional water conveyance structures and, if necessary, upgrade of existing structures. All lands required for this project are owned by the local sponsor(s). This project is associated with several other south Florida restoration projects including the Southern Golden Gate Estates Restoration critical project.

Status of Project

This critical project was ranked second by the South Florida Working Group and is proceeding as scheduled according to the project's implementation schedule. The project is now within the design phase and a proposed plan is expected to be completed by September 1998. Initiation of NEPA coordination with the FWS is expected at that time.

Recommendations

The implementation of this proposed flow enhancement project is likely to provide improvements to the water quality of the coastal estuaries by converting the freshwater point discharge to sheetflow along an approximately 34-mile wide front. The reintroduction of this overland flow through coastal marshes would serve to increase marsh and mangrove habitat productivity, moderate salinity fluctuations, and provide a more desirable mix of fresh and saline water conditions that will produce a more favorable environment for the survival and protection of juvenile fishes and shellfish beds. Recreational and commercial fisheries would also be expected to improve by the re-establishment of this overland flow. However, it would be important to monitor (i.e. sample) this re-routed water flow into the coastal estuaries to evaluate the potential for pollutant transport. Culverts should be placed, to the extent possible, at the ground surface so as to not promote pooling of water on either side of the road.

Restoration of flows into certain portions of marsh habitat located south of the highway that will be affected by this project may need to be evaluated for impacts to historic breeding habitat of the endangered Cape Sable seaside sparrow (*Ammodramus maritima mirabilis*). Although this particular section of south Florida is not designated critical habitat for the sparrow, the potential exists for birds to recolonize marl prairie communities that support hydroperiods conducive to breeding. Therefore, identification and protection of potential habitat in this region should be evaluated. In addition, consultation with the FWS and GFC will need to be initiated for this project, in part, for listed species, such as the State-listed (threatened) Everglades mink (*Mustela vison evergladensis*) that have been documented in this area.

8. Spring Creek Connection and Rehydration Project

Background, Scope, and Objectives

In the early 1960's, a 40-foot wide canal was dug that cut off approximately 2,200 linear feet of Spring Creek which flows into Estero Bay in Lee County, Florida. In 1990, the canal was designated an Outstanding Florida Water (OFW). The project, located in Lee County, Florida, will restore approximately 2,200 linear feet of the original Spring Creek floodplain through three major construction components: 1) re-establishment of the headwaters of Spring Creek by construction of a weir to redirect flow into the floodplain flow-way, 2) removal of approximately 1,015 cubic yards of spoil that currently segments the floodplain into three segments in order to restore the creek channel and floodplain, and 3) revegetation in areas where spoil has been removed. Construction of the weir and storage for stormwater runoff is required by the SFWMD for the permit. The project would allow land to be configured for the 75 lots approved by zoning for low-cost housing (G. Beardsley, Tropical Environmental Consultants, personal communication 1998).

Status of Project

Some preliminary design work has been completed for this project, including a wetland delineation within the proposed development. There is no partnership funding for this project which is why Partnership in Housing submitted the proposal. Partnership in Housing is the local sponsor for this OPE and is requesting funding support.

Recommendations

The project will enhance approximately 11 acres of wetlands adjacent to the original Spring Creek channel. The project is directly connected to the Private (Pueblo Bonito) Partnership in Housing, Inc. for development of 75 lots. Partnership for Housing stated SFWMD was a sponsor for the project which is incorrect. SFWMD has no involvement with the housing project except to permit the storage requirements. In addition, SFWMD has plans underway to restore hydrology to many of the old creek channels east of I-75 which will provide more ecological benefits than the proposed project. (C. Merriam, SFWMD, personal communication 1998).

The DOI recommends that this project be removed from consideration since there is no project sponsor and more ecological benefit would be provided from other SFWMD projects.

Points of Contact

Paul Warner (SFWMD); Chip Merriam (SFWMD-Big Cypress Basin); Gary Beardsley (Tropical Environmental Consultants, Naples FL)

References

Beardsley G. Written communication, Letter to Lee County, February 27, 1998.

Merriam C. Telephone communication, May 26, 1998.

9. Lakes Park Restoration Project

Background, Scope, and Objectives

Lakes Park is located east of Cape Coral in Lee County, just west of Highway 41. The park consists of an old rock mine with a series of borrow pit "lakes." The entire area drains south into Hendry Creek, an Outstanding Florida Water, which flows for a few miles before entering Estero Bay. Lee County has developed the area as a regional park with a bathing area along the shoreline of the lakes. Adjacent to the developed area, the remaining natural habitat contains pine flatwoods with some cypress heads. Gopher tortoises have been documented within this upland habitat.

The pits capture runoff from the surrounding developed area (commercial, industrial, and residential). County monitoring has indicated a decline in water quality in the lakes. The lakes are infested with hydrilla and adjacent uplands and islands are covered with exotic plant species such as Australian pine and Brazilian pepper.

The project proposes to restore the 10-foot deep rock mine/borrow pit area to 40 acres of meandering flow-way lined with littoral marsh. Fill will be placed between islands to direct flow into a meandering channel. The vegetated littoral zones and trees in the uplands will provide habitat and a nutrient sink for incoming flows. The littoral zone will be harvested periodically to remove excess nutrients from the system. Exotic vegetation will be removed and replaced with native vegetation on 11 upland acres.

Status of Project

Lee County has committed to funding 50% of the project. Planning actions are on hold pending additional funding.

Future Needs for Information or Design

Natural resource needs for effective planning include a freshwater marsh and water quality management plan.

Recommendations

The DOI supports improvement of water quality and habitat conditions by creation of a marsh/flow-way in the mine site at Lakes Park. Should funds become available for planning, we recommend that the mine site, wetlands/flow-way, and Hendry Creek be combined into one comprehensive management effort. Fire and drawdowns may need to be considered for the management of early wetland plant successional stages with more diverse habitat niches. Management actions should be evaluated for different areas at different times in order to sustain and improve habitat heterogeneity (FWS 1998).

Provisions need to be made to sustain the gopher tortoise and potential eastern indigo snake populations on site. Biologists should inspect the area prior to exotic vegetation removal and be on site during vegetation removal procedures to ensure heavy machinery does not coincidently cave in tortoise burrows or run over the animals.

Best management practices need to be evaluated and implemented for adjacent areas in the drainage, especially golf courses. An upland buffer should also be maintained on either side of the wetlands/flow-way and linked with any other existing or planned greenways in the region.

Points of Contact

DEP (John Outland); Lee County (Rick Joyce or George Parker)

References

U.S. Fish and Wildlife Service. 1998. Freshwater marsh ecological community account. Multi-species recovery plan for the threatened and endangered species of south Florida. Volume II of II. The communities. Technical/Agency Draft. Vero Beach, Florida.

10. Reversing Overdrainage from the Barron and Turner River Canal Basins

Background, Scope, and Objectives

This conceptual project is intended to provide hydrologic restoration to approximately 500 square miles of impacted wetlands in the Big Cypress National Preserve (BICY), a unique 729,000 water-dependent ecosystem. The Barron River Canal and the Turner River Canal, which lie within the western portion of BICY, currently act to channelize overdrainage from the BICY watershed. These canals directly connect freshwater uplands of the BICY with the saline estuaries within ENP causing rapid drainage of these areas. The reduced hydraulic head enhances salt water penetration into the freshwater environment of the BICY. This rapid drainage also reduces the productivity of cypress forests and wet prairie ecosystems.

The restoration of historic flow-ways is expected to reintroduce the historic natural environment and help to eliminate nuisance exotic species. This project should also provide water quality improvements to the Ten Thousand Islands NWR and ENP by converting freshwater, point source discharges to traditional overland sheetflow.

The project proposes the use of the SFWMD Natural System Model to evaluate the impacts of overdrainage by simulating pre- and post-channelization conditions in the BICY. Water management strategies may include the installation of canal blocks and operation/design changes of water control structures.

Status of Project

This project is unfunded and has not proceeded beyond the nomination stage.

Recommendations

The conceptual nature of this project does not allow for a complete evaluation of the hydrologic restoration components of this project. The reintroduction of overland sheetflow would enhance marsh and mangrove productivity, moderate salinity fluctuations, and provide overall enhancement of the recreational and commercial fishery resources of the estuaries currently impacted by point source discharges of fresh water. However, there are potential constraints to the installation of water control structures that may be considered for the project. Two major highways are located adjacent to the canals - Highway 29 to the west of the Barron Canal and Highway 41 to the south of the Turner River Canal. The restoration of sheetflow may cause flooding in these areas. In addition, the potential for transport of pollutants, such as pesticides from nearby agricultural areas (i.e. Immokalee), will need to evaluated in the project design.

EVERGLADES NATIONAL PARK

1. Nutrient Removal/Dosing Studies at ENP

Background, Scope, and Objectives

One of the major problems facing the Everglades wetlands is the quality of water being delivered into these areas directly from the Everglades Agricultural Area (EAA) and surrounding urban areas. Changes in the vegetation community have occurred as a result of phosphorus enrichment has been documented in Everglades National Park (ENP) (Davis 1994). The Everglades ecosystem apparently developed under conditions of relatively low nutrient inputs with phosphorus being the limiting macronutrient. Historically, the marshes are considered to be nutrient-starved and the overlying water highly oligotrophic. Because of this nutrient limitation and extreme dependence on internal recycling of elements, Everglades wetlands are highly susceptible to excessive inputs of allochthonous nutrients. Walker (1991) reported significant increases (4-21%) in total phosphorus at eight of nine inflow sites to the ENP. The problem posed for researchers and managers is to determine how much phosphorus is excessive.

This project is part of an ongoing Phosphorus Threshold Dosing research study being conducted in the ENP by Dr. Ron Jones of Florida International University. Research efforts will be designed to provide critical baseline information needed to establish Class III water quality standards for the Everglades Protection Area. Included in this research project are the construction of three, four-channel flows or flumes in pristine *Eleocharis* spp. wet prairie marshes to investigate the effects of low-level phosphorus addition on Everglades wetland communities. Each flume will have a control channel and three experimental channels representing a range of phosphorus concentrations that bracket current proposed water quality standards.

An understanding of the interaction of ecosystem changes is essential to predicting the effects of the addition of phosphorus on Everglades wetlands. This study will examine ecosystem responses at several hierarchal levels and the project will quantify all major processes associated with macronutrient cycling and generate biogeochemical budgets for each. The structural and functional dynamics of the various plant and animal communities will also be measured along with the quantification of food web structure and energy flow.

Status of Project

This ongoing project is currently funded via a contract with SFWMD and the ENP, with a three year extension beyond 1998 at $250,000 per year, pending budget approval by SFWMD. The three flumes have been constructed and are fully operational. Phosphorus dosing was scheduled to begin at the onset of the 1998 wet season, or approximately June 1. Dosing will continue for three full years when there is adequate flow.

Recommendations

This critical project represents an important short-term study concerning nutrient loading in Everglades wetland habitat. The DOI supports these projects, while recognizing that they are just one step in providing a solution to this problem.

References

Davis, S.M. 1994. Phosphorus inputs and vegetation sensitivity in the Everglades. Pp. 357-378 *in* S.M. Davis and J.C. (eds.) Everglades: The ecosystem and its restoration. St. Lucie Press; Delray Beach, Florida.

Walker, W.W. 1991. Water quality trends at inflows to Everglades National Park. Water Res. Bull. 27(1):59-72.

FLORIDA BAY AND FLORIDA KEYS

1. Florida Keys Tidal Creek Restoration

Background, Scope, and Objectives

The objective of this proposed critical project for the Florida Keys area is to restore flows to tidal creeks by installing culverts under U.S. Highway 1 at three locations in Monroe County (between mile markers 54 and 57). These projects are similar to a culvert project at Key Colony Beach completed in 1991, which was very successful in improving the near-shore water quality The individual projects can be described as follows: 1) restore Tarpon Creek just south of mile marker 54 on Fat Deer Key, 2) restore an unnamed creek between Fat Deer Key and Long Point Key south of mile marker 56, and 3) restore tidal connection between Florida Bay and the Atlantic Ocean at mile marker 57. Restoration benefits expected by installation of these culverts include enhanced circulation and flushing, improved water quality, and restoration of marine habitats. The accumulation of organic material in these creeks has resulted in a degradation of water quality and sea grass habitat. Impacts originally occurred as a result of the construction of the Flagler Railroad bed (currently U.S. Highway 1) which blocked tidal flow and circulation in near-shore waters.

Status of the Project

At the present time, this project is unfunded and has not proceeded beyond the nomination stage.

Recommendations

The culvert project known as the Key Colony Beach restoration provided evidence that tidal creeks of the type described above can be restored with significant improvement to water quality and thus to the entire marine ecosystem. Additional restoration projects of this type will provide further benefits to improving surface water circulation and the DOI supports this project.

BASIN-WIDE PROJECTS

1. Exotic Plant Eradication Project

Background, Scope, and Objectives

Melaleuca trees and other invasive exotic species are rapidly invading the natural Everglades habitat. The exotic tree *Melaleuca quinquenervia* was introduced in the 1900's, rapidly spread in the 1940s and now infests approximately 500,000-1,500,000 acres of south Florida's fragile wetlands. The potential range of melaleuca includes the entire peninsula of Florida south of Lake Okeechobee, excluding the saline zone (Bodle, M.J. *et al*. 1994). Lake Okeechobee, Everglades National Park, Big Cypress National Preserve and the Water Conservation Areas are all at risk. Growth has become so dense in some areas that native habitats have been replaced resulting in a dramatic decrease in native flora and fauna. Melaleuca also represents a navigation and fire hazard. Experts agree that we are unlikely to control this pest without the aid of biological agents.

Research in its native Australia indicates that biological control agents offer immense potential to reduce the projected billion dollar impact to the south Florida ecosystem. One melaleuca insect, *Oxyops vitiosa*, has been through the quarantine process and was released in April 1997. Initial field reports indicate that this insect is very effective in controlling melaleuca.

Quarantine studies and release of approved candidates are being delayed due to limited quarantine facilities. Conventional chemical and mechanical melaleuca control continues, but incorporation of biological control agents into the management strategy is essential. A consortium of Federal, State and local agencies have funded overseas research to identify candidate biological control insects for melaleuca. Approximately ten candidates have been identified.

This is a three part project consisting of: 1) construction of a Melaleuca Quarantine and Research Facility to enable the testing of organisms brought into the United States from Australia for biological control of Melaleuca at Fort Pierce Florida, 2) upgrading existing quarantine facilities at Gainesville, Florida and 3) implementation of biological controls. These facilities would accelerate the integration of biological control technology into melaleuca management efforts.

Status of Project

Construction of the new quarantine facility was initially to be located at Davie, Florida and the pre-final design of the facility was completed by the Jacksonville District in 1997. However, since the project is now proposed to be located in Ft. Pierce, Florida, some modification of the design will be required. The project will be located on University of Florida property adjacent to the U.S. Department of Agriculture/Agricultural Research Service Facilities Division. Surveys and rights of entry have not been conducted and an Environmental Assessment has not been prepared.

Recommendations

The DOI strongly supports the construction of a Melaleuca Quarantine and Research Facility, upgrading the existing quarantine facilities and implementation of biological control agents. The invasive nature of *Melaleuca quinquenervia* requires immediate attention to prevent further spreading of this exotic species. The proposed actions would significantly accelerate the quarantine process and are highly recommended.

References

Bodle, M.J., A.P. Ferriter, and D.D. Thayer. 1994. The biology, distribution, and ecological consequences of *Melaleuca quinquenervia* in the Everglades. Pp. 341-355 *in* S. M. Davis and J. C. Ogden (eds.) Everglades: The ecosystem and its restoration. St. Lucie Press; Delray Beach, Florida.

TABLE V-1. OTHER PROJECT ELEMENTS (OPEs) ECOLOGICAL BENEFIT MATRIX[a,b]

OPE Title	T&E Benefits[c]	Enhancement of Fish & Wildlife Habitat	Improvements to Water Quality	Time-sensitive Land Acquisition	Hydrologic Restoration of Natural Areas	Scope of Benefits[d]	Comments
Kissimmee River Watershed							
Increase storage in the Kissimmee Chain of Lakes	H	H	M	L	H	r	Provides benefits to lake wetlands and promotes restoration of the Kissimmee River
Additions to the Authorized Kissimmee River Restoration:							
Pool A	H	H	M	N/A	H	r	Up to 3,200 acres of wetlands may be enhanced
Pool E	H	H	M	M	H	r	Up to 2,700 acres of wetlands may be enhanced
Paradise Run	H	H	M	M	H	r	Great benefits to sport fishery and wading birds
Lake Istokpoga Restoration	M	H	H	N/A	H	r	Provides restoration to ecology of lake ecosystem
Lake Okeechobee							
Restoration of Torry, Kreamer, and Ritta Islands	H	H	M	N/A	H	r	Provides benefits to Okeechobee gourd and waterfowl; ecotourism feature

OPE Title	T&E Benefits[c]	Enhancement of Fish & Wildlife Habitat	Improvements to Water Quality	Time-sensitive Land Acquisition	Hydrologic Restoration of Natural Areas	Scope of Benefits[d]	Comments
Lake Okeechobee Water Retention/Phosphorus Removal (CP)	M	H	H	N/A	L	r	Pilot project underway
Lake Okeechobee Tributary Sediment Dredging (CP)	M	M	H	N/A	N/A	r	Need details on sediment disposal sites/stabilization
Caloosahatchee River							
Removal of the Sanibel Island Causeway	M	H	H	N/A	M	l	Benefits San Carlos Bay and Ding Darling NWR
Caloosahatchee River Remnant Oxbow Rehabilitation	M	H	H	M	M	r	Potential benefits to sport fishing, wading birds, and waterfowl
Upper East Coast							
Ten Mile Creek Water Preserve Area (CP)	M	M	H	H	H	l	Provides improvements to St. Lucie estuary
C-25 Basin Water Preserve Area	M	M	H	H	H	l	Same as above
Lower East Coast: Palm Beach County							
Pal-Mar/Corbett Land Acquisition Project	L	M	N/A	H	N/A	r	Contributes to the establishment of wildlife corridor
Winsberg Farms Wetland Restoration (CP)	M	H	H	H	H	l	Restores previously-farmed wetlands

OPE Title	T&E Benefits[c]	Enhancement of Fish & Wildlife Habitat	Improvements to Water Quality	Time-sensitive Land Acquisition	Hydrologic Restoration of Natural Areas	Scope of Benefits[d]	Comments
Wetlands-based Water Reclamation Project (CP)	M	M	N/A	N/A	M	l	
Hillsboro Pilot Aquifer	N/A	M	N/A	N/A	M	r	Enhances water budget for Everglades restoration
L-8 - Water Catchment - Loxahatchee Slough Infrastructure Improvements (CP)	L	L	M	N/A	L	l	Unclear if L-8 water is needed for Slough
Loxahatchee Slough Restoration (CP)	H	H	H	N/A	H	r	Land already purchased
Lake Worth Lagoon:							
Lake Worth Lagoon Water Quality Restoration - Sediment Removal (CP)	M	M	M	L	L	l	
Lake Worth Lagoon Water Quality Improvements	H	H	H	N/A	L	r	
Lake Worth Lagoon Habitat Restoration	H	H	H	L	L	r	
Lower East Coast: Broward County							
Restoration of the North Fork of the New River (CP)	L	M	H	N/A	N/A	l	Water quality improvements; environmental outreach

OPE Title	T&E Benefits[c]	Enhancement of Fish & Wildlife Habitat	Improvements to Water Quality	Time-sensitive Land Acquisition	Hydrologic Restoration of Natural Areas	Scope of Benefits[d]	Comments
Western C-11 Basin Water Quality Improvement Project (CP)	N/A	M	H	N/A	M	r	
Lower East Coast: South Dade County							
WCA 3B Seepage Reduction (CP)	L	L	N/A	N/A	L	l	More information needed for complete evaluation
South Dade Agriculture: Rural Land Use and Water Mgt Plan (CP)	M	M	M	N/A	M	r	Includes South Biscayne Bay Watershed Management Plan
South Dade/C-111 Basin Hydrological/Water Quality and Sustainable Agriculture Program (CP)	M	M	M	N/A	L	r	May provide water quality benefits to ENP, Biscayne Bay, and Florida Bay
Water Quality Treatment and/or Urban and Agriculture BMPs (CP)	M	M	H	N/A	L	r	Water quality benefits to Biscayne Bay
Restoration of Pineland and Tropical Hardwood Hammocks in C-111 Basin in Dade County (CP)	M	H	N/A	N/A	L/M	l	Important demonstration project for native species restoration
L-31E Flow Redistribution Project (CP)	M	H	H	N/A	H	r	Benefits Biscayne NP; reduces point source discharges to estuary

OPE Title	T&E Benefits[c]	Enhancement of Fish & Wildlife Habitat	Improvements to Water Quality	Time-sensitive Land Acquisition	Hydrologic Restoration of Natural Areas	Scope of Benefits[d]	Comments
Biscayne Bay Coastal Wetlands Project	M	H	H	M/H	H	r	Creates sheetflow through coastal wetlands into Biscayne Bay
Western Basin and Big Cypress							
Henderson Creek/Belle Meade Drainage Basin Restoration (CP)	H	H	H	H	H	r	Extensive restoration project
Southern Golden Gate Estates Hydrologic Restoration (CP)	H	H	H	H	H	r	Extensive watershed restoration project
Southern CREW Project Addition/Imperial Flow-way (CP)	H	H	H	H	H	r	Extensive watershed restoration project
Seminole Tribe Big Cypress Water Conservation Plan (CP)	Unclear	Unclear	H	N/A	M	r	Conceptual project for watershed management system
Town of Fort Myers Beach (CP)	L	H	H	N/A	N/A	l	Very localized project
Lake Trafford Restoration (CP)	M	H	H	N/A	N/A	r	Muck removal project
Tamiami Trail Culverts (CP)	M	M	H	N/A	H	r	Provides restoration of sheetflow
Spring Creek Connection and Rehydration Project (CP)	N/A	L	N/A	N/A	L	l	Mitigation for development project

OPE Title	T&E Benefits[c]	Enhancement of Fish & Wildlife Habitat	Improvements to Water Quality	Time-sensitive Land Acquisition	Hydrologic Restoration of Natural Areas	Scope of Benefits[d]	Comments
Lakes Park Restoration Project (CP)	M	L	M	N/A	M	l	May provide benefit to Hendry Creek
Reversing overdrainage from the Barron and Turner River Canals	M	H	H	Unclear	H	r	Conceptual project for restoring sheetflow over portions of western Big Cypress National Preserve
Everglades National Park							
Nutrient Removal/Dosing Studies at ENP (CP)	M	M	H	N/A	N/A	r	Sets basin-wide phosphorus standards for restoration goals
Florida Bay and Florida Keys							
Florida Keys Tidal Creek Restoration (CP)	L/M	H	H	N/A	H	l	Nearshore water quality improvements
Basin-wide Projects							
Exotic Plant Eradication Project (CP)	H	H	N/A	N/A	N/A	r	

[a]Matrix developed using “best professional judgement”; see text for detailed project descriptions

[b]L=Low, M=Moderate, H=High

[c]This column includes both direct or indirect benefits

[d]local (l) or regional (r)

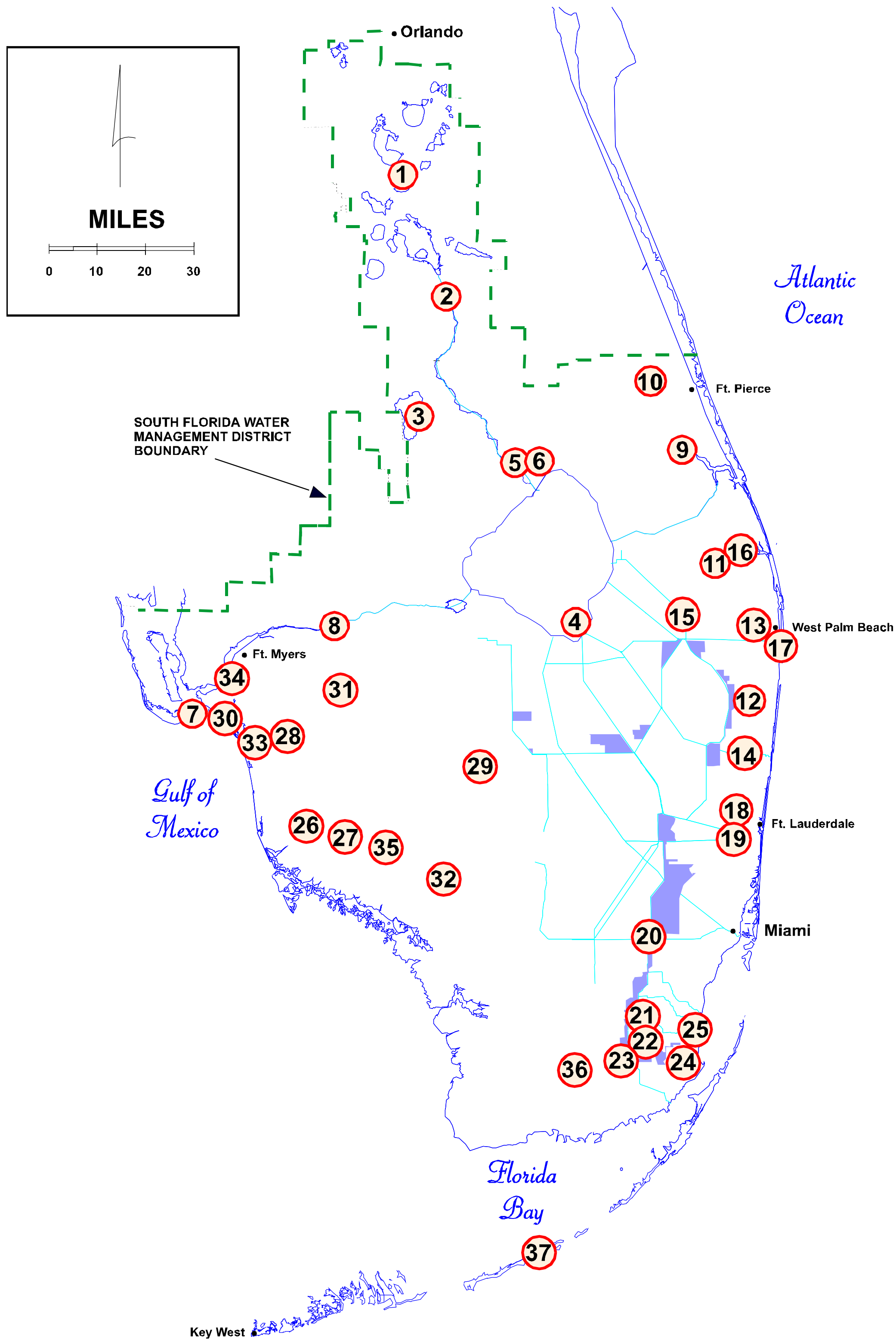

Figure VI-1. General location of the Other Project Elements. Table VI-2 provides the names of the projects associated with the key numbers on this map.

Table VI-2. Names of the Other Project Elements associated with the key numbers in Figure VI-1. (Page 1 of 2)

Name	Key Number
Increase storage in the Kissimmee Chain of Lakes	1
Additions to the authorized Kissimmee River Restoration (3 projects)	2
Lake Istokpoga restoration	3
Restoration of Torry, Kreamer, and Ritta islands, Lake Okeechobee	4
Lake Okeechobee water retention/phosphorus removal	5
Lake Okeechobee tributary sediment dredging	6
Removal of the Sanibel Island causeway	7
Caloosahatchee River remnant oxbow rehabilitation	8
Ten Mile Creek Water Preserve Area	9
C-25 basin Water Preserve Area	10
Pal-Mar/Corbett land acquisition	11
Winsberg Farms wetland restoration	12
Wetlands-based water reclamation	13
Hillsboro pilot aquifer	14
L-8 catchment area-Loxahatchee Slough infrastructure improvements	15
Loxahatchee Slough restoration	16
Lake Worth Lagoon (3 projects)	17
Restoration of the North Fork of the New River	18
Western C-11 basin water quality improvement	19
WCA 3B seepage reduction	20

Table VI-2. Names of the Other Project Elements associated with the key numbers in Figure VI-1. (Page 2 of 2)

Name	Key Number
South Dade agriculture: Rural land use and water management plan; South Dade/C-111 basin water quality and sustainable agriculture program	21
Water quality treatment and/or urban and agricultural BMPs	22
Restoration of pineland and tropical hardwood hammocks in Dade County	23
L-31E Flow redistribution	24
Biscayne Bay coastal wetlands	25
Henderson Creek/Belle Meade drainage basin restoration	26
Southern Golden Gate Estates hydrologic restoration	27
Southern Corkscrew Regional Ecosystem Watershed addition	28
Seminole Tribe Big Cypress water conservation plan	29
Town of Fort Myers Beach	30
Lake Trafford restoration	31
Tamiami Trail culverts	32
Spring Creek connection and rehydration project	33
Lakes Park restoration	34
Reversing overdrainage from the Barron and Turner River canal basins	35
Nutrient removal/dosing studies at ENP	36
Florida Keys tidal creek restoration	37

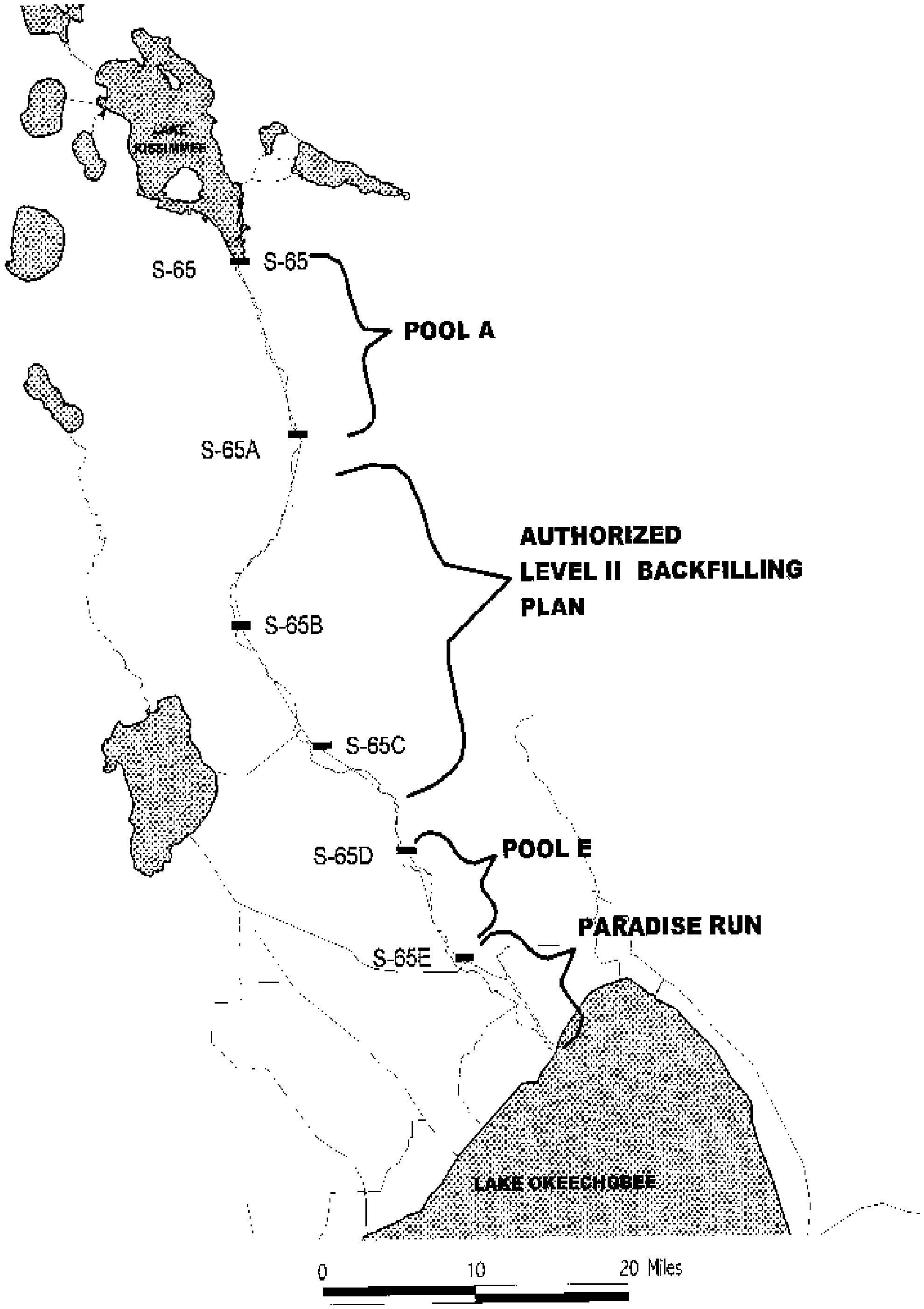

Figure VI-2. Location of potential additions to the authorized Kissimmee River Restoration.

CHAPTER VII --WATER SUPPLY ISSUES

Compiled by Cheryl Buckingham, FWS

A. Introduction

This issue paper does not attempt to resolve all of the varying opinions presented below, only to summarize some of them. Most of these ideas have been raised at one time or another, but never expressed clearly in writing. It is hoped that initiating discussions with representatives who have different viewpoints and attempting to clarify each position will elicit further constructive comments. Once the arguments on all sides are understood, perhaps more common ground can be found.

B. The Issues

1. Issue: "Is there enough water to restore the Everglades or are urban and agriculture water supply demands too high? Are the Lower East Coast (LEC) and the environment in direct competition for water?"

There is no evidence that the climate in south Florida has changed sufficiently to alter the dry and wet season rainfall patterns since the first attempts to drain the Everglades. Many people believe, therefore, that restoration is possible, even with the water supply requirements of the urban and agricultural community, given that the sharply-reduced size of the Everglades will reduce its demand for water.

One of the primary functions of the C&SF Project is to provide a highly-efficient flood control system designed to keep urban and agricultural areas dry in the wet season by discharging excess water to tide or into the WCAs and ENP. Rapid wet season flood releases, coupled with the lack of retention in Lake Okeechobee, the northern historical sawgrass plains, and the eastern peripheral wetlands and sloughs, have severely reduced storage within the system causing excessive dry season demands on the regional system. The sawgrass plains, for example, once stored and slowly passed on much of the water that overflowed from the Lake. Today, a large portion of the sawgrass plains habitat that was converted to agriculture within the Everglades Agricultural Area (EAA), quickly passes excess runoff to the WCAs and the coast during the wet season. Releases of Lake Okeechobee water are then necessary to meet dry season demands. The lack of storage, not the lack of water, is the problem.

Minimum levels for LEC canals are set by Florida Legislation principally to provide the volume of water needed to protect the Biscayne aquifer from saltwater intrusion, a major threat to this water resource. The head created in the canals raises groundwater levels, recharging the aquifer and the urban wellfields. During the wet season, wellfields are recharged by local rainfall and by the regional system which provides ongoing seepage from the WCAs and the canals. During the dry season, they are more dependent on the regional system. Unfortunately, during the wet season, "excess" storm water is passed through the canals and out to tide when it should be stored and used during the dry season. Without sufficient storage, it has been difficult to have water available during the dry season without causing flooding during the wet season.

Water users within the urban areas argue that the LEC is largely self-sufficient and efficient because the ground water seeping through the LEC would eventually reach coastal waters were it not withdrawn by the utilities. The SFWMM illustrates how this works. As demands increase, the volume of water that reaches coastal waters decreases. In the SFWMM, at Snake Creek, north of Miami, 121,000 ac-ft of water was lost through groundwater seepage during the wet season in the 1995 Base. That amount *decreased* to 114,000 ac-ft in the 2050 Base as urban water supply demand *increased*. In the Miami River, in the 1995 Base, over 192,000 ac-ft was unrecoverable (wet and dry season total). In the 2050 Base, only 121,000 ac-ft was unrecoverable.

Others argue that the urban area is far from self-sufficient. While the pattern described above occurs during wet seasons and during normal rainfall years, during extremely dry years, no water reaches the coast and the urban wellfields depend heavily on the WCAs, (including the ongoing seepage from these areas), the canals, and Lake Okeechobee for water supplies. Even during normal dry seasons when flood releases are minimal, some believe that the high demands on the system from urban water supply withdraw water from the natural environment that should be kept in the system for late winter and spring biological rejuvenation. In addition, during drought years, the urban and agricultural areas create additional demands as the need for irrigation increases. Those needs, they expect, will be given priority status well above the environmental demands, increasing the harm to the natural system.

In a related issue, one concern is that, at present, the flow of water along the eastern protective levee is from the wetlands to the coast. Some argue that keeping the water levels high west of the Atlantic coastal ridge and levels low to the east of it results in large groundwater losses from the remnant Everglades throughout the year. This situation, they say, is what has severely reduced the coastal groundwater flows into estuaries like Biscayne Bay and has made it necessary to import regional water to the LEC to maintain adequate coastal groundwater levels to prevent saltwater intrusion.

The amount of water needed to recharge urban wellfields is small compared to the tremendous volumes needed to prevent saltwater intrusion. Preventing saltwater intrusion is important for several reasons. For example, if significant saltwater intrusion occurred even once, the easternmost wellfields would be contaminated indefinitely and would be replaced with wells further west. This situation has already occurred in Metro-Dade County.

Although significant, the amount of water needed to prevent saltwater intrusion is much less than the wet season coastal releases. Some people maintain that those flows alone, if captured and stored, would be more than sufficient to maintain the dry season salinity barriers without the need to take water from the natural system. Also, retaining coastal outflows near the coast and maintaining higher groundwater levels along the coastal ridge would allow large quantities of regional water to be used for dry-season environmental benefits.

There are also ecological benefits within the Lower East Coast to maintaining groundwater levels. Lower groundwater levels can and have had serious negative effects on estuaries. Biscayne Bay for example, has suffered the consequences of both ground and surface water losses, including increased salinity, lower visibility, and lower water quality. Alternative 3 simulated cutting off groundwater seepage from the WCAs which reduced flows to Biscayne Bay from 20% to 55%. In south Dade County, lowered groundwater levels have caused wetland desiccation and produced shifts in vegetation types.

Sensitivity analyses were performed using the SFWMM for Alternative 5 in which urban water supply demand (as measured by the demand from urban wellfields) was reduced to zero in one scenario and doubled in another. The results showed only minor stage improvement in the natural areas by reducing water supply to zero. These results appeared at first glance to back the view that water supply represents a relatively small volume of water. Others note that the reduction in pumping in the "zero demand" scenarios was roughly equal to the total amount of LEC ASR yield in the alternatives.

When the Alternative 5 scenario was run that *doubled* water supply, however, two issues arose. First, Shark River Slough was significantly drier in dry years. Although the stage differences appear small, in such a shallow system, even slight reductions in stage in drought years can vastly extend the spatial extent and duration of dryouts. Small stage differences also translate to large flow differences and a reduction in flows would affect the deliveries to Florida Bay. Therefore, in very dry years when demands are high everywhere in the system, the LEC, under the double-demand scenario, would rely heavily on the regional system to the detriment of the natural system. This implies that if urban water supply demand continues to expand *beyond the 2050 projection*, eventually the natural system will receive an inadequate water supply unless alternative, non-traditional supply sources like reverse osmosis are used.

Second, a significant percentage of the per capita use of water goes towards landscape maintenance, primarily watering lawns from shallow wells. Unfortunately, this element was not modeled in a way that allowed it to be "turned off" in the zero–demand sensitivity analysis. In that scenario, the regional system is still recharging the aquifer and watering lawns, even under the "zero-water-supply" scenario. Consequently, the total urban water demand as such was underestimated and the more general benefits of maintaining ground water were overestimated.

2. Issue: "Are canals without salinity barriers wasting water?"

For locations without salinity barriers, much more water is required to maintain ground water due to the large losses through the canals. Appropriate canals need to fitted with salinity control structures.

3. Issue: "Were the wrong projections used for future water supply demand?" Depending on the source, these projections are viewed as either too conservative or not conservative enough.

Two different methods of extrapolating the future demands were used. The Bureau of Economic and Business Research (BEBR), University of Florida, Gainesville, developed a method that projects only to the year 2020. The other method used the Department of Commerce Bureau of Economic Analysis (BEA) rates of growth. The BEBR model indicated a higher growth curve than BEA. According to the U.S. Army Corps of Engineers (COE), they used the BEBR figures up to the year 2020, then extrapolated to 2050 using the BEA rate. Once the projections were in place, the IWR-MAIN Water Use Forecasting System was used to estimate water consumption as a function of population, employment, demographics, income, and variables such as rainfall and temperature. Dade County asserted that its population growth projection is even higher than the BEBR estimates because of immigration, so for Dade County, the COE used the County's projections up to the year 2020 instead of the BEBR values and extrapolated to 2050 at the BEA rate. Dade County is still concerned that the estimate may be low. The COE believes they have struck a balance.

4. Issue: "Is the level of conservation in Alternative D13R too high to be realistic?"

One of the most effective components for avoiding water supply shortages in the system, as modeled in the alternatives, is to implement water conservation in the urban areas. In the 1995 Base, 173,000 ac-ft/year was pulled from the WCAs; in the 2050 Base, urban water supply demand increased to 252,000 ac-ft/yr. Yet, due to the addition of water conservation in the 2050 Base, all Phase 2, 3, and 4 water restrictions were eliminated in the North Palm Beach area. In Alternative D13R, demand from WCAs was reduced to 133,000 ac-ft/year, 47% below the 2050 Base, because of the additional conservation component.

There were three different conservation scenarios identified in the alternatives:

- Use the conservation measures now in place, already approved and adopted, assuming the very modest 2-3% of water saved for 1990 remains the same through 2050. This is the high demand scenario.
- Use aggressive conservation measures, apply the already approved measures, retrofit existing structures, enforce requirements, and require that all new structures meet requirements. This is the low demand scenario. This scenario reduces demand about 18%
- Use a program that lies in between these two options. Following St. Lucie County's example, this model assumes less rigorous enforcement and no requirement to retrofit existing structures, only implementation of existing measures. This model reduces demand about 12%.

The high demand scenario was used during the formulation of Alternatives 1-5. A team was formed at the time the "re-scaling" of alternatives took place to determine whether conservation projections needed to be revised. Some team members were worried that the high-demand scenario gave the LEC counties too little credit for the conservation strategies they have adopted. They preferred the aggressive scenario because they preferred to assume that by the year 2050, approved conservation measures would be in place and technological problems would be worked out. Even the “aggressive” approach, they noted, included only already-approved measures and assumed these would be fully implemented and enforced. Other county representatives believed the aggressive conservation scenario would require additional measures on their part, stricter regulations, and more enforcement. They cited the uncertainty associated with some of the technical conservation problems, like low-volume toilets that must be flushed a number of times. They also are aware that conservation will result in loss of revenue unless rates are raised. The team decided in the end to use the more conservative 12% reduction from the high demand scenario for the 2050 Base and the 18% reduction, low demand scenario for Alternatives C and D.

In a similar issue, some team members would have preferred that all the alternatives assume maximum buildout, with maximum per capita consumption figures. Utilities prefer maximizing demand to ensure the greatest amount of recharge from the regional system, thereby diminishing the need for local water development projects. Resource agency representatives believe that planning for the worst-case scenario would allow a system to be built that would last far beyond 2050, rejecting the assumption that consumption will tend to level off. The resource agency concern is that future escalating water supply demands could cause future political forces to tap into the Everglades again. (This concern also added fuel to the desire for decompartmentalization of the Everglades. That is, water management structures that will not exist cannot be used in the future to fulfill urban water supply demands.)

5. Issue: “Why don’t you monitor the urban water supply demand to make sure they do not exceed their projections?”

Water supply demand projections should be included in the adaptive management program. Hypotheses need to be developed based on the projections, targets need to be defined, a thorough monitoring program should be developed, modeling should continue and be refined, and an annual analysis should be conducted as a part of the ongoing annual assessments producing report cards with recommendations every year. If urban water supply demands exceed projections, resource agencies tend to believe the burden should be on the urban areas to supplement their water supply with reverse osmosis or some other source, rather than request additional water from the C&SF system.

6. Issue: “What is a ‘1-in-10 level of certainty’ and does having it as a goal for the LEC conflict with Everglades restoration efforts?”

Chapter 375.0361(2)(a)1 of the Florida Statutes requires that the South Florida Water Management District plan for a 1-in-10 level of certainty. The AET accepted a performance measure proposed by the water supply subgroup that set a target of no more than three water supply cutbacks of any severity that last for more than seven months for the 31-year period of record for the LEC Service Area.

The 1-in-10 level of certainty for water supply represents an ideal goal, but like many of the targets of the Restudy, the target cannot be completely met. In addition, model results must be viewed with a certain degree of uncertainty because it is unlikely that the SFWMM model can predict a 1-in-10 scenario with a high level of accuracy. Regardless, the 1-in-10 water supply planning goal is designed to encourage planners to minimize the frequency of restrictions. In Alternative D13R, North Palm Beach and Service Area 1 meet this goal while Areas 2 and 3 fail to meet the goal by only 1 and 3 months of restrictions, respectively. The situation in Alternative D13R is far better than the 1995 Base and is a significant improvement over conditions in the 2050 Base.

7. Issue: "Isn't the purpose of a regional water supply system to meet all local water demands."

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Those who work with urban water supply issues on a daily basis understand that urban water supply demands cannot always be met all of the time. Urban demands have been and will always be "unquenchable." The purpose of planning targets has been to build a system that requires extreme measures only during extremely low water years which may occur in Florida every 10 years or so. Water supply planners believe the performance measures and projections developed for the Restudy allow them to evaluate what to expect in the future and will help garner support for or generate opposition to projects.

Others strongly believe it is not appropriate to insist that all urban and agricultural water supply demands must be met as a priority over the natural system because restoration of the Everglades is the primary goal of the Restudy. They believe that the comprehensive review study was initiated as an attempt to halt and even reverse the decline of the natural system. Uncontrolled demands for flood control and water supply have been the primary causes for placing the natural system in such poor condition. To continue to demand the same or increased anthropogenic demands on the natural resources will undoubtedly set the restoration effort up for failure. Many environmentally conscious people are of the opinion that current urban and agricultural demands are already beyond the level that will support a sustainable natural system and that future increases as proposed by the Restudy will accelerate the decline of the south Florida ecosystem.

Some parties have expressed concern that the performance measures used to evaluate success in the LEC are overly restrictive, and are, in fact, much stricter than those used to define success in the natural areas. Water restrictions are imposed at certain points and the effects on the urban landscape are immediate, noticeable, and easy to quantify (even if the measure is number of consumer complaints or acres of lawn degraded). On the other hand, in the natural system, a certain number of dryouts are healthy, even in the wettest parts of the system. Dryouts can "pulse" the system by releasing nutrients bound in the soils. Unfortunately, it is difficult to define the point at which drought conditions begin to cause excessive damage to the ecology, damage that may take years to repair. Some say the natural system is being penalized because not enough is known about the system to define the stricter ecological performance measures they believe will be necessary. In addition, while the amount of water available to the project and the amount of water needed for the natural system remain steady over time, the LEC demand increases from 925 mgd in the 1995 Base to 1278 mgd in the 2050 Base. Yet, the definitions of success for both the steady-state natural system and the ever-increasing LEC demand remain the same. Looking beyond 2050, the situation does not appear to be sustainable. At some point, it seems the ever-growing, highly specific demands from the urban sector may take priority over the unchanging, less well-defined needs of the natural system unless alternative water supply sources are developed or demand is kept in check.

8. Issue: "Isn't the placement of urban water supply wells more of a problem than the absolute number of wells or the volume of water pumped from them?"

Local wells need to be placed where they can be recharged more easily, for example, near the influence of canals. Unfortunately, municipalities located at greater distances from canals or the WCAs have little flexibility while larger municipalities have the advantage of distributing wells over a larger area. When wells cannot be recharged easily, they either suffer saltwater intrusion or draw down the groundwater table. As a result, they usually place an undue demand on the regional system. Unfortunately, political entities are reluctant to relocate wellfields independent of political boundaries.

9. Issue: "Some of the technologies proposed for the Restudy, such as ASR, have a great deal of risk and uncertainty associated with them. What happens if they do not work as well as expected?"

Will they be able to get permits to implement them? Will water quality be acceptable? Will they work at a regional scale? Some alternatives proposed that a large proportion of Palm Beach County's water supply rely on ASR, for example. If these technologies do not work as expected, there is a risk of not meeting water supply demands. While inter-aquifer transfer seems to work well, storing large volumes of surface water in ASR wells remains much more uncertain as a water management technique. If water quality treatment is required, it will increase the cost of the project.

The COE is performing risk and uncertainty analyses to determine how dependent the alternatives will be on uncertain technologies. If dependency and uncertainty remain high, it would be wise for a task team to draft alternative components.

10. Issue: "Is the Restudy attempting to wean urban water supply from the regional system, the WCAs and Lake Okeechobee? If urban areas are expected to rely on either expensive alternatives or water supply cutbacks in the future, rather than on the regional system as they do now, why should they support the plan?

All of the alternative plans do, in fact, reduce the dependence of users on the regional system. In Alternative D13R, there is less water delivered from the regional system through the structures to the LEC than in the 1995 Base case and almost 23% less than in the 2050 Base case. The future for urban water supply looks very bleak in the 2050 Base without a C&SF Restudy, even if the health of the environment were not a consideration. The urban areas will benefit from a sustainable system that supports their *future* water supply demands *and* restores the Everglades ecosystem. In addition, as expensive as these projects are, they are likely to be even more expensive if delayed farther into the future.

11. Issue: “Are large, complex, regional reuse facilities to costly to ever be built?

Treating the water to the level necessary to discharge into the natural system makes them even more expensive.

Because of time constraints and the relatively coarse 2-by-2-mile scale of the SFWMM, only large-scale projects could be evaluated. There may well be better, smaller-scale ways to include “reuse” water that are worth investigating as planning continues. For example, reuse facilities could be designed to reduce demands on the natural system. Reuse facilities could store water and release it back to agricultural areas during the dry season without the requirement for nutrient removal if other water quality requirements were met. Nutrients could be useful in irrigation water. Depending on the location, a reuse facility could reduce the demand on Lake Okeechobee, freeing up water for other uses. Reuse water could also be used to maintain canal levels, preventing saltwater intrusion and recharging urban wellfields, while reducing the demand on the natural system. Water is currently being discharged to deep wells or out to tide that could be available for reuse. In the S-4 basin, water with high phosphorous concentrations flows into Lake Okeechobee when lake stage drops below 15.5 feet. This water could be captured in reservoirs in Hendry and Glades Counties and used for irrigation, or if an STA were added to remove nutrients, the water could be made available to the Big Cypress basin or the Caloosahatchee River. These possibilities and others should be addressed in the detailed planning phase. At this time, however, counties and resource agencies are wary of reuse water being used for these purposes, primarily because of high cost and water quality concerns. Reuse water systems are feasible only if the water does not contain pesticides, heavy metals, or pathogens.

12. Issue: “If Congress mandated the C&SF Restudy project to be truly multi-objective and to meet all water supply needs, why have water supply and flood control concerns not received adequate attention in the plan formulation process?”

Some local governments did not believe they were sufficiently represented in the planning process. Local governments believe they have much to offer. They believe that the COE has a more balanced approach, but others, particularly DOI, need to take a more holistic view. As the Restudy gets closer to defining its goals, all the participants need to work together. This group believes that DOI should recognize where real improvements will be made and not take the approach that NSM goals must be met. The Restudy should identify *all* goals and objectives for South Florida.

The impetus of the Restudy has been to restore the Everglades. Congress has directed the COE to pursue this objective while enhancing water supply and not compromising flood control and other original purposes of the project. While there has been resistance to the idea of enhancing water supply as part of a restoration project, the definition of water supply includes water supply to the natural areas, not just urban and agricultural water supply. Indeed, much of the planning process was aimed at increasing water supply throughout the system.

Many components in the alternatives were designed to enhance urban water supply. Many believe that planning for the expected growth of the LEC and its unavoidable increase in urban water supply demand will better protect the water supply earmarked for natural areas. Refusing to give water to a rapidly growing urban area is unlikely to slow or stop the influx of new residents, as urban planners in the western states have discovered. Instead, as happened out west, as the urgency of the situation increases, political pressure mounts to take the water from natural areas regardless of ecological consequences. Not recognizing urban growth would put the Everglades at risk again in the future.

The original AET was asked to set hydrologic goals for the natural system and the ADT was tasked with meeting those goals within the confines of water supply and flood control systems. Performance measures allowed both teams to see how well each alternative functioned. Fortunately, both the AET and the ADT refused to stay in their defined "boxes." For example, the AET began recommending structures as well as targets. The give-and-take that occurred with each AET/ADT round resulted in the hydrologic targets being refined and redefined until a single set of targets was agreed upon and understood. The process was an organic one that grew from putting together a group of highly motivated, often polarized agency representatives and interested stakeholders. While team members still do not represent a united front, in the nine months since the process began, a number of misconceptions have been brought to light concerning urban and environmental water supply. This learning process will continue as the project progresses into detailed planning and design. The team has learned that it is highly important to bring important stakeholders, including local governments, together with people from the diverse fields of planning, ecology, hydrologic modeling, and hydrologic engineering. As detailed planning continues, representation of all groups will continue to be a high priority.

CHAPTER VIII -- WATER QUALITY ISSUES

Susan Jewell, Betty Grizzle, and Kofi Fynn-Aikins, FWS; Mike Zimmerman, ENP

A. Overview

The completion of the C&SF Project's water control facilities provided a primary flood control system to south Florida. With the mitigation of floods and droughts produced by this water management program, urban and agricultural development proceeded rapidly. However, because this water control system was not designed for water quality concerns, degradation of the Everglades ecosystem and many coastal estuaries has occurred.

The natural Everglades system evolved under oligotrophic conditions and is therefore very sensitive to eutrophication produced by elevated nutrient levels. Drainage from the Everglades Agricultural Area (EAA) has severely impacted Everglades marsh surface waters, with phosphorus identified as the primary pollutant. Coastal estuarine environments, particularly Florida Bay, Biscayne Bay, and the St. Lucie estuary, have been damaged by both poor water quality conditions and unnaturally high volumes of water discharged by the C&SF Project canals. Stormwater runoff and point source discharges from extensive urban developments have also contributed to the degradation of water quality in coastal ecosystems and within local watershed basins.

The natural Everglades system evolved under sheet flow conditions. There were no levees, canals and pumps. The construction of internal canals and levees has caused drying and oxidation of soils in some areas of the Everglades and ponding in other areas. The canal system has allowed various pollutants to be transported deeper into pristine areas of the Everglades. Bechtel *et al.* (1996) found that pumping at S-7 pump station caused negative impacts to water quality, specifically dissolved oxygen. Point source discharges as opposed to surface water sheet flows or groundwater flows, have also caused water quality degradation to the Everglades Protection Area and the estuaries. For these reasons, decompartmentalization that includes the removal of pumps and levees and filling of canals, will be an important ingredient in the total strategy to restore water quality in central and south Florida.

Although the Restudy attempts to reduce seepage from the remaining Everglades to urban areas, the present amount of seepage has a positive effect on water quality through dilution of the agricultural and urban pollutants present in the canals adjacent to the Everglades. Walker (1997) discovered a negative correlation between phosphorus concentration and head differential between marshes in ENP and adjacent canals in the C-111 Basin. Increasing water elevations to NSM values is not only desirable to restore the intrinsic ecology of the Everglades, but also in maintaining a higher head differential between the Everglades and surrounding areas. Localized rainfall in urban areas at the edge of the Everglades can temporarily reverse the normal head differential and threaten to carry pollutants into the Everglades via seepage. The closer water levels are to NSM targets in the Everglades, the lower the likelihood of this reversal in head differential.

The Governor's Commission for a Sustainable South Florida conceptual plan for the C&SF Project Restudy (1996) stated that the natural system, including the Everglades and coastal estuaries, can only be restored through the supply of clean rainwater and surface water from upstream marshes, rivers and sloughs, and Lake Okeechobee. The Restudy alternatives proposes water storage in wetlands, reservoirs, and aquifer storage and recovery (ASR) facilities. This water will be delivered from a variety of sources including ground water, surface water, and agricultural and urban runoff. Water released from these storage areas will be used for maintenance of groundwater levels, wellfield recharge, Everglades water supply, and estuarine water supply. Water-management alternatives being considered under the Restudy can influence water loads, nutrient loads, and depth regimes in reservoirs and stormwater treatment areas (STAs). These changes can effect performance, as measured by outflow phosphorus concentrations or load reductions (Walker 1998).

B. Stormwater Treatment Areas (STAs)

STAs have been designed under the Everglades Construction Project (ECP) to reduce phosphorus concentrations in agricultural runoff and releases from Lake Okeechobee prior to discharge into the Everglades Water Conservation Areas. STAs are defined as constructed wetlands (also known as filtration marshes) that provide enhanced filtration and nutrient removal based on water flow operations and maintenance of specific plant species. Agricultural best management practices (BMPs) and STAs will be used to meet interim treatment requirements established in the State/Federal Settlement Agreement (1991) and Everglades Forever Act (EFA) (1994). BMPs have been fully implemented in the EAA since about 1995. The Everglades Nutrient Removal Project (a 3700-acre pilot-scale STA) has been in operation since August 1994. The first full-scale STA (STA-6) began operation in December 1997, while the last STA (STA-3/4) is scheduled to be fully operational by October 2003 (Walker 1998).

Although STAs represent an important water treatment technology for Everglades restoration efforts, there are operational issues to consider. For example, STAs have not, to date, been proven to remove phosphorus to the low levels required in state standards (10 ppb). Also, some pollutants may not be removed by STAs. Determining the best operational schedule will be essential for meeting the target goals defined by the STA design.

Requirements of the EFA and the Settlement Agreement are included in the base conditions for the Restudy and are assumed to be met in the alternatives. The EFA does not specify treatment strategies for other areas which discharge to the Everglades. Those areas are covered by the non-ECP permit issued to the SFWMD by DEP, which requires evaluation of, among other things, the construction and operation of water treatment facilities.

Additional technologies, other than STAs, are also available for the treatment of surface runoff. Drawbacks of these alternatives include: 1) the addition of potentially harmful chemicals to the water source, 2) removal of beneficial organisms and elements with filters, 3) treatment of a single pollutant, 4) production of contaminated sludge, 5) large land requirements, 6) high operation and maintenance costs, and 7) the construction of artificial complexes surrounding the Everglades environment (PEER Consultants 1996).

C. Environmental Pollutants

At present, very few water quality pollutants can be modeled within the Restudy alternatives. Phosphorus has been the focus for Lake Okeechobee, the WCAs, and Everglades National Park. Lack of model results (particularly the Everglades Landscape Model) for much of southwest Florida, including Big Cypress National Preserve, and Holey Land/Rotenberger Wildlife Management Areas make it difficult to determine water quality impacts of Restudy alternatives. A preliminary mercury model being developed by the Environmental Protection Agency (EPA) will provide some answers relative to atmospheric depositional loads in the natural Everglades system.

Environmental pollutants are ubiquitous and an ever increasing problem in south Florida. Human activities have degraded water quality in large areas of south Florida during the last century. Water in urban and agricultural canals commonly has high concentrations of nutrients and toxic compounds compared to water in marshes that are remote from canals. Drainage of nutrient and pollutants from urban and agricultural lands has degraded lakes, streams, canals, estuaries, and bays of the region (McPherson and Halley 1997). In addition, discharge of nutrient-laden sewage and storm water runoff into canals also carries bacteria, viruses, oil and grease, toxic metals, and pesticides. The urban canal water discharges into coastal waters or enters the groundwater system and the public water supply (Klein *et al.* 1975).

Federal and State agencies and environmental organizations have agreed that the south Florida environment, and especially the Everglades, should be protected and restored, to the extent possible, to its pre-drainage conditions. Contaminants play a role in the decline of species, keeping numbers at suppressed levels and preventing species from recovering. Therefore, the restoration goals can be successfully accomplished only if serious consideration is given to the negative effects of contaminant loading from agricultural, industrial, and urban sources on our trust resources and their habitat. The effect of toxins in the food chain and their long-term adverse effects on ecosystem integrity are also largely unknown. These types of scientific information would be valuable for the restoration effort in south Florida.

1. Nutrients -- Fertilizers are widely used in south Florida to maintain high levels of agricultural productivity. From July 1, 1990 through June 30, 1991, fertilizers sold in south Florida, contained 127,000 metric tons (140,000 tons) of inorganic nitrogen and 50,800 metric tons (56,000 tons) of phosphate (McPherson and Halley 1997). Nutrient loading from the Everglades Agricultural Area (EAA) and urban areas have significantly increased nutrient concentrations, particularly phosphorus, in south Florida (Stober *et al.* 1996). This has resulted in increased soil phosphorus content, changed periphyton communities, loss of native sawgrass communities, increased organic matter in water, loss of water dissolved oxygen, conversion of wet prairie plant communities to cattails and loss of important wading bird habitats (Stober *et al.* 1996). Because the Everglades were historically nutrient poor, with phosphorus concentrations less than 10 ppb, nutrient loading from the EAA has been associated with eutrophication in the Water Conservation Areas having greater than 50 ppb phosphorus concentrations.

Atmospheric deposition also contributes to the nutrient load infiltrating the south Florida environment. The highest deposition rates for nutrients occur in agricultural and urban areas, and lowest in coastal and rural areas (Brezonik *et al.* 1983, Hendry *et al.* 1981). Greening (1997) estimated that 29 percent of the nitrogen and 31 percent of the phosphorus entering Tampa Bay come from wetfall and dryfall directly deposited to the bay's surface, making this source second to only stormwater as the largest bay nitrogen loading source, and the largest source of phosphorus. Overall, atmospheric nitrogen is a more important source for the nutrient budget than atmospheric phosphorus (Brezonik *et al.* 1983).

2. Pesticides and Polychlorinated Biphenyls -- Pesticides have also been widely used in agricultural and urban areas in south Florida for more than 50 years to control insects, fungi, weeds and other undesirable organisms. Because of year-round warm temperatures and moist climate, Florida agriculture requires vigorous pest control; thus, while Florida agricultural production ranks approximately 30th in the U.S., pesticide usage per acre is in the top 5. The compounds used vary in their toxicity, persistence, and transport.

Although pesticides are usually applied to specific areas and directed at specific organisms, these compounds often become widely distributed and are potentially hazardous to nontarget species (McPherson and Halley 1997). Since the late 1960s, persistent organochlorine pesticides have been detected in fish that are part of the Everglades food chain (Kolipinski and Higer 1969, McPherson 1973, Haag and McPherson 1997). Some of the more persistent pesticides, such as DDT, chlordane, dieldrin, and aldrin have been banned for use in the state, but their residues still occur in the environment. Herbicides, including atrazine, bromocil, simazine, 2-4-D, and diuron, which have the highest rate of application, are commonly detected pesticides in Florida's surface waters (Shahane 1994). The most frequently detected insecticides in surface waters are the chlorinated hydrocarbons that are no longer used in the State, such as DDD, DDE, DDT, dieldrin, and heptachlor. These insecticides are also the most frequently detected pesticides in bottom sediments (Shahane 1994).

Chlorinated chemicals, such as polychlorinated biphenyls (PCBs), dioxins, and furans, which are generated and used primarily in urban and industrial areas, pose a serious concern to fish, wildlife, and human populations (Colborn *et al.* 1993). Although most uses of PCBs have been banned since the late 1970s, these persistent chemicals are still found in the environment and continue to pose potential threats to fish, wildlife, and humans. In recent years, many organochlorine pesticides and PCBs have been linked to hormone disruption and reproductive problems in aquatic invertebrates, fishes, birds, and mammals (Colborn *et al.* 1993).

3. Mercury -- The evidence of mercury contamination in fish and wildlife in south Florida freshwater and terrestrial ecosystems is extensive. Trends in mercury accumulation in south Florida, as evidenced by sediment profiles, show that atmospheric mercury deposition has increased approximately fivefold since 1900 (Rood *et al.* 1995). The deposition rate of mercury by rainfall measured today is at least double that of other remote sites in North America (Guentzel *et al.* 1995). Piscivorous freshwater sport fish and alligators in many watersheds, especially in the Everglades, have high mercury levels in their tissues (Ware *et al.* 1990, Eisler 1987). After discovering the extent and severity of mercury in fish in 1989 the State Health Officer issued advisories to fishermen warning against consumption of several species of fish in more than 400,000 ha (1,000,000 ac) of the Everglades, and advising restricted consumption of others over most of the state. Besides human health concerns, ecological resources may be at risk as well. In the early 1990s three Florida panthers (*Felis concolor coryi*) inhabiting the Everglades died, with mercury poisoning determined to be the proximate cause of death in one and a contributing cause of death in the other two cases (Roelke *et al.* 1991). High mercury levels have been detected in the endangered wood stork and other birds (Sundlof *et al.* 1994). There is concern that the 50-year decline in wading bird numbers in south Florida may partially be a result of increased mercury exposure. Intensive studies are underway to further define this concern.

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CHAPTER IX -- NON-INDIGENOUS SPECIES

Steve Peacock, FWS; and David T. Jones, ENP

A. Introduction

Non-native plants and animals that have been introduced to an ecosystem are referred to as non-indigenous or exotic species. These exotic species have been introduced into the United States through various means. Many of the plant and animal species that have become established in the subtropical climate of Florida were introduced for agricultural or ornamental purposes, escaped to the wild from horticulturists or aquariums, or were transported inadvertently to Florida. "Some introduced species, though persistent, have seemed ecologically innocuous, while others are scourges. Some plant species have changed entire major ecosystems, while others are harmless curiosities." (Simberloff *et al.* 1997, p. xi).

Non-indigenous species incur both direct and indirect impacts on native species. These impacts can be extensive and can result in reducing native populations to a fraction of their status prior to introduction of the non-native species. The C&SF Restudy will affect both native and non-native species in different ways. This chapter is divided into sections providing information on the past and potential future impacts of the C&SF project on various plant and animal taxa.

B. Exotic Pest Plants

1. Existing Conditions Florida's exotic (non-indigenous) plant species, totaling about 1200 taxa (Wunderlin *et al.* 1996), currently constitute nearly 30% of the State's flora (Schmitz *et al.* 1997). These species, many of which are tropical and subtropical in origin, have arrived in Florida by a variety of pathways, mostly with the assistance of man, and often intended for agriculture and the ornamental trade (U.S. Congress 1993, Gordon and Thomas 1997). The majority of these introductions are not known to occur outside cultivation and even those that have spread beyond their planting site are not always invasive (Austin 1978, Science Subgroup 1996). Certain species, however, have not only escaped cultivation and invaded disturbed sites, but have also become established in Florida's natural areas, which are intended for the preservation of native communities and landscapes.

The Florida Exotic Pest Plant Council lists 62 species as invading and disrupting the native plant communities in the State, and an additional 57 species as showing a potential to do the same (Florida Exotic Pest Plant Council 1997). Exotic plants can disrupt native biotic communities in several ways. Examples of the disruptive effects of exotics, which modify the original habitat, include: 1) changes in community structure and composition, 2) alteration of ecological processes, and 3) hybridization between exotic species and their related native ones, resulting in potentially new pests (Austin 1978, Schmitz *et al*. 1997, Simberloff 1997). In addition, exotics can affect the quality of human life in the State by impacting water quality and use, diminishing property values, colonizing agricultural lands, increasing fire risk, and producing less aesthetically-pleasing views (Schmitz *et al*. 1997).

Florida's insularity (the southern third of the peninsula is essentially a "habitat island") and the mosaic of disturbed or novel habitats across its landscape have rendered the State especially susceptible to invasive exotic plants (Simberloff 1997). The State's near tropical conditions, prominence as a transportation hub and center for tourism, and abundance of aquatic habitats, both natural and man-made, have promoted the arrival and establishment of exotic plant species (Simberloff 1997). Disturbed areas such as abandoned farm land, drained wetlands, roadsides, and canals and ditches are sites typically invaded by exotic plants (U.S. Congress 1993). In southern Florida, drainage and development, particularly of the Everglades, have increased the opportunities for exotic species to become established (McPherson and Halley 1996). The modification of the State's waterways for irrigation, water supplies, flood control, and recreation has further facilitated the spread of some of these species (U.S. Congress 1993).

Both wetland and upland habitats in southern Florida are affected by exotic pest plants. Over one million acres of wetlands alone are currently infested with exotic water-tolerant trees and shrubs and aquatic weeds. Estimates for the extent of infestation by the most widespread invasive exotic plants in natural areas of southern Florida are tabulated below (from Schmitz *et al*. 1997):

Table IX-1. Acreage covered by the most widespread species of exotic plants in southern Florida

Species	Acres
Schinus terebinthifolius (Brazilian pepper)	700,000
Melaleuca quinquenervia (melaleuca)	490,000
Casuarina spp. (Australian pine)	375,000
Hydrilla verticillata (hydrilla)	100,000
Eichhornia crassipes (water hyacinth)	1,700
Total	**2,366,700**

Brazilian pepper has invaded a broad range of moist to mesic sites, both disturbed and undisturbed, often forming monotypic, dense stands. It thrives on disturbed, well-drained soils created by natural disruptions (e.g. hurricanes) and is especially invasive in areas affected by human activities, particularly the newly created habitats resulting from agriculture and drainage, such as abandoned farmlands, roadsides, and canal banks (Ewel 1986). In Everglades National Park (ENP), it is commonly found in disturbed tropical hardwood hammocks of Shark Slough and bayhead tree island sites of the East Everglades where over-drainage has created conditions suitable for its establishment. It does not become established in deeper wetland communities and rarely grows on sites with periods of flooding lasting longer than six months, thus it is typically absent from long hydroperiod marshes and prairies (Jones and Doren 1997).

Similarly, Australian pine has invaded well-drained habitats disturbed by human activities and natural events. Once commonly planted to form windbreaks around canals, agricultural fields, houses and roads, it has spread extensively throughout southern Florida (Schmitz *et al*. 1997) and can be found in many of the same habitats invaded by Brazilian pepper. Hybridization occurs between the two most common species, *Casuarina equisetifolia*, widely distributed in coastal areas, and *C. glauca*, typically found in more interior areas.

Melaleuca grows in a variety of habitats – natural and man-made - throughout southern Florida, including roadsides, ditch banks, lake margins, pastures, mesic prairies, sawgrass marshes, cypress forests, and mangrove areas (Bodle *et al.* 1994). Wetter areas are more susceptible to invasion than drier areas. The heaviest infestations are found in Loxahatchee NWR, Big Cypress National Preserve, and the East Everglades portion of ENP. Portions of ENP other than the East Everglades and WCA 2A have the lowest infestations (Bodle *et al.* 1994). Melaleuca has invaded essentially every plant community type known to occur from Lake Okeechobee to southern Miami-Dade County, including healthy, seemingly undisturbed areas. Bodle *et al*. (1994) note that virtually all of these communities could be considered indirectly disturbed (and thus increasingly susceptible to invasion by melaleuca and other exotic plants) because hydrologic patterns in southern Florida have been greatly altered and no freshwater wetlands remain in their natural (historical) state.

Hydrilla and water hyacinth have long been recognized as a problem in aquatic environments throughout the State (Schortemeyer *et al.* 1981). These species have rapidly expanded throughout southern Florida via the hundreds of miles of canals and ditches dug for water management. Excessive growth of hydrilla and other aquatic plants has been linked to increased pollution due to agricultural run-off (Canfield *et al*. 1983). Additional species may not be widespread in southern Florida but can be locally abundant. For example, torpedo grass (*Panicum repens*), which covers over 18,000 acres, forms monospecific stands in the marshes of Lake Okeechobee (Schmitz *et al*. 1997), but is not known to be abundant elsewhere.

Control of exotic plants in southern Florida costs millions of dollars annually. Because of their highly widespread occurrence and disruptive nature, melaleuca, Brazilian pepper, Australian pine, and hydrilla receive top priority in natural areas managed by the NPS, SFWMD, FWS, and GFC. A combination of mechanical and chemical (herbicidal) control methods are currently used to arrest the spread of most species. The Florida Exotic Pest Plant Council has developed management strategies for melaleuca and Brazilian pepper (Laroche 1994, Ferriter 1997). Biological control agents are currently available for melaleuca and hydrilla and are being developed for Brazilian pepper (Center *et al*. 1997).

Fire can be used to control woody exotic plants, but if used incorrectly, it can result in the inadvertent spread of undesirable species. For example, periodic fires in marl prairies of southern Florida can be used to kill Australian pine trees. However, if the fire occurs just before seed maturation and release, establishment of the plant on the improved seed bed may be enhanced (Wade *et al.* 1980). Brazilian pepper seedlings are vulnerable to fire but thickets of the plant are effective barriers to fire and can quickly re-sprout if burned (Jones and Doren 1997). Wade *et al.* (1980) noted that Brazilian pepper is a major component of post-burn vegetation because the fruits of this species are readily eaten by wildlife drawn to burned sites, and wildlife disperse Brazilian pepper seeds through defecation. Melaleuca, on the other hand, is a fire-adapted species: it re-sprouts vigorously after fire and fire induces capsule opening and seed release (Wade *et al.* 1980). The timing of fire, however, can be used to keep it in check (Bodle *et al.* 1994). Application of fire can be timed so that germinating seeds are exposed to fire, because seedlings less than several months old may perish if burned (Wade *et al.* 1980).

2. Effects on Fish and Wildlife Australian pines may disrupt native plant communities by producing a dense litter that smothers vegetation beneath the trees (Mazzotti *et al*. 1981). Melaleuca can also almost totally displace native vegetation, as well as raise soil elevations and cause higher water loss than native sawgrass through evapotranspiration (Woodall 1980). Melaleuca may also affect fire regimes: the combination of its flammable volatile oils and extreme density of stems are conducive to crown fires that can be destructive to surrounding native vegetation (Wade *et al.* 1980, Flowers 1991). Similarly, when Brazilian pepper forms monotypic stands, it can almost completely obliterate the native understory plants. Ewel *et al.* (1982) found only several fern and shrub species, and small numbers of native and exotic tree species, in the understory of the densest stands of Brazilian pepper. Gogue *et al.* (1974) reported that Brazilian pepper has the ability to inhibit the growth of competing vegetation through the production of allelopathic substances.

The effects of exotic plant communities on the local fauna are not well known, but it is generally believed that fewer animals are associated with them Curnutt (1989) found that while a nearly monospecific stand of Brazilian pepper was utilized to some extent for breeding and feeding by native avifauna, both total population density and species diversity were much lower in the Brazilian pepper, compared to the native pineland and forest-edge habitats it replaced. Beever (1994) reported that bird rookeries in mangroves surrounded by Brazilian pepper were abandoned.

On the other hand, the herpetological fauna of Brazilian pepper forests was found to be similar in species numbers and foraging guilds to those of southern Florida's hammock communities, probably due to the fact that both communities have closed canopies and similar soil development (Schmitz *et al.* 1997). In ENP, however, Brazilian pepper threatens nesting habitat of the gopher tortoise (*Gopherus polyphemus*), a State-listed species of special concern (Doren and Jones 1997).

Wildlife studies are lacking for Australian pine forests in Florida. Populations of small mammals in freshwater wetlands invaded by Australian pine may be depauperate compared to those in native plant habitats (Mazzotti *et al*. 1981). In sandy beach communities, where these trees are commonly found, there is evidence that their root system can interfere with the excavation of nests by threatened and endangered sea turtles and the endangered American crocodile (Schmitz *et al*. 1997).

Despite widespread concerns, little research has been conducted regarding the impact of melaleuca on southern Florida fauna. Schortemeyer *et al*. (1981) found that wildlife use of randomly selected melaleuca stands was low, indicating an overall low rate of wildlife utilization of melaleuca. Because melaleuca spreads from isolated patches, the wildlife values of these adjacent native habitats will be diminished due to their loss of and replacement by extensive melaleuca stands (Schortemeyer *et al*. 1981). In their study of wildlife in southern Everglades wetlands invaded by melaleuca, O'Hare and Dalrymple (1997) reported that transient and winter-resident birds occurred at much lower abundances in moderately dense melaleuca infestations compared to native forested habitats such as cypress swamps and hardwood hammocks. They also found that areas with moderate levels of melaleuca retained species composition and productivity typical of the natural wetland community; animal populations were found to persist in areas with disturbed vegetation as long as the hydrologic regime remained unaltered.

Preliminary results of another study indicate that a variety of bird species utilize melaleuca under some circumstances; the trees may provide nesting and roosting sites for native bird species (Schortemeyer *et al*. 1981). While Sowder and Woodall (1985) note that melaleuca generally provides poor habitat for rodent populations, Ostrenko and Mazzotti (1981) found that a mature melaleuca stand was able to enhance a permanent breeding population of one species of rodent, the cotton mouse (*Peromyscus gossypinus*), over that of the surrounding sawgrass community.

Although hydrilla is an exotic species, studies on the littoral zone of Lake Okeechobee indicate that where hydrilla grows at moderate densities, it oxygenates the water column and its complex vegetative structure supports the most abundant and diverse assemblage of above bottom invertebrates among the cover types in the littoral zone (GFC 1991). The rich invertebrate fauna within hydrilla beds is known to attract carnivorous species of game fish (Furse and Fox 1994) and waterfowl (Schmitz *et al.* 1997).. However, when dense hydrilla "tops out", that is, when it completely covers the water surface, light penetration is reduced, the water column below the canopy of leaves is deprived of oxygen, and the benthic invertebrate community is depauperate (GFC 1991). Other adverse effects of extremely dense growths of exotic aquatic plants, like hydrilla and water hyacinth, include, increased water temperature, greater evapotranspiration, higher sediment loading due to leaf decay, lower fish production, and smothering of beds of native submerged vegetation (Schmitz *et al*. 1993). Large floating water hyacinth beds, uprooted by heavy winds, have destroyed emergent plants important to waterfowl (Schmitz *et al.* 1993). Dense hydrilla infestations are known to change the trophic-state classification (based only on water quality) and can shade out native bottom vegetation and altered ecological processes (Schmitz *et al.* 1993). Shifts in zooplankton and macroinvertebrate densities and richness have been linked to hydrilla expansion (Schmitz *et al.* 1997). In water bodies where hydrilla forms a dense canopy, populations of popular game fish species tend to have greater numbers of smaller individuals due to insufficient predator cropping (Colle and Shireman 1980).

3. Mitigating the Continued Threat of Plant Pests According to Moody and Mack (1988), exotic pest plant species may exist in the landscape at low abundances for several decades before experiencing rapid population growth. Many of Florida's widespread exotic plant species were introduced long before they became invasive (Schmitz *et al*. 1997). Examples are Brazilian pepper, which occurred in Florida 50 years before becoming a nuisance species (Ewel 1986), and melaleuca, introduced into Florida in 1906 but not a problem until the 1960s (U.S. Congress 1993). It is reasonable to assume that additional species that have already been introduced, but are now not especially invasive, may become problems in the future (Schmitz *et al.* 1997). As explained by Ewel (1986), certain sites can act as "staging areas" from which exotic species disperse vast quantities of seed into the surrounding landscape, and the resulting exotic populations may eventually produce genetic variants adapted to local conditions. It is also plausible that continued habitat change (destruction of wetlands and alteration of hydrologic regimes) in southern Florida will further enhance conditions for the spread of both current and future species.

Whether a species will be invasive in a new habitat is difficult to predict (Gordon and Thomas 1997). Perrins *et al.* (1992) note that establishment in a new site depends on the life history of the species, the new habitat, and management practices in the habitat, with chance events and timing interacting with these factors to determine establishment success. Rejmanek (1994) and Crawley (1987) noted the following characteristics that enable many exotics to replace native plants: seed size, fruit dispersal by vertebrates, bark thickness, better ability to acquire resources (like nitrogen and light), and ability to form dense thickets. The majority of the plant species placed on the List of Non-native Invasive Species (Florida Exotic Pest Plant Council 1997) have two common traits: 1) mechanism for long-distance seed transport and 2) ability to reproduce vegetatively. These two features allow exotic plants to quickly spread to new sites and form dense stands that make it difficult for other species to penetrate (Gordon and Thomas 1997).

Schmitz *et al.* (1997) note that several exotic plant species seem ready to expand their range greatly in southern Florida wetlands and hammocks. One such species is cat-claw mimosa (*Mimosa pigra*), native to Central America and invasive in many sites around the world, including central Florida. Sutton and Langeland (1993) observed that because of the plant's ability to grow on low-fertility soils, coupled with the conducive hydrological cycle prevailing in southern Florida, the Everglades may be especially susceptible to invasion by cat-claw mimosa. The laurel fig (*Ficus microcarpa*) has been in Florida since the 1930s, but its pollinators have only been introduced within the past 15 years (Nadel *et al.* 1992). More recently, tropical soda apple (*Solanum viarum*) has spread in the State since the early 1980s, typically colonizing ditch banks, roadsides, and pasture lands. It is of interest to note that 39% of the Florida Exotic Pest Plant Council's 1993 list of 94 invasive plant species in Florida, including the laurel fig, were still commercially available in Florida in 1994 (Gordon and Thomas 1997).

The U.S. Congress (1993) reports that the large influx of exotic plants entering the U.S. through various routes has set the stage for potential escapes and unintentional and intentional releases of these organisms. Eighty-five percent of all plant shipments into the U.S. pass through the Miami Inspection Station (U.S. Congress 1993). Florida's woody ornamental industry, worth $1 billion, continues to import large numbers of plants for the nursery and landscaping trades (U.S. Congress 1993). Florida's aquaculture industry is the largest in the U.S. The aquarium trade industry was responsible for introducing hydrilla into canals in central Florida around 1950 and later into Miami canals (U.S. Congress 1993). These industries will continue to threaten native ecosystems if import regulations are not developed, especially for the importation of potentially invasive plants. Without early identification and importation restrictions, the number of invasive species introduced into Florida will continue to rise. The U.S. Congress (1993) recommends that the State of Florida adopt similar legislation and educational programs as those developed in Hawaii and Australia to restrict the importation of exotic plants. Because of the unpredictability of invasiveness that species display, the U.S. Congress (1993) and Gordon and Thomas (1997) have recommended that Florida should consider implementing a policy that essentially states: "...species should be considered invasive and subject to import restrictions until demonstrated otherwise." (U.S. Congress 1993)

4. Effects of the Alternatives and Recommendations (Plants) Total system annual average hydroperiod differences, ponding depth differences, and peak stage differences for Alternatives A, B, C, and D13R were used to determine the possible effects of alternatives on exotic plant species. This evaluation will consider only the effects of these alternatives for five widespread terrestrial and aquatic exotic plant species -- melaleuca, Brazilian pepper, Australian pine, hydrilla, water hyacinth.

Determination of the effects of each alternative on these exotic plant species has been guided by a basic understanding of the ecological conditions that promote or discourage the establishment and spread of terrestrial and aquatic plants in general. For example, Australian pine and Brazilian pepper prefer dry conditions for seed germination and seedling establishment, hence prolonged inundation (long hydroperiods) would limit the success of these two developmental periods, affecting the spatial extent of the species. Established trees of these two species are more tolerant of wet conditions although extended periods of flooding could reduce plant vigor and reproductive capability and may eventually lead to the death of the tree. Melaleuca, on the other hand, prefers wet conditions although invasion of dry areas can occur, especially if these areas become wetter than normal. Continuous flooding of a site may inhibit seed germination in melaleuca, but it does not seem to affect established trees.

Artificial structures, especially canals and levees, represent suitable habitats for both terrestrial and aquatic species. Australian pine and Brazilian pepper are capable of colonizing the elevated, disturbed portions of levees and roadbeds, but melaleuca is not, because these sites are generally not wet enough. The aquatic species (hydrilla, water hyacinth, and others) are widely distributed throughout canals where water levels and conditions are favorable for the establishment of these plants. Thus, the extent that canals, levees, roadbeds and other structures associated with water management operations occur within the system may further influence the occurrence of exotic plants: the more such structures are present, the more habitat becomes available for exotic establishment and spread.

For hydroperiods and ponding depth criteria, Alternatives A, B, C and D13R are similar in the overall hydrological conditions they predict for the system, but they do show some local differences. Lack of water is the main concern, as it can produce localized site conditions favorable for the establishment of Australian pine, Brazilian pepper, and other potentially invasive "upland" species. All four alternatives predict a continuation of short hydroperiods and low ponding depths along the eastern boundary of ENP, especially the area extending from northeast Shark Slough south to northern Taylor Slough. The C-111 basin and the Model Lands show a similar pattern. All of these areas currently support infestations of Australian pine and Brazilian pepper and will continue to do so under the conditions predicted by the four alternatives. On the other hand, an increase in hydroperiods predicted in the East Everglades (Indicator Region 8) may reduce the vigor and spread of these two species that currently inhabit many of the tree islands in this area.

Melaleuca will continue to occur and spread throughout the wetlands under the conditions predicted by the four alternatives except, perhaps, in areas experiencing the hydrological extremes: long hydroperiods and deep ponding or short hydroperiods and low ponding. However, the presence of these conditions at a particular site does not make it immune to melaleuca invasion; reversals in hydrological conditions can make these areas more susceptible. Generally, once melaleuca becomes established at a site, hydrologic changes are ineffective in eliminating it.

Canals, levees, and associated structures function as conduits for the persistence and often rapid spread of both terrestrial and aquatic exotic plants. The filling of canals and the degradation of levees and other raised sites, accomplished by decompartmentalizing the system and eliminating the barriers to water flow, are partially addressed under Alternatives B and D13R. Canals, and the deep water habitats they provide, support the greatest infestations of aquatic weeds (hydrilla, water hyacinth, water lettuce, and others) and are the primary corridors through which these organisms can extend their ranges rapidly from points of introduction and move into wetlands. These structures allow for the distribution and expansion of these pest plants from the north and developed lands to the east. Only Alternatives B and D13R are significantly superior to the present condition with respect to their effect on exotic plants, because they incorporate some removal of structures (canals, levees, roadbeds) from the system.

Levees and other raised earth structures provide prime disturbed “upland” habitat for a wide range of weedy, terrestrial native and exotic plant species, most notably the exotic tree species Australian pine and Brazilian pepper, and exotic grasses such as Burma reed (*Neyraudia reynaudiana*) and napier grass (*Pennisetum purpureum*). They serve as important avenues for the spread of these plants over great areas; their persistence on levees makes them available for dispersal into pristine habitat.

We find that any alternative that approaches NSM conditions, restores natural fluctuations in hydropatterns throughout the landscape, and includes removal of canals and levees in the Everglades Protection Area will reduce exotic plant establishment and spread in the Everglades. Conversely, any alternative that retains or adds to the present array of water management structures in the Everglades Protection Area s should not be viewed as restoration. Alternatives B and D13R come closest to satisfying these conditions.

C. Fish

The Biological Resources Division of the U.S. Geological Survey, Florida Caribbean Science Center, maintains a list of non-native fish in Florida, currently totaling 129 species (USGS 1998). This list is continually growing as more exotics are introduced into the State. The impacts of these fish on native populations in south Florida are far-reaching. Non-indigenous taxa represent well over 50 percent of the State's inland fish fauna south of Lake Okeechobee (Simberloff *et al.* 1997). These introduced species affect native fish populations by using the same food sources and spawning sites, and in many instances, preying upon the native fish.

Non-indigenous fish have been introduced to Florida's waters through a variety of means. Aquaculture operations have intentionally introduced several varieties of fish, including the Nile tilapia (*Oreochromis niloticus*), to ease permitting procedures for their culture as a food fish (Simberloff *et al.* 1997). Other pathways of non-indigenous fish introductions include release from aquarium-fish farms, individual aquariums, dispersal by birds, and intentional stocking. The Florida Game and Fresh Water Fish Commission (GFC) intentionally released the peacock cyclid (*Cichla ocellaris*) to provide biological control of other non-indigenous species and create a new sport fishery (Simberloff *et al.* 1997).

Responding to a request by the South Florida Ecosystem Restoration Working Group, ENP conducted a survey to identify the major species of concern within the NPS managed areas of south Florida (Snow 1998). The major fish species identified as established by the survey included: pike killifish (*Belonesox belizanus*), walking catfish (*Clarius batrachus*), oscar (*Astronotus ocellatus*), black acara (*Cichlasoma bimaculatum*), Mayan cichlid (*Cichlasoma urophthalmus*), blue tilapia (*Oreochromis aureus*), and spotted tilapia (*Tilapia mariae*). Mozambique tilapia (*Oreochromis mossambicus*) and the peacock cichlid, commonly referred to as the butterfly peacock bass (*Cichla ocellaris*) have been recorded but are not known to be breeding on NPS lands (Snow 1998). In addition to those exotic species already located on lands managed by the NPS, several non-indigenous species are established in the canal system adjacent to those parks. These species include the African jewelfish (*Hemichromis letourneauxi*), sailfin catfish(*Liposarchus multiradiatus*), banded cichlid (*Heros severus*), and jaguar guapote (*Cichlasoma managuense*) (Snow 1998).

The largest project element in the Initial Draft Plan that will affect exotic fish is the creation/expansion of canals. Canals provide a means for non-indigenous species which have become established in canals outside the Everglades to move into the natural system. These canals also act as artificial deep-water habitats which provide refuge to non-native aquatic predators in the dry season and during the winter, enhancing their survival and ultimate population sizes. During the dry season, these predators prey heavily on small marsh fishes and invertebrates moving in from the adjacent wetland (Howard *et al.* 1995).

Components SS6, YY6, and O4 involve the construction of two canals approximately 26 miles in length along the eastern border of WCA 3B. These canals could provide a conduit for introduction of non-indigenous species into the periphery of the Everglades. The COE should analyze the impacts of construction of these canals on aquatic species. Under Alternative D13R (Initial Draft Plan), partial removal of the L-67 canals, and the total removal of Miami canal, L-29, and L-28 should reduce the spread of exotic fish species in interior portions of the Everglades and Big Cypress Swamp.

D. Insects

There are approximately 1,000 documented species of non-indigenous insect species in Florida (Simberloff 1997). Pest insects in Florida cause losses of over $1 billion annually, and many of the worst pests are non-indigenous (Simberloff 1997). Many species arrived by walking, flying, swimming, or rafting; more recently, insect immigrants have arrived by hitchhiking or stowing away in cargo (Sailer 1978, Frank and McCoy 1990). These undocumented invaders continue to arrive at a rate of one major new pest species annually, while minor pests and insects that are not pests arrive and become established at a rate of more than 10 species annually (Frank and McCoy 1992). Many other insects in Florida were purposely imported for release as biological control agents (Frank and McCoy 1993). The ENP survey, prepared for the South Florida Working Group, revealed that information is not readily available regarding non-indigenous insects inhabiting NPS lands in south Florida. The report indicated the need to prepare a list of all insects through further surveys so an assessment can be made (Snow 1998). The only significant non-indigenous insect identified in the ENP survey was the imported red fire ant (*Solenopsis invicta*). This ant has the potential to disperse into native habitats and can be expected to spread throughout south Florida parks. It is considered a potential threat to native species, including threatened and endangered species, because it consumes many wildlife species, including alligator eggs, Florida tree snail (*Liguus fasciatus*) nesting individuals and eggs, sea turtle eggs and hatchlings, and has the potential to compete with native ants (Snow 1998).

The impact of the C&SF Restudy on insect species is unknown. However, the removal of levees which serve as a conduit for migration of insects, should reduce the spread of fire ants into the Everglades.

E. Other Invertebrates

A survey conducted by ENP identified two species of non-indigenous aquatic freshwater snails, which were unintentional introductions, and are now considered established in South Florida parks. These are the red-rimmed melania (*Melanoides tuberculata*) and *Marissa cornuarietus*, for which there is no common name (Snow 1998). *M. tuberculata* is considered established in ENP and is found in the mangrove zone, Shark River Slough, and Taylor Slough. This species can serve as the first intermediate host for the human lung fluke (Snow 1998). *Marissa cornuarietus* is found in disturbed habitats, such as canals, adjacent to Everglades and Biscayne National Parks (Snow 1998). The tree snail (*Orthalicus floridensus*), which is a native of south Florida and the Florida Keys was intentionally introduced into inland hammocks for the purpose of future collection by the snail trade. This species is a competitor with the native Florida tree snail (*Liguus fasciatus*). The spike-topped apple snail (*Pomacea bridgesi*) a native of Brazil was introduced by aquarists and aquaculturists into Florida. It is similar in appearance and size to the native Florida apple snail (*Pomacea paludosa*) and researchers working in the Everglades have determined that *P. bridgesi* could displace *P .paludosa (*Warren 1997*)*. Since *P. paludosa* is the primary food source for the endangered snail kite (*Rostrhamus sociabilis plumbeus*), which is unable to feed on *P. bridgesi,* it could create a serious food shortage for the snail kite. Several other mollusks and crustaceans have been identified as non-indigenous species residing in Florida (USGS 1998).

The zebra mussel (*Dreissena polymorpha*), and the Asian clam (*Corbicula fluminea*) pose a potential threat to Florida waters. Zebra mussels have not yet been reported in Florida, but it is believed they will soon enter the State. Zebra mussels have been found to severely impact native freshwater mussel, snail, and crayfish populations (G. Warren, GFC, personal communication 1998). *C. fluminea* is found in many areas of Florida and poses perhaps the greatest threat to native mollusk populations, because it can displace the sand or soft silt used by native mussels with its dense congregation of shells. (G. Warren, GFC, personal communication 1998). The Asian clam has been reported for ENP at the pump station in L-31W in Taylor Slough (W. Loftus, BRD-USGS, personal communication 1998).

Construction of canals may expedite the proliferation of *C. fluminea* and *P. bridgesi* which may directly impact native populations of snails. This will cause indirect impacts to other native species such as the endangered snail kite. Other possible impacts from construction of the project cannot be determined at this time. These impacts should be addressed in the more detailed feasibility studies for discrete phases of the Restudy.

F. Mammals

Several species of non-indigenous mammals were found to occur within the national parks in south Florida. The species identified in the survey include: the nine-banded armadillo (*Dasypus novemcinctus*), Mexican red-bellied squirrel (*Sciurus aureogaster*), Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), house mouse (*Mus musculus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), feral dogs (*Canis familiaris*), feral cats (*Felis catus*) and feral pigs (*Sus scrofa*) (Snow 1998). Some species have been introduced through accidental introduction from sources such as game ranches, tourist attractions, wild-animal importers, and dealers. Hurricanes may also liberate non-indigenous and domestic species.

The nine banded armadillo and the feral pig seriously impact Florida's native ecosystems. These mammals alter native plant communities through soil disturbance and by eating the eggs of native ground-nesting birds, native reptiles, and native soil invertebrates. Both species also pose a significant localized threat to cultural resources, both surface and sub-surface, as a result of soil disturbance (Snow 1998).

The only exotic aquatic mammal identified in Florida is the nutria (*M. coypus*) (USGS 1998). This mammal burrows into the side of dikes and roads, compromising the stability of the structure. This species does not commonly occur in the project area.

Implementing Alternative D13R will result in negligible impacts to exotic mammals. Other direct and indirect impacts should be addressed in the more detailed feasibility studies for discrete phases of the Restudy.

G. Birds

Several species of non-indigenous birds were found to occur in the National Parks in south Florida. Many non-indigenous birds, including parakeets, macaws, and toucans, have been reported from NPS managed lands in south Florida (Snow 1998). These birds were introduced either unintentionally by escaping from bird cages or intentionally for biological control of insects (Simberloff 1997). The total number of species of avifauna in Florida depends on the criteria chosen for inclusion. One accounting includes 483 species, of which 22 (4.5 percent) are deemed non-indigenous (Stevenson and Anderson 1994). Another more conservative estimate lists 461 species, of which 11 (2 percent) are non-indigenous (Robertson and Woolfenden 1992).
The NPS survey identified 6 non-indigenous species as occurring on NPS lands. Three other species, the cattle egret (*Bubulcus ibis*), shiny cowbird (*Molothrus bonariensis*), and the brown-headed cowbird (*Molothrus ater*) are considered simply to be expanding their natural ranges (Snow 1998). The six species that were identified in the survey, the Muscovy duck (*Cairina moschata*), rock dove (*Columba livia*), Eurasian collared dove (*Streptopelia decaocto*), European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), and the common myna (*Acridotheres tristis*) pose no ecological threat to the NPS areas (Snow 1998). Another six non-indigenous species which have established breeding populations in Florida include: budgerigar (*Melopsittacus undulatus*), monk parakeet (*Myiopsitta monoachus*), canary-winged parakeet (*Brotogeris versicolurus*), red-whiskered bulbul (*Pycnonotus jocosus*), spot-breasted oriole (*Icterus pectoralis*), and the house finch (*Carpodacus mexicanus*) (Simberloff 1997). Of these six species, only *M. monachus*, *B. versicolurus*, *P. jocosus*, and *I. pectoralis* are found in south Florida (Robertson and Woolfenden 1992).

Elimination of levees, which act as corridors for predators, may reduce predation on nesting birds, both native and non-indigenous. Other direct and indirect impacts should be addressed in the more detailed feasibility studies for discrete phases of the Restudy.

H. Amphibians and Reptiles

It has been suggested that the mechanism by which non-indigenous amphibians and reptiles have invaded Florida has changed over the years. The earliest colonizations, prior to about 1930, were by species from nearby islands of the West Indies that immigrated to southern Florida with cargo shipments. During the middle part of the 1900's, additional immigrants from the West Indies were supplemented with intentional and unintentional introductions (King and Krakauer 1966). A survey by ENP found that fifteen species of non-indigenous amphibians and reptiles are of particular concern to NPS management in south Florida. These species include: brown caiman (*Caiman crocodylus*), brown anole (*Anolis sagrei*), giant toad (*Bufo marinus*), spineytail iguana (*Ctenosaura pectinata*), green iguana (*Iguana iguana*), boa constrictor (*Boa constrictor*), Cuban treefrog (*Osteopilus septentrionalis*), greenhouse frog (*Eleutherodactylus planirostris*), Indo-Pacific gecko (*Hemidactylus garnotii*), wood slave gecko (*Hemidactylus mabouia*), tokay gecko *(Gekko gecko*), bark anole (*Anolis distichus*), knight anole (*Anolis equestris*), brahminy blind snake (*Ramphotyphlops bramina*), and Burmese python (*Python molurus*). Other non-indigenous amphibians and reptiles are not yet found in south Florida NPS areas, but occur in canal waters and lands adjacent to the parks, and have the potential to readily disperse into the parks. These include: red-eared slider (*Trachemyus scripta elegans*), crested anole (*Anolis cristatellus*), brown basilisk (*Basiliscus vittatus*), and whiptail lizard (*Cnemidophorus motaguae*). Among the lizards, the brown basilisk is the most closely associated with aquatic ecosystems and therefore has the greatest potential for exploiting canal systems (Snow 1998).

A query for non-indigenous amphibians and reptiles on the USGS Web site resulted in 12 amphibian species and 16 reptiles in Florida (USGS 1998). However, a list compiled by Butterfield *et al.* (1997), included 36 non-indigenous species. Thirty-two of the species originated in tropical regions, two are of temperate origin, and two have wide ranges in both temperate and tropical areas (Simberloff 1997). Butterfield *et al.* (1997), stated that the species that are most likely to colonize natural areas in ENP include the following species: red-eared slider, yellow-headed gecko (*Gonatodes albogularis*), ocellated gecko (*Sphaerodactylus argus*), ashy gecko (*Sphaerodactylus elegans*), bark anole, knight anole, northern curly-tailed lizard (*Leiocephalus carinatus*) and Texas horned lizard (*Phrynosoma cornutum*).

The Initial Draft Plan (Alternative D13R) of the C&SF Restudy involves the removal of existing levees and filling of some canals, and construction of many new canals and levees. Removal of levees will influence migration patterns into the natural areas of the Everglades for many of the reptiles. These levees are used by terrestrial species and aquatic species, expanding the range of their populations. Removal of these levees will reduce the potential for expansion of some species of exotics. However Components SS6, YY6, and O4 involve the construction of two canals approximately 26 miles in length along the eastern border of WCA 3B. Construction of these canals could provide a conduit for introduction of non-indigenous amphibian species to the edge of the remaining Everglades.

I. Summary and Recommendations

All of the Alternatives proposed for the Restudy contain components for the removal or alteration of man-made structures such as canals and levees. The primary difference among the alternatives relative to non-indigenous species is the number and placement of canals and levees that are removed or constructed. Levees provide prime disturbed habitat for almost all of the noxious terrestrial plant species, while acting as a barrier to the dispersal of native marsh plants, thereby artificially affecting plant distribution. Canals are major sites for aquatic exotic infestations, including hydrilla, water lettuce, and water hyacinth. Canals also act as corridors through which non-native animals and plants can extend their ranges rapidly from points of introduction, and can move into wetlands where they can alter habitats and affect food webs (Loftus and Kushlan 1987).

The DOI provides the following summary comments and recommendations:

1. Any alternative that approaches NSM conditions, restores natural fluctuations in hydropatterns throughout the landscape, and includes removal of canals and levees in the Everglades Protection Area will reduce exotic plant establishment and

spread in the Everglades. Conversely, any alternative that retains or adds to the present array of water management structures in the Everglades Protection Area should not be viewed as restoration. Alternatives B and D13R come closest to satisfying these two recommendations

2. During detailed planning for removal of existing structures or construction of new facilities, a plan of action to control exotics should be submitted for review and comment by all interested parties. All practical measures must be taken to control exotic species prior to construction. This is particularly important for detailed design and construction of two canals approximately 26 miles in length along the eastern border of WCA 3A in association with Components SS6, YY6, and O4.

3. We endorse the recommendation of the U.S. Congress (1993) that legislation and educational programs to restrict the importation of exotic plants be adopted for Florida. Because of the unpredictability of the invasive ability that species display, Florida should consider implementing a policy that essentially states: **species should be considered invasive and subject to import restrictions until demonstrated otherwise**.

4. The South Florida Ecosystem Restoration Task Force and Working Group Exotic Pest Plant Task Team are developing a statewide strategic plan for managing and controlling exotic pest plants. This effort should be vigorously supported and implemented. We recommend that an equivalent Task Team for invasive exotic animals be established.

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CHAPTER X -- WETLAND MITIGATION, PERMITTING, AND THE C&SF RESTUDY

David L. Ferrell, FWS

A. Introduction

This chapter discusses the ecological, operational, and policy issues surrounding the authorization of section 404 Clean Water Act wetland mitigation activities within project features of the Comprehensive Review Study for the Central and Southern Florida Project (C&SF Restudy). The following discussion is not intended to be all encompassing; rather, it is intended to provide a brief overview of existing guidance, identify where in the C&SF Restudy project boundary wetland mitigation issues lie, stimulate discussion, and provide the DOI's recommendations for the potential resolution of these issues. This section also addresses wetland mitigation accountability associated with the construction of C&SF Restudy project features and provides recommendations which would account for the losses and gains of wetland functions.

B. Wetland Mitigation Banking

Mitigation Banking is a process by which wetland losses are mitigated in advance of the loss in an attempt to achieve "no net loss of wetland function." In Florida, the Mitigation Bank Review Team (MBRT) of Federal and State regulatory agencies reviews applications for banks. At the Federal level, Mitigation Banking is guided by the Federal Guidance for the Establishment, Use and Operation of Mitigation Banks (Federal Register, Vol. 60, No. 228, dated November 28, 1995).

In South Florida, there are currently 30 proposed and/or operational entrepreneurial Mitigation Banks (Table X-2) and Regional Offsite Mitigation Areas (ROMs) encompassing about 60,000 acres of land within the boundary of the South Florida Water Management District (SFWMD). Several of these banks lie within or affect project features of the C&SF Restudy, particularly in the Water Preserve Areas (WPAs) of southeastern Florida (Palm Beach, Dade, and Broward counties).

The primary issues associated with the permitting of Mitigation Banks as related to the C&SF Restudy involve "supplanting public programs planned, or in place," operational compatibility (primarily hydrologic), ecological functional replacement in the C&SF for private wetland losses (zero sum gain issue), relying on private monies to acquire/mitigate in lieu of public monies (shrinking the public revenue stream issue), and mitigating on lands in the public domain (the "level playing field" and "shrinking of the spatial extent of wetlands" issues).

The approach of authorizing Mitigation Banks which fall within planned C&SF project features has been on a case-by-case basis, and has been somewhat inconsistent in regard to the "supplanting" issue. Supplanting involves those instances where the wetland functional lift generated by a Mitigation Bank for future private wetland losses replaces the wetland functional lift generated by a public project (either planned, or in place) which are not subjected to private wetland losses. In effect, a Mitigation Bank generates wetland functional lift at the "expense" of private wetlands losses, and, ideally, "no net loss of wetland function" is realized. Thus, a "zero sum gain" of wetlands is realized (both spatially and functionally).

On the other hand, a public project, funded by public monies and not funds generated by wetland losses, generates wetland functional lift without the "expense" of wetland losses. Thus, a "net gain" in wetlands, both spatially and functionally, is realized.

To date, of the five known Mitigation Banks currently proposing to mitigate in the C&SF study area, the U.S. Army Corps of Engineers (COE) has determined that two banks are inappropriate (they "supplant" the C&SF Restudy) and have not been processed (Overstreet and Lake Okeechobee Mitigation Banks), one has been deemed appropriate since it does not "supplant" the C&SF Restudy, (even though it lies inside the C&SF Restudy boundary and would replace wetland functional lift generated by the C&SF Restudy) and continues to be processed (Loxahatchee Mitigation Bank), and one was deemed partially appropriate (functional lift for hydrologic improvements cannot be calculated until more detailed C&SF Restudy studies are finalized) and continues to be processed (FP&L Mitigation Bank). There are also several new proposals to establish Mitigation Banks inside the C&SF Restudy boundary in Broward County (Buffer Strip Mitigation Bank - Cells 17 and 18) and Palm Beach County (Water Catchment Area) which will involve the "supplanting" issue. There are likely other banking proposals in the planning process, thus additional new banks will need policy review.

There is also concern among the resource agencies involved in C&SF Restudy planning efforts that wetland mitigation authorized by a Mitigation Bank, if eliminated or otherwise altered by a project feature of the C&SF Restudy, can create a situation where previously authorized wetland mitigation will need to be appropriately mitigated by the C&SF Restudy project. Thus, the issue of "mitigating for previous mitigation" arises.

C. Need for Consistent Policy

The DOI recommends that a consistent policy regarding Mitigation Banking inside project features of the C&SF Restudy be implemented as soon as possible, as implementation of the C&SF Restudy is years away, and the need to mitigate for wetland losses will continue and may actually increase as development pressures continue. A potential course of action would be to formally request the South Florida Ecosystem Restoration Working Group, in conjunction with the MBRT, to review this issue and provide recommendations to the South Florida Ecosystem Restoration Task Force. The Task Force would then transmit these recommendations to the COE for implementation.

A primary policy issue which needs clarification is the establishment of a "threshold" when "supplanting" is reached. The DOI is of the opinion that once the Initial Draft Plan is selected for the C&SF Restudy (June 1998) and that alternative is described in the draft PEIS (October 1998), the "threshold" has been reached (the public project is now officially "planned" with defined boundaries). The C&SF Restudy plan should then guide the MBRT in making decisions as to whether a given Mitigation Bank "supplants" the C&SF Restudy and, accordingly, whether that bank is or is not appropriate.

D. Section 404 Permit Program

Similar to the Mitigation Banking program, policy questions regarding the continued practice of issuing section 404 permits inside project features of the C&SF Restudy needs resolution. This is especially true in the WPAs where continued urbanization abuts the Water Conservation Areas. The exact number of individual section 404 permits, issued and proposed, in the C&SF Restudy is unknown, but is very likely considerable (e.g. the Lakebelt/Pensucco Area in Dade County and the WPA in Broward County). The exact acreage of wetland losses for private development mitigated in the C&SF Restudy boundary is likewise unknown at this time.

The DOI recommends that a similar approach to that described above for Mitigation Banking be applied to section 404 permits (including Letter Permits, General Permits and Nationwide Permits). A similar "threshold" applied to Mitigation Banking should also be applied to section 404 permits. First, however, an accounting of pending and issued permits in the C&SF Restudy boundary needs to be tabulated by the Corps of Engineers (COE), Florida Department of Environmental Protection, and SFWMD. Wetland mitigation authorized, by permit, should be discounted from the calculation of ecological benefits attributable to the C&SF Restudy. Likewise, any previous mitigation eliminated or altered by construction activities associated with the C&SF Restudy implementation should be replaced, in-kind, by public monies authorized for the C&SF Restudy.

E. Other Wetland Planning Procedures

The Clean Water Act authorizes other wetland planning procedures which may be applicable in this case. The Advanced Identification (ADID) program administered jointly the COE and the Environmental Protection Agency has been applied to regions of south Florida to guide wetland development/mitigation. The Loxahatchee Slough ADID, Florida Keys ADID, and the Rookery Bay ADID are examples of such wetland planning actions in South Florida. In addition, the COE's Special Area Management Plan (SAMP) program can be applied where wetland mitigation is planned on a regional/watershed basis. A good example of this program is the Bird Drive SAMP in Dade County, which is an on-going wetland mitigation planning program.

In addition, the use of Regional Off-site Mitigation Areas (ROMs) is a State planning process similar to Mitigation Banking. ROMs are designed to "pool" wetland mitigation into larger, well-planned units in order to achieve more wetland functional benefits. While not officially a Mitigation Bank, a ROM functions very similar to a bank, except that a ROM mitigates for wetland losses at the time of permitting, while a Mitigation Bank generates functional lift for future wetland losses.

The DOI recommends that these on-going programs, as well as other watershed approaches, be examined for potential applicability to the C&SF Restudy.

F. Developing a Common Vision for the Water Preserve Areas

There is a growing consensus that a "common vision" for the WPAs is needed. The WPAs are an integral component of the C&SF Restudy. This roughly 100 sq. mi. area stretches from Palm Beach to Dade Counties and is essential for reducing seepage from the remaining Everglades. The WPAs are also important for water supply and maintaining water quality. Public monies are currently being expended to acquire lands in the WPAs. Prior to April 1996, the SFWMD purchased 9,600 acres for WPA implementation. Since April 1996, the SFWMD and the Department of Interior have purchased another 6,100 acres under the Farm Bill.

What is our collective vision of the WPAs in the year 2050, the planning horizon of the C&SF Restudy? Is the use of wetland mitigation to acquire and set aside the necessary lands to implement the WPAs in the overall public interest? If so, what ecological benefits can the C&SF Restudy claim for the WPAs if those benefits have been previously used to mitigate for private wetland losses?

And, who is responsible for "mitigating for previous mitigation" if the C&SF Restudy alters or otherwise eliminates those wetland functions? Finally, should the entire WPA be removed from the C&SF Restudy as a "with -project condition" to avoid these policy issues altogether? If so, what ecological benefits, if any, could the C&SF Restudy claim for the WPAs and how would this effect the overall justification for spending the funds to implement the C&SF Restudy?

The FWS recommends that the regulatory and resource agencies convene to discuss these types of questions in an attempt to reach consensus and to provide consistent guidance for future Mitigation Bank and section 404 permitting decisions as they effect the WPAs.

Table X-1 provides a listing (by cell) of some of the known permitted wetland mitigation areas and their acreages inside the Water Preserve Areas which would require "mitigation for mitigation" if their functional capacity is adversely affected.

Table X-1. Known permitted wetland mitigation sites inside the Water Preserve Areas of Palm Beach, Broward and Dade counties, listed by WPA cell number.

PALM BEACH COUNTY

Cell 4	Loxahatchee Mitigation Bank (proposed)	1,500 acres

BROWARD COUNTY

Cell 10	Arvida Mitigation (residential development)	1,195 acres
Cell 11	Arvida Mitigation (residential development)	228 acres
Cell 18	Sunset Lakes (residential development)	45 acres
Cell 19	Sunset Lakes (residential development)	640 acres

Note: I-75 wetland mitigation and Harbour Lakes wetland mitigation also proposed inside WPAs.

DADE COUNTY

Cell 26	Pennsuco Wetlands (residential development)	1,123 acres
Cell 26	Pennsuco Wetlands (rockmining mitigation)	1,249 acres

G. Wetland Conservation, Permitting, and Mitigation Strategy

One of the stated goals contained in the Interagency Agreement signed by the five Federal Departments creating the South Florida Ecosystem Restoration Task Force in October of 1995 was to develop a Wetland Conservation, Permitting and Mitigation Strategy (Strategy). While the development of the Strategy has been delayed, the need for such a Strategy is increasing clear. The goal of the Strategy is to: "Develop a comprehensive wetlands permit mitigation strategy for South Florida that furthers ecosystem restoration."

The DOI recommends that the South Florida Ecosystem Restoration Task Force, acting through the Working Group, actively pursue the completion of this important and far-reaching effort. The Strategy should embody the collective input of the regulatory and resource agencies and should guide future decision making for wetland conservation and mitigation as the concerted effort to restore the South Florida ecosystem moves forward.

H. Conclusion

The DOI finds that it is imperative, as the C&SF Restudy plans are finalized, that consensus on South Florida wetland conservation and mitigation issues be achieved and a consistent, far-reaching approach be adopted. Today, almost 5 million people reside on the east coast of south Florida, and by 2050 the number is expected to rise to 12 million. Keeping in mind that one-half of the spatial extent of wetland resources of the greater Everglades are irrevocably lost and that human population increases will result in the need for more space and, consequently, more wetland mitigation, we must carefully consider all available means to conserve our remaining wetlands if South Florida ecosystem restoration is to become a reality.

I. Summary Recommendations

1. Mitigation Banking:

The DOI recommends that a consistent policy regarding Mitigation Banking inside project features of the C&SF Restudy be implemented as soon as possible. A primary policy issue which needs clarification is the establishment of a "threshold" when "supplanting" is reached.

2. Section 404 Permit Program:

Similar to the Mitigation Banking program, policy questions regarding the continued practice of issuing section 404 permits inside project features of the C&SF Restudy needs resolution. This is especially true in the WPAs where continued urbanization abuts the Water Conservation Areas. A similar "threshold" applied to Mitigation Banking should also be applied to section 404 permits.

3. Other Wetland Planning Procedures:

The DOI recommends that other wetland planning procedures such as Advanced Identification, Special Area Management Plans, Regional Off-site Mitigation Areas, as well as watershed approaches, be examined for potential applicability to the C&SF Restudy.

4. A Common Vision for the Water Preserve Areas:

The DOI recommends that the regulatory and resource agencies convene to discuss the future of the Water Preserve Areas in an attempt to reach consensus and to provide consistent guidance for future mitigation bank and section 404 permitting decisions as they effect the WPAs and future planning for the C&SF Restudy.

5. Wetland Conservation, Permitting and Mitigation Strategy:

The DOI recommends that the South Florida Ecosystem Restoration Task Force, acting through the Working Group, actively pursue the completion of this important and far-reaching effort. The Strategy should embody the collective input of the regulatory and resource agencies and should guide future decision making for wetland conservation and mitigation as the concerted effort to restore the South Florida ecosystem moves forward.

Table X-2. Approved and Pending Mitigation Banks in the C&SF Restudy Area (April 1998) (Page 1 of 2)

NAME	LOCATION	ACRES
Florida Mitigation Bank Florida Power & Light	Dade County	13,455
Dade County Mitigation Bank Fl. Mitigation Trust Corp.	Dade County	1,640
Pensucco Everglades Bank	Dade County	6,730
Lee County Mitigation Bank Fl. Mitigation Trust Corp.	Lee and Collier Counties	440
Corkscrew Swamp Mitigation Bank SFWMD/Mariner Properties	Lee County	632
Little Pine Is. Mitigation Bank Mariner Properties	Coastal Lee, Charlotte, Sarasota and Collier Counties	4,670
Three Lakes Mitigation Bank FDOT - District 5	Osceola County	535
American Equities Mitigation Bank Am. Equities, Inc.	Polk and Osceola Counties	3,530
HRI Mitigation Bank Habitat Restoration, Inc.	Osceola County	2,000
Split Oak Mitigation Bank Orange County	Upper Kissimmee Basin	640
Avatar Mitigation Bank Avatar Properties, Inc.	Polk County	983
Palm Beach County Mitigation Bank Unit 11	Palm Beach County	1,369
Loxahatchee Mitigation Bank SFWMD/Foster Wheeler	Palm Beach County	1,400
City of WPB Mitigation Bank	Palm Beach County	320
Bear Point Bank St. Lucie Mosquito Control Dist.	St. Lucie County	300

Table X-2. Approved and Pending Mitigation Banks in the C&SF Restudy Area (April 1998) (Page 2 of 2)

NAME	LOCATION	ACRES
Treyburn/Collier Mitigation Bank CZR, FMTC	Collier County	640
Florida Wetlandsbank	Broward County	445
Hole-in-the-Donut Everglades National Park	Dade County	6,250
Panther Island Mitigation Bank Florida Wetlandsbank	Collier County	4,200
Sheriff's Youth Ranch	Martin County	4,400
D & J Ranch	Osceola County	1,500
Middle Torch Key Mitbank	Monroe County	75
Boca Chica Key Mitbank U.S. Navy	Monroe County	100
Becker Groves - 10 Mile Creek	St. Lucie County	102
Overstreet Mitigation Bank	Osceola County	2,000
Big Cypress Mitigation Bank	Hendry County	640
TOTAL		58,996

CHAPTER XI — LAND ACQUISITION AND THE C&SF RESTUDY

Allen Webb, FWS

A. Federal Programs

Lands can be purchased by Federal agencies either through federal legislation authorizing the purchase of lands for a specific purpose (e.g. congressional action), usually through willing seller programs, or through condemnation of lands for activities that are in the best interest of the general public (eminent domain). Two examples of congressional land purchase authorizations from willing sellers are section 104 of the Everglades National Park Protection and Expansion Act of 1989 (P.L. 101-229) and section 390 of the Federal Agriculture Improvement and Reform Act of 1996 (P.L. 104-127).

The Everglades National Park Protection and Expansion Act of 1989 authorized the purchase of lands to be added to the park that encompass approximately 109,578 acres within northeast Shark River Slough (NESS) and the East Everglades. The purchase of these lands and the hydrological improvements to these lands is critical to restoring ecosystem productivity in the southern Everglades and maintaining adequate freshwater inflow to the downstream estuaries along the Gulf of Mexico and Florida Bay. Acceleration of land purchases in NESS is also required to ameliorate habitat availability for the Cape Sable seaside sparrow. The Everglades National Park requested $58 million in funds in fiscal year 1999 to assist the State of Florida in purchasing lands located within these areas, which are referred to locally as transition lands, and include the Frog Pond, Rocky Glades, and 8.5 Square-Mile Area. The purchase of these lands is necessary to limit further losses suffered by the park due to habitat destruction outside former boundaries and to restore natural water flow patterns that are critical to the long-term viability of the park. Additional land purchases will occur as funds are appropriated and willing sellers are identified. The $58 million requested would be utilized under cost-share terms that require the State of Florida to match the Federal share.

The second example of congressional land purchase authorization is section 390 of the Federal Agriculture Improvement and Reform Act of 1996, referred to as Farm Bill 390. Farm Bill 390 provides two distinct funding programs for land acquisition to support restoration of the Everglades. The first program provided $200,000,000 to the Secretary of the Interior to conduct restoration activities in the Everglades ecosystem in South Florida, including acquisition of real property and interests in real property and resource protection and resource maintenance activities. The second program under the Farm Bill 390 authorization provides for a special account (known as the Everglades Restoration Account). This account receives funds from the sale of surplus real property located in the State of Florida. Any Federal real property located in the State of Florida (excluding lands that are set aside for conservation purposes) shall be identified for disposal or exchange under this legislation and shall be presumed available for public sale, unless the head of the agency controlling the property determines that there is a compelling program need for any property identified as surplus. The total amount of funds deposited in the special account cannot exceed $100,000,000. Provisions of the Farm Bill 390 program require the State of Florida to match the Federal share for this account.

The South Florida Ecosystem Restoration Task Force interagency working group has identified the acquisition of lands in the Everglades Agricultural Area and the East Coast Buffer/Water Preserve Areas as its number one priority for Farm Bill appropriations (South Florida Ecosystem Restoration Task Force Integrated Financial Plan, August 1996). As of January 1998, the Secretary of Interior through the Fish and Wildlife Service has provided approximately $40 million in grants to the South Florida Water Management District resulting in the acquisition of over 4,400 acres in the East Coast Buffer/ Water Preserve Areas and in the Everglades Agriculture Area. These lands will provide important water storage capacity and stormwater treatment. The Secretary of Interior through the Fish and Wildlife Service is also providing financial support to the State of Florida for two additional important acquisitions: 1) purchase of nearly 37,000 acres within the Southern Golden Gate Estates (approximately $25 million), located in the western basin of southwest Florida, and 2) purchase of approximately 50,000 acres of the Talisman Sugar Holdings in the Everglades Agricultural Area (approximately $135 million). The proposed grant monies for these two additional purchases will exhaust the remaining funds available under the $200 million appropriation. Cost sharing and land acquisition expertise are being provided by the SFWMD and DEP for these Federal land purchases.

Limited funds are currently available in the Everglades Restoration Account from the sale of Federal surplus lands. Excess properties in the former Richmond Naval Air Station in Dade County have been tentatively identified as properties that are surplus to Federal needs. Estimated funds generated from these land sales range from $3.4 million to $11.2 million. Once these funds become available, additional lands necessary for Everglades restoration will be purchased. Other properties throughout Florida have also been tentatively identified as potential Federal surplus properties, but land values have not been estimated for these properties.

The Department of Interior's land protection policy is to acquire lands only when other protective means (e.g., zoning or regulation to achieve program goals) are not appropriate, available, or effective. When lands are acquired, the minimum interest necessary to reach land protection and management objectives is retained. The Federal government acquires fee title (control of all property rights) only if control of lesser property interests through easements or leases will not achieve land protection objectives. If fee title is required, full consideration will be given to granting extended use reservations, entering into exchanges, or using other alternatives that will lessen the impact on the owner and the community. Funding for land acquisition can also come from receipts, such as Federal Duck Stamp sales, entrance fees to certain National Wildlife Refuges, import duties on arms and ammunition, and appropriations under the Land and Water Conservation Fund Act of 1965 (P.L. 88-578, as amended) as well as other legislative mandates.

Eminent domain land purchases (lands purchased through condemnation proceedings) can occur under a variety of actions. However, it must first be determined that the purchase is in the best interest of the general public and has been authorized by federal legislation. Examples of these land condemnation purchases are those authorized by section 309(l) of the Water Resources Development Act of 1992 (P.L. 102-580), and by two resolutions passed by the Committee on Public Works and Transportation of the House of Representatives on September 24, 1992. Under these authorizations, the Secretary of the Army can design and construct any features of the C&SF Project that were authorized on or before the date of the enactment of the Water Resources Development Act. The Secretary of the Army also has the authority to modify an authorized project, including features authorized under other Federal actions, where the design and construction will accelerate the restoration, preservation, and protection of the South Florida ecosystem and will generally be consistent with the conceptual framework described for Everglades restoration. The modifications must be compatible with the overall authorized purposes of the Central and Southern Florida Project.

Previously authorized projects are referred to in the Everglades restoration program as Critical Restoration Projects (CPs). Thirteen such project have been currently identified and authorized. CPs have been identified as those projects that are essential to the success of the Restudy. Once these projects are evaluated, they are authorized for approval and funding through the Army Corps of Engineers Headquarters. Following approval, an abbreviated one-year feasibility study is then conducted. This study is followed by a NEPA review and design evaluation. Once the NEPA process is completed, the project undergoes a detailed plan and specification phase, leading to contract award and construction. In general these project require a non-Federal project sponsor and usually will require matching State and/or local funding. Another group of projects are termed Other Project Elements (OPEs). These projects must include the following features: 1) located outside the boundaries of the South Florida Water Management District's Everglades Restoration Hydrological Model, 2) support and be consistent with the C&SF Restudy objectives, 3) contain federal interest, and 4) should not be a stand-alone research or data collection project.

B. State Programs

State land purchases occur through similar mechanisms as those listed for Federal land purchases. The State of Florida's land acquisition program, as administered by the DEP, is the largest and most aggressive in the country, with over $300 million spent annually to purchase environmentally sensitive lands through Preservation 2000 (P2000), Conservation and Recreation Lands Program (CARL), and Save Our Rivers Program (SOR). The State of Florida Bureau of Land Acquisition (Bureau) reviews and evaluates all P2000 and CARL acquisitions for the Board of Trustees of the Internal Improvement Trust Fund. The Bureau also handles land exchanges and negotiates and acquires lands for the DEP and other state agencies. The P2000 program was created in 1990 by the Florida legislature in response to the Governor's Commission on the Future of Florida's Environment that examined the threats to Florida's natural resources. This 10-year, $3 billion land and water conservation program uses funds to purchase endangered species habitat, archaeological and historical sites, water resource areas and public recreation lands. To date, the funds have protected more than 820,000 acres of the State's natural areas. However, funding for the P2000 program is contingent upon annual appropriations from the state legislature. The P2000 program mission of acquiring land to protect ecologically significant areas and the diversity of life supported by those areas is complimentary with the goals of the Restudy. Since its authorizations in 1990, the P2000 program has become the largest state land and water conservation program in the nation. Recent acquisitions include 48,000 acres of rare Florida prairie (once abundant in the Kissimmee River basin) and nesting beaches for the endangered loggerhead and green sea turtles in Indian River County.

The Conservation and Recreation Lands Trust Fund (CARL) was established by Section 259.032, Florida Statutes, as amended. The purpose of the funds is to assure that the citizens of this state shall be provided public ownership of natural areas for purposes of maintaining the state's unique natural resources; protecting air, land, and water quality; and providing lands for natural resource based recreation. It is the intent of the State of Florida to provide public lands for the people residing in urban and metropolitan areas of the state as well as those residing in less populated, rural areas. A high priority is to be given to the acquisition of lands in or near counties exhibiting the greatest concentration of population and within any area designated as an area of critical state concern under Section. 380.05, Florida Statue. The Conservation and Recreation Lands Trust Fund is established within the DEP. The fund shall be used as a nonlapsing, revolving fund exclusively for the purposes of land acquisition and management. An amount up to 1.5 percent of the cumulative total of funds deposited into the Florida Preservation 2000 Trust Fund shall be made available for the purposes of management, maintenance, and capital improvements for lands acquired pursuant to this fund to which title is vested in the State of Florida. The fund shall be credited with proceeds from excise taxes on documents generated under Statue 201.15, Florida Statute and on excise tax generated on the severance of phosphate rock as provided in Statute 211.3103, Florida Statute.

Another state funding program is the Water Management Lands Trust Fund. This documentary tax stamp revenue totals about $12 million per year. The Water Management Lands Trust Fund (WMLTF) was established by Section 373.59, Florida Statutes. The fund is established within the DEP and is to be used as a nonlapsing fund for the purposes of this land acquisition and management. The monies in this fund are continually appropriated for the purposes of land acquisition, management, maintenance, capital improvements, payments in lieu of taxes, and fund administration. By January 15 of each year, each Water Management District shall file with the Florida State Legislature and the Secretary of the DEP a report of acquisition activity together with modifications or additions to its 5-year plan of acquisition. Monies from the fund shall be used for continued acquisition, management, maintenance, and capital improvements on lands identified in the 5-year land acquisition plan developed by the SFWMD. Lands available for purchase by funds generated from the WMLTF program included lands in the water conservation areas and areas adversely affected by raising water levels of Lake Okeechobee in accordance with present regulation schedules, and the Savannahs Wetland area in Martin County and St. Lucie County. The SFWMD receives thirty percent of the monies generated each year by the fund.

The SFWMD also administers funds received from the P2000 program, the CARL program, and the SOR program. In addition to these program funds, the SFWMD also provides funds from their general revenue account that are generated by *ad valorem* taxes. Recent acquisitions by the SFWMD include matching land purchases for Federal lands purchased under the Farm Bill 390 program. Properties in the East Coast Buffer/Water Preserve Areas of Dade, Broward, and Palm

Beach counties were purchased by the District as matching lands. In 1997, the SFWMD purchased approximately 100,000 acres through their various land acquisition programs.

C. County Programs

Land acquisition programs are also available at the local level through county land purchase programs. Counties within the C&SF Restudy provide funds through tax programs, sale of bonds, and other revenue generators. These programs as a whole are often referred to as Environmentally Endangered Lands programs. These land purchases are used to acquire local and county parks, water storage and retention areas, and wildlife preserves. As with both the Federal and State programs, lands are usually purchased from willing sellers. However, lands can be purchased through condemnation when the land purchase is in the public interest and no willing sellers are identified.

D. The Challenge of the Restudy

Many of the land acquisition projects described above were already under way before selection of a preferred plan for the Restudy. To our knowledge, the selected plan for the Restudy does not conflict with any of the ongoing actions; current projects should continue. However, the Restudy adds significantly to the land acquisition needs for restoration of the Everglades. Some of these additional needs are described in Chapters XII, XIII, and VI of this report. These include expansion of the Water Preserve Areas north of C-51 in Palm Beach County; additional reservoirs in the St. Lucie basin, the Caloosahatchee basin, and north of Lake Okeechobee; and many of the Other Project Elements.

As restoration and habitat enhancement concepts and actions are identified in the various basins within the scope of the Restudy, land acquisitions will continue to occur. Lands that can be purchased from willing sellers receive top priority whether the purchase is initiated at the Federal, State, or local government levels. However, once a critical land acquisition component of the Restudy is identified, lands will be purchased through condemnation, if necessary. Funding for land purchases will continue to be provided through the various programs identified above and from new sources of revenue yet to be identified. Specific parcels should be identified as soon as possible, and land acquisition activities should promptly respond. This will minimize the purchase of tracts from willing sellers that would later have to be swapped because the tracts are found to fall outside of the detailed design of the project.

CHAPTER XII -- WATER PRESERVE AREAS

Steve Peacock and David L. Ferrell, FWS

A. Introduction

The Water Preserve Areas (WPAs) Feasibility Study, currently being conducted under the Central and Southern Florida (C&SF) Comprehensive Review Study, is developing a conceptual design for an interconnected series of marshlands, reservoirs, and aquifer recharge basins (Figure XII-1). The objectives of the WPAs are to: 1) hold more water in the natural system by reducing seepage losses from the Everglades; 2) capture, store, and treat stormwater currently lost to tide; 3) provide a buffer between the urban areas and the Everglades; and, 4) protect and conserve wetlands and habitat values outside the Everglades. The WPAs are intended to provide additional regional storage to assist in meeting the future needs of all users - agriculture, urban, and the environment. Ecosystem restoration benefits that are anticipated include: improved water supply for restoring hydropatterns of the Everglades; improved water quality; and preservation of wetland habitat. The WPAs will be located on lands located along the eastern side of the Everglades Protection Area in western Palm Beach, Broward, and Dade counties.

Several studies were completed, reports generated, and many meetings were held by various organizations which focused on the need for establishing a wetland buffer or conservation zone along the eastern Everglades.

The reconnaissance phase of the C&SF Project Comprehensive Review Study clearly demonstrated that WPAs would be an integral part of ecosystem restoration, as authorized by Congressional legislation in 1992. The purpose of the legislation was to reexamine the C&SF system for ecosystem restoration benefits, while enhancing other project purposes. WPAs were identified as critical to system-wide restoration of the south Florida ecosystem of the Everglades for the following reasons: 1) natural system modeling indicates that additional historic runoff must be returned to the Everglades hydrologic system; 2) development continues to encroach on the areas identified as being sensitive to ecosystem restoration, and 3) water supply to the urban and agricultural areas must be maintained at existing levels to ensure a sustainable south Florida. In addition, the WPAs will address other water-related needs such as water supply and water quality. The WPAs could provide a mechanism for increased aquifer recharge and surface and subsurface water storage capacity to enhance regional water supplies for the lower east coast urban areas.

The South Florida Water Management District (SFWMD) has investigated numerous alternatives for the WPAs. These range from a continuous Everglades buffer, consisting of an interconnected system of marshlands (proposed by the National Audubon Society as Water Supply Preserves) to individual “cells” that were combined to form wetland areas, reservoirs, and aquifer recharge basins, termed the East Coast Buffer. In 1994 the U.S. Army Corps of Engineers (COE) endorsed the East Coast Buffer concept as “Water Preserve Areas.” These alternatives will be assessed in more detail in the Water Preserve Areas Feasibility Study. The timely implementation of the WPAs has been identified as an early action item for Everglades restoration. In July 1995, the COE proposed, and the SFWMD Governing Board approved, the Water Preserve Areas Feasibility Study.

A preliminary land suitability analysis was conducted in 1994 by CH2M Hill for the SFWMD, in conjunction with the East Coast Buffer study, to identify lands which could be used as or converted to water preserve areas, including reservoirs and marshes. A more detailed study was conducted in 1996 by CH2M Hill for the SFWMD Restudy Team. The study utilized databases from the National Wetlands Inventory and soil-surveys. The total area of the current study is 1,643,000 acres (2,567 square miles) which was subdivided into 2.5 acre grids for analysis (SFWMD 1997).

The National Audubon Society (NAS), the SFWMD, and the U.S. Environmental Protection Agency sponsored a scientific conceptual design workshop for the eastern Everglades WPAs on September 19-20, 1996, in Miami, Florida, which convened 31 biologists and experts in the ecology of eastern Everglades wetlands. The purpose of this meeting was to identify: 1) functions or values in the WPAs, 2) spatial extent of the WPAs, and 3) high value areas which should be protected (NAS 1997).

Both the reconnaissance report, which was completed in November 1994, and the project study plan, which was completed in July 1995 for the Comprehensive Review Study of the C&SF, identified WPAs as a major element of the C&SF Restudy in the area between the Everglades and the Atlantic Ocean (SFWMD 1997).

B. Habitat Characteristics of the Water Preserve Areas

Several areas adjacent to the WPAs have been identified and recommended for the expansion of the spatial extent of wetlands, to provide additional buffer zone, and to enhance biological connectivity and hydrological connectivity to the Everglades. The WPAs have been grouped into cells for the East Coast Buffer project. These cells begin with cell 1 at the northeast corner of Loxahatchee National Wildlife Refuge in Palm Beach County, and end at cell 32 south of the Bird Drive recharge area in Dade County, with larger areas south of the Lakebelt identified by letters D thru G and/or associated components. Components of the C&SF project associated with these cells assist in identifying the location within the project boundary. The Florida Land Use, Cover and Forms Classification System (FLUCCS) was used in evaluating existing conditions within the WPAs. A cell-by-cell habitat analysis of the WPAs is found in Table XII-1.

1. Palm Beach County

Water Storage Areas: Components GGG6 (L-8 Basin), VV6 (Areas A&D), and M4 (Cells 7&8) have been identified as storage areas. These storage areas range from 1,200 acres and 40 feet deep in component GGG6 to 1,660 acres and 12 feet deep in component VV6, and 1,660 acres and 6 feet deep in component M4, for a total of 4,500 acres of storage. These areas have been designated as storage based on the Land Suitability Analysis, which identified minimal environmental impacts and maximum potential for storage capacity. Location of these storage components in rock mining areas or agricultural areas will result in negligible impacts to fish and wildlife. In addition, if features for fish and wildlife enhancement, as discussed below, are incorporated into the design, an overall ecological benefit could result in these areas.

Stormwater Treatment Areas: Components Y6, K6, and X6 have been identified as Stormwater Treatment Areas (STAs). Component Y6 is a proposed 600 acre area south of the M-Canal and west of the Water Catchment Area. A location and size for component K6 has not been determined. Component X6 is a proposed 550 acres STA to be located east of the Water Catchment Area. No information on existing habitat conditions at these sites has been obtained. A detailed analysis of environmental impacts associated with these components will be conducted in the Fish and Wildlife Coordination Act Report for the Water Preserve Areas Feasibility Study.

2. Broward County

Water Storage Areas: Component Q5 (cell 11/area B) has been identified as a storage area. This component will inundate 1,600 acres up to 4 feet deep. Conservation easements of 114 and 118 acres are included in this component as preservation areas for wetland mitigation for the Sunset Lakes permit. Inundating with up to 4 feet of water will impact sawgrass marsh and freshwater wetlands. Incorporating fish and wildlife enhancement features into the design will reduce the overall impacts to fish and wildlife. However, an overall negative impact to native vegetation and wetlands will occur in this area. An analysis of wetland acreage impacted by various components in the WPAs needs to be conducted, and a determination of impacts/benefits made, in order to determine if mitigation will be required.

Stormwater Treatment Areas: Component R4 (cells 17, 18, 19 and area D) has been identified as an STA. This component will impound 2,500 acres 4 feet deep. This component will impact a large section of freshwater marsh. The use of this area as an STA for water quality treatment will introduce nutrients which may cause displacement of native vegetation by non-indigenous species.

Seepage Control: Components SS6, YY6, and O4 involve the rerouting of water supply deliveries to North New River Canal, diversion of water to NE Shark River Slough and Central Lake Belt, and reducing seepage from WCAs 3A and 3B. This will be accomplished through widening and converting two borrow area canals in cells 9, 12, 13, 14, 15 and 16. This provides several opportunities to enhance fish and wildlife values in those sections of the WPAs. Manipulation of water levels, construction of small islands and removal of *Melaleuca* and Brazilian pepper can all provide great benefits to fish and wildlife. However, the construction of canals also pose a threat to the dispersal of exotic fish to new areas. An analysis of impacts on aquatic species associated with construction of these canals should be conducted during the Feasibility Study.

3. Dade County

Water Storage Areas: Components XX6 (cell 20), S6 (cell 21) and HHH6 (cell 28) have been identified as water storage areas. A total of 11,700 acres will be impounded by these three components. Component XX6 is a 4,500 acre impoundment also known as the North Lake Belt Storage. This impoundment will be operated on a schedule which can fluctuate by 20 feet. The FLUCCS codes for this area indicate that a section of pine flatwoods will be impacted by this component. This area is considered a Resource Category 2 which is described as "of high value for evaluation species and is scarce or becoming scarce on a national basis or in the ecoregion section." The mitigation goal for Resource Category 2 is no net loss of in-kind habitat value. If this area cannot be avoided, the FWS recommends compensation by replacement of the same type of habitat value.

Component S6, also known as the Central Lake Belt, will inundate 5,200 acres, and will fluctuate as much as 36 feet. This component will inundate existing lakes, rock quarries, and *Melaleuca* and appears to be best suited for this area.

Component HHH6 will impound 2,877 acres up to a depth of 4 feet. This component will impact approximately 2,000 acres of freshwater marsh. Existing conditions include both short and long hydroperiod wetlands with predominant vegetation being spikerush (*Eleocharis* spp.), sawgrass (*Cladium jamaicense*), muhly grass (*Muhlenbergia* spp.), punk tree (*Melaleuca quinquenervia*) and scattered tree islands with willow (*Salix* spp.). The change in water levels will alter the plant and wildlife communities from those associated with prairie and freshwater wetlands to species associated with deeper aquatic systems. Inundation of the area will help reduce the spread of *Melaleuca;* however, the dense patches that exist on the northern fringe of the component will remain in their current state.

Stormwater Treatment Areas: Component XX6 includes the construction of 3 STAs. Two of the units are located south of the North Lake Belt impoundment and are 250 and 235 acres in area, respectively. These STAs are to be situated on what is mainly agricultural land with some freshwater marsh located within the boundaries. The third STA of 640 acres will be located northeast of the impoundment and will impact according to FLUCCS codes will impact a large pine flatwood area. Recommendations for this area will be the same as mentioned above for the impoundment portion of component XX6, which also impacts pine flatwoods.

Buffers: A section of privately owned land located in sections 9, 15, and 16, township 35 south, range 39 east which is located between the Pennsuco wetlands and the wellfield in Dade County is recommended for acquisition. This land would provide a wildlife corridor from the wellfield to the Pennsuco wetlands as well as acting as a buffer to the wellfield.

A section of land located in sections 23, 24, 25, and 26, township 35 south, range 39 east currently not included in the comprehensive plan should be acquired. These parcels, which are existing lakes located south of the wellfield, are currently owned by mining companies. Acquisition of this property would provide an opportunity for wetland creation/enhancement and expand the spatial extent of the project in that area, as well as further buffer adjacent developed areas.

C. Project Effects

Impacts of the WPAs on the natural resources of the area are both positive and negative. The positive aspects of the project include: 1) acquisition of land to act as a buffer from nearby developed areas, 2) control of exotic plant species, 3) recharge the aquifers to restore natural hydroperiods to the Everglades and provide vital urban water supply, and 4) improve water quality. Negative impacts associated with the project include: 1) loss/degradation of freshwater wetlands and other Resource Category 2 habitats, and 2) spread of exotic species to other areas.

The DOI recommends that a full ecological trade-off analysis be conducted of the WPAs during the Feasibility Study. A wetland functional assessment such as the SFWMD's Wetland Rapid Assessment Procedure (WRAP) or the COE's Hydrogeomorphic Methodology (HGM) should be utilized to quantify wetland functional losses and gains. Further, an accounting of the effects of constructing the WPAs on previously permitted mitigation under the section 404 program is necessary.

D. Mitigation

Mitigation for losses of previously permitted mitigation areas through the section 404 permit program will be required. In accordance with the FWS Mitigation Policy (Federal Register, Vol. 46, No. 15; Pp. 7644-7663; January 23, 1981), the loss of Resource Category 1, 2, or 3 habitats will require mitigation. A Resource Category 1 designation requires no loss of existing habitat and the FWS will recommend that all losses of existing habitat be prevented as these unique habitats cannot be replaced. A Resource Category 2 designation is an area of high value for evaluation species and is scarce or becoming scarce on a national basis or in the ecoregion. The mitigation goal for Resource Category 2 is no net loss of in-kind habitat value. If Resource Category 2 areas cannot be avoided, the FWS recommends compensation by replacement of the same kind of habitat value. A Resource Category 3 designation has a mitigation goal of no net loss of habitat value while minimizing loss of in-kind habitat. The FWS recommends ways to avoid or minimize losses of Resource Category 3 habitat; however, if losses are likely to occur, then the FWS will recommend ways to rectify those losses or reduce or eliminate them over time. The FWS will recommend that these losses be compensated by replacement of habitat value.

E. Fish and Wildlife Enhancement Features

The marshes of the East Everglades have been systematically eliminated due to agricultural and urban development over the last several decades. Large acreage of short-hydroperiod marshes, critical to the life-cycle of many water birds when water levels in the WCAs are high, no longer exist. Exotic invasive species, particularly *Melaleuca* and Brazilian pepper, now occupy significant portions of the WPAs. It is essential that fish and wildlife resources be integrated into the planning for the management of the WPAs.

The DOI recommends that fish and wildlife enhancement features be included in WPA project design (Figure XII-2). Priority fish and wildlife planning objectives for the WPAs include: 1) devising an aggressive plan for the perpetual removal of invasive exotics (both plants and animals); 2) managing the WPAs to maximize short-hydroperiod marshes for foraging water birds, particularly during high water events in the WCAs; 3) designing project features to enhance fish and wildlife resources, such as vegetated buffer zones between developed and natural areas and creation of vegetated islands within the deeper impoundments for as refugia for nesting/foraging water birds and other wildlife; and, 4) ensuring adequate water quality. Public access to the WPAs should be carefully planned to avoid and minimize sensitive nesting/breeding areas during critical periods.

F. Unresolved Issues

Outstanding unresolved issues which will require additional review include: 1) mitigation for permitted mitigation areas which will be impacted as a result of the project, 2) spread of exotic plant and animal species through construction of canals and storage reservoirs, 3) prioritization of land acquisition prior to development, 4) degradation of existing wetlands through construction of storage areas and STAs, and 5) maintenance of adequate water quality.

G. Recommendations

The DOI recommends the following actions be integrated into the design and operation of the WPAs:

1. Remove exotic vegetation in all of the identified WPAs;

2. Identify and implement applicable wetland mitigation to off-set previously permitted mitigation through the issuance of section 404 wetland permits in order to achieve "no net loss of wetland functions and values;"

3. Provide a detailed accounting of other habitat losses in the PEIS and utilize a functional assessment (e.g., WRAP, HGM) to address these losses during the Feasibility Study.

4. Incorporate a feature for fish and wildlife enhancement into the design of storage areas and STAs to make them more environmentally compatible and to off-set habitat functional losses;

5. Maximize flow-ways (e.g., the two-canal area in Broward) and other short-hydroperiod wetlands whenever possible to benefit fish and wildlife and to expand the spatial extent of wetlands to the east of the WCAs;

6. Minimize deep water impoundments (greater than four feet deep) that support little or no wetlands and wetland-dependent wildlife; and,

7. Recognize that a Management Plan will be needed for fish and wildlife resources and potential recreational uses.

H. References

National Audubon Society. 1997. Water Preserve Areas: Defining biological functions and spatial extent. National Audubon Society, Everglades Ecosystem Restoration Campaign. February 1997.

South Florida Water Management District. 1997. Water Preserve Areas land suitability analysis. (Draft) South Florida Water Management District and the U.S. Army Corps of Engineers; West Palm Beach, Florida.

U.S. Fish and Wildlife Service. 1981. FWS mitigation policy. Federal Register, Vol. 46, No. 15; Pp 7644-7663; January 23, 1981.

TABLE XII-1
WATER PRESERVE AREAS HABITAT ANALYSIS (Page 1 of 5)

	HABITAT CHARACTERISTICS			
COMPONENT/ LOCATION	EXISTING CONDITIONS	WITH PROJECT CONDITIONS	NAS/FWS VALUE	COMMENTS
Palm Beach County				
GGG6	Mined area	40' storage depth; 1,200 acres with a slurry-wall	Low	A rock mine, currently being mined, used for storage to restore natural hydroperiods to Loxahatchee NWR.
Y6 /K6 and X6 (L-8 Basin)	Unknown	Unknown	Unknown	Components K6 and Y6 include a 600 acre STA but a location has not been determined and only one of the components may be implemented (Y6 to be located north of M-canal). Component X6 includes a 550 acre STA.
Other Project Element (OPE) (Cells 1,2,3)	Sawgrass marshes and cypress habitat	Levied sawgrass marshes and cypress habitat, 1.5' max depth	High	Managed to enhance/protect the unique habitat; minor hydrologic restoration may be considered. Cell 1 is currently managed by Loxahatchee NWR on a lease agreement, and the Refuge owns cell 3. Recommend hydrology not be altered.
VV6 (Area A and a portion of Area D)	Agriculture	1,660 acre impoundment, 12' deep with ASR.	Low	Impoundment 12' deep, with ASR. Area D has been reduced from 21,000 acres and is included in VV6.
No component Cells 4, 5 and Area B	A mixture of temperate, tropical and wetland hardwoods, sawgrass, Brazilian pepper.	Withdrawn from comprehensive plan by COE.	Moderate/ High	Proposed SFWMD Loxahatchee Mitigation Bank, pending review of agencies. Recommend it remain in Comp Plan and be restored with project funds instead of permitted wetland losses.
No component Area C	Improved pasture, under construction for a county park.	County Park	Moderate	The acquisition of this site would provide vital connectivity/wildlife corridor. This site is in the NAS report but not designated for acquisition by SFWMD on the latest maps. Recommend acquisition.
M4 (Cells 7 and 8)	Improved pasture; pine flatwoods with Melaleuca, fallow cropland.	Site 1 storage area = 1,660 acres; max depth= 6 ft.	Ranked low in NAS report	The creation of a water storage area in this agricultural location is appropriate. Permitted for rock mining.

TABLE XII-1
WATER PRESERVE AREAS HABITAT ANALYSIS (Page 2 of 5)

COMPONENT/ LOCATION	HABITAT CHARACTERISTICS: EXISTING CONDITIONS	HABITAT CHARACTERISTICS: WITH PROJECT CONDITIONS	NAS/FWS VALUE	COMMENTS
Broward County				
QQ6 Cell L68A	Dense sawgrass marsh; some cattails on south end of L-68A.	Dense sawgrass. Levee to be removed and Miami Canal filled in.	High	Will reconnect this area with WCA-3. It appears that cattails have infested the WCA west of the levee. Removal of the levee will allow spread of cattails throughout this cell. Recommend aggressive management of cattails/noxious plants prior to levee removal.
SS6 , YY6, O4 (Cell 9)	Dense sawgrass marsh	Area will be situated with a canal on each side	High	Will reroute water supply deliveries to N. New River Canal; divert water to NE Shark River Slough and Central Lake Belt; and reduce seepage from WCAs 3A and 3B.
Weston Development mitigation site	Moderate/dense sawgrass	Moderate/dense sawgrass. Levee on the eastern boundary	High	Weston development mitigation site. Will remain intact.
Q5 Cell 11/Area B (reduced size)	Sawgrass, dense/moderate *Melaleuca*, wetlands, dry pasture	1,600 acre impoundment; 4' deep. Levee on the eastern boundary.	Variable	Proposed for water storage. Will impact wetlands south of cell 10. Contains conservation easements of 114 and 118 acres for Sunset Lakes mitigation.
SS6 and YY6 (Cells 12, 13, 14) Also 15 and 16 in Dade Co.	Cells12/13/16- serious *Melaleuca* problem . Cells 14/15 - valuable marshes and mixed shrub	Canal on each side of the cells.	Moderate	No change to existing uses. A canal will be placed on either side of the cells. Recommend treatment/removal of *Melaleuca* prior to implementing and construction of managed marsh in these areas. May disperse exotic fish population through new canals.
Trailer park (Area C)	Trailer park	Flood control around trailer park	None	Recommend acquisition to provide contiguous wildlife corridor. Would provide high wildlife value.

TABLE XXI-1
WATER PRESERVE AREAS HABITAT ANALYSIS (Page 3 of 5)

	HABITAT CHARACTERISTICS			
COMPONENT/ LOCATION	EXISTING CONDITIONS	WITH PROJECT CONDITIONS	NAS/FWS VALUE	COMMENTS
Broward County (cont.)				
R4 (Cells 17, 18 and 19 and area D)	Cell 17- dense Melaleuca Cell 18- dense *Melaleuca* in north half with freshwater marsh in south Cell 19- rock quarries in north with improved pasture	Will become part of C-9 STA 2,500 acre impoundment 4' deep. Upper third of Cell 19 (rock quarries) proposed for mitigation. 185 acres of mitigation for Sunset Lakes will be inundated.	Moderate	An analysis of lost mitigation will be required. If a permitted mitigation area is lost, then mitigation for that site will be required. Cell 19 has been reduced in size and Area D eliminated from the plan since it would be fragmented from other property in the plan.
Dade County				
XX6 (Area A)	Agriculture, airport Melaleuca, pine flatwoods and freshwater marsh	2 STAs North of Miami Canal and 1 STA in adjacent to Florida Turnpike and Canal 9 Ext	Low except for moderate in pine flatwoods	Much of this area has been scheduled as a 1997 project addition by Save Our Rivers. The 2 southern STA's total approximately 500 acres. The north STA (pine flatwoods) totals about 640 acres. A portion of the pine flatwoods will become part of the North Lake Belt Storage (see below).
XX6 (Cell 20)	Pine flatwoods, improved pasture and borrow pits	Inundated, North Lake Belt Storage	Low except for moderate in pine flatwoods	Will be inundated by a 4,500 acre water storage area with a 20' variance in depth. Some of the proposed land acquisition has been completed. Recommend pine mitigation for flatwood habitat with short hydroperiod wetlands.
Area B	No baseline information	Unable to determine	Unknown	This parcel was proposed for acquisition in NAS for water storage but has been dropped from consideration for acquisition. Potential mitigation site for mitigation required as a result of the project. Adjacent to pine flatwood area.

TABLE XII-1
WATER PRESERVE AREAS HABITAT ANALYSIS (Page 4 of 5)

	HABITAT CHARACTERISTICS			
COMPONENT/ LOCATION	EXISTING CONDITIONS	WITH PROJECT CONDITIONS	NAS/FWS VALUE	COMMENTS
DADE COUNTY (CONT.)				
S6 (Cell 21)	Rock quarries, *Melaleuca*, lakes, cabbage palm	Inundated, Central lake Belt Storage	Low, except moderate in cabbage palm	Area will be inundated by a 5,200 acre water storage area with a 36' variance in depth.
S6 (Cell 22 north half)	Mosaic of native vegetative systems including prairie	Will become a 640 acre STA final polishing cell.	High	The NAS report states this area should be preserved and managed for its intrinsic ecological functions. If an STA is placed here it will impact/degrade the native vegetation. Recommend relocating STA.
BB5 (Cells 26 & 23)	High plant diversity and high wildlife value. Cell 23 heavy invasion of Melaleuca.	Should maintain existing values.	High	The Dade/Broward levee will be constructed/improved to 5' height with 2' top with a conveyance capacity of 300 cfs.
Central Cells 21 and 22	Dense Melaleuca saplings	Proposed for rock mining.	Low	Miner-owned (resolved and unresolved) areas are located here.
Wellfield Area C	High plant diversity and high wildlife value	Not proposed for acquisition on latest SFWMD maps.	High	NAS stated this area would be important as a wildlife corridor between the Pennsuco wetlands and the northwest Dade wellfield. Recommend acquisition of sections 9, 15 and 16..
Not in Comp plan Cells 24 & 25	Rock mines; existing and permitted lakes	Rock mines; existing and permitted lakes	Low	Potential for interstitial wetland development. Recommend acquisition.
Cell 27 and Cell 22 south half	Mosaic of marsh, open prairie, Melaleuca and a large tree island.	Extent of rock mining will determine the functions and values to be lost.	High	An assessment of the permitted rock mining in the area needs to be made before a determination of effects can be completed.
HHH Cell 28	Approximately 65% of the area is marsh, with the remainder Melaleuca	Will become a 2,877 acre impoundment, 4' deep.	Moderate/ High	The impoundment will inundate approximately 2,000 acres of freshwater marsh. We recommend strategic placement of islands/sloughs with deeper water for fish and wildlife habitat.

TABLE XII-1
WATER PRESERVE AREAS HABITAT ANALYSIS (Page 5 of 5)

	HABITAT CHARACTERISTICS			
COMPONENT/ LOCATION	EXISTING CONDITIONS	WITH PROJECT CONDITIONS	NAS/FWS VALUE	COMMENTS
	DADE COUNTY (CONT.)			
Not in Comp plan (Cells 29 and 30)	cell 30 - freshwater marsh cell 29 - freshwater marsh and *Melaleuca*	Not included in comprehensive plan.	High	Potential mitigation area for impacts associated with the project.
Not in Comp plan (Cells 31 and 32)	Rock mines and miner owned property both resolved and unresolved cell 31 (sect. 13) and cell 32 (sect. 24) both excellent sawgrass prairie	Proposed for rock mining. Area will be dredged and all wetland functions and values lost. Permit submitted for polo field and housing in cell 3; section 13.	High	Section 13 in Cell 31 and Section 24 in Cell 32 both contain excellent sawgrass prairie habitat which should be avoided if possible.
Not in Comp plan (Area D)	Miccosukee bingo hall, detention center, shooting range	Not proposed for acquisition. Conditions to remain the same	Low	Not in land acquisition map or mentioned in East Coast Buffer feasibility study.
FF6 Area E	Agriculture	Wetland habitat-present	Low; High with project	Component to provide sheetflow across area.
8.5 sq mile (Area F)	Scattered residential and freshwater wetlands	Proposed for flood protection	Low/Mediu m	Not in Comprehensive plan. SERA project.
WW6 C-111 Project (Area G)	Sawgrass, mixed shrubs, agricultural lands	Restore hydrology and expand spatial extent of wetlands	Medium	Separate funding under SERA.
Loveland Slough (Area H)	Agricultural lands	Restore flows to Slough to connect Areas G and I		Not part of the Comprehensive plan.
WW6 Southern Glades (Area I)	Sawgrass, mangroves, FPL Mitigation Bank , FL Rock and Sand mine	Spreader canal would restore flows to Model Lands	Medium/high	Improve water deliveries to Southern Glades and Model Lands. FPL Mitigation Bank is problematic. Placement of STA could impact native vegetation and nutrient loading.

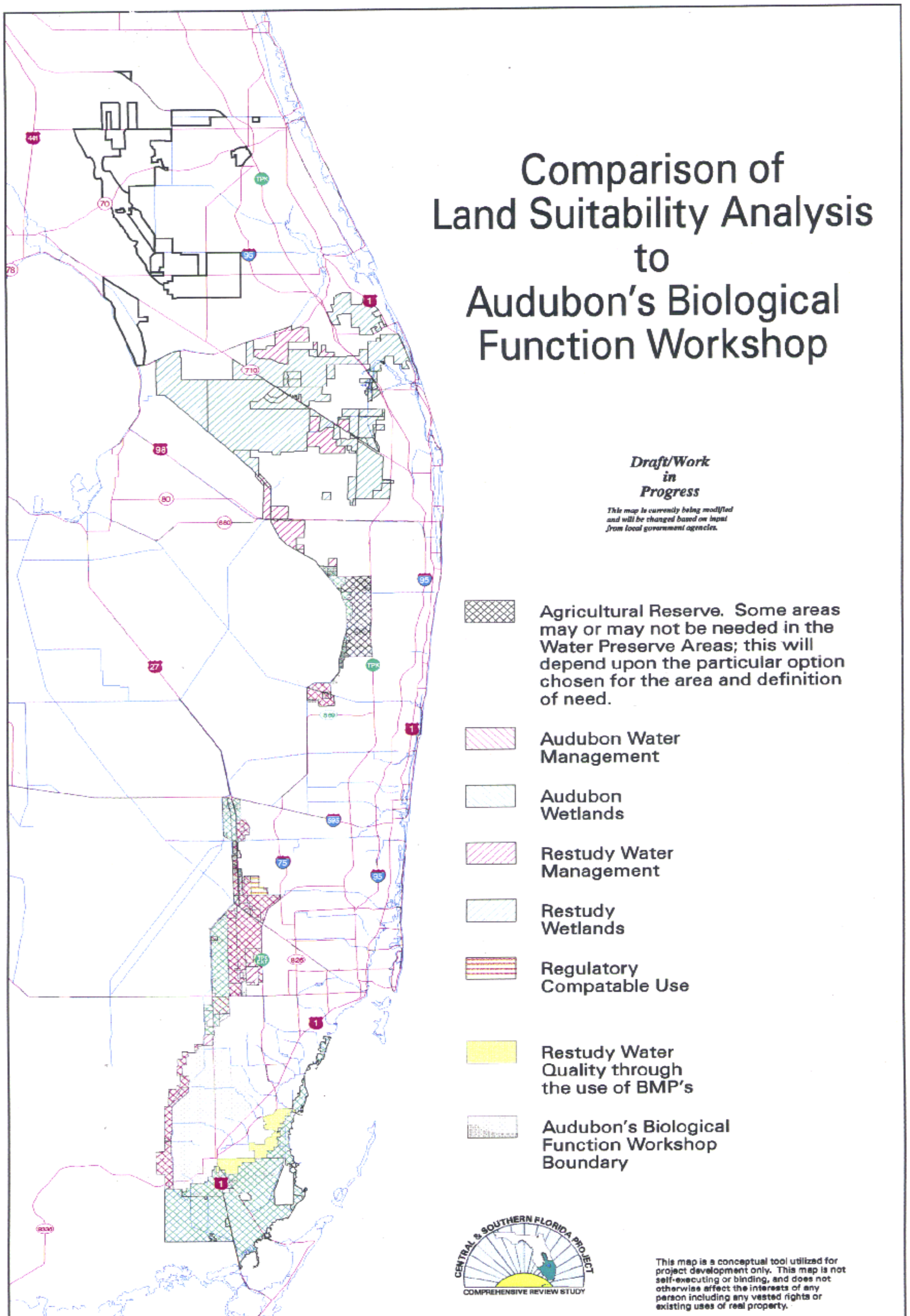

Figure XII - 1. Location of Water Preserve Areas

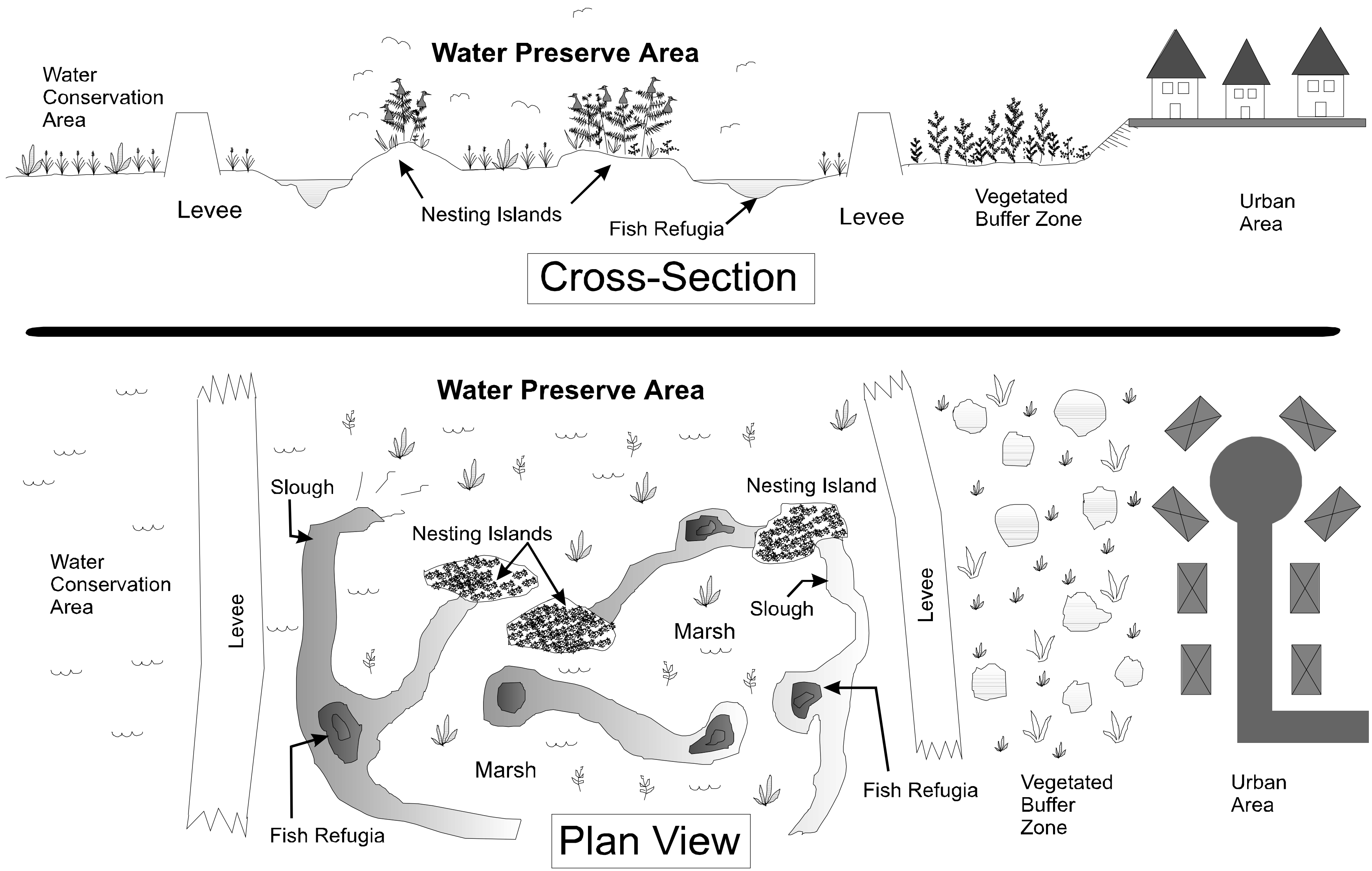

Figure XII-2. Conceptual diagram of fish and wildlife habitat enhancement features in the Water Preserve Areas.

CHAPTER XIII -- EFFECTS OF STORAGE RESERVOIRS AND STAs ON HABITAT CONDITIONS (EXCLUDING WATER PRESERVE AREAS)

Robert Pace, FWS

A. Introduction

The present design of Alternative D13R includes conversion of approximately 151,200 acres of uplands and wetlands for water storage and treatment (Table XIII-1). The degree to which the COE and the SFWMD have determined locations for these facilities varies greatly among the components. For example, the Indian River Lagoon Feasibility Study has already screened sites for suitability and has defined options for sites, which would apply, in part, to Restudy components B and UU in the St. Lucie basin. The COE has also identified preliminary locations for the facilities north of Lake Okeechobee (2 options for siting Restudy Component A) , storage in the Caloosahatchee basin (Component D), and an STA in the Caloosahatchee basin (Component DDD). However, other storage and treatment facilities have only been screened for their hydrologic effects on the C&SF system through coding in the SFWMM, without an analysis of the availability of suitable lands. Examples include both of the W Components in the Taylor Creek/Nubbin Sough basins, and the three storage compartments in the EAA (Component G). Because the EAA has relatively homogeneous and has low habitat value and is relatively homogeneous, we are not especially concerned about the siting of the 60,000 acres of storage in the EAA as long as it produces the desired restoration benefits. Although we understand the conceptual level of detail in the Restudy, we have attempted to provide as complete an analysis as the present information allows.

An accounting of impacts is needed to assess the loss of habitat functions versus gains in habitat functions through ecosystem restoration in the C&SF system as a whole. These gains and losses should be discussed in the PEIS and appropriate methods to avoid or minimize these impacts should be identified during subsequent detailed project planning. Although the restoration benefits of the Restudy **may** offset the construction impacts, an accounting of the habitat gains and losses should be included in the PEIS. The ecological benefits of the Restudy are principally in the form of improved hydrologic functioning in existing (primarily herbaceous) wetlands. In contrast, the storage reservoirs will impact a variety of upland and wetland habitats, including some forested wetlands. Therefore, in order to accept the premise that the ecological benefits of the Restudy far outweigh the impacts on existing habitat values in the areas to be converted to storage reservoirs and treatment facilities, it will be necessary to assess and accept "out-of-kind replacement" of habitat function and value as defined in the FWS' mitigation policy (Federal Register, Vol. 46, No. 15; Pp. 7644-7663; January 23, 1981).

Table XIII-1. Water storage and treatment areas proposed in the Restudy, excluding the Water Preserve Areas.

Component	Location	Area (Acres)	Max. Depth (Ft)
A	N. of Lake Okeechobee	20,000	10
B	St. Lucie drainage (C-44)	10,000	4
UU	St. Lucie drainage (C-23, C-24, North and South Forks)	26,200	8
D	Caloosahatchee drainage (Storage)	20,000	8
G	EAA (3 compartments)	60,000	6
W	Taylor Creek/Nubbin Slough (Storage)	5,000	10
W	Taylor Creek/Nubbin Slough (STA)	5,000	4
DDD	Caloosahatchee drainage (STA)	5,000	4
Total		151,200	

We have performed preliminary analyses of the cover types and the threatened, endangered, or rare species present in the areas so far identified as potential storage areas. This analysis was performed to assist the COE in evaluating the habitat impacts discussed above. We must express caution that the cover type analyses are based on classification of a satellite image, which is subject to variable levels of error, depending on the habitat type. (For an assessment of the accuracy of the specific GFC classification we used, see Kautz *et al.*, 1993.) The data we reviewed for presence of threatened, endangered, and rare species of plants and animals have been compiled from a variety of sources. Some of these sources have not been updated in recent years. Site-specific field surveys must be performed before final decisions are made regarding location of the proposed storage areas so that the presence of habitat types and sensitive species can be confirmed. The results presented here should be considered as indications of what resources **might** be expected to occur in these areas. We have also reviewed siting proposals to determine whether the facilities would occur in the Strategic Habitat Conservation Areas (SHCAs) defined by Cox *et al.*(1994) in their publication entitled, “Closing the Gaps in Florida’s Wildlife Habitat Conservation System.”

B. Storage in the EAA (Component G)

The DOI finds that locating storage areas in the EAA will have relatively less impact on fish and wildlife resources than elsewhere in the C&SF Restudy area. The EAA presently provides habitat for wading birds, particularly during periods of high water in the late rainy season (Sykes and Hunter 1978). The principle wading bird species include the federally endangered wood stork (*Mycteria americana*) and three wading bird species listed by the GFC as species of special concern: little blue heron (*Egretta caerulea*), tricolored heron (*Egretta tricolor*), and snowy egret (*Egretta thula*).

However, the EAA contains little native habitat and is not a stable, sustainable ecosystem. The cover types in the EAA are almost entirely classified as "grassland", whether these are sugarcane fields or other crops. The scarcity of native cover types within the EAA led to Cox *et al.* (1994) not including any portion of the EAA in their designation of SHCAs. We therefore recommend that as detailed design proceeds for the features of the Restudy, storage in the EAA take priority in implementation over storage elsewhere in the study area.

C. Storage north of Lake Okeechobee and in the Caloosahatchee Basin (Components A and D)

The COE has identified preliminary locations for these facilities; a single site was identified in the Caloosahatchee basin and two options were identified for the region north of Lake Okeechobee.

The cover types, as defined by Kautz *et al.* (1993), within the three potential storage reservoir sites are provided in Table XIII-2. In general, grassland (most likely improved pasture) is the predominant cover type in both of the storage locations for storage north of Lake Okeechobee. The location provided for Option 2, which lies between the Paradise Run section of the lower Kissimmee River and the Indian Prairie Canal, has a greater area classified as dry prairie than the Option 1 location, to the northeast (east of the Kissimmee River). Because dry prairie is a native community and pasture is not, we would prefer selection of Option 1, although either of the sites appears to be acceptable. The proposed reservoir site north of the Caloosahatchee River is substantially more diverse in cover types than either of the two options for storage north of the lake. It displays greater spatial heterogeneity in a rather complex pattern of cover types, including grassland, dry prairie, pineland, freshwater marsh, and hardwood hammock. The following paragraph includes a discussion of why we suspect that the area remotely sensed as dry prairie in Option 2 may in fact contain more xeric oak scrub or sand pine scrub than was classified as the latter two land cover types.

The two optional locations for storage north of Lake Okeechobee are similar with respect to the presence of threatened, endangered, or rare species. Each of these has a relatively low density of observations for these species, compared to other parts of south Florida. Both sites contain records of nesting by the federally threatened bald eagle (*Haliaeetus leucocephalus*); some of these nest sites are active, while others are older records. The federally threatened Audubon's crested caracara (*Polyborus plancus audubonii*) is present within and around both sites. We have found that the caracara occurrence database is biased towards reporting a greater number of observations near public roads. It is therefore likely the occupied caracara home ranges on private properties away from roads are underestimated. We recommend that a thorough survey for the distribution of caracara habitat must be conducted within and outside the proposed storage reservoirs before they are finally selected. Caracara observations are also reported around the periphery of the proposed site north of the Caloosahatchee River, and we find it likely that caracara territories also occur within the site. Although we have no record of bald eagle nesting within the Caloosahatchee reservoir area, eagle nest locations change over time, and we would recommend a detailed search for nests in this area prior to any construction. According to a survey conducted by Archbold Biological Station (Fitzpatrick *et al.* 1994), the threatened Florida scrub jay (*Aphelecoma coerulescens coerulescens*) occupies habitat in two locations within the proposed Caloosahatchee reservoir site. Their survey characterized the habitat at both locations as "moderately overgrown." The reported locations for scrub jays in the Caloosahatchee reservoir site overlay areas remotely sensed as dry prairie; we believe that xeric oak scrub and sand pine scrub habitat types are likely dominant in this area, but were not classified as such. State-listed species within any of the three sites may include the Florida sandhill crane (*Grus canadensis pratensis*), threatened; and the burrowing owl (*Speotyto cunicularia*), species of special concern. We anticipate that the gopher tortoise (*Gopherus polyphemus*), which is also a species of special concern, may be present in the scrub habitat within the Caloosahatchee reservoir site.

The proposed storage sites differ substantially with respect to potential impacts on the SHCAs described in Cox *et al.* (1994). Option 1 for storage north of Lake Okeechobee contains a relatively small area designated as a SHCA. Roughly the southern third of the Option 2 site north of the lake is designated as such, coinciding with clusters of native cover types, primarily dry prairie and hardwood forest, which are more abundant than in the Option 1 site (Table XIII-2). The storage area north of the Caloosahatchee River is almost entirely designated as a SHCA, and more importantly, forms part of a much larger contiguous region designated as a SHCA in western Glades County. In contrast, smaller and more fragmented areas are designated as SHCAs south of the Caloosahatchee River in Hendry County, which should be examined as an alternative to the COE's currently recommended site.

We find that within the three possible storage sites north of Lake Okeechobee or in the Caloosahatchee basin, only the Caloosahatchee storage area contains xeric scrub habitat, which we consider to be "unique and irreplaceable," as described in the FWS' mitigation policy as Resource Category 1. The Resource Category 1 designation calls for no loss of existing habitat value, that is, avoidance of adverse impact. Because it is not practical to create compensatory scrub habitat, this habitat should be avoided in siting the proposed storage. The COE can avoid this habitat either by splitting the storage impoundment in two around the scrub habitat or by shifting the storage elsewhere in the Caloosahatchee basin. Other potential sites where the storage reservoir could be relocated include portions of Glades County, east of the COE's currently recommended location, or south of the Caloosahatchee River in selected portions of Hendry County. We are ready to assist the COE in siting this facility in a less sensitive location. Although impacts on crested caracara habitat may be unavoidable in these other sites, they appear to have less habitat heterogeneity than the currently recommended site, and impacts to the scarcer scrub habitat could be avoided.

In summary, the Option 1 site is preferred over Option 2 north of Lake Okeechobee, but either of these options is most likely acceptable. The COE should seek an alternative to the currently selected site north of the Caloosahatchee River. Less sensitive sites appear to be available east of the currently recommended location (north of the river) and in selected areas south of the Caloosahatchee River.

D. Proposed Storage Sites as Part of the Indian River Lagoon Feasibility Study (Components B and UU)

Fourteen potentially suitable sites have been proposed under the Indian River Lagoon Feasibility Study, seven sites in St. Lucie County, and seven in Martin County (Figure XII-1--The numbers in this figure have been assigned strictly as points of reference for this document.) These sites were selected following a series of GIS-based land suitability analyses and workshops attended by experts on regional environmental conditions. This planning has resulted in a relative lack of concern with respect to impacts of the facilities on fish and wildlife habitat. The Restudy modeling runs assumed 10,000 acres of storage, at a maximum depth of 4 feet, along C-44 (Component B); and a total of 26,200 acres of storage, up to 8 feet deep, along C-23, C-24, and the North Fork and South Fork of the St. Lucie River. We determined that a total of 72,957 acres (bottom of Table XIII-3) of potentially suitable area has thus far been defined through the Indian River Lagoon Feasibility Study. Modeling of the Restudy alternatives suggests that the desirable salinity envelope for the St. Lucie estuary will be maintained much more often than under the current C&SF system, but extreme high and low flows (outside of the desired salinity regime) will not be entirely eliminated. The Restudy modeling assumed a total of 36,200 acres of storage out of a potential 72,957 acres of suitable land. Depending on the outcome of future studies, it may be necessary to increase the total water storage areas beyond the 36,200 acres to achieve the ecological goals. It also should be noted that much of the Upper East Coast drainage into the St. Lucie estuary originates from areas outside the geographic scope of the SFWMM. This indicates the need for more detailed hydrological modeling under the Indian River Lagoon Feasibility Study which may in turn confirm the need for a greater total acreage of storage than that modeled in the Restudy alternatives.

Land cover designations in each of the 14 proposed sites is summarized in Table XIII-3. In general, the site selection effort mentioned above has been successful in limiting the extent of impact on fish and wildlife habitat. The majority of the existing cover types that would be affected by the storage areas were classified as grassland or barren, with smaller areas of freshwater marsh. The prevalence of freshwater marsh ranges from less than 1 percent to about 9 percent of the total area of each site. The area classified as grassland would include citrus groves, which are common in the region. The proposed sites have low habitat heterogeneity.

The potential storage areas identified to date in the Indian River Lagoon Feasibility Study are not known to be located in habitats of particular significance to threatened, endangered, or rare species, based on the survey data we have available. One record of the crested caracara has been reported from Site 2 in northern St. Lucie County. Site 6 has been delineated to avoid impacts to a valuable, complex, wetland along its western boundary. Two nesting colonies in a cypress swamp just west of Site 6 have historically supported several species of waterbirds. In various years, these have included the federally endangered wood stork (*Mycteria americana*) and three

State-listed species of special concern: little blue heron (*Egretta caerulea*), tricolored heron (*E. tricolor*), and white ibis (*Eudocimus albus*) . Other species that have nested there include great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), anhinga (*Anhinga anhinga*), and cattle egret (*Bubulcus ibis*). If Site 6 becomes part of the storage needed for the C&SF system, extreme caution would be required to avoid adverse impacts on surrounding wetlands during levee construction, and the construction schedule might need to be managed to avoid construction during the nesting season close to any active waterbird nesting colonies. In the long term, storage of no more than 4 feet of water in this area could enhance foraging capabilities for birds nesting in the area, compared to the site's current land use as a citrus grove.

None of the proposed sites for storage from the Indian River Lagoon Feasibility Study would affect SHCAs.

E. Storage/Treatment in the Taylor Creek/Nubbin Sough Basins (Component W)

The Restudy proposes 5,000 acres of storage at 10 feet deep and a 5,000-acre STA in the Taylor Creek and Nubbin Slough basins, but the COE has not provided maps of proposed locations. The DOI supports these features because these basins currently export the highest nutrient loads to Lake Okeechobee. The chapter of this report dealing with Other Project Elements (OPEs) includes a section entitled "Lake Okeechobee Water Retention/Phosphorus Removal." That project will also assist in retention of phosphorus in the basin, and that endeavor can, if adequately planned and coordinated, be complimentary to the facilities discussed here. The individual projects that make up the Lake Okeechobee Water Retention/Phosphorus Removal critical project should occur outside the areas to be converted to the larger storage and treatment areas. Therefore, the COE should identify as soon as possible potential sites for the two 5,000-acre storage and treatment areas. This will ensure that efforts related to the Lake Okeechobee Water Retention/Phosphorus Removal are not expended in areas that will become the larger storage and treatment areas.

Although we have not been provided potential locations for the storage and treatment facilities in these basins, we have conducted a preliminary analysis on the availability of suitable sites. We found three areas in the Taylor Creek/Nubbin Slough basins that may be suitable for water storage and treatment (Figure XII-2). All of the sites are dominated by grassland, with some inclusions of freshwater marsh and dry prairie, similar to the two options for storage north of Lake Okeechobee described above. Site 1 (Figure XII-2) is comprised of approximately 6,165 acres in an area north of State Road 68 and west of U.S. Highway 441. Site 2 is just east of the first, across U.S. Highway 441. Because Site 2 contains about 3,612 acres, it is not capable by itself of accommodating either of the two 5,000-acre facilities, but it may be possible to split the facility on either side of the highway. Site 3, measuring 7938 acres, is located in the southeastern portion of the Taylor Creek drainage basin and the northern end of the Nubbin Slough basin, north of State Road 70.

Preliminary screening indicates that known occurrences of threatened, endangered, or rare species are not abundant in these sites. Sites 1 and 2 have one record each of the presence of the federally threatened Audubon's crested caracara, and Site 3 has no records for any of the species in our databases. Sites 1 and 2 have relatively small scattered portions designated as SHCAs (not part of any larger contiguous areas), and Site 3 has virtually no portion designated as a SHCA.

In summary, areas with relatively low environmental sensitivity appear to be available for the proposed facilities, but the two 5,000-acre sites for the storage area and the STA may have to be separated within the two basins to avoid adjacent more sensitive areas.

F. STA in the Caloosahatchee Drainage Near Lake Okeechobee (Component DDD)

The COE has identified a preliminary location for this 5000-acre facility. Table XIII-4 indicates the cover types that will be affected if that site is finally selected. The area appears to be situated well away from the rarer habitat types. No records of endangered, threatened, or rare species are present within the COE's recommended site, but there are records for the federally threatened Audubon's crested caracara in the area around the site. We recommend that more detailed surveys be performed to determine caracara habitat use within the site prior to detailed project planning. The proposed site has negligible effect on SHCAs. Therefore, we find that the currently recommended site has low environmental sensitivity and would generally appear to be suitable.

G. Effects of the Initial Draft Plan

The focus of this chapter has been an assessment of the existing habitat conditions in the areas that may be converted to storage areas and STAs. We can confidently predict that habitat value for upland species (such as gopher tortoise and scrub jay) would be lost in conversion of these areas. However, it is more difficult to predict the net effect on wetland-dependent species (wading birds) or species that primarily are found in upland habitats but are known to forage in wetlands (Audubon's crested caracara) or use wetlands for breeding (Florida sandhill crane).

A principal reason for this uncertainty is that some of facilities proposed here are unprecedented in south Florida in terms of size and hydrologic regime. It is difficult to predict what vegetative communities, and other habitat characteristics, will be present in most of the storage areas, because these act as large "surge tanks" to buffer the effects of flood and drought on the Everglades Protection Area. The SFWMM predicts the most extreme hydrologic regimes for the 20,000-acre storage area north of Lake Okeechobee and the 5,000-acre storage area in the Taylor Creek/Nubbin Slough basins. In the storage area north of Lake Okeechobee, the surface is either dry or nearly dry for periods as long as 1.75 years, and is filled with water 10 feet deep for periods ranging from a few days, to several months, to as long as 1.25 years. Other storage areas also experience less extreme, but still unnaturally large, fluctuations in water levels. We are presently unable to determine what wildlife species might find habitat in these areas; however, we are concerned that not only might these areas have low intrinsic habitat value, but also that they may become "traps" or "population sinks" for certain opportunistic species. These impacts can include direct mortality when the areas are flooded and/or population declines caused indirectly by the loss of suitable habitat in some years.

A second uncertainty arises for the STAs. Although we have several years of data on the habitat conditions in the existing Everglades Nutrient Removal Project, which is similar to the proposed facilities, the long-term habitat conditions in these areas are uncertain. Even if water levels are normally suitable for many species of fish and wildlife, it is likely that the areas will become filled with sediment, cattails, and other nutrient-tolerant vegetation. In this event, the STAs most likely will have to be periodically drained and cleaned of accumulated sediment and vegetation to achieve long-term efficiency in nutrient removal. Thus, although they may provide temporarily suitable habitat conditions for some species, they will not be stable high quality habitats for a variety of species. STAs that do not exceed 4 feet deep, and that are not in a stage in their maintenance cycles when they are clogged with vegetation, would be expected to provide foraging habitat over many years for widely ranging species, such as the federally endangered snail kite (*Rostrhamus sociabilis plumbeus*) and wading birds.

These unprecedented facilities will serve as experiments that must be closely monitored. Scientific studies should be focused on information that will be useful to decision-makers in an adaptive management framework.

H. Recommendations

1. Water storage or treatment areas should be developed first in the EAA before affecting more valuable wildlife habitats in other parts of the C&SF system.

2. For water storage north of Lake Okeechobee, the site identified by the COE as Option 1 (east of the Kissimmee River in southeastern Okeechobee County) is somewhat preferable over Option 2 (west of the Kissimmee River in northwestern Glades County) to avoid impacting more valuable wildlife habitat.

3. We strongly recommend that the COE seek an alternative to the site currently recommended for water storage in the Caloosahatchee River drainage. Environmentally less sensitive sites appear to be available in some areas south of the Caloosahatchee River. If the currently identified site cannot be avoided entirely, we recommend that detailed design should avoid any impact on occupied scrub jay habitat.

4. Adaptive management of both the storage areas and the STAs should be based on focused scientific study of their intrinsic and external effects on wildlife, including their potential threat as “traps” or “sinks” to wildlife populations normally supported in adjacent habitats.

I. References

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Fitzpatrick, J.W., B. Pranty, and B. Stith. 1994. Florida scrub jay statewide map 1992-1993. Archbold Biological Station; Lake Placid, Florida.

Kautz, R.S., D.T. Gilbert, and G.M. Mauldin. 1993. Vegetative cover in Florida based on 1985-1989 landsat thematic mapper imagery. Florida Scientist 56(3):135-154.

Sykes, P.W., Jr., and G.S. Hunter. 1978. Bird use of flooded agricultural fields during summer and early fall and some recommendations for management. Florida Field Naturalist 6:36-43.

Table XIII-2. Cover types (as defined by Kautz *et al.* 1993) to be affected by water storage reservoirs in the Caloosahatchee basin and north of Lake Okeechobee (two optional locations).

	CALOOSAHATCHEE BASIN		N. OF LAKE OKEECHOBEE (OPT. 1)		N. OF LAKE OKEECHOBEE (OPT. 2)	
COVER TYPE	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**
GRASSLAND	3,430	17	15,510	82	14,324	68
DRY PRAIRIE*	69,531	34	264	1	4,045	19
PINELANDS	3,844	19	366	2	-----	------
SHRUB AND BRUSHLAND	1,788	9	665	4	1,030	5
FRESHWATER MARSH & WET PRAIRIE	2,023	10	371	2	444	2
HARDWOOD HAMMOCKS AND FORESTS	833	4	371	2	1,119	5
BARREN	1,035	5	1,168	6	45	<1
OPEN WATER	243	1	124	<1	12	<1
MIXED HARDWOOD FORESTS	73	<1	23	<1	-----	-----
HARDWOOD SWAMP	-----	-----	22	<1	-----	-----
SHRUB SWAMP	-----	-----	-----	-----	10	<1
CYPRESS SWAMP	2	<1	-----	-----	-----	-----
XERIC OAK SCRUB*	-----	-----	2	<1	-----	-----
SAND PINE SCRUB*	-----	-----	1	<1	2	<1
TOTAL	82,802		18,887		21,031	

*Other evidence (Fitzpatrick *et al.* 1994) suggests that a portion of the site recommended by the COE for the Caloosahatchee storage area may contain scrub (xeric oak and/or sand pine), mainly in an area characterized by Kautz *et al.* (1993) as dry prairie.

Table XIII-3 Cover types (as defined in Kautz *et al.* 1993) potentially affected by water storage reservoirs as part of the Indian River Lagoon Feasibility Study. (Page 1 of 3).

Please refer to Figure XII-1 for the locations of the numbered sites. Sites 1 and 2 are in northern St. Lucie County, and Sites 3 and 4 are adjacent to C-24.

	SITE 1		SITE 2		SITE 3		SITE 4	
COVER TYPE	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**
GRASSLAND	5,279	76	5,370	71	2,046	81	3,535	87
BARREN	1,244	18	1,805	24	408	16	353	9
FRESHWATER MARSH & WET PRAIRIE	405	6	307	4	67	3	29	1
CYPRESS SWAMP	10	<1	6	<1	---	---	---	---
HARDWOOD SWAMP	4	<1	26	<1	---	---	---	---
BAY SWAMP	1	<1	12	<1	---	---	---	---
SHRUB SWAMP	14	<1	55	1	---	---	137	3
PINELANDS		---	20	<1	---	---	2	<1
OPEN WATER		---	2	<1	---	---	---	---
TOTAL	6,957		7,603		2,521		4,056	

Table XIII-3 (Continued). Cover types (as defined in Kautz *et al.* 1993) potentially affected by water storage reservoirs as part of the Indian River Lagoon Feasibility Study (Page 2 of 3).

Please refer to Figure XII-1 for the locations of the numbered sites. Sites 5, 6, 7, and 8 are adjacent to C-23.

	SITE 5		SITE 6		SITE 7		SITE 8	
COVER TYPE	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**
GRASSLAND	5,026	64	3,969	62	6,392	67	1,402	75
BARREN	2,304	29	2,147	34	2,560	27	350	19
FRESHWATER MARSH & WET PRAIRIE	421	5	219	3	495	5	114	6
CYPRESS SWAMP	53	1	5	<1	---	---	---	---
HARDWOOD SWAMP	1	1	1	<1	---	---	---	---
SHRUB SWAMP	26	<1	45	1	13	<1	1	<1
PINELANDS	2	<1	1	<1	---	---	---	---
OPEN WATER	---	---	---	---	30	<1	---	---
BAY SWAMP	---	---	---	---	---	---	---	---
TOTAL	7,833		6,387		9,490		1,867	

Table XIII-3 (Continued). Cover types (as defined in Kautz *et al.* 1993) potentially affected by water storage reservoirs as part of the Indian River Lagoon Feasibility Study (Page 3 of 3).

Please refer to Figure XII-1 for the locations of the numbered sites. Sites 9, 10 and 14 are adjacent to C-44, and sites 11 12, and 13 are adjacent to tidally influenced portions of the St. Lucie estuary.

	SITE 9		SITE 10		SITE 11		SITE 12		SITE 13		SITE 14	
COVER TYPE	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**	**ACRES**	**%**
GRASSLAND	11,440	80	2,431	77	408	63	1,094	63	260	82	4,944	82
BARREN	2,494	17	439	14	215	33	516	29	30	9	1,045	17
FRESHWATER MARSH & WET PRAIRIE	407	3	296	9	26	4	127	7	30	9	17	<1
CYPRESS SWAMP	---	---	---	---	---	---	2	<1	---	---	2	<1
HARDWOOD SWAMP	---	---	---	---	---	---	---	---	---	---	---	---
SHRUB SWAMP	2	<1	---	---	---	---	8	<1	---	---	---	---
PINELANDS	9	<1	---	---	---	---	---	---	---	---	---	---
OPEN WATER	---	---	---	---	---	---	---	---	---	---	---	---
BAY SWAMP	---	---	---	---	---	---	---	---	---	---	1	<1
TOTAL	14,352		3,166		649		1,747		320		6,009	

TOTAL ACREAGE FOR ALL IDENTIFIED STORAGE IN ST. LUCIE BASIN	**72,957**

Table XIII-4. Cover types (as defined by Kautz *et al.* 1993) likely to be affected by the 5,000-acre STA proposed in the Caloosahatchee basin near Lake Okeechobee.

COVER TYPE	ACRES	%
GRASSLAND	1,565	31
DRY PRAIRIE	1,035	21
PINELANDS	74	1
SHRUB AND BRUSHLAND	669	13
FRESHWATER MARSH & WET PRAIRIE	185	4
HARDWOOD HAMMOCKS AND FORESTS	203	4
BARREN	1,248	25
OPEN WATER	13	<1
MIXED HARDWOOD FORESTS	28	1
TOTAL	5,020	

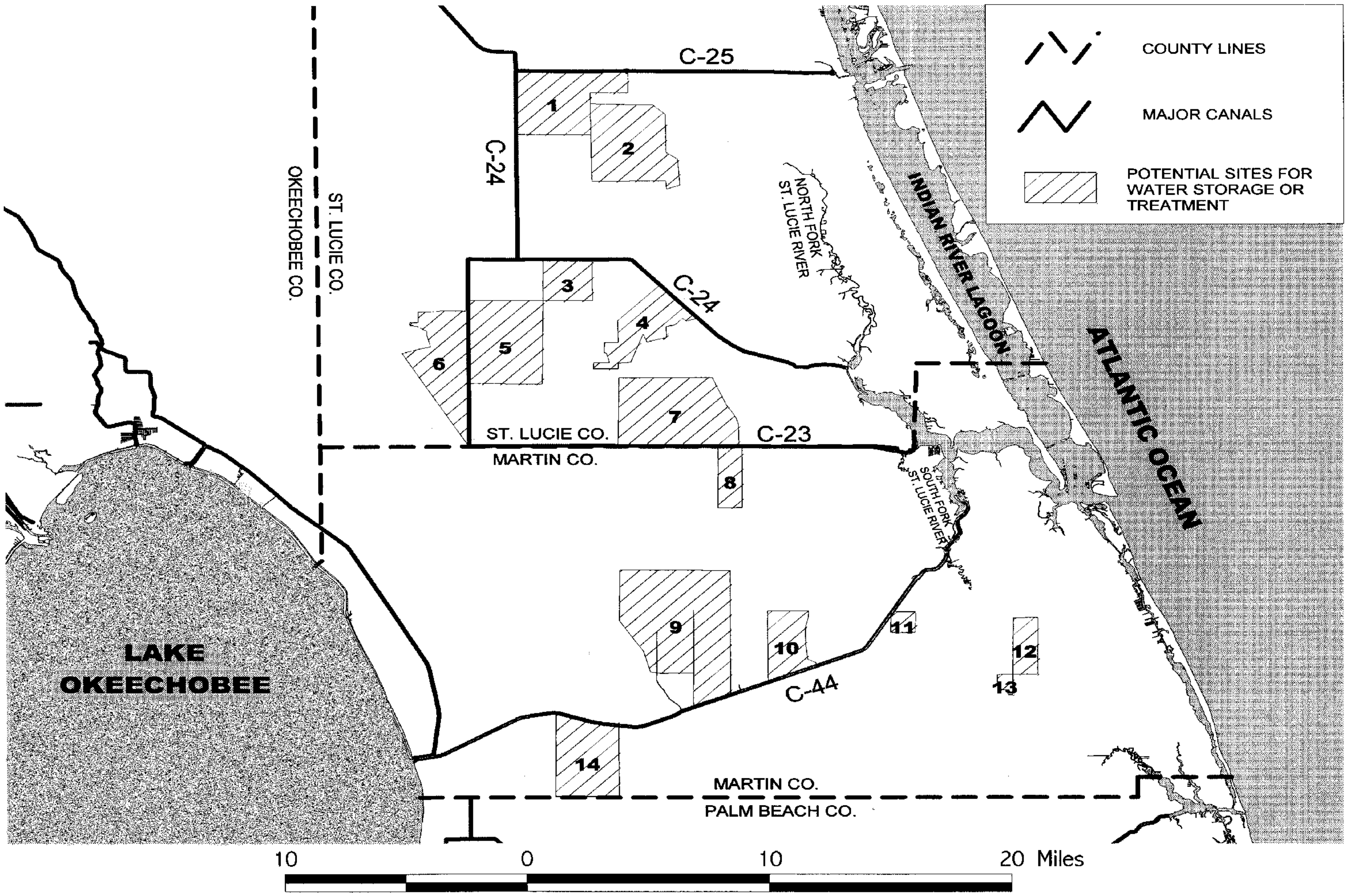

Figure XIII-1. Location of fourteen potential water storage/treatment areas in the Indian River Lagoon Feasibility Study..

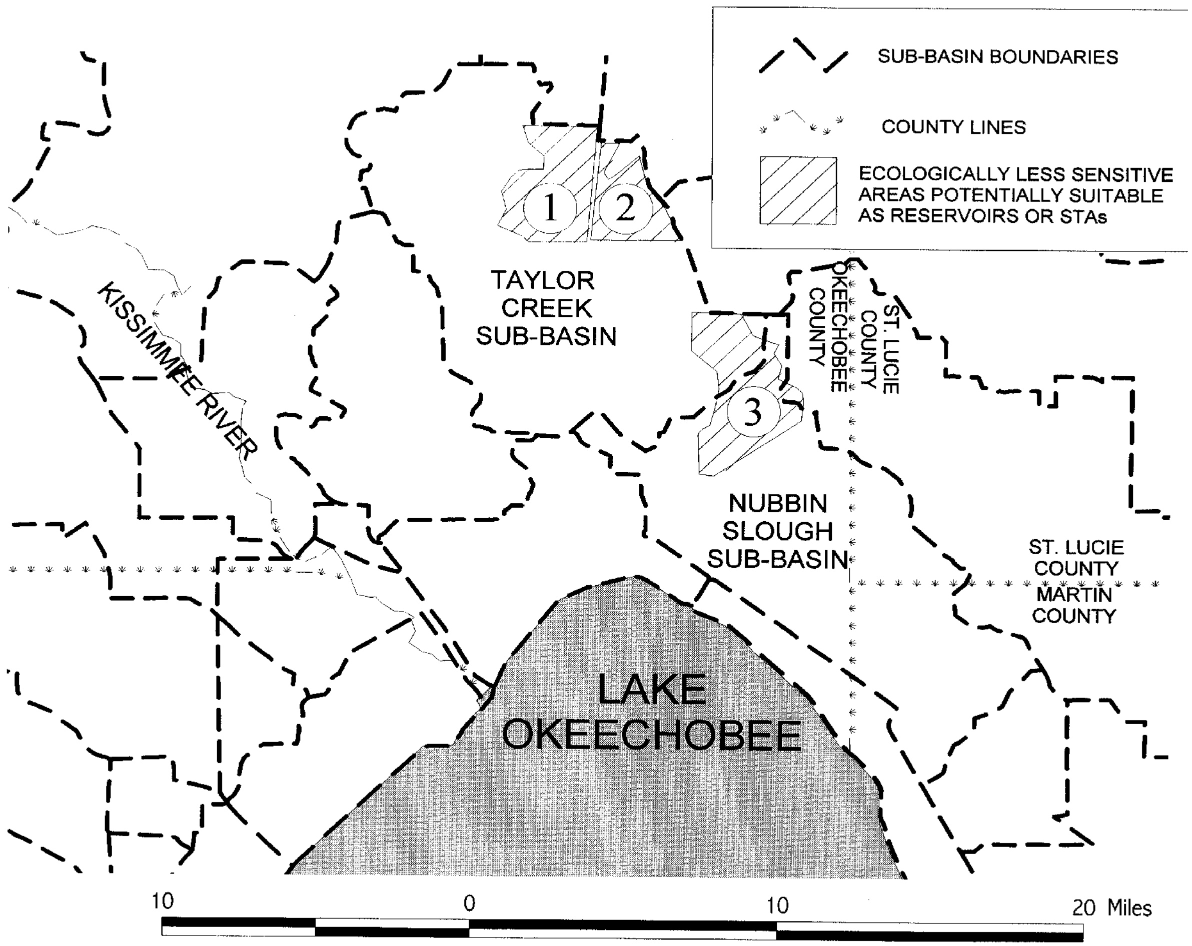

Figure XIII-2. Areas potentially suitable for water storage/treatment in the Taylor Creek/Nubbin Slough basins.

CHAPTER XIV -- ADAPTIVE MANAGEMENT

Cheryl Buckingham, FWS

A. Introduction

A conceptual adaptive management strategy was developed for the South Florida Restoration Program (Figure XIV-1). Its purpose is: a) to strengthen the overall role of science in the planning, implementation and evaluation phases of restoration programs, b) to suggest a logical sequence of points during the restoration planning process where science can contribute, c) to follow a more structured and predictable scientific process during the development of restoration programs, and d) to create the framework of ecological models and hypotheses that will be necessary to build adaptive management feedback loops into the restoration programs. This strategy for a science-based process is designed to operate over a range of scales, from local to regional. It can be applied to ecological activities in a variety of habitats in south Florida; it applies equally well to defining proper fire management practices for scrub on the Lake Wales Ridge as it applies to assessing the hydrologic changes anticipated from the C&SF Restudy.

Adaptive management focuses on the importance of building in the ability to learn about systems and to incorporate new information into the restoration process. Hypotheses are formed, tested, and revised in a systematic way to produce the greatest amount of useful information. Classical adaptive management strategies consist of a continuing cycle of conducting true experiments, monitoring the results, and revising both the hypotheses and the experiments with the ultimate goal of discovering new information. When adaptive management is applied to restoration projects, the goal of reaching restoration targets is added to that of discovering new information. Additionally, the step of modifying or revising the restoration projects in light of new information is added to the cycle.

In the Everglades, there may never be enough management flexibility to conduct true experiments. To do so would require the ability to manipulate the system on large enough spatial and temporal scales to test major hypotheses. Nevertheless, this adaptive management strategy has created a very strong scientific framework for guiding restoration planning and for evaluating system responses. The key to achieving this goal is to reach consensus on a strong set of hypotheses that describe causal relationships affecting the altered south Florida ecosystems.

Because the scale of the program makes conducting experiments improbable, the adaptive management process will need to depend on the combined influences of large scale changes in management practices and variation in climatological patterns as the means for "testing" the hypotheses and, at the same time, evaluating the management actions. One avenue for using management practices to "test" hypotheses will come with the development of the implementation plan. The same interdisciplinary consensus will be needed to properly sequence the order in which components go on-line. The additions of components must be carefully orchestrated to act as experiments, to test hypotheses, to help evaluate the effects of management plans, and to generate as much information as possible, although it is understood that the information will be limited in scale and time. This new information will be used to refine future actions. An example of treating climatological events as experiments was seen during the high water years of 1994-1995 where the responses of wildlife and wildlife habitat to extreme depths and extended hydroperiods were carefully recorded both during and in the years following those events. Although this does not constitute a controlled experiment, the information obtained from those years gave a great deal of insight into what might occur in a much wetter ridge and slough system.

B. Implementing the Adaptive Management Strategy

The following four steps are being used to implement the Restudy's restoration adaptive management strategy:

1. Develop Conceptual Models. Representatives of a number of essential disciplines held several workshops and charettes over the period of two years. From these came a set of landscape-scale, conceptual ecological models of the south Florida ecosystems. These ecological models explain how the natural systems functioned in terms of **stressors** on the system, the **effects** of those stressors, the **attributes** or **endpoints** that felt the effects, and the **measures** of those endpoints that were altered in the managed system. The models integrated information from empirical studies, modeling and monitoring and best professional judgement of the participants. While many conceptual models already existed, this was the first time they were integrated among and across multi-disciplinary and institutional lines to the degree that they could be used as driving forces for restoration planning and adaptive assessment. Consensus on the characteristics of these conceptual models was an essential step in the process of refining the list of restoration endpoints, also called success criteria.

2. Develop Causal Hypotheses. A set of hypotheses were generated from the conceptual models to explain why changes occurred in each of the major ecological functions and components of the natural systems. Many causal relationship hypotheses had been described before this process, but again, they needed to be integrated across disciplinary and institutional lines. These hypotheses are relatively specific in their explanations of causal relationships even though those relationships operate at a range of different scales. They serve to define the sources of ecological problems in the system and therefore suggest what management actions need to be taken to correct the problems. During the plan formulation process, these hypotheses drove the development of a large number of **performance indicators** and **performance measures**. Performance indicators and measures are the standards and rationale against which model outputs are evaluated. Performance indicators do not have specific targets but are useful to show whether restoration plans are causing changes in a particular direction in relation to the existing conditions and future without project conditions. Performance measures have targets that were approved by the AET and were used to determine whether restoration objectives have been achieved. Performance measures were helpful in a) predicting how the systems would respond as a result of each restoration action modeled, b) evaluating how well each of these management actions appeared to accomplish its objectives, and c) gaining new information and insights into how the systems operate.

3. Develop a Robust Monitoring Program. An ecological monitoring program is being developed to collect data, determine baseline conditions, and monitor the attributes that the hypotheses predict will be affected by specific management plans within the restoration program. The monitoring program will measure the responses of the attributes at the same range of scales as those addressed by the array of hypotheses.

4. Adaptive Assessments Multi-disciplinary teams of scientists will conduct periodic, regular (at least annual), assessments of system responses to compare the actual responses as seen in the monitoring program to the pre-determined sets of responses predicted by the hypotheses. These comparisons will provide a means to: a) evaluate the effectiveness of the management action, b) test and evaluate the causal hypotheses, and c) recommend any revisions to the conceptual ecological models, the causal hypotheses, or to the management action. The report cards prepared by these teams create the feedback loop that characterizes an adaptive strategy, in that revisions to the conceptual models and hypotheses can and should lead to revisions in the restoration plans.

The use of a strong set of widely accepted causal hypotheses as the technical framework of restoration planning has improved the linkage between science, effective management, and policy actions. This strategy also avoids the lack of consistent support adaptive management has fallen prey to in the past. Specifically, because an interdisciplinary group has developed the program, the monitoring program will generate research that is consistent with and has the backing of policy-makers. Political consensus will help ensure the program's continued existence. Subjects of study will be determined by the needs of the program rather than just the interests of scientists. Proper baselines will be established (as much as possible) so that the changes made to the system will be measured against the proper references. Natural events will be used as test cases to glean further information and to test hypotheses. Because the monitoring program is an integral part of the restoration program, the problem of inadequate institutional commitment to monitoring will be less of a problem and the lengthy timetable will be determined and approved in advance. Also, as the list of subjects to be monitored will develop from the conceptual models and be agreed upon by an interdisciplinary group, the problem of "trying to measure everything," will be less likely to occur.

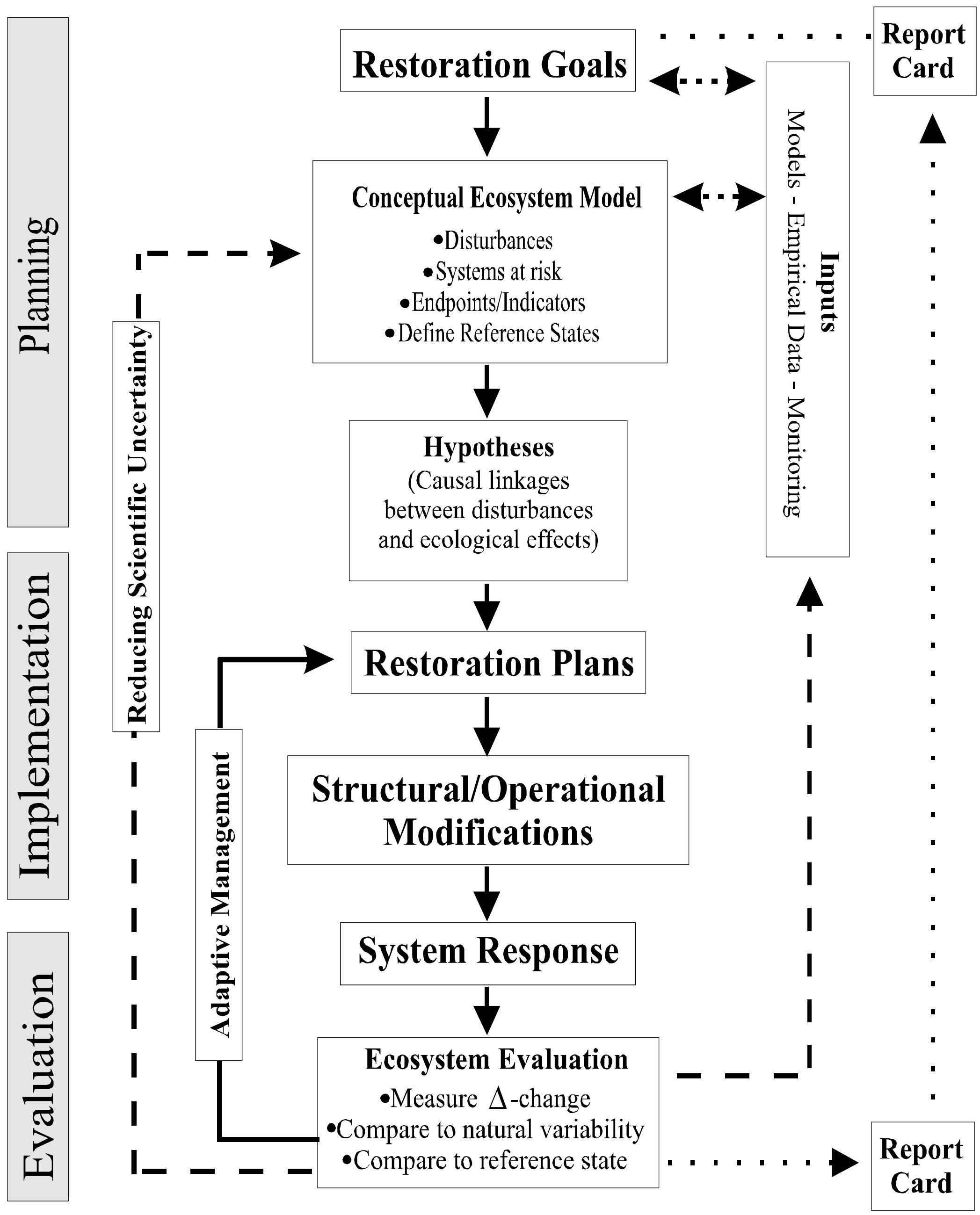

Figure XIV-1. A science-based strategic process for the south Florida restoration program.

CHAPTER XV -- SCHEDULING, SEQUENCING, AND PRIORITIES

David L. Ferrell, FWS

A. Integrating Currently Authorized Projects

There are currently several congressionally authorized federal projects within the C&SF Restudy planning boundary. While authorized projects are considered a "future without project" condition in planning ecosystem restoration in South Florida, consideration must be given as to how these authorized projects are integrated into the larger restoration envisioned by the C&SF Restudy. Planning for a smooth integration of authorized projects will be critical during implementation of the larger C&SF Restudy.

Viewing the entire ecosystem, the northern Kissimmee River Basin and the southern Water Conservation Areas/Everglades have been subject to recent environmental restoration planning, reporting, and authorization. In the headwaters of the Kissimmee/Okeechobee/Everglades ecosystem lie the authorized Kissimmee Headwater Lakes Revitalization Project and Kissimmee River Restoration Project, while at the southern end of the ecosystem, some 200 miles south, lie the authorized Modified Water Deliveries Project and the C-111 Project. The C&SF Restudy is intended to provide a system-wide view of restoring and enhancing ecological conditions throughout south Florida. This entails further improvement on conditions in areas, such as the Kissimmee River and Shark River Slough, that are presently covered by congressionally authorized studies, and includes investigation of opportunities for solving hydrologic problems in all the portions of the C&SF system that lie between its northern and southern ends.

1. Kissimmee Headwater Lakes Revitalization Project

Authorized by Section 1135 of the Water Resources Development Act (WRDA) of 1986, the purpose of this project is to restore fish and wildlife resources and to provide the volume and timing of water discharges to enable restoration of the Kissimmee River. By elevating lake regulation schedules in five major lakes to between 52.5 feet and 54 feet NGVD, restoration of the necessary storage (an increase in seasonal storage capacity of 100,000 acre-feet) and discharge characteristics to restore flow to the Kissimmee River would be realized. Additionally, breaching the confining levees surrounding three lakes would restore an estimated 6,000 acres of short hydroperiod wetlands. Implementation of this project would supply a continuous minimum flow of 250 cfs to the restored Kissimmee River.

Based on the 1998 Save Our Rivers Land Acquisition and Management Plan, 3,222 acres of land remain to be acquired to fully implement the Kissimmee Headwater Lakes Revitalization Project. Completion of land acquisition is critical to realize restoration benefits and to restore flow to the Kissimmee River.

The DOI recommends that the Kissimmee Headwater Lakes Revitalization Project be given priority and, if at all possible, be implemented prior to the construction and operation of the major project features of the C&SF Restudy in the central and southern Everglades. To accomplish this, remaining land acquisition in the headwaters area must be accelerated before lake levels are elevated. An estimated additional 100,000 acre-feet of water, delivered according to seasonal flow characteristics, is a significant amount of water to be stored, potentially contributing to enhancement of the natural system south of Lake Okeechobee.

2. Kissimmee River Restoration Project

The Kissimmee River Restoration Project was authorized by Section 1135 of the WRDA of 1986, and funding for preparation of a Feasibility Report/Environmental Impact Statement was authorized by WRDA of 1990. Backfilling the 30-foot deep Canal 38 and restoring flow to over 25 miles of presently isolated river channel would restore an estimated 24,000 acres of floodplain wetlands and associated fish and wildlife resources. The project would also provide more natural seasonal flow to Lake Okeechobee.

Land acquisition necessary to restore the Kissimmee River in accordance with the Level II Backfilling Plan is nearly complete. Of a total project area of 62,628 acres, only 334 acres remain to be purchased.

The DOI recommends that the current scheduled completion date of 2011 be adhered to, as the completion of river restoration is not anticipated to disrupt restoration efforts to the south, provided the additional water is delivered to the remaining natural system in an uninterrupted seasonal flow pattern.

3. Modified Water Deliveries Project

This project has been in the planning stage for a number of years. Authorized by the Supplemental Appropriations Act of 1984, the purpose of the project is to improve the timing, quantity, and distribution of water delivered to Everglades National Park by redirecting water in the Water Conservation Areas to Shark River Slough according to a rain-driven schedule.

Now under the direction of the interagency Southern Everglades Restoration Alliance (SERA), the project is undergoing additional modifications and is subject to closer scrutiny due to its direct hydrological and structural connection with project components of the C&SF Restudy. For example, authorized structural modifications to the L-67A and L-67C levees for the Modified Water Deliveries Project by constructing gated culverts and spillways needs to be re-examined in light of the proposed series of notched weirs proposed for the C&SF Restudy. Additionally, passage of flow under the Tamiami Trail, critical for rehydrating northeast Shark River Slough, needs to be re-assessed to meet the restoration goals of the Initial Draft Plan of the C&SF Restudy.

4. C-111 Project

This authorized project has a lengthy planning history. Originally authorized as an addition to the C&SF Project by the Flood Control Act of 1962, the C-111 Project has been further modified by authorization of the ENP-South Dade Conveyance System in 1968 and the Everglades National Park Expansion Act of 1989. The purpose of the project is to restore natural values in the ENP and maintain flood protection within the C-111 basin east of the L-31N and C-111 canals. A Final Integrated Reevaluation Report/Environmental Impact Statement was completed in May 1994 and recommended a preferred alternative to meet these project purposes. The C-111 Project is also managed by SERA.

A significant assumption utilized in formulating the preferred alternative was that the volume of water entering the C-111 basin was not expected to increase. Additionally, it was recognized that the C&SF Restudy, Modified Water Deliveries Project, the SFWMD's Lower East Coast Water Supply Study, and on-going Everglades litigation would likely effect the operations in the C-111 basin in the future.

Similar to the Modified Waters Delivery Project, the C-111 Project is directly connected, hydrologically and structurally, to C&SF Restudy plans to restore Shark River Slough. Thus, the project features described for the C-111 Project will likely change as the C&SF Restudy is implemented. To avoid potentially removing structures and changing operational criteria for the C-111 Project as authorized, plans to implement the C-111 Project should reflect components (specific structural and operational features) described in the Initial Draft Plan for the C&SF Restudy.

DOI recommends that the identified project features of the C&SF Restudy be included in the C-111 Project and Modified Water Deliveries Project to ensure smooth integration of the two projects and to achieve maximum ecosystem restoration in the C-111 basin. Integrating these projects will require close coordination between the C&SF Restudy and SERA.

B. Water Preserve Areas

The Water Preserve Areas (WPAs) Feasibility Study, currently being conducted under the Central and Southern Florida (C&SF) Comprehensive Review Study, is developing a conceptual design for an interconnected series of marshlands, reservoirs, water treatment areas, and aquifer recharge basins. The objectives of the WPAs are to 1) hold more water in the natural system by reducing seepage losses from the Everglades; 2) capture, store, and treat stormwater currently lost to tide; 3) provide a buffer between the urban areas and the Everglades; and 4) protect and conserve wetlands and habitat values outside the Everglades. The WPAs are intended to provide additional regional storage to assist in meeting the future needs of all users - agriculture, urban, and the environment. Ecosystem restoration benefits that are anticipated include: improved water supply for restoring hydropatterns of the Everglades; improved water quality; and preservation of wetland habitat. The WPAs will be located on lands located along the eastern side of the Everglades Protection Area in western Palm Beach, Broward, and Dade counties.

Both the reconnaissance report which was completed in November 1994, and the project study plan which was completed in July 1995, for the Comprehensive Review Study of the C&SF, identified water preserve areas as a major element of the C&SF Restudy in the area between the Everglades and the Atlantic Ocean. The total area of the current study is 1,643,000 acres (2,567 square miles) which was subdivided into 2.5 acre grids for analysis (Water Preserve Areas: Land Suitability Analysis) (SFWMD 1997). The C&SF Restudy will initiate a separate Water Preserve Area Feasibility Study in the year 2000, leading to a Integrated Feasibility Report/EIS for the design and construction of this important project component.

1. Sequencing of Implementation. Before the full benefits of restoration of the Everglades can be attained, the WPA's must be operational. With the WPA's subject to a separate Feasibility Study, it is anticipated that the implementation of construction, subject to land acquisition efforts, of the estimated 43,492 acres of various water impoundments and new canals will be accelerated early in the next century. Implementation of the WPA plan should be timed to occur prior to, or at least concurrent with, the implementation of the other C&SF Restudy project features.

2. Land Acquisition. According to the 1997 Save Our Rivers report (SFWMD 1998), 66,400 acres of land are required to implement the conceptual design. Currently, approximately 10,627 acres have been purchased or are in public ownership, leaving 55,773 acres yet to be purchased. With continued development pressure in the western portions of Palm Beach, Broward and Dade counties, it is imperative that land acquisition be given a high priority to ensure the benefits of the WPA's are realized before the "window of opportunity" for land acquisition is foreclosed. Priority land acquisition areas, based on factors such as importance of location and the level of development potential, need to be identified. Land acquisition funding then needs be secured and these critical areas purchased.

3. Prioritizing Management of Fish and Wildlife Resources within the WPA's. Over the last 100 years, the marshes of the East Everglades have been systematically eliminated due to agricultural and urban development. Large acreage of short-hydroperiod marshes, critical to the life-cycle of many water birds when water levels in the WCAs are high, no longer exist. Exotic invasive species, particularly *Melaleuca* and Brazilian pepper, now occupy significant portions of the WPA's. It is essential that fish and wildlife resources be integrated into the planning for the management of the WPA's. Priority fish and wildlife planning objectives include: 1) devising an aggressive plan for the perpetual removal of invasive exotics (both plants and animals), 2) managing the WPA's to maximize short-hydroperiod marshes for foraging water birds, particularly during high water events in the WCAs, 3) designing project features to enhance fish and wildlife resources, such as vegetated buffer zones between developed and natural areas and creation of vegetated islands within the deeper impoundments for as refugia for nesting/foraging water birds and other wildlife, and 4) ensuring adequate water quality. Public access to the WPA's should be carefully planned to avoid and minimize sensitive nesting/breeding areas during critical periods.

C. Water Conservation Areas

1. Adaptive Management. The remaining Everglades are now contained in the Water Conservation Areas of central and southern Florida. Establishing the priorities for ecological restoration of this estimated five million acre area will be complex, and will be subject to the process of adaptive management. Adaptive management focuses on the importance of building upon the ability to learn about ecological systems and to incorporate new information into the restoration process. Hypotheses are formed, tested, and revised in a systematic way to produce the greatest amount of useful information which is utilized to guide future restoration efforts.

The adaptive management process entails four basic steps: 1) develop conceptual models (landscape-scale ecological models of south Florida have been developed), 2) develop causal hypotheses (hypotheses have been developed to define the sources of ecological problems and to identify management actions necessary to correct those problems), 3) develop a monitoring program (currently under development), and, 4) conduct adaptive assessments (compare actual ecological responses to the hypotheses, evaluate effectiveness and adjust restoration efforts as necessary).

The DOI recommends that the adaptive management process be formalized and that at each step in the restoration process, appropriate modeling/testing be conducted and adjustments to restoration be implemented. This process would ensure that the most available scientific information is integrated into restoration decision making.

2. Sequencing of Implementation. Sequencing the necessary actions to restore the WCAs will require linking hydrologic performance to ecological performance. Priority for implementation should focus on increasing water storage and reducing seepage. Three basic steps, conducted in the following order, would accomplish this:

a) <u>Optimize operation of existing infrastructure</u>: This would be the first step in improving hydrologic, and concurrently, ecologic performance. Establishing new operational criteria to begin returning hydrologic conditions to NSM targets inside the WCAs is the focus of this step;

b) <u>Construct and begin operating the necessary infrastructure outside the WCAs</u>: This important step, conducted concurrently with step 1, involves the construction of such features as the water preserve areas north of Lake Okeechobee and in the Caloosahatchee and St. Lucie basins to store water for restoration, the Storm Water Treatment Areas to the north of the WCAs to provide clean water and distribute water in a more historical manner, and the Water Preserve Areas of Palm Beach, Broward and Dade counties to reduce seepage to the coast and to provide flows to northeast Shark River Slough, the ASR facilities to store water for release during the dry season, and water re-use facilities to conserve water lost to the coast and returned to the natural system;

c) Decompartmentalize and construct/operate infrastructure inside the WCAs: This final step, which could be phased in near the end of step two, would build on the first two steps and would lead to fulfillment of established restoration goals. With seepage reduced and adequate water storage realized, the internal infrastructure of the WCAs and decompartmentalization could then proceed. Attention should be given to the fact that decompartmentalization will result in less control for managing water in the WCAs. Therefore, adequate storage and seepage control are essential before decompartmentalization begins in earnest.

D. Indian River Lagoon Feasibility Study

The Indian River Lagoon Feasibility Study is the second feasibility study to be authorized under the Comprehensive C&SF Restudy. The purpose of the study is to examine alternatives which address the water resource problems and needs within the C&SF project canal watersheds in Martin and St. Lucie counties. The three watersheds in the 1,160 square mile study area include the C-44 (St. Lucie Canal) and the C-23, C-24 and C-25 canal system. Currently, sixteen sites totaling 58,000 acres are under review as WPAs (COE 1996). Several flow-ways, designed to improve water quality, increase short-hydroperiod wetlands, and reduce sediment loading to the estuaries are also proposed.

The study will determine the feasibility of making structural and operational modifications to the C&SF project for environmental quality, water supply and other project purposes. The study is anticipated to conclude in 2001.

1. Implementation Timing and Priorities. Similar to the WPAs discussed above, it is critical to identify and purchase available land before opportunities are foreclosed. The DOI recommends that **siting WPAs and flow-ways and land acquisition**, in that order, be identified as the top priorities for the Indian River Lagoon Feasibility Study.

While the C-44, the primary discharge canal from Lake Okeechobee to the east coast of Florida, is hydrologically and structurally linked to Lake Okeechobee, the remaining WPAs are separable and can be constructed and operated independently from the remainder of C&SF Restudy components. Thus, the DOI recommends that the Indian River Feasibility Study proceed as scheduled and not be delayed until all C&SF Restudy component features are planned and/or implemented. The exception to this is the C-44 canal, which is tied to Lake Okeechobee regulation schedules. Until the Headwater Lakes Revitalization Project and Kissimmee River Restoration projects are implemented and additional flows (estimated at 100,000 acre-feet) are delivered to Lake Okeechobee, the final operation of WPAs in the C-44 basin will be difficult to finalize.

2. Sediment Removal. The SFWMD studied the feasibility of removing muck from the estuary to enhance fishery production and overall productivity in the estuary (SFWMD 1984). While this study identified the ecological benefits of muck removal, it recommended additional study and initiation of a muck removal demonstration project. On a larger scale, however, the St. Johns

River Water Management District (SJRWMD) is examining a similar muck removal program in the northern portions of the Indian River Lagoon. The DOI recommends that, in addition to studying a pilot muck removal demonstration project, a more holistic approach to muck removal, including both the SFWMD and SJRWMD and other agencies, be pursued. System-wide muck removal priorities and funding needs should be identified.

3. Environmental Considerations for Siting WPAs and Flow-ways. The DOI recommends that environmental considerations be included in the siting process. The principles of avoiding important habitats, expanding the spatial extent of wetlands, improving water quality and compensating for unavoidable habitat losses are important to keep in mind. These are summarized as follows:

a) Avoid Areas of High Habitat Value: These habitats, both wetland and upland, should be avoided to the maximum extent possible. Particular attention is needed for areas supporting threatened and endangered species. The DOI will implement the FWS Mitigation Policy (FWS 1981) to designate resource values and compensation needs during future planning;

b) Compensate for Unavoidable Habitat Losses: For those unavoidable habitat losses, a mitigation plan should be developed and appropriate measures incorporated to off-set those losses;

c) Implement Fish and Wildlife Enhancement Measures: As discussed in the Water Preserve Areas section above, the DOI recommends that fish and wildlife enhancement features such as water bird nesting islands, foraging sloughs, and deeper water fish refugia, vegetated buffer zones and water quality maintenance be factored into the WPAs and flow-ways. An exotic species removal program should also be included in these measures.

E. Southwest Florida Feasibility Study

For the southwest Florida region, the Restudy alternatives include components that will provide storage reservoirs in the Caloosahatchee River basin for capturing basin runoff and regulatory releases from Lake Okeechobee. While these facilities may provide improvements to this basin, additional water resource problems and opportunities exist for southwest Florida that, to date, have not been fully examined in the Restudy. The COE and SFWMD have proposed a separate feasibility study for southwest Florida as a part of the Comprehensive C&SF Restudy. In Fiscal Year 1999, a reconnaissance study will be initiated to identify water resource problems and opportunities, leading to the initiation of a full feasibility study in Fiscal Year 2000.

Several initiatives with public and private interests have formed to address the problems associated with the increasing development pressure being experienced in southwest Florida. Some of these include the Southwest Florida Project Coordination Team, Southwest Issues Group of the Governor's Commission for a Sustainable South Florida, Southwest Coast Ecosystem Management Team, Estero Bay Agency for Bay Management, Southern Golden Gate

Technical Committee, Big Cypress Basin Science Steering Committee, Southwest Focus Group and others. In addition, the COE is conducting a Programmatic EIS to address the cumulative effects of section 404 wetland permitting in the region. The DOI recommends that the feasibility study incorporate the findings of these types of initiatives in future planning efforts.

Most of southwest Florida lies outside the spatial extent of the South Florida Water Management Model (SFWMM) and the Natural System Model (NSM). The SFWMM covers the Big Cypress National Preserve and the southern fringing mangrove system east of State Road 29, but does not include most of Hendry County nor those portions of Lee and Collier counties west of State Road 29. The NSM has slightly broader coverage, including a larger part of Hendry County, but not the western portion of Lee and Collier counties. Existing hydrological models used by the SFWMD, Big Cypress Basin, and others primarily focus on stormwater management and are inadequate in providing essential information regarding how changes in the hydrologic regime will affect the ecosystem.

Because the existing models do not provide adequate coverage for southwest Florida, a Southwest Florida Water Management Model (SWFWMM) and expanded coverage of NSM should be developed (Figure XV-1). The models should be characterized by 1) a grid-based (spatially explicit) connected surface and surficial groundwater model that includes existing water control structures and 2) a corollary model without control structures that simulates the natural response of the system to rainfall. The model should be designed to seamlessly connect to both the SFWMM and NSM to minimize boundary effects and address boundary issues. As recommended in Chapter XX of this report, development of the new SWFWMM should integrate water quality modeling.

In the interim, there are a number of identified Critical Projects (CPs) and several Other Project Elements (OPEs) in southwest Florida that DOI recommends not be delayed pending completion of the feasibility study. In particular, the Southern Golden Gate Estates Hydrologic Restoration, a CP, would restore an estimated 100 square miles of over-drained habitat and would help stabilize base flows to the Ten Thousand Islands National Wildlife Refuge. This project and others should move forward as planned and be integrated into a larger restoration plan developed during the feasibility study.

1. Restoration Planning Objectives. The Working Group of the South Florida Ecosystem Restoration Task Force has identified the following restoration objectives for Southwest Florida. The DOI supports these objectives and recommends they be used to guide the feasibility study:

a) Restoration of more natural timing, distribution, and quantities of fresh water into the coastal estuaries;

b) Improvement to water quality by addressing point source and non-point source discharges;

c) Restoration of degraded habitat and minimization of further habitat loss;

d) Protect of floodplains from further development to minimize needs for additional drainage projects;

e) Improvement of aquifer recharge, and protection of ground water from pollutant loading and saltwater intrusion;

f) Promotion of best management practices for agriculture, development, local governments and the general public; and,

g) Protection, buffering and management of existing public lands.

2. Planning Priorities. The DOI provides the following recommended planning priorities for the Southwest Florida Feasibility Study:

a) Priority should be given to developing a comprehensive hydrologic model for southwest Florida to define regional restoration needs;

b) Identified CPs and OPEs should not be delayed by completion of the feasibility study; rather, these projects should move forward to derive more immediate ecological restoration benefits; and,

c) The feasibility study should integrate the best science-based knowledge from the initiatives described above, ecological experts, engineers, and others.

Successful watershed planning in southwest Florida would reduce the threat of additional fragmentation and compartmentalization and avoid a repetition of the impoundment of the remnant Everglades that has taken place to the east.

F. Uncertain Technologies

It is extremely important that, early in the Restudy planning process, technologies upon which the Restudy relies upon for implementation and ecological restoration be proven and demonstrated to work. Pilot studies and demonstration projects will be necessary to document with some level of confidence that uncertain technologies will meet DOI expectations.

1. Aquifer Storage and Recharge (ASR) ASR is an important water management component of the C&SF Restudy. Pumping water down deep wells into the underground aquifer during the wet season allows for water to be retrieved during the dry, high-demand periods. ASR can accelerate restoration by reducing dependency on the natural system during periods of drought, reduce peak flows to tide, manage saltwater intrusion, and generally restore more environmentally compatible water levels in the remaining Everglades.

Before ASR can be widely adopted, however, technical issues need to be resolved. There remain concerns about adequate characterization of the storage zones and confining layers, hydraulic characteristics of aquifers with test wells, uncertainty regarding recovery rates, water quality and regulatory issues, effects on subterranean invertebrates, and long-term effects of cycling water, to name a few.

The proposed ASR program for Lake Okeechobee involves over 200 ASR wells to store significant amounts of water to be used during the dry season. The results of a recent ASR test well in Okeechobee County was deemed inconclusive by some researchers, demonstrating the need for more rigorous testing of ASR feasibility.

The DOI, with the USGS as the lead, recommends that two major ASR initiatives be given priority:

a) Development of a regional hydrogeologic model to predict the areas of greatest potential for successful site-specific ASR feasibility projects based on information collected from regional hydrogeologic characterization of receiving waters and injection water sources; and

b) ASR pilot wells to test the injection rates and recovery rates of injected waters.

2. Water Reuse The need for water reuse has been subject to extensive debate by the C&SF Restudy Team. Reuse water (treated wastewater) has been modeled as the only means of meeting some of the ecological restoration goals (e.g. Biscayne Bay). Additionally, there is a general recognition that the more water that is reused, the more water there will be for restoration of the remaining system. Reuse, however, is expensive, and must be justified. The DOI continues to recommend that opportunities to wisely reuse water, particularly in Dade, Broward, and Palm Beach counties, be pursued in the C&SF Restudy.

G. South Miami-Dade County

1. Model Lands Acquisition The Model Lands, a body of wetlands in Miami-Dade County that form a wedge between Palm Drive on the north and US 1 on the west, have been identified by the county as eligible for the Environmentally Endangered Lands (EEL) Program. This area has been degraded by canals and exotic plants to varying degrees, but remains a significant feature in providing surface flow into Barnes and Card Sounds. Hydrologically these two bodies of water are upstream extensions of Biscayne Bay.

The EEL Program authorizes and funds willing seller purchases of private lands for environmental purposes, and Miami-Dade County has begun to purchase tracts in the Model Lands. A large segment of the Model Lands also constitutes a mitigation bank operated by Florida Power and Light. Once most of the private lands are purchased by the county, the combined acreage of EEL properties and the FP&L mitigation bank will offer outstanding opportunities for storing and redistributing surface water that flows into the coastal estuaries.

Progress on EEL purchases in the Model Lands has languished in recent years. If this program were accelerated, it could significantly enhance and complement Restudy efforts to achieve restoration goals.

Completing this land acquisition effort will make possible a range of restoration activities in concert with the Restudy, that will not otherwise be possible. The best scientific knowledge and the most effective scientific modeling will be meaningless without a land base upon which to apply them. This EEL project should be completed no later than 2003.

2. South Dade Wetlands Addition As with the Model Lands, the South Dade Wetlands Addition is a body of somewhat degraded wetland parcels eligible for purchase by the county under the Environmentally Endangered Lands program. These wetlands, interspersed with similar tracts that are already under county ownership, are largely west of Biscayne National Park and north of the Model Lands and form part of the Biscayne Bay drainage. Surface water flows from these lands into canals that discharge into the bay. These wetlands provide opportunities to store and distribute surface water that is vital to Biscayne Bay's estuarine restoration and, like the Model Lands, provide opportunities to enhance and complement Restudy objectives. This EEL project should be completed no later than 2003.

3. L-31-E Redistribution Project This project will add culverts and spreader canals to the L-31-E levee that now forms a barrier to sheetflow into Biscayne Bay. This project has been ranked high as a critical project for Corps of Engineers funding, but is not yet funded. Because it does not depend on land acquisition, this rare opportunity to replicate sheetflow directly into Biscayne Bay can be the first true restoration project to be completed in this drainage. It should be targeted for completion by 2002.

4. Study of Groundwater Discharge into Biscayne Bay The US Geological Survey is conducting a study to create a model of groundwater flows into Biscayne Bay. This study examines the significance of present groundwater flows into the bay and how those flows might be altered by changes in canal flows in the same area. Little is now known about groundwater flows into the bay, and a successful model will be able to answer questions that are fundamental to any effort to restore estuarine conditions. To ensure timely application, the model should be available by 2000.

5. Biscayne Bay Hydrodynamic Model This project is funded by the Corps of Engineers and involves Miami-Dade County and Biscayne National Park, is developing a circulation model for Biscayne Bay. It will be an essential tool in the effort to manage groundwater and surface water inflows to replicate pre-development estuarine conditions. Until this model is completed, decisions to alter freshwater delivery to the bay will continue to be based more on estimates of the consequences than on scientific evaluation. A second phase of this effort will examine water quality in the same area. As with the groundwater model, this circulation model should be ready to use by 2000.

The EEL Program authorizes and funds willing seller purchases of private lands for environmental purposes, and Miami-Dade County has begun to purchase tracts in the Model Lands. A large segment of the Model Lands also constitutes a mitigation bank operated by Florida Power and Light. Once most of the private lands are purchased by the county, the combined acreage of EEL properties and the FP&L mitigation bank will offer outstanding opportunities for storing and redistributing surface water that flows into the coastal estuaries.

Progress on EEL purchases in the Model Lands has languished in recent years. If this program were accelerated, it could significantly enhance and complement Restudy efforts to achieve restoration goals. Completing this land acquisition effort will make possible a range of restoration activities in concert with the Restudy, that will not otherwise be possible. The best scientific knowledge and the most effective scientific modeling will be meaningless without a land base upon which to apply them. This EEL project should be completed no later than 2003.

H. Lake Okeechobee

The COE is currently re-evaluating the regulation schedule for Lake Okeechobee. Three time frames are applicable for possible modification of the lake's regulation schedule. The meteorological forecasting described by Zhang and Trimble (1996) could be applied in any of these three phases, and the options available to modify the regulation schedule will be less constrained as water managers move through the three phases. The DOI recommends that immediate modification to the schedule should only be allowed if it can be demonstrated that no additional phosphorus loading to the Everglades Protection Area will occur. Compliance with the Everglades Settlement Agreement will restrict the options available to water managers until STAs 3 and 4 are brought on-line. A second phase of potential changes to the lake's regulation schedule will open up new possibilities once STAs 3 and 4 are operating, but will still be constrained by lack of water storage options outside of the lake. This will allow Lake Okeechobee to discharge more water to the Everglades Protection Area without violating the Settlement Agreement. The third phase will involve construction of the additional storage around the lake and the implementation of large-scale ASR around the lake, as projected in the Restudy's Initial Draft Plan. If fully implemented, this phase should culminate in the projected benefits to the lake's littoral zone.

I. Estuaries

Altered and unnatural flow situations in coastal waters have created a loss of historically abundant estuarine species such as red drum (*Sciaenops ocellata*), black drum (*Pogonias cromis*), and eastern oyster (*Crassostrea virginica*), the loss of juvenile fish habitat, and an increase in stress tolerant species such as the gulf toadfish (*Opsanus beta*) (Serafy *et al.*, 1997).
In addition to loss of species, many fishes in Biscayne Bay exhibit tumors and deformities, probably as a result of water and/or sediment quality factors. As discussed in Chapter V, fish with tumors, lesions, and scale and deformities have also been found in the St. Lucie River and estuary. The Restudy project design should benefit all the coastal receiving waters by providing the

quantity and quality of flow needed to support optimum quality habitat for wildlife, fish, and other aquatic resources.

1. Implementation Priorities A priority objective for coastal waters in the Restudy is to maintain adequate mean monthly flows in order to maintain favorable salinities and water quality conditions for estuarine organisms. This involves input of fresh water and nutrients into the systems in appropriate quantities and timing to support primary and secondary productivity. High volume discharge events such as those in the St. Lucie estuary, Lake Worth Lagoon, and Caloosahatchee estuary that damage aquatic environments should be eliminated.

With or without the Restudy, several projects should be accomplished to benefit coastal waters. A Critical Project proposed for Ten Mile Creek Water Preserve Area should be funded, planned, and implemented as soon as possible to provide protection for the St. Lucie estuary. Two Other Project Elements (OPEs) can immediately benefit Biscayne Bay and should be given priority: 1) South Dade Agriculture: Rural Land Use and Water Management Plan and 2) Biscayne Bay Coastal Wetlands.

Many concerns for the estuaries have to be addressed in the detailed design phase. The assumption made for Biscayne Bay has been that "re-use" water or tertiary treated domestic wastewater will be available and appropriate for use in this sensitive and valuable marine environment. Alternative sources of water other than "reuse" water and ASR well water should be identified and investigated as part of the detailed design process.

Additional flow is also needed through Shark River Slough to Florida Bay to reach NSM targets. In the Model Lands/C-111 Area, additional flow is needed to reach Joe Bay and Long Sound in Florida Bay. The water should be of appropriate quality and timed so as not to cause further perturbations in Florida Bay.

2. Further Environmental Considerations The DOI has two recommendations regarding the Miami River and the estuaries in southwest Florida. The Miami River is experiencing reduced flows; we recommend that if extra water is ever available in this area of the project, moderate flows should be sent down the Miami River to keep the water flushing out into Biscayne Bay, without transporting contaminated bottom sediments. For southwest estuaries, modeling of Restudy alternatives predicted better flows overall under Alternative D13 than under Alternative D13R. Flow dynamics need to be modeled in greater detail for the southwest coast to determine the cause of this apparent decrease in flow to this region.

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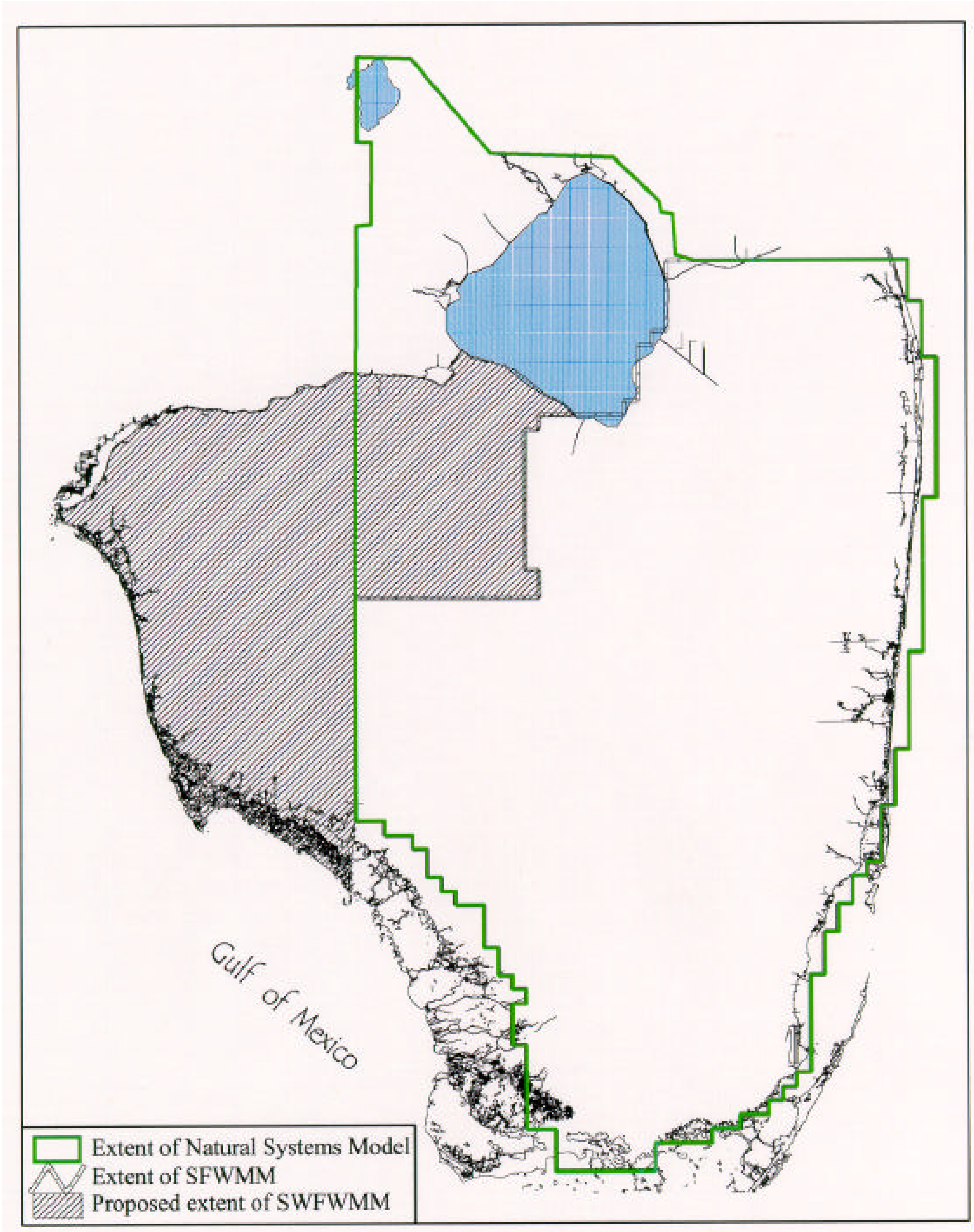

Figure XV-1. Proposed extent of the Southwest Florida Water Management Model, relative to the existing SFWMM and NSM.

CHAPTER XVI -- THREATENED AND ENDANGERED SPECIES

Heather McSharry and Robert Pace, FWS

Detailed findings and recommendations regarding the effects of the C&SF Restudy on Federally-listed threatened and endangered species are found in the Biological Opinion that accompanies this FWCA Report. This chapter provides a brief summary of those findings.

The Florida panther (*Felis concolor coryi*), red-cockaded woodpecker (*Picoides borealis*), Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), and five species of pine rockland plants in Dade County are not likely to be affected by the Restudy.

The bald eagle (*Haliaeetus leucocephalus*), Audubon's crested caracara (*Polyborus plancus audubonii*), eastern indigo snake (*Drymarchon corais couperi*), and the Florida scrub jay (*Aphelocoma coerulescens*) may be adversely affected by the Restudy, but we do not anticipate that the level of adverse effect will be likely to jeopardize the continued existence of any of these species.

The snail kite (*Rostrhamus sociabilis plumbeus*) would likely be slightly benefitted overall by the Restudy through improved quality in foraging habitat and a reduction in high water damage to nesting substrate. Although these beneficial effects would slightly improve the species' chances for recovery, it must be noted that recovery of the snail kite in Florida is considered to be more dependent on maintaining or expanding widespread suitable habitat in the Kissimmee Chain of Lakes and in the St. Johns marsh. The Kissimmee Chain of Lakes will not be significantly affected by the Restudy, and the St. Johns marsh is outside its geographic scope. Although the Restudy may provide moderate net gains in habitat quality for the snail kite, the proposed changes are not beneficial in all areas; some areas will likely be improved, while others will be degraded. Therefore, **sequencing of project elements** will be crucial in assuring that improved habitat quality is already available to offset anticipated losses in other areas. This will give the species time to adjust to the changing landscape with a low level of risk.

The wood stork (*Mycteria americana*) should be benefitted overall due to improved timing and volume of water flow that should substantially increase nesting success, particularly in the estuarine areas of Everglades National Park, adjacent to Florida Bay.

Higher water levels in the northeastern portion of the Cape Sable seaside sparrow's (*Ammodramus maritimus mirabilis*) range are expected to improve habitat quality through a reduction in the fire frequency and a reversal in the invasion of shrubs in an area that was previously more suitable habitat. The central population of the Cape Sable seaside sparrow near Mahogany Hammock is not likely to be affected by the Restudy. The crucial subpopulation west of Shark River Slough should be benefitted by the Restudy.

The Okeechobee gourd (*Cucurbita okeechobeensis okeechobeensis*), American crocodile (*Crocodylus acutus*), and West Indian manatee (*Trichechus manatus*) are expected to be greatly benefitted by the Restudy.

The Initial Draft Plan appears to be the most favorable overall to promote recovery of listed species.

Literature citations supporting these findings are available in the Biological Opinion.

CHAPTER XVII -- FISHING AND WILDLIFE - RELATED RECREATION

D. Timothy Towles, Florida Game and Fresh Water Fish Commission

A. Introduction

The C&SF Restudy encompasses a very large geographic area delimited by the South Florida Water Management District (SFWMD) boundary and includes a number of public properties that are managed by the Florida Game and Fresh Water Fish Commission (GFC) for their recreational value related to fish and wildlife. Those areas that are presently thought to be little affected, if at all, by the Initial Draft Plan (Alternative D13R), but which lie within the drainage basin, include six Type I wildlife management areas: Three Lakes Wildlife Management Area (WMA) and Kicco WMA in Osceola County, Arbuckle WMA in Polk County, Kissimmee River WMA in Highlands and Okeechobee counties, Fred C. Babcock/ Cecil M. Webb WMA in Charlotte County, and Frog Pond WMA in Dade County; and one Type II wildlife management area (Avon Park Air Force Base) in Polk and Okeechobee counties. Type I wildlife management areas are public hunting and recreation areas operated by the GFC in cooperation with private, State, and Federal landowners. Type II wildlife management areas are public hunting and recreation areas operated by the landowner in cooperation with the GFC. Those wildlife and (WEAs) that are presently not expected to be affected include the John G. and Susan H. Dupuis WEA in Palm Beach and Martin counties and the CREW WEA in Lee and Collier counties. Other areas managed by the GFC that are not expected to be influenced by the C&SF Restudy include the Lake Harbor and Terrytown Public Waterfowl Areas (PWA). However, the use of Terrytown as a Public Waterfowl Area may be temporary, because this area was acquired by the SFWMD for use as a stormwater treatment area as part of the Everglades Forever Act. The remaining wildlife management areas detailed in this report are the ones that we thought had the most potential for being affected if Alternative D13R were implemented.

A measure of the amount of recreational hunting in each of those wildlife management areas that are anticipated to change under the C&SF Restudy is portrayed in Table XVII-1. The level of monitoring for harvest pressure varies among wildlife management areas due to budgetary and staffing constraints, and to differences between areas in check station operation and amount of hunter use. For example, the highest 5-year mean (13,306 man-days) for harvest pressure recorded in the Everglades region was for the Big Cypress Wildlife Management Area (Big Cypress WMA) (Table XVII-1). Harvest pressure information for this area was derived from vehicle counts on Saturdays of every weekend during the 93 days comprising the archery, muzzle-loading, and general gun seasons. By contrast, harvest pressure data were not collected in the Holey Land and Rotenberger WMAs during portions of some hunting seasons. For instance, during the 1997-98 season, harvest pressure data were gathered only on the opening weekends of muzzle loading and general gun-walk seasons. Consequently, the 5-year mean figures for harvest pressure in the Holey Land (635 man-days) and Rotenberger (766 man-days) WMAs should be viewed as minimal estimates of harvest pressure that are not directly comparable to areas such as the Big Cypress WMA, where the hunting pressure is more consistently measured.

B. Everglades and Francis S. Taylor Wildlife Management Area

The Everglades Wildlife Management Area (EWMA) is a Type I wildlife management area located in southwestern Palm Beach, western Broward, and northwestern Dade counties, Florida. The EWMA consists of Water Conservation Areas (WCAs) 2 and 3 and encompasses approximately 671,831 acres (Figure XVII-1). Different hydrological regimes exist due to the division of WCA 2 into two compartments forming WCA 2A and WCA 2B, and the division of WCA 3 into two compartments forming WCA 3A and WCA 3B (Francis S. Taylor Wildlife Management Area). Consequently, wildlife populations and associated recreational opportunities vary considerably between these compartments, necessitating the implementation of an array of management strategies that also varies with regional weather patterns. The principal landowners of the EWMA are the South Florida Water Management District (SFWMD) and the State of Florida's Board of Trustees, with the remainder owned by other public agencies and private individuals. Water Conservation Areas 2 and 3 were designated as the EWMA in 1952 and are operated by the GFC under the terms of a cooperative management agreement with the SFWMD.

The Everglades WMA has traditionally been used by the public for a variety of recreational activities including hunting, fishing, frogging, airboating, camping, and nature appreciation. Utilization of the interior marsh is limited due to physical constraints and lack of access. Airboats are the primary mode of transportation into the marsh when surface water is present, whereas all-terrain vehicles (ATVs), tracked vehicles, and swamp buggies are used to access the area when water levels recede below ground.

Several other recreation areas are located along the boundary of the EWMA: Loxahatchee Recreation Area, Sawgrass Recreation Area, Everglades Holiday Park, and Mac's Fish Camp. These facilities, along with several others operated by the Miccosukee Indians on the Tamiami Trail, provide amenities such as boat ramps, camping facilities, boat rentals, airboat tours, fishing guides, bait and tackle supplies, and food to the general public. During 1997, commercial airboat tours out of Everglades Holiday Park transported 116,306 tourists into nearby Everglades canals and marsh.

Frogging is permitted throughout the year. This is a favorite past-time of many airboaters. Although frogging occurs throughout the EWMA, the portion of WCA 3A south of Alligator Alley has traditionally harbored the best frog populations and consequently has received the most use (GFC 1960).

Hunting for selected game species is allowed during the fall-winter period. However, check stations erected to monitor harvest pressure and collect biological information are only operated during the fall deer season. Consequently, there is no information for hunting pressure on other game species. The mean time spent on deer hunting in the EWMA, based on the five-year period of 1989-93, was 1,984 man-days (Table XVII-1). However, this level of hunting pressure is exceptionally low for the EWMA due to the unprecedented high water event of 1994-95 that nearly eliminated the area's deer herd and necessitated the complete closure of the deer season for three years (Table XVII-1). Other game often sought by hunters in the EWMA, when hydrological conditions are favorable, include waterfowl, snipe, and wild hogs.

The canal system of the EWMA also supports a very popular sport fishery, with fishing permitted throughout the year. Two of the areas that have traditionally supported some of the best fishing and consequently have been monitored by the GFC's Everglades fisheries program through creel surveys are the L-35B/ L-38E canals and the L-67A Canal. Creel survey data collected for the five-year period of 1985-89 in the L-35B/L-38E canals estimated a fishing effort ranging from 55,659 hours in 1985-86 to 128,430 hours in 1986-87, with an annual mean of 81,665 hours (Table XVII-2). A five-year mean total of 79,755 fish were harvested, with a harvest success rate of 0.91 fish per hour (Table XVII- 2). Any body of water in Florida that maintains a harvest success rate of at least 0.5 bass per hour is considered to be a quality fishery (GFC 1998c). A no-consumption advisory is in effect for bass due to high levels of mercury in the EWMA. Consequently, anglers routinely release their fish, which has resulted in high populations of 2- to 5-pound bass (J. Fury, GFC, personal communication 1998).

Fishing effort in the L-67A Canal for the seven-year period of 1990-97 ranged from 25,848 hours in 1992-93 to 58,150 hours in 1995-96, with an annual mean of 43,167 hours. The seven-year mean total recorded harvest was reported to be 41,765 fish, with a mean success rate of 0.98 fish per hour. The results from these creel surveys are derived from a six-month sampling period during each of the years, so these data do not include fishing effort expended during the remainder of those years. Although creel surveys were discontinued for the L-35B/L-38E in 1990, observations by fisheries personnel indicated that the fishing effort in this canal system appeared to be comparable to that expended for the L-67A for the time period of 1992-97. High water levels in the EWMA since 1993, however, have contributed to below-normal fishing effort due to the dispersion of fish into the adjoining marsh, resulting in lower catch rates. It should also be noted that even though the year 1995-96 experienced the highest amount of fishing effort in the L-67A canal over the past seven years (Table XVII-2), access was greatly curtailed due to the closure of the boat ramps at the primary access site of Everglades Holiday Park for about three months and the closure of the canal itself for about one month.

Although these two canal systems represent no more than 16% (assuming a total of 330 miles) of the total canal mileage within the EWMA, they receive a disproportionate amount of the fishing pressure from boats. Due to staffing and budgetary constraints, no recent creel survey data have been collected for the rest of the canal system within the EWMA. There is also a considerable amount of bank fishing in the canals adjacent to State Road 27, I-75, and the Tamiami Trail.

Due to the institution of slot possession limits on largemouth bass in 1996, it became necessary to issue regulation exemption permits for bass tournament participants. Outside of Lake Okeechobee, the canal system within the EWMA has proven to be the most popular location for holding bass tournaments. There are approximately 65 fishing clubs in the Everglades region, many of which periodically host tournaments. In fiscal year 1996-97, 91 of the 116 bass tournaments (78%) in the Everglades region (excluding Lake Okeechobee) were held in the EWMA. During that year, 3,202 participants landed 5,061 bass, with a combined weight of

13,906 pounds. Thirty-seven of these bass caught in WCA 3A weighed more than 8 pounds, and the largest weighed almost 10 pounds. During fiscal year 1997-98, 117 of the 180 bass tournaments (65%) in the Everglades region (excluding Lake Okeechobee) were conducted within the canal system of the EWMA. In that fiscal year, 4,312 anglers landed 6,759 bass, with a combined weight of 16,920 pounds. Of these bass, 54 caught in WCA 3A weighed more than 8 pounds, and the largest weighed in at nearly 11 pounds. It is estimated that approximately 95% of the WCA 3A tournaments originate at Everglades Holiday Park, with most of the fishing pressure concentrated in the L-67A canal (J. Fury, GFC, personal communication 1998).

There are currently more than 65 privately constructed camps scattered throughout the EWMA. These camps consist of permanent buildings constructed by private individuals on tree islands or on pilings over the water. These camps are primarily used as weekend retreats and hunting camps.

C. Holey Land Wildlife Management Area

The Holey Land Wildlife Management Area is a tract of Everglades marsh encompassing approximately 35,350 acres in the southwest corner of Palm Beach County (Figure XVII-1). Title to this tract is held by the State of Florida's Trustees of the Internal Improvement Trust Fund, and the area is leased to the GFC for fish and wildlife management purposes.

The Holey Land WMA was a popular deer hunting area prior to its rehydration under the Holey Land Restoration Project. Since hydrological restoration was begun in 1991, the Holey Land WMA has undergone a transition in recreational use that has been more strongly oriented towards fishing in the perimeter canal and waterfowl hunting (GFC 1997g). Recreational access to the marsh areas may be achieved by airboat, ATVs, or tracked vehicles. Vehicle use is permitted in the Holey Land WMA from May 1 to the end of the duck season, except during specified big game hunts when further restrictions apply. Tracked vehicle deer hunts may be conducted under appropriate hydrological conditions if deer population indices indicate a sufficient population level.

The hunting pressure on the Holey Land WMA has ranged from 214 to 972 man-days during the time period extending from the 1993-94 through the 1997-98 seasons (Table XVII-1). However, due to a severe reduction in the deer herd as a result of the higher water regulation schedule adopted for the Holey Land WMA and above-average amounts of rainfall, the gun-vehicle hunt season was closed from the 1993-94 through the 1996-97 seasons. Also, only the archery season was open during the 1994-95 season. Consequently, the annual mean hunting effort for the years 1993-98 in the Holey Land WMA, using only the figures for those hunts that were open each season, was calculated to be 635 man-days.

Although waterfowl hunting has become popular in the Holey Land WMA since hydroperiod restoration began in 1991, no data on duck hunter use was collected until the 1996-97 season. During that season, a minimum of 266 man-days of hunting pressure were estimated for duck hunters, which surpassed the minimum estimate of 156 man-days expended by deer hunters during that season. During the 1997-98 season, man-days attributed to hunting in Holey Land were 392, with a reported harvest of 382 ducks and two deer. Although frogging is permitted in the Holey Land WMA, the hydrological regime and vegetative structure is not conducive to an exploitable frog population; the area therefore receives little pressure from recreational froggers (B. Sasse, GFC, personal communication 1998).

No creel surveys have been conducted in the Holey Land WMA by the GFC's Fishery Division; however, an attempt was made in 1996 by Division of Wildlife personnel to estimate fishing pressure by counting vehicles at boat ramps whenever they visited the management area. Fishing pressure was estimated to be 5,054 angler-days in 1996, with the majority of fishermen using the G-200 and G-201 boat ramps. From this survey, it was concluded that fishing had apparently become the primary recreational use in the Holey Land WMA(GFC 1997g).

D. Rotenberger Wildlife Management Area

The Rotenberger Wildlife Management Area is a tract of Everglades marsh comprising approximately 27,810 acres in the southwest corner of Palm Beach County, bordered to the east by the Miami Canal and to the south by WCA 3A (Figure XVII-1). The area is owned by the State of Florida under fee-simple title to the Trustees of the Internal Improvement Trust Fund and leased to the GFC for fish and wildlife management purposes (GFC 1997e).

The primary public use of the Rotenberger WMA has been deer hunting. Other game commonly sought include wild hogs and snipe. Although frogging and fishing are also permitted, these resources are in limited supply due to the short hydroperiods that presently exist in the area (GFC 1997e). Recreational access to the area can be achieved by ATVs, airboats, swamp buggies, or tracked vehicles during designated times of the year (May 1 to the end of the waterfowl season) when hydrological conditions are appropriate for each particular mode of transportation.

The hunting pressure on the Rotenberger WMA has ranged from 106 man-days during the 1994-95 deer hunting season to 946 man-days during the 1996-97 season. The low hunting pressure during 1994-95 could be attributed to the combined effects of extremely high water levels in the adjacent EWMA, a low deer population index, and the closure of all big game seasons except the archery season. The mean hunting effort for the five-year period from 1991-96 was reported as 766 man-days, using only those figures for the hunts that were open during that particular season (GFC 1998b).

E. Big Cypress National Preserve

The federally owned Big Cypress Wildlife Management Area comprises approximately 565,848 acres in northwestern Dade, eastern Collier, and northwestern Monroe counties (Figure XVII-1) with the game animal populations managed by the GFC under a cooperative agreement with the Big Cypress National Preserve (BICY).

Due to the great diversity of both upland and wetland habitats in the BICY, a wide array of game species are harvested from the area. A significant amount of the hunting pressure within the Big Cypress WMA takes place in the Corn Dance, Loop Road, and Stairsteps units, which, since 1991, have together accounted for almost half of the total hunting pressure during those years when all units are open to hunting (Table XVII-3). Due to the high level of interest in the big game general gun hunting season, this hunt is regulated by a weekly quota that has been consistently reached during the past six years for the Corn Dance and Loop Road units, but not in the Stairsteps unit (E. White, GFC, personal communication 1998). The number of permits allocated to the Stairsteps unit, however, is also usually three to four times the number issued to either the Corn Dance or Loop Road units. Although deer and hog hunting constitutes a significant component of recreation in the BICY (Jansen 1986), wild turkey, waterfowl, and small game (including doves, snipe, quail, marsh rabbits, grey squirrels, and racoons) provide additional recreational opportunities. Fishing is a popular activity in the canals accompanying roadways through the Big Cypress WMA (U.S. 41, SR 94, and Turner River Road) (J. Schortemeyer, GFC, personal communication 1998) although the use of outboard motor boats is limited due to the narrowness and generally densely vegetated nature of the canals (Duever *et. al* 1986). Most frogging activity occurs in the wet prairie and dwarf cypress forest habitats in the Stairsteps unit south of US 41 (Duever *et. al* 1986).

There are several established seasons for different user groups for the harvest of deer and wild hogs. These include a 30-day archery season extending from early September until early October that has been in effect since 1990, a 16-day muzzle-loading gun season in the latter half of October, and a 47- to 51-day general gun season extending from mid-November through the first of January (GFC 1997b). Access to the interior of the preserve is attained by the use of wheeled swamp buggies, all-terrain vehicles, and airboats, depending on hydrological conditions and the regulations for a particular management unit. Wheeled swamp buggies are the most commonly employed mode of transportation in most of the Big Cypress WMA, including the Corn Dance unit. On the other hand, airboats are the preferred type of transportation into the Everglades type habitats of the Stairsteps unit (Duever *et. al* 1986).

F. Southern Glades Wildlife and Environmental Area

The Southern Glades Wildlife and Environmental Area (WEA) consists of 30,080 acres of Everglades marsh in southeastern Dade County that is bisected by the C-111 and C-109 canals and associated levees (Figure XVII-1). Most of the area was acquired by the SFWMD through the Save Our Rivers program (although small private in holdings are present), with the GFC given the responsibility of managing the fish and wildlife resources of the area. The Southern Glades WEA is divided into four management units. Unit 1 is that portion of the area lying west and south of the C-111 canal; unit 2 is that portion of the area located between the C-111 canal and the C-110 canal; unit 3 is that portion of the area located between the C-110 canal and the C-109 canal north of the C-111 canal; and unit 4 is that portion of the area north of the C-111 canal that is located between the C-109 canal and highway U.S. 1. All motorized vehicles are prohibited, except airboats in units 1 and 4 from December through March 1 and outboard motor boats within the canals.

Fishing, primarily within the C-111 canal, is the primary recreational use within the Southern Glades WEA. A public use survey conducted from September through November 1997 revealed weekend use by the public that averaged 7 people per day (GFC 1997h). Fishing was shown to be the most common use, followed by sightseeing, hunting, and biking. A foot trail has been established along the area's levees, and horse gates have been installed to improve access for equestrian groups to the trail system.

Fishing is permitted throughout the year within the Southern Glades WEA, while frogging is restricted to the period of December 1 through March 1. An annual deer season is open 30 days from early September through early October for archery hunters; 3 days in mid-October for muzzle-loaders, and approximately 35 days from late October to late November for general gun hunting participants. Due to low deer populations and limited access, however, hunter participation has been low (Table XVII-1). Waterfowl hunting is limited because of low densities and wide year-to-year variation in the local populations (GFC 1997f).

G. J. W. Corbett Wildlife Management Area

The J.W. Corbett Wildlife Management Area, a Type I wildlife management area located northwest of West Palm Beach (Figure XVII-1), comprises only 60,224 acres but receives a disproportionately high amount of recreational use for the Everglades region. Most popular among hunters is the big game season, which consists of an archery season that begins the end of August and lasts for about 22 days, followed by a muzzleloading gun season that lasts for about 16 days, and a general gun season that extends from early November into early January. Although deer and wild hogs are the favored big game species, the Corbett WMA possesses a relatively good mixture of habitat types that support a wide array of other game species. The Corbett WMA is one of the most popular management areas in the Everglades region for snipe hunting (GFC Florida wildlife management area harvest data report, 1997). Other game sought on the Corbett WMA include grey squirrels, wild turkeys, puddle ducks, bobwhite quail, rabbits, and racoons. Since low flatwoods swamp is poor habitat for terrestrial species, populations of upland species like wild turkeys, bobwhite quail, and grey squirrels are low; consequently, hunting pressure on these species is also low (GFC 1997c). During the racoon night-hunting season, racoons may be pursued with dogs for about 40 days as part of the winter small game season. Fishing and frogging are permitted throughout the year. Due to the seasonal nature of most natural ponds on Corbett WMA, fishing is limited to drainage canals, some of the deeper marshes, and six ponds excavated for fishing.

Access to hunting areas in the Corbett WMA is attained most commonly by swamp buggies and ATVs. Vehicular recreational access is also allowed on designated grades from late April through mid-August. Tracked vehicles, airboats, motorcycles, and ATVs having a wheelbase less than 60 inches are not permitted in the management area at any time. Primitive camping is allowed at designated campsites both during the big game season and on weekends following the end of the general gun season.

The Corbett WMA provides other nature-oriented recreational opportunities such as bird watching, horseback riding, hiking, and nature study (GFC 1997c). The Hungryland boardwalk and self-interpretive nature trail is used by those who wish to become better educated about the natural history of the area. Those hiking the Florida Trail also pass through the Corbett WMA. Prior to fiscal year 1997-98, there was no way to track use of the Corbett WMA by users in the non-hunting season. However, with the institution of a daily use permit in July of 1997, the area has been estimated to receive on average about 30 to 40 people per week. Most of these users are reported to be interested in either observing or photographing wildlife (J. Schuette, GFC, personal communication 1998).

Although the John G. and Susan H. Dupuis Jr. Wildlife and Environmental Area lies to the west of the Corbett WMA within the L-8 basin, no impacts on recreation have been predicted for the Restudy at this time and no analyses were conducted in this area.

H. Lake Okeechobee

Lake Okeechobee is nationally recognized as supporting high quality largemouth bass and black crappie fisheries (Bell 1987). For the four-year period from the 1992-93 creel survey period through the 1995-96 period, creel estimates of fishing effort ranged from 742,347 angler hours in 1992-93 to 1,003,508 hours of effort in 1995-96 (Table XVII-4). This estimate equates to an annual mean fishing effort of 879,616 hours for this four-year period. Creel surveys were conducted each year during the peak six-month period extending from December through May. During that four-year period, the black crappie fishery received the most use, with an annual mean creel estimate of fishing effort of 510,403 hours, followed by largemouth bass with 312,722 hours, and bream with 56,492 hours. It should be noted that these creel survey data are based on four high use areas, with each area covering approximately 20,000 acres, for a total creel survey area of 80,000 acres. This creel survey area thus amounts to only about 10% of the areal extent of the lake; but it is estimated that these areas receive approximately 70% of the fishing pressure on the lake (D. Fox, GFC, personal communication 1998). If the summer-fall months were included, the estimated annual fishing effort would undoubtedly be greater. Bell (1987) used creel survey data collected during the summer-fall period in the late 1970s, and found the low-season fishing pressure to constitute approximately 23.8 % of the total annual fishing effort. Assuming that this relationship has continued until the present, the four-year period from 1992 to 1996 would have had an annual mean fishing effort totaling 1,088,965 hours.

Bass fishing tournaments have become very popular events on the lake, but prior to 1996, no permitting system existed for conducting bass tournaments on Lake Okeechobee, and consequently, no monitoring of this activity occurred. Between April 1996 and March 1997, a total of 520 bass tournaments consisting of 28,128 anglers were permitted through the GFC's Division of Fisheries. These anglers caught 25,164 bass, yielding a total weight of 55,486 pounds, with an average weight of 2.2 lb/ fish. Between April 1997 and March 1998, a total of 484 bass tournaments were held on Lake Okeechobee consisting of 33,021 anglers. Angler success during these two years was considered to be low due to extremely high water levels that reduced fish vulnerability to capture (D. Fox, GFC, personal communication 1998).

Pleasure boating (including airboats) on Lake Okeechobee is also a popular activity. As of 1987, there were 18 marinas on Lake Okeechobee supplying a total of 705 wet slips and 315 dry slips. Boat access to the lake is achieved through the use of 40 boat ramps with 65 lanes (Bell 1987). In addition to recreational fishing and boating, Lake Okeechobee serves as a popular duck hunting and frogging area.

Lake Okeechobee is probably the most important freshwater recreational fishery in the state of Florida, with an asset value assessed at nearly $100 million in 1987 dollars and an annual economic impact of approximately $28 million (Bell 1987). It was also estimated that tourists spend $65.51 (1986 dollars) per fishing day, compared to $24.23 for residents of Lake Okeechobee counties, on largemouth bass fishing (Bell 1987).

The lake is divided into four alligator management units, and a set number of alligator harvest permits, based on annual alligator population survey data, are issued for the lake each year. Interest in the alligator harvest program remains high and, statewide, only about 5% of the applicants are randomly selected to participate each year. During the most recent alligator harvest in 1997, 1,256 permits were issued to 251 participants, resulting in the harvest of 981 alligators on Lake Okeechobee (Table XVII-5). The number of alligator harvest permits issued for Lake Okeechobee in 1997 accounted for approximately 40% of the permits issued for the entire state of Florida. The only other public body of water in the Everglades region where regulated alligator harvests still occur is on Lake Trafford, a relatively small lake located near Immokalee. This lake has had a rather modest annual harvest quota ranging from 30 to 70 permits over the last five years (Table XVII-5).

I. Waterfowl Hunting in the C&SF Project Area

Waterfowl hunting is an important outdoor recreational activity in central and southern Florida with a significant economic impact. A Midwinter Waterfowl Inventory is conducted by the GFC. Data from the years 1994-1997 were included in this report for those survey routes within the scope of the C&SF Restudy that were consistently covered in those years (Table XVII-5; Figure XVII-2). Although these data should not be interpreted as representing a comprehensive count of waterfowl in central and southern Florida, they provide useful comparisons of the relative abundance of different species (or groups of species) in a particular area and their relative abundance among areas. The data could also be used to identify inter-annual variability in waterfowl abundance, and if consistently surveyed and analyzed over many years, might indicate long-term trends. The most abundant species found on the surveys were the American coot (*Fulica americana*); ringnecked duck (*Aythya collaris*); either blue-winged (*Anas discors*) or cinnamon (*Anas cyanoptera*) teal, which were counted together; and mottled duck (*Anas fulvigula*). The survey routes with the highest total waterfowl counts, averaged over the four years, were, in order of decreasing abundance: Lake Okeechobee, Lake Weohyakapka, Lake Hatchineha, Lake Istokpoga, and Fisheating Bay in Lake Okeechobee.

Migratory bird hunting stamp sales data (Table XVII-6) and harvest data (Table XVII-7) for counties within the scope of the Restudy were obtained from the Office of Migratory Bird

Management, Laurel, Maryland. These data demonstrate the economic importance of waterfowl hunting in central and southern Florida.

J. Potential Impacts of the Interim Draft Plan (D13R) on Recreation

1. Everglades Wildlife Management Area

The unauthorized construction and augmentation of camps on tree islands in WCAs 2 and 3 has been a controversial issue almost since the inception of the original C&SF Project in 1949 (GFC 1958). Prior to the construction of the eastern perimeter levees, hydroperiods were relatively short, airboat access to interior portions of much of the Everglades was limited primarily to the rainy season, and no camps were present. Wetter conditions following levee construction led to longer periods of accessibility by airboat, and camps started to appear in the EWMA in the mid-1950s, with more than 20 camps by 1958 (Wallace 1958). Similarly, there has been a resurgence of new camp construction on tree islands over the last five relatively wet years (1993-97). Under Alternative D13R, WCA 3B and northern WCA 3A will be wet for a greater proportion of the year; thus airboat access would probably be increased in these areas. The increased accessability of tree islands in this area may lead to an increase in privately constructed camps. Although the construction of permanent structures is prohibited in all wildlife management and environmental areas in the Everglades region, the continued erection of hunting camp structures in the EWMA remains a problematic issue.

Although airboat activity may increase as a result of the longer hydroperiods predicted by Alternative D13R, the use of vehicles that require relatively little or no surface water for operation (tracks, swamp buggies, ATVs, etc) would be expected to decline. The use of tracked vehicles in the Everglades appears to be steadily declining due to the high maintenance requirements of these vehicles; a decline in operator opportunities to use them for hunting because of higher water levels in recent years; and lower deer densities, which in turn resulted in the closure of the area to vehicle hunting seasons. During the 1997-98 hunting season on Rotenberger WMA, only 64 track permits were issued, with 50 tracked vehicles reportedly participating in the hunt (B. Sasse, GFC, personal communication 1998). Information derived from hunter questionnaires revealed that an average of 4 hunters occupied a track on any one occasion (GFC 1998a). In the last big track hunt that occurred in WCA 3A north of I-75 in 1990, 109 track permits were issued. The number of tracks for which hunting applications have been submitted in the Everglades during the past six years has ranged from as few as 83 in 1996 to as many as 165 in 1992 (E. White, GFC, personal communication 1998). It is evident, however, that not all track owners have decided to participate in the vehicle hunts during recent years, perhaps because of limited opportunities due to the continued closure of the northern part of WCA 3A to track hunting because of depressed deer population levels. During the 1996-97 season, only 83 of the 123 tracks that had their tags renewed applied for a hunting permit. At present, it has been estimated that probably no more than 100 to 200 tracked vehicles (although many are in various stages of disrepair) remain in south Florida (B. Sasse, GFC, personal communication 1998). The number of tracks has probably dwindled even more, because the track hunting season has remained closed in WCA 3A since 1994, and in Holey Land WMA from 1993 through 1996.

Although tracked vehicle use may continue to decline, hydrological conditions in Holey Land WMA and Rotenberger WMA, and perhaps the northern portion of WCA 3A in drier years would probably still be suitable for tracked vehicle operation. The use of swamp buggies is currently minimal on Everglades mucky soils, and would likely disappear altogether under the elevated water table proposed under the 2050 Base (which assumes that the Everglades Forever Act and Modified Water Deliveries to Everglades National Park are fully implemented). Thus, the use of swamp buggies is not expected to be affected under the Initial Draft Plan.

The adoption of Alternative D13R would result in a very large decline in the mileage of canals available to fishermen. The decrease in canal mileage as modeled in the SFWMM was 19 miles for the 2050 Base, but with the increased decompartmentalization under Alternative D13R, an additional 127 miles of canals would be backfilled. Although many of these canals may not be easily accessible with an outboard motorboat, or provide exceptionally good fishing opportunities, other more accessible canals do receive a considerable amount of fishing pressure. This projected decline in the mileage of canals available to fishermen will most definitely have an impact on recreational fisheries in south Florida. However, the planned addition of 6,977 acres of water preserve areas with maximum water depths of 4 feet; 9,700 acres of above-ground water storage areas with variable depths in the Lakebelt region; and a 1,600-acre stormwater treatment area of an unspecified depth in Broward and Dade and counties may offer some potential for the development of new fisheries resources in this region.

Of particular concern is the L-67A canal. Alternative D13R proposes to backfill approximately six miles of the southern end of this canal. The “three pines” area, located near the proposed end of the canal, has been a particularly productive fishing spot, and may be eliminated if this portion of the canal is backfilled. In general, the southern half of the L-67A canal receives the most fishing pressure, probably due in part to the prolonged hydroperiod in the southern portion of WCA 3A (J. Fury, GFC, personal communication 1998) Although access to the remaining portion of the L-67A canal would be reduced due to a loss of access from the Tamiami Trail, this effect may not be so pronounced. Due to a lack of security at the somewhat isolated boat ramp on the L-67 canal off the Tamiami Trail, most fishermen prefer to launch from Holiday Park, at the northern end of the L-67A canal, and motor south to their favorite fishing holes. Information gathered by GFC from creel surveys on the L-67A canal during 1991-97 found that 75% of those anglers interviewed launched their boat at Holiday Park with the remaining 25% launching their boat at the southern end of the L-67A levee (J. Fury, GFC, personal communication 1998). Regardless of what access problems may exist, modeled hydrological conditions for the WCA 3A marsh adjacent to the L-67A canal predict somewhat lower mean water depths than would exist under the 2050 Base and considerably lower mean depths (more than 1 ft lower) than would occur under the 1995 Base. Consequently, the areal extent and duration of water depths in WCA 3A sufficient to maintain a productive marsh/canal bass fishery are expected to decline dramatically with implementation of the Modified Water Deliveries Project in the 2050 Base, and even further under Alternative D13R. At this time, it is not clear how the weir design and operations across the L-67A levee will affect the fishery in the L-67A canal.

The L-67C canal, although not as popular a fishing area as the L-67A canal, also receives fishing pressure, especially when marsh water levels recede during the dry season. A count of the boat trailers parked at the L-67C boat ramp during the 6-month period extending from December 1996 through May 1997 yielded a total count of 2,900 boats using this canal, with an average of two persons per boat (J. Fury, GFC, personal communication 1998). This canal would be backfilled entirely in Alternative D13R, and this fishery would be lost as well.

Under Alternative D13R, the areal extent of upland refugia in the form of tree islands and levees is expected to decline in WCA 3B. The removal of the entire length of the L-67C levee and portions of the L-67A levee would significantly reduce the areal extent of existing high elevation habitats in this portion of the Everglades. Such habitats in the current remnant Everglades, where suitable upland refugia have been lost to development east of the L-30 levee and to devastating muck fires in the northern portion of WCA 3A and in WCA 2, have high wildlife value and function. For example, following the recent high water episode of 1994-95 in WCA 3B, the deer population was essentially eliminated from the marsh interior, with the only known survivors persisting on the levee system. The L-67C was one of the most used levees by deer seeking relief from high water levels, which may have been due in part to the movement of deer to the northwest along the natural elevation gradient and to the relatively close proximity of several "low" elevation tree islands that were vacated when submergence occurred. The L-67C also serves as a corridor for expediting deer immigration from the levee back to tree island habitats following water level recession in the area.

Due to increased water levels in WCA 3B, recreational opportunities in terms of huntable deer populations is likely to decline in this area, where tree islands occur at lower densities and many are at relatively low elevations. Conversely, the areal extent and duration of emergence of tree islands above ambient water levels is expected to increase in the southern portion of WCA 3A upon the removal of the impounding effects of the L-28, L-29, and partial removal of the L-67 levees, and this situation would allow a relatively large number of tree islands to remain above ambient water levels for much longer periods of time. The greater density of tree islands in southern WCA 3A and a considerable reduction in the length of time that slough water levels remain above 30 inches deep in Alternative D13R may permit a more stable environment for upland game animals. Hence, deer hunting opportunities should improve in the southern portion of WCA 3A. Although the removal of the L-28 levee would result in the loss of dry habitat that has served as relief for deer and other upland-dependent wildlife in the past, lower water levels and reduction in prolonged high water events predicted by Alternative D13R would make this levee less critical as an upland refugium. In addition, the removal of the L-28 levee and its associated borrow canal will help to recreate the natural hydrological gradient based on the region's topography and allow longer periods of time for deer to move "upslope" to areas of higher elevation in the Big Cypress WMA during times of rising water.

The removal of the L-29 levee and canal by Alternative D13R could have negative impacts on recreational access into WCA 3A and WCA 3B from U.S. 41, since the roadway would have to be elevated in some way. Three public boat ramps provide airboat access into WCA 3B, and three public boat ramps provide airboat and jon boat access into the L-29 canal and the WCA 3A.

marsh. One of the boat ramps for WCA 3B also provides jon boat access into the L-67C canal, which would be backfilled in Alternative D13R. Therefore, it will be necessary to construct on and off ramps to these recreational areas and provide ample parking space for vehicles and boat trailers.

2. Big Cypress Wildlife Management Area

The AET's summary evaluation of those geographic regions encompassing the Stairsteps and Loop Road units suggests that the hydrology of these areas would more closely resemble NSM conditions under Alternatives D and D13R. The ATLSS Cape Sable Seaside Sparrow Model and Breeding Potential Index output for Alternative D13R predict a slight decrease in average hydroperiod relative to the 2050 Base in the Stairsteps and Loop Road units. Ponding depths in the eastern portion of the Stairsteps unit also are projected to be slightly less in Alternative D13R than under the 2050 Base. Although the ATLSS White-tailed deer Breeding Potential Index was not run for Alternative D13R, output was available for Alternative B, which was structurally similar to Alternative D13R in that both the L-28 and L-29 levees were removed. The analysis for Alternative B projected a slightly higher mean deer breeding potential in the Stairsteps and Loop Road units under Alternative D13R when compared to the 2050 Base. The index remained relatively unchanged in the Corn Dance unit with Alternative B.. Assuming the results would be similar for Alternative D13R, somewhat more favorable hydrological conditions will likely exist for deer and other upland game animals in the Stairsteps and Loop Road units of the Big Cypress WMA than would occur in the 2050 Base, and conditions will probably remain relatively stable in the Corn Dance unit.

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Table XVII-1. Wildlife Management Area harvest pressure data for the years 1993 to 1998, in those areas that could be affected by the Restudy.

Harvest Pressure (Man-Days)

Harvest Season	Big Cypress	Corbett	Roten-berger	Holey Land	Everglades	Southern Glades
1993-94	15,910	11,431	800	972	2,232	6
1994-95	9,735[a]	10,801	106	214	0	15
1995-96	11,290[a]	10,280	416	294	0	27
1996-97	15,185	10,961	907	274[c]	0	4
1997-98	14,410	11,298	944	281[c]	294	8
5-Year Mean	**13,306**	**10,954**	**766**[b]	**635**[d]	**1,984**[f]	**12**

Total Mean Harvest Pressure = 28,030 Man-Days

[a]Hunting seasons were shortened during these years due to the closure of some units because of high water.

[b]Those hunting seasons closed during 1994-95 were omitted from the 5-year mean.

[c]Includes opening weekend of the regular waterfowl hunting season..

[d]All closed hunts were omitted when calculating the 5-year mean.

[e]The 1997-98 season was open for only 15 days as a gun-vehicle season in WCA 3A south of Alligator Alley.

[f]The five year average for the EWMA was based on the years 1989-93, since the area has remained closed since the 1994 season due to low deer population levels resulting from the 1994-95 flood event.

TABLE XVII-2. Expanded harvest, effort, and harvest success estimates for all fish categories obtained from the roving angler use surveys in WCA 2A (L-35B and L-38E canals) and WCA 3A (L-67A Canal) between 1985 and 1997.

Year	Harvest	Effort	Harvest Success
WCA 2A			
1985-86	46,698	55,659	0.84
1986-87	167,444	128,430	1.30
1987-88	90,115	90,925	0.99
1988-89	59,129	77,617	0.76
1989-90	35,389	55,693	0.64
WCA 3A			
1990-91	51,312	49,536	1.04
1991-92	82,176	52,414	1.54
1992-93	24,471	25,848	0.95
1993-94	37,475	28,709	1.31
1994-95	33,520	41,244	0.81
1995-96	30,846	58,150	0.53
1996-97	32,557	46,265	0.70

TABLE XVII-3. Creel estimates of effort, catch and success by species and for four winter-spring seasons on Lake Okeechobee, from data collected December 4, 1992, through May 30, 1996.

Species	1992-93 Season	1993-94 Season	1994-95 Season	1995-96 Season
Effort (Angler Hrs)				
Largemouth bass	283,814	323,408	296,457	347,211
Black crappie	412,890	538,617	487,719	602,385
Bream	45,643	69,514	56,896	53,912
Total	**742,347**	**931,539**	**841,072**	**1,003,508**
Harvest (Number of Fish Caught)				
Largemouth bass	230,321	213,810	225,951	226,855
Black crappie	714,454	889,161	1,033,205	997,854
Bream	152,936	260,779	201,402	159,287
Total	**1,097,711**	**1,363,750**	**1,460,558**	**1,383,996**
Success (Fish/Hr)				
Largemouth bass	0.82	0.68	0.78	0.67
Black crappie	1.71	1.60	2.08	1.64
Bream	3.60	3.88	3.48	2.89
Total	**1.49**	**1.45**	**1.72**	**1.37**

Table XVII-4. Harvest quotas and harvest levels for American alligators from Lake Okeechobee and Lake Trafford Alligator Management Units (AMU's), 1993 through 1997.

	Harvest Quotas					Number Harvested				
AMU	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997
601 - Lk Okeechobee (west)	475	432	570	510	561	286	353	512	429	450
602 - Lk Okeechobee (north)	160	246	384	310	330	97	183	339	254	226
603- Lk Okeechobee (east)	45	48	48	50	65	39	44	43	49	49
604 - Lk Okeechobee (south)	220	252	258	280	300	138	193	234	254	256
Lake Okeechobee Totals	**900**	**978**	**1260**	**1150**	**1256**	**560**	**773**	**1128**	**986**	**981**
741 - Lake Trafford	60	36	42	30	70	40	27	42	27	49
TOTALS	**960**	**1014**	**1302**	**1180**	**1326**	**600**	**800**	**1170**	**1013**	**1030**
Percent of Quota Harvest						**62%**	**79%**	**90%**	**86%**	**78%**

Table XVII-5. Four-year (1994-1997) average annual count of waterfowl in South Florida aerial survey routes. Averages are rounded to nearest whole number. Table includes only those routes consistently flown in the four-year period. Data are from the GFC's Midwinter Waterfowl Inventory. Figure XVII-2 shows the locations of the survey routes.

SPECIES	SURVEY ROUTE															
	212	214	503	504	505	905	906	907	908	XH	XI	XJ	XL	XM	XO	XP
Mallard	1	1	0	0	1	0	1	0	0	3	0	0	0	0	0	0
Mottled duck	98	110	15	0	18	73	26	49	1	27	10	1	0	5	7	0
Gadwall	0	0	0	0	0	0	4	4	0	0	0	0	0	0	0	0
Wigeon	49	30	0	0	70	0	39	29	44	5	0	40	0	0	0	3
G-W teal	13	23	12	0	11	198	0	13	0	8	0	0	2	0	1	0
BW/Cinn teal	116	791	14	0	242	451	60	308	46	46	8	0	0	0	4	1
Shoveler	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pintail	0	0	0	0	5	4	0	0	0	0	0	0	0	0	0	0
Wood duck	6	24	0	0	0	4	3	5	0	2	0	1	6	2	0	0
Whistling duck	107	206	0	0	0	0	4	243	5	0	0	0	0	0	0	0
Canvasback	1	0	0	0	0	0	343	16	15	0	25	112	0	2	0	0
Scaup	500	258	0	4,620	0	0	1	78,000	0	0	0	0	0	0	0	0
Ringneck	1,897	8,584	0	0	0	3	10,047	2,107	5,275	6,613	3,471	13,099	3,012	2,715	48	49
Ruddy duck	500	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0
Merganser	125	0	27	11	31	4	0	0	0	0	0	4	0	0	0	0
Unident ducks	0	4	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Canada goose	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Coot	12,224	9,461	0	75	73	15	13,320	8,256	15,985	20,090	6,704	25,934	4,611	3,693	75	2,321
TOTAL [1]	**15,638**	**19,491**	**68**	**4,705**	**450**	**751**	**23,847**	**89,030**	**21,371**	**26,792**	**10,218**	**39,221**	**7,630**	**6,418**	**134**	**2,373**

[1] The four-year average of the total waterfowl count for each survey route

Table XVII-6. Numbers of migratory bird hunting stamps sold by county within the C&SF study area, from 1991-92 through 1995-96, as reported by the U.S. Postal Service..

COUNTY	1991-92	1992-93	1993-94	1994-95	1995-96	5-YEAR TOTAL FOR COUNTY	5-YEAR AVERAGE	PERCENT
BROWARD	1,373	1,153	872	1,068	1,284	5,750	1,150	13
CHARLOTTE	60	45	52	44	9	210	42	<1
COLLIER	173	199	170	140	5	687	137	2
DADE	477	3,193	224	1,174	25	5,093	1,019	11
GLADES	107	95	84	98	0	384	77	1
HENDRY	66	63	58	43	0	230	46	1
HIGHLANDS	61	75	77	69	4	286	57	1
LEE	2,299	1,858	2,215	2,159	1,718	10,249	2,050	23
MARTIN	225	248	252	179	18	922	184	2
MONROE	28	50	62	52	36	228	46	1
OKEECHOBEE	312	258	163	163	1	897	179	2
ORANGE	1,000	681	1,006	531	3,002	6,220	1,244	14
OSCEOLA	107	137	165	607	1	1,017	203	2
PALM BEACH	2,311	2,047	2,275	1,909	1,543	10,085	2,017	23
POLK	391	392	395	402	3	1,583	317	4
ST LUCIE	174	156	84	129	1	544	109	1
ANNUAL REGIONAL TOTALS	9,164	10,650	8,154	8,767	7,650	44,385		

Table XVII-7. Total duck harvest, by county, in the C&SF study area, during the 1991-1992 through 1996-1997 hunting seasons (data from Office of Migratory Bird Management, Laurel, Maryland).

COUNTY	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	6-YR TOTAL
BROWARD	4,058	2,087	548	44		156	6,893
CHARLOTTE	305	730	1,199		1,358		3,592
COLLIER	1,727	1,021	1,216	149	1,452	617	6,182
DADE	2,069	804		107			2,980
GLADES	19,588	23,490	9,586	9,863	24,893	38,525	125,945
HENDRY	640	2,549	941	43	1,035		5,208
HIGHLANDS	9,155	3,053	834	548	518	3,944	18,052
LEE	212	439	1,051				1,702
MARTIN	237	289	83				609
OKEECHOBEE	10,767	13,865	5,268	1,408	1,055	2,286	34,649
ORANGE	1,355	328	462	1,006	8,421		11,572
OSCEOLA	494	581	5,561	879	13,346	9,449	30,310
PALM BEACH	2,868	2,753	3,710	1,347	3,149	10,311	24,138
POLK	6,358	3,170	7,360	1,655	6,528	4,273	29,344
ST LUCIE	634	217	82				933
ANNUAL TOTALS	**60,467**	**55,376**	**37,901**	**17,049**	**61,755**	**69,561**	

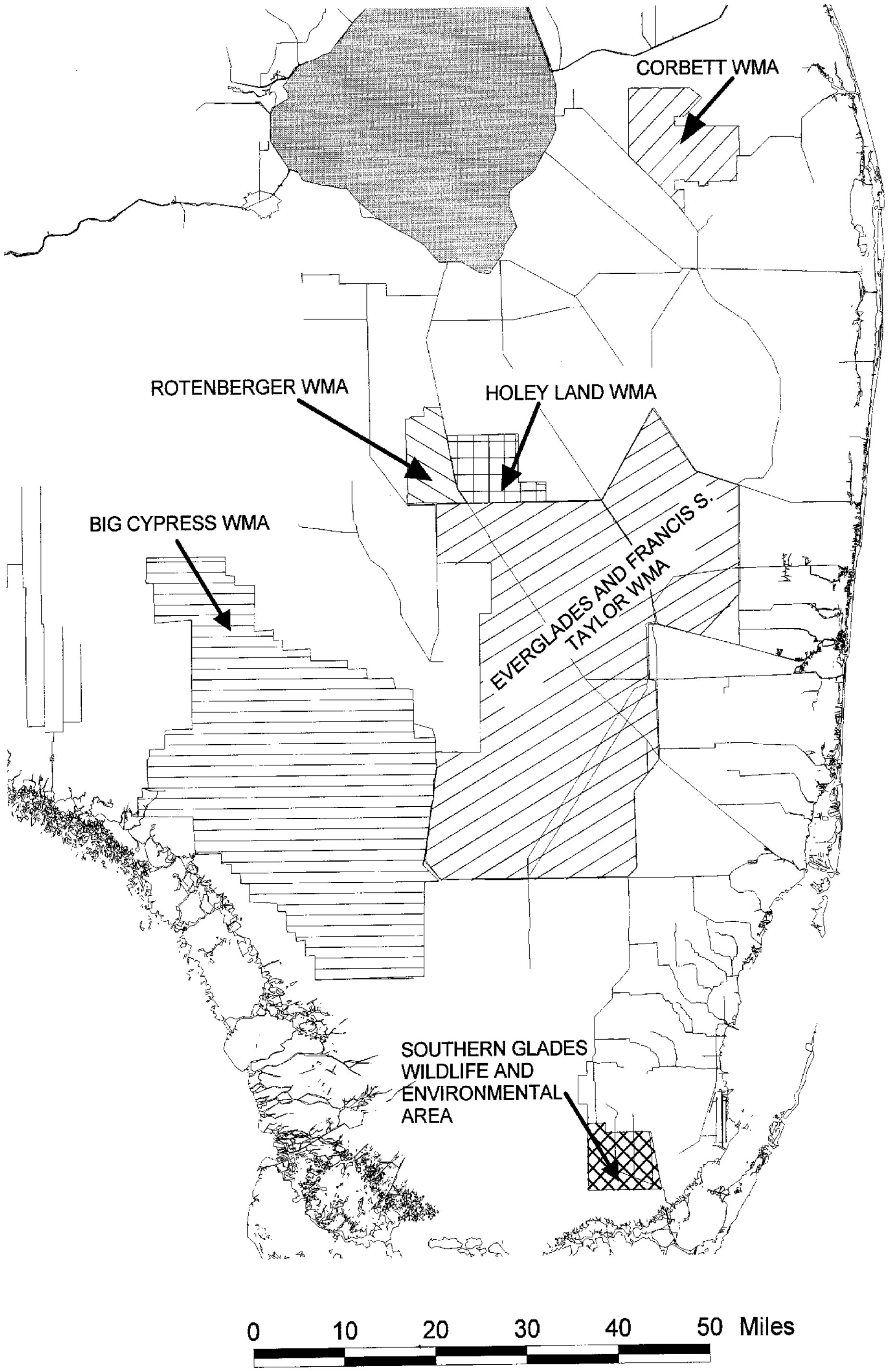

Figure XVII-1. Locations of the Wildlife Management Areas mentioned in this chapter.

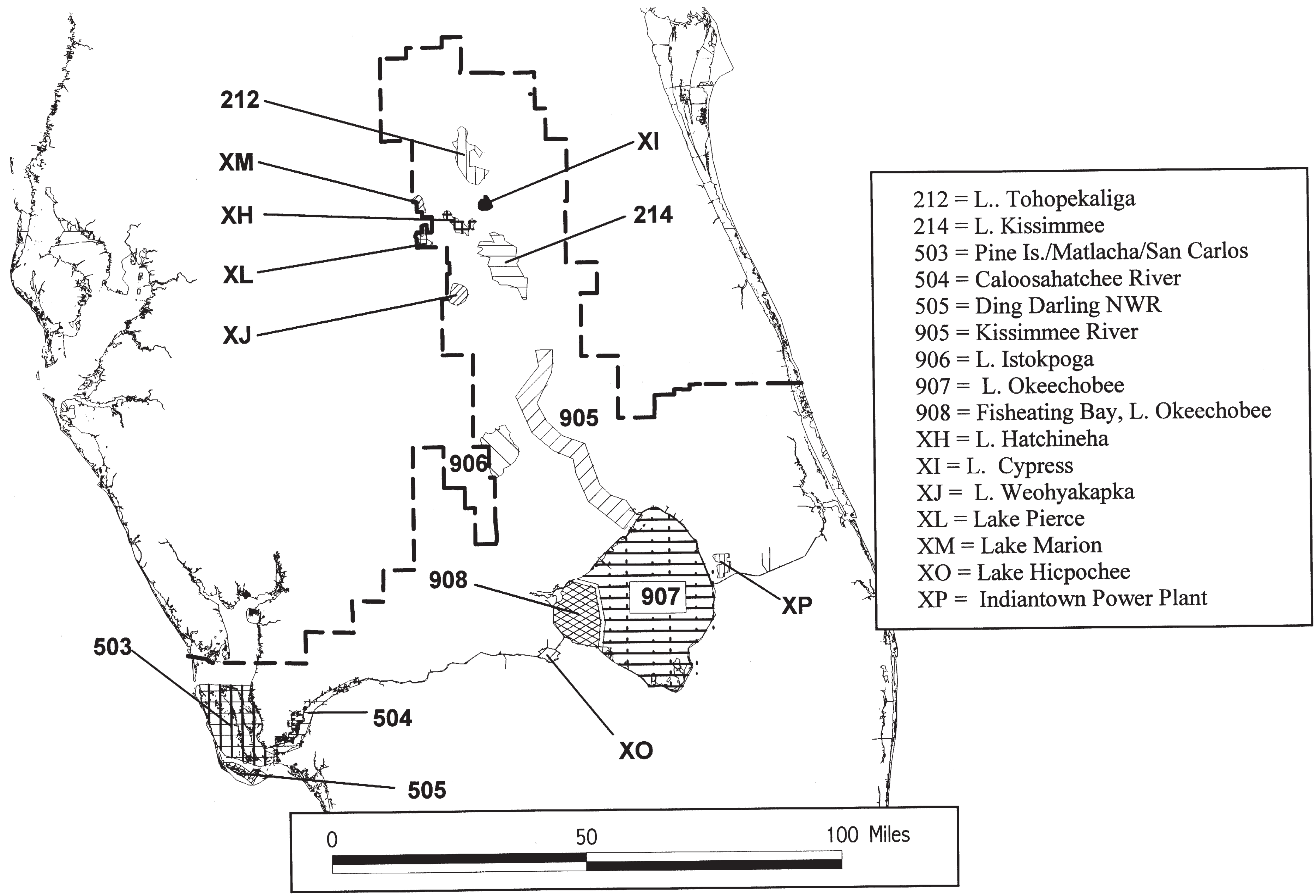

Figure XVII-2. Location of the Midwinter Waterfowl Inventory survey routes that were consistently surveyed in central and south Florida in the years 1994-1997.

CHAPTER XVIII -- ESSENTIAL FISH HABITAT

Dawn Whitehead, FWS

The Magnuson-Stevens Fishery Conservation and Management Act of 1996 (PL 104-208) establishes in part, an ecosystem approach to conserving fisheries habitat. It includes a framework for conserving and enhancing essential fish habitat (EFH) which is defined as "the waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Waters include aquatic areas and associated physical, chemical, and biological properties that are utilized by fish. Some examples are open waters, wetlands, estuaries, and rivers. Substrate includes sediment, hard bottom, under water structures, and associated biological communities.

The National Marine Fisheries Service (NMFS) published an Interim Final Rule in December, 1997 to clarify the EFH concept and to set the general process for State and Federal agencies and Fishery Management Councils to coordinate, consult, or provide recommendations on Federal and State activities that may adversely affect EFH. Using existing environmental review procedures, NMFS is to coordinate with and provide information to other Federal agencies to further the conservation and enhancement of EFH. When it is determined that an action would adversely effect any EFH, measures will be recommended that can be undertaken by the agency to conserve such habitat. Exact coordination mechanisms and levels have yet to be determined for agencies to consult with NMFS on EFH.

EFH can be affected by non-fishing related activities such as dredging, fill, excavation, mining, oil and gas exploration, shipping, impoundment, discharge, water diversions, thermal additions, pollution, sedimentation, introduction of exotic species, and conversion of aquatic habitat. Some general conservation and enhancement for EFH includes enhancement of rivers, streams, and coastal areas; protection of water quality and quantity; recommendations to local and state organizations to minimize destruction and degradation of wetlands; restoration and maintenance of the ecological health of watersheds, and replacement of lost or degraded EFH.

EFH will be a consideration as Restudy plans are refined. Both the Gulf of Mexico and the South Atlantic Fishery Management Councils have jurisdictions in South Florida and much information on EFH. The Councils have each prepared extensive source documents on the range of managed fish species, their habitat requirements by life stage, and the distribution and characteristic of those habitats. This includes some mapping of EFH by species and by life stage.

CHAPTER XIX -- HYDROGEOLOGIC ISSUES FOR AQUIFER STORAGE AND RECOVERY

Kevin Cunningham and Ronald S. Reese, WRD, USGS

A. Introduction

Assuring adequate water supply to meet the demands of natural systems, agriculture, and urban areas in southern Florida presents an enormous challenge to water managers. The current regional water supply system meets the needs of urban areas and agriculture fairly well, while large portions of the Everglades and important estuarine environments do not receive sufficient quantity, timing, or distribution of water. A key objective to the C&SF Restudy is to assure adequate water supply for all stakeholders while providing restoration of natural systems.

In general, aquifer storage and recovery (ASR) is a water management technique implemented during the wet season in which excess potable water is pumped down a deep well for storage in underground aquifers. During the dry, high-demand season, when consumption of water is high, the stored water is withdrawn and distributed to users. ASR is currently used in southern Florida as a water management strategy and is under consideration for augmentation of future water supplies. The South Florida Water Management District has proposed to meet the goals of the C&SF Restudy with as many as 225 deep storage wells as an option to improve water supply. The critical issues concerning the implementation of cost-effective ASR are: 1) selection of suitable hydrogeologic storage zones, 2) location of injection water sources, and 3) treatment requirements.

Ideal conditions for hydrogeologic storage zones include: 1) good confinement, 2) adequate thickness, porosity, and permeability, and 3) appropriate distribution of pore space and permeability. Good confinement reduces loss of injected freshwater while adequate thickness, porosity, and permeability ensure that water can be injected at a high enough rate over a long enough period of time. The distribution of pore space and permeability need to be defined within the strata such that flow is fairly uniform and steady over the entire interval of injection. Thin zones of high permeability may provide poor recovery because of rapid lateral movement of most of the injected water away from the injection well. Additionally, a low ambient hydraulic gradient is desirable so that the injected water does not move such a substantial distance from the injection well that it prevents recovery.

B. Future Needs for Information or Design

Assessment of technical issues in any hydrogeologic evaluation of ASR requires the following data on the receiving aquifer and injected water: 1) inventory of existing data, 2) core analysis, 3) lithology, 4) aquifer characterization, 5) characterization of confining layers, 6) lithostratigraphy and sequence stratigraphy, 7) hydraulic characteristics, 8) mineralogy of geologic materials, 9) geophysical logs, 10) well construction, 11) water quality of aquifer water and injection source water, 12) geologic structure, 13) potentiometric surface, 14) recharge and discharge boundaries, 15) groundwater velocity and direction, and 16) proximity to potential sources of contamination.

In southeastern Florida, the Floridan aquifer is used for storage. However, other shallower and potentially more cost effective aquifers such as the gray limestone (lower Tamiami), Hawthorn Group, and Miocene-Pliocene quartz sands have been inadequately tested and need to be rigorously evaluated. In southern Florida, municipal ASR projects have been completed in the Upper Floridan aquifer. Based upon test results from wells in Dade, Broward, and Palm Beach counties, it appears that the Upper Floridan aquifer can be productive (D. Pyne, CH2M Hill, personal communication, 1998).

Two major studies, at different scales, are needed: 1) regional hydrogeologic characterization of receiving aquifers and injection water sources and 2) ASR pilot projects. The USGS has begun mapping the top of the Floridan aquifer in southeastern Florida. However, other potential storage aquifers need to be defined by intensive mapping using interpretive results from well data and reflection seismic surveys. A reconnaissance and mapping study of the gray limestone aquifer in central southern Florida is in progress by the USGS and needs to be augmented with an ASR feasibility study.

A multi-disciplinary regional analysis of all potential storage aquifers (Floridan, Hawthorn Group, gray limestone, and Miocene-Pliocene quartz sands) should be implemented. This would involve the collection and interpretation of geologic, geophysical, hydrologic, and geochemical data. These data can be used in creating a regional hydrogeologic model to predict the areas of greatest potential for successful site-specific ASR feasibility projects, which is the second major study identified. At each ASR feasibility project, injection rate and efficiency of recovery of injected water needs to be determined and integrated with hydrogeologic data and interpretations. Hydrogeologic modeling will be **critical** to long-term management of each ASR site and expanded project development in each area.

Very little information exists concerning the effects of pumping large volumes of water into the Floridan aquifer, including how additional water pressure will effect the integrity of the aquaclude, or confining layers at the top of the Floridan. There are also questions relative to the draw down of water in well clusters, particularly if simultaneous draw downs create a negative pressure or suction in the aquifer causing the confining layer of the aquifer to implode (T. Corcoran, National Audubon Society, personal communication 1998).

C. Feasibility of the Lake Okeechobee ASR Component

The C&SF Restudy has proposed large-scale ASR for the area around Lake Okeechobee in the Floridan aquifer system. An ASR test well was drilled in Okeechobee County, but was completed in the Lower Floridan aquifer over a large interval. Because of the large vertical extent of the interval completed and the high permeability of thin zones within it, some researchers believe the results from this test well are inconclusive. The Upper Floridan aquifer was not tested. Limited mapping of the Upper Floridan aquifer on the eastern and southern sides of the Lake has been completed and indicates that there are significant variations in the thickness, hydrologic character, and water quality of the aquifer, dependent on the proximity to and direction from Lake Okeechobee.

D. Water Quality Concerns

Current EPA drinking water standards require that water pumped into an aquifer must meet promulgated drinking water standards. Within the Everglades, most water meets the state primary standards except for coliform bacteria (T. Corcoran, National Audubon Society, personal communication 1998). To meet these standards, the water would require treatment prior to injection into an ASR well. If chlorine is used as the treatment technology, there is a potential that a chemical reaction may occur between chlorine and organic matter naturally present in the water, producing a class of chemical compounds known as trihalomethanes or THMs. Chloroform, a carcinogenic compound, is one type of trihalomethane. Because both Lake Okeechobee water and the Everglades/Biscayne aquifer water commonly contain organic material, there is a concern that the use of ASR in the Restudy alternatives will create harmful THMs if chlorination is used to treat water pumped into an ASR well. Furthermore, water removed from ASR wells should be placed into a "buffer zone" before being discharged into the natural environment in order to provide aeration and pH adjustment (D.Pyne, CH2M Hill, personal communication 1998).

Regional ASR at the scale proposed in the Restudy is unprecedented in central and south Florida; regulators must consider water quality data from ASR pilot studies and data that will be available after implementation of regional-scale facilities to determine if modification of existing water quality requirements governing use of ASR is warranted.

E. Summary

ASR as a water management tool should be used in combination with surface storage reservoirs since the reservoirs would modulate peak flows to the wells. It would be preferable to recover the water from ASR wells into a buffer zone area designated for this purpose rather than directly into natural environments. As an example, marginal EAA land could be utilized for this purpose. It is important to keep in mind that the overall time frame from feasibility study to demonstration well to expansion of the program is approximately 3.5 years (T. Corcoran, National Audubon Society, personal communication, 1998). Other water storage options should be investigated in the event that ASR cannot be implemented on the scale proposed for the Restudy.

F. References

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CHAPTER XX -- RECOMMENDATIONS FOR IMPROVEMENTS IN HYDROLOGIC MODELS AND TOPOGRAPHIC DATA

Eric Swain, WRD, USGS

The hydrologic models that will be used in detailed planning for Restudy components must represent water depths and flows with a degree of accuracy compatible with desired objectives and performance measures. All current models represent water depths with a greater degree of accuracy than flow values; this is an inherent property of numerical models in low gradient regimes. The relationship of flow to water level gradient must be refined as much as possible in order to optimize the predictive capabilities of the models. Other model enhancements are required to more accurately represent flow in the surface-water system, groundwater system, and the interaction between the two systems. The dominant surface-water regime requires high-accuracy topography to correctly model the flow.

Refining the models involves both the computational algorithms and the input data. This refinement has several aspects, which are discussed below:

1. Accounting for smaller scale features - One of the primary sources of model uncertainty is the fact that parameters must be discretized and averaged for the model grid size. In almost all cases, data is sparser than the actual variability in any parameter, so even if a smaller grid is implemented in a model, the data do not exist to support it. It is impractical to collect data over the entire study area or to construct a model grid with dimensions of several feet. The best approach is to collect intensive data in important or highly variable areas and use these data to develop insight into appropriate spatial means for the model . Identifying areas where more data are needed, both for determining better spatial means and determining optimum grid size, is therefore an important priority.

2. Refining functional flow relationships, flow depths - The hydrologic models with surface-water components in the south Florida area are all sensitive to ground surface elevation. High-order topographic measurements are needed for the entire model domain. However, simply refining the average elevation in a model cell is not sufficient. The effective average cell elevation for flow computation is not the same as the elevation below which flow ceases. This difference in elevations accounts for depression storage. The depression storage term is very important in sporadically inundated areas. Intensive topography data in test areas is needed to develop representative depression storage numbers.

3. Refining functional flow relationships, frictional terms - The surface-water friction coefficient (Manning's *n* or Chezy's *c*) has been notoriously difficult to define. Several studies have been implemented in south Florida to develop more accurate friction coefficients and define factors which affect frictional resistance. The findings of these studies must be transferred to the restoration models and further study needs defined. Field scale studies are needed to investigate the space-averaged characteristics of the friction coefficients.

4. Groundwater flow representation - Model enhancements are required to properly represent groundwater flow in the C&SF Project area. The coastal saltwater interface affects the freshwater flow to the coast. Its location can threaten water supply, and the upwelling of groundwater flow over the saltwater wedge intrudes on the surface-water regime. Numerical representation of variable-density flow at the coast should be included in future modeling efforts.

5. Evapotranspiration (ET) and rainfall - These two major components of the water budget have been the subject of studies in the south Florida area, especially ET. All new findings should be integrated into the modeling efforts and several other topics need to be addressed. For example, rainfall/runoff in urban areas differs from that in agricultural or wetlands areas. Drainage and developed areas control the distribution of infiltration in the urban environment. This also has implications in the water quality components of any model. The ET in agricultural areas is likewise affected by irrigation and plant uptake. The relative significance of the unsaturated zone in ET and rainfall recharge needs to be resolved.

6. Surface water/ground water interactions - The exchange of water between the surface and sub-surface is an important part of the hydrology in south Florida. Studies of the leakage phenomena indicate the aquifer flow fields in close proximity to surface-water bodies are more complex than most model representations. Further model enhancements are required in the area of localized leakage phenomena. Vertical leakage in lake and wetland areas must be represented with the same degree of accuracy as horizontal leakage to canals.

7. Large scale topography - The importance of parameterizing the small scale topographic variations was discussed under item 2 above, but large scale topographic measurements to a common datum are also needed. Many model users reference elevations to the NGVD 1929 datum. However, the best accuracy can be obtained by converting all elevations to NAVD 1988 and using this datum for all new measurements. Error bounds on existing stations and benchmarks should be established to properly define the uncertainty in the models.

8) Water quality modeling - Two types of numerical models, dealing with water quality and quantity, have generally developed separately, with minimal information transfer between them. Rather than using the flows computed by the quantity models as input to chemical and biological models, coupled flow and transport codes need to be implemented and expanded. Because the primary Restudy objectives involve ecological restoration, water quality concerns must be addressed. More detailed hydrologic studies required for project design should use this integrated approach to assess water quality impacts.

CHAPTER XXI -- THE EFFECTS OF DECOMPARTMENTALIZATION AND THE C&SF RESTUDY

Sue Perry, ENP; Cheryl Buckingham, FWS; Bill Loftus, BRD, USGS

The C&SF Project has imposed extensive physical changes on the Everglades landscape in the form of canals and levees to meet its goals of providing water supply and flood protection. While the effects of canals and levees in draining wetlands and impounding waters is well understood, there has been less information available concerning what the presence of those structural features has meant to the ecology of the system. In planning for the restoration of the Everglades, emphasis has shifted toward finding non-structural solutions to problems whenever possible and toward removal of structures that offer few benefits to the natural system.

There are three general categories of beneficial effects to the Everglades system expected to result from adopting a decompartmentalization approach (i.e. filling canals or degrading levees): 1) the restoration of wetland sheetflow, 2) the reconnection of fragmented wetlands, and 3) the elimination of artificial habitats that support introduced plants and animals. Descriptions of these effects follow:

1. The restoration of **sheetflow** across marshes, instead of rapid canal routing of water will provide the advantage of slowing the flow of water on the landscape. Allowing water to flow slowly across the landscape rather than sending it to tide through artificial canals alleviates the adverse effects of flood releases on the estuaries while maintaining persistent dry-season flows in the interior marshes, an aspect of the present system that is deficient. A water quality benefit of increasing sheetflow in the central Everglades is the further reduction of phosphorus and other nutrients. Sheetflow moves particulate and dissolved materials across wetlands to allow more natural cycling of nutrients and energy. The flow of water across wetlands also fosters the passive dispersal of plant and animal species and their propagules.

2. By degrading **levees** that act both as barriers and terrestrial corridors into the wetlands, several important restoration goals will be approached. The unnatural pooling of water, caused by levees that impound water flow, would be reduced or eliminated. That action would lessen the incidence of tree island flooding and reduce the need for regulatory flood releases downstream. Flood releases have been implicated in the destruction of alligator nests and the disruption of wading bird prey concentrations.

Contiguous wetlands, now isolated by the C&SF Project levee system, would be reconnected so as to not restrict the movement of aquatic animals and plants. There is evidence that genetic divergence in populations of mosquitofish and grass shrimp is related to levee barriers. The community composition and standing stocks of aquatic animals also differ in the wetlands of Shark Slough and the Water Conservation Areas, in part as a result of the hydropatterns created by the compartmentalization of the C&SF Project. As wetlands are reconnected, natural disturbance processes, such as fires, would be able to operate without interruption across the landscape.

Levee deconstruction will also eliminate artificial terrestrial corridors in the wetland landscape that act as habitats and dispersal conduits for exotic animals and plants

3. **Canals** represent a dramatic change in the landscape of the Everglades. Few net ecological benefits can be attributed to this artificial habitat. Removal of canals by infilling with levee material will eliminate the major habitat for exotic floating and submersed aquatic plants, fishes, and snails in the ecosystem. The non-indigenous plants alone require a substantial annual expense to control and result in the addition of unwanted herbicides to the Everglades system. Because the canals act as pathways for dispersal for exotic plants and animals, their filling would slow the colonization of introduced aquatic organisms that presently occur east of the Everglades with the interconnected canal system.

The filling of canals would help to restore the natural populations of native predatory fishes, small forage fishes and invertebrates that have been altered by the presence of the spatially extensive canal system. Canals act as long, deep drought and thermal refuges in which large native and introduced species achieve higher numbers than in natural, shallower water habitats. When open to adjacent marshes, canals are thought to alter energy flow in the wetland system by acting as sinks for wetland secondary production in the dry season. As marshes begin to dry, large fishes move into canals to feed on smaller, native fishes. This process depletes marsh fish stocks, reducing the number of fish available to recolonize the marsh, and suppressing reproductive effort and available prey base for competing predators such as wading birds. Filling the canals should result in a greater prey base for those wading birds that feed in drying marshes.

The continual accumulation of data for Everglades community structure and functioning fails to demonstrate positive benefits for the system resulting from fragmentation. On the contrary, many of the demonstrated factors contributing to degradation of the system can be tied directly to the structural components of the C&SF system and their secondary effects of drainage and flooding. Removal of as much of this infrastructure as possible can be expected to provide many benefits.

We realize that some infrastructure is necessary to meet the C&SF system demands in the highly modified system and that man-made structures are destined to remain a fact of life in south Florida for several reasons. The natural system has been reduced to approximately half of its historic spatial extent. It can no longer handle the tremendous volumes of water necessary to maintain hydroperiods in Shark River Slough and proper salinities in Florida Bay without increasing the severity of damaging extreme depths and hydroperiods in the Water Conservation Areas. Canals are capable of conveying water to the south quickly and efficiently, substituting for the missing part of the Everglades. Other structures pay for themselves ecologically by protecting the natural system from developed areas. The east coast protective levee may aggravate the exotic species problem, for example, but it allows water to remain in the Everglades that would otherwise flow into canals and eventually out to sea. Other structures serve water quality functions. For example, the canal along the interior perimeter of Loxahatchee National Wildlife Refuge is important for routing lower quality water around the pristine center of the Refuge. The levees surrounding the refuge protect it from over-drainage during dry years and allow for future adaptive management options. The C&SF Project canals can be used to move floodwaters quickly into storage areas to prevent sending harmful flows through the estuaries. New storage areas are an essential feature in all of the restoration alternatives. These extremely large, man-made features can have serious ecological impacts for many habitats. However, their regional benefits to the Everglades are expected to far outweigh the local ecological costs.

Ecologists strongly favor minimizing the number of ecologically disruptive structures **within** the natural areas while searching for non-structural solutions to problems whenever possible. When structures are inevitable, they should be located, whenever feasible, outside natural areas, either on the perimeter or in less environmentally sensitive areas. Structures should be designed and redesigned so that their impacts to the ecology are minimized. Substantial justification should be required for adding structures because they are needed for adaptive management strategies.

Fortunately, there is much more information available today on the effects of canals, levees, and structures on the ecological system than during the 1940s when the C&SF Project was conceived. As a result, the Everglades' restoration planners have become sensitized to the issues and no longer automatically search for structural solutions to every problem. Each proposed structure must face close scrutiny in the upcoming years and prove to be invaluable to the greater restoration effort or it can and should be removed. The adaptive management strategy being developed for the C&SF Project will provide a systematic way to continue to examine the role of structures in the greater Everglades ecosystem and for modifying or removing them in light of new information.

CHAPTER XXII -- CONFLICTING GOALS AND TRADE-OFFS

Robert Pace, FWS; Sue Perry, ENP

A. The Need to Address the Present Constraints of the C&SF System

It has often been assumed that restoration or enhancement of natural areas in south Florida may conflict with other societal values, such as water supply and flood control. In addition, the current operational and physical constraints of the C&SF system seem to prevent attainment of all ecological goals in the various portions of the system. Chapter VII of this report deals with water supply issues, while the following discussion includes apparent conflicts in reaching all ecological restoration goals. Regulation of water in Lake Okeechobee provides an example of the inability to meet the four key objectives for managing the lake: 1) protection of the lake's littoral zone, 2) water supply, 3) protection of the St. Lucie and Caloosahatchee estuaries, and 4) Everglades hydroperiod restoration (Trimble and Marban 1988, Neidrauer *et al.* 1997). Another example is the need to store water in the Water Conservation Areas to meet water supply demands for the Lower East Coast; this leads to frequent low and high water extremes in the WCAs and alters the timing of drying and wetting of the wetlands from the seasonal patterns these areas experienced prior to construction of the C&SF system. The Restudy was initiated to explore ways to rectify these problems and constraints and many others of a similar nature.

The Alternative Evaluation Team (AET) and Alternative Development Team (ADT) initially approached the problem primarily by increasing water storage outside the Everglades Protection Area. Some constraints were considered irremovable, including: 1) the Herbert Hoover Dike around Lake Okeechobee, 2) the Eastern Protective Levee, and 3) portions of the EAA will remain in agriculture. The third assumption means that storage/treatment will be the purposes for any land acquired in the EAA, rather than attempt to restore remaining portions of the EAA to wetlands similar to those found in the pre-drainage condition. Despite these remaining constraints, the AET and ADT attempted to define and achieve ecological goals in all of south Florida's natural areas.

B. Efforts to Eliminate or Minimize Anticipated Conflicts Through Alternative Design

Continued refinement of the alternatives throughout the Restudy evaluation process indicated that many of the presumed conflicts among objectives could be either eliminated or minimized. The majority of the design components put in the Restudy alternatives are based on simple proven technology. These include the Water Preserve Areas and additional seepage control features between the Everglades and the Lower East Coast urban area, storage/treatment areas in other portions of the C&SF system, removal or modification of certain structures and canals in the Everglades Protection Area, and modification of operational rules. These features are essential pieces of the Restudy, but the AET determined during plan development that these were still not adequate to meet all restoration objectives. Subsequent Restudy designs included features that are more dependent on presently uncertain technologies, and in many cases are more energy-dependent, because they rely more on pumping large volumes of water.

Entering the Restudy, some participants were concerned that the health of Lake Okeechobee's littoral zone would have to be sacrificed to meet future water demands or to provide the necessary volume of water to restore the Everglades. Modeling indicated that complete decompartmentalization of Loxahatchee NWR or WCA 2 was not possible without harming the lake's littoral zone. Even the partial decompartmentalization scenarios required large volumes of surface water storage and 200 ASR wells around the lake to meet ecological goals in the lake, the estuaries, and the Everglades, while also meeting projected water supply demands. The modeling demonstrated that the constraints of the present system could be surmounted, but this conclusion is highly dependent on the feasibility of the 200 ASR wells around Lake Okeechobee.

C. Potentially Remaining Trade-offs

Lake Okeechobee provides just one example of the uncertainty surrounding assumptions that the Restudy will resolve many of the trade-offs in the current C&SF system. The following brief summaries discuss trade-offs that may be unavoidable in carrying out the Initial Draft Plan, particularly if uncertain technologies do not prove feasible for technical, regulatory, or financial reasons:

1. Lake Okeechobee littoral zone health versus urban and agricultural water supply; Lake Okeechobee versus St. Lucie and Caloosahatchee estuaries; and Lake Okeechobee versus water for Everglades restoration. As noted above, full decompartmentalization of the Everglades jeopardizes the littoral zone of the lake with periods of extremely low water. Other modeled scenarios indicate that even if L-39 (which separates Loxahatchee NWR from WCA 2A) is not removed, adoption of a rain-driven schedule for Loxahatchee NWR also has a less severe, but significantly adverse, effect on water levels in Lake Okeechobee. Implementation of the Initial Draft Plan, which does not include either full decompartmentalization of the WCAs or a rain-driven schedule for Loxahatchee NWR, requires the high volumes of pumping associated with the surface storage around Lake Okeechobee and the 200 ASR wells. If these prove to be infeasible, some level of trade-off will remain among the ecological goals and between ecological goals and other societal goals.

2. Water quantity versus water quality. The Restudy has attempted to provide additional STAs (beyond those provided by the Everglades Construction Project) in some locations where water quality is known to be a problem. However, in the Restudy's attempts to capture more water to deliver to the natural system, we remain uncertain that the proposed facilities will be adequate to meet ecologically-based water quality standards for the Everglades, including the removal not only phosphorus, but a full range of potential pollutants. As a general principle, water in the natural system should be retained in the natural system. Detailed design of the Restudy should minimize the import of water to the natural system from surrounding urban and agricultural lands, particularly when these sources are known to contain high concentrations of nutrients, mercury, pesticides, or other pollutants.

3. Matching hydroperiod versus decompartmentalization. Because roughly half of the original extent of the Everglades has been lost, and because none of the Restudy alternatives propose restoration of the EAA or the urban east coast, physical constraints (most notably the

Eastern Protective Levee) remain in place, preventing full restoration of Everglades. Attempting to restore NSM-like inundation patterns in one portion of the system has consequences elsewhere in the remaining natural system. Decompartmentalization of the remaining natural system causes water to accumulate along certain portions of the eastern levee during high rainfall periods, and lacking the full storage capacity of the original Everglades, water is often not available to hydrate the southern Everglades during periods of low rainfall. Early model runs for the Restudy showed that a highly managed system can produce a high percentage of hydroperiod matches relative to NSM. However, ecologists pointed out that such a highly managed and fragmented system was not in keeping with the concept of ecosystem restoration. Therefore, subsequent models attempted to find a balance between hydroperiod matches and removal of barriers in the system. The Initial Draft Plan appears to have the most desirable balance of the two, but as the Restudy enters detailed design, components should be analyzed in terms of this trade-off.

4. Ecosystem management versus species management. The DOI generally supports the principles of ecosystem management, but must point out that special recommendations will still be necessary on a case-by-case basis to comply with provisions of the Endangered Species Act. We find no fundamental conflict for any particular species in achieving the hydrologic conditions predicted to occur after full implementation of the Initial Draft Plan. However, arriving at the final conditions will involve a series of interim actions that must be evaluated in a step-wise manner to ensure that they do not jeopardize listed species and to recommend ways to reduce adverse effects that do not reach the jeopardy threshold. Proper sequencing of projects should minimize potential conflicts, and priority should be given to preferentially protect those species that are : 1) most imperiled, 2) most limited in their distribution to areas affected by the action, and 3) least able to adjust to proposed changes. Seasonal timing of construction activities to protect particular species or groups of species will also remain a concern, even when the cumulative effect of the interim actions do not reach the level of jeopardy. For example, if disturbance of a wading bird colony containing nests of the endangered wood stork (*Mycteria americana*) can be avoided by scheduling construction activity outside the nesting season of the wood stork, such scheduling changes are justified regardless of whether the long-term effects of the project will benefit the species as a whole.

5. Benefits to the whole system or to one portion of the system versus potential harm to other portions of the system. The Initial Draft Plan has minimized these types of trade-off, which were more evident in earlier iterations of design. However, trade-off issues that have been diminished by features of the plan will return to prominence if some of the components of the Initial Draft Plan prove to be infeasible. We have provided below two examples of these types of issues--one dealing with WCA 3 and the other dealing with Biscayne Bay.

Initial attempts at partial decompartmentalization of WCA 3 indicated that attempting to reach the wet season water levels in Shark River Slough was not entirely possible, and that the frequency and duration of both high water stages and low water stages were detrimental to eastern WCA 3A and WCA 3B. The AET asked the ADT to increase the use of Central Lake Belt storage and to design a variable crest weir along L-67, both of which were intended to extend the period of continuous flooding through the dry season in Shark River Slough and reduce the severity of extreme drying and flooding events in eastern WCA 3A and WCA 3B. There was general agreement that areas, such as WCA 3B, that appear to be functioning well ecologically should not be allowed to deteriorate significantly from the 1995 Base condition in order to restore other areas of the system. The Initial Draft Plan is much improved over the other alternatives in avoiding detrimental conditions in WCA 3, but it has not been completely successful. Sensitivity analyses must be performed to determine to what degree the minimization of extreme high and low water stages in WCA 3 is attributable to the provision of variable crest weirs along L-67 and to the use of Central Lake Belt storage. If Central Lake Belt storage does not prove to be feasible, the trade-off between approaching restoration targets for Shark River Slough and reducing the frequency of detrimental high and low water stages in WCA 3 could be more significant.

6. Surface flows of fresh water to Biscayne Bay versus level of treatment proposed for southern Dade County water reuse. Increased water supply demands in the 2050 Base would reduce the surface water flows of fresh water available to maintain a desirable salinity regime in nearshore portions of southern Biscayne Bay below the current levels of flow, which are already considered inadequate. The iterations of Restudy alternatives through Alternative B involved increased storage of fresh water in the C&SF system. The increased storage seemed to benefit the percentage of demands met for agricultural and municipal water supply and also partially restored the hydrology of the remnant Everglades. However, to that point, surface flows to southern Biscayne Bay had not met targets. In Alternatives C and D, water reuse facilities were modeled for south Dade County. This component was effective in reaching surficial fresh water inflow targets for southern Biscayne Bay without compromising urban water supply or restoration of the Everglades. Rather than place ecological restoration goals (fresh water retained in the Everglades versus flows to Biscayne Bay) in apparent competition, we find that other provisions must be made to achieve restoration goals in both areas, should water reuse plans fall short of expectations. We are concerned that, because the presently recommended reuse facilities are among the most expensive components in the Restudy, actions may be delayed in this area. Part of the high projected cost may be the intent to treat the water to the quality standards for drinking water; less costly treatment may make captured water suitable for reuse as irrigation for household lawns, golf courses, and agriculture. Priorities should not be established on the basis of what is politically or financially uncomplicated, but on the need for action to resolve environmental problems.

7. Water storage versus existing habitat values (central versus disjunct natural areas). The Restudy has concentrated largely on improving hydrologic conditions in remnant natural areas of south Florida. A primary principal in restoration of the Everglades had been the need to rectify the loss of its spatial extent (Science Subgroup 1993, Davis and Ogden 1994), but the Initial Draft Plan does not propose restoration of large areas of existing agricultural or urban areas to natural areas. Facing the realities of increased human population in south Florida's future, the emphasis has shifted to restoring or enhancing remaining "core" natural areas, while limiting the impact of the features of the Initial Draft Plan on the more peripheral natural areas. These "core" natural areas include the remnant Everglades, Florida Bay, Big Cypress National Preserve, Lake Okeechobee, the St. Lucie and Caloosahatchee estuaries, the Kissimmee River, and the

Kissimmee Chain of Lakes. Other chapters of this report describe the efforts to reduce the environmental impact of the Water Preserve Areas and the other water storage and treatment facilities, which collectively total close to 200,000 acres of land. Some of these areas are of limited habitat value for fish and wildlife (e.g. improved pasture, citrus groves). The Restudy has attempted to minimize impacts on native cover types (marshes, swamps, dry prairie, pine flatwoods, and others), but some impacts on significant fish and wildlife habitats will be unavoidable. We have recommended that the COE avoid unique and irreplaceable habitats, such as the xeric oak scrub vegetative community, particularly when this habitat is occupied by the Florida scrub jay. If the Initial Draft Plan is completed and functions as a whole as we anticipate, the impacts on disjunct natural areas should be outweighed by the benefits to the "core" natural areas. However, the conceptual plan will likely evolve from our current design, and we must continually re-assess the anticipated benefits of the total plan versus adverse impacts of individual components.

8. Passive systems versus active control. Many new structures have been added in the Restudy alternatives outside of the Everglades Protection Area, including additional pump facilities, reservoirs, wells, curtain walls, canals, and levees. Some of these structures are designed to have environmental benefits, such as increased storage of water that is currently lost to tide so that it can be delivered to natural areas during the dry season. All of the restudy alternatives except Alternative A involve removal of some levees, water control structures, and canals within and around WCA 3. Alternative B removed more structures and canals than any of the other alternatives and would be favored strictly on this basis. However, modeling results indicated that a series of weirs had to be placed along the present location of the L-67 levee to reduce the amount of water ponding in WCA 3B and along the eastern side of WCA 3A, and to prevent the too rapid flow of water to the south. Water is retained by the levee when water stages drop below the control elevations of the weirs and is available to be delivered to Shark River Slough during periods of lower rainfall.

Alternative A was unfavorable not only in its failure to provide even partial decompartmentalization of the Everglades Protection Area, but also in its inclusion of large pumps designed to deliver water south of Tamiami Trail to Shark River Slough. In addition to the enormous operating costs for such pumps, pumping can kill and injure fish and invertebrates through direct injury, reduction of dissolved oxygen in water delivered through pumping, and temperature shock.

The passive weirs along the present location of L-67 (included in Alternative D and refined in Alternative D13R) are preferable over levees and water control structures because they provide a continuous flow of water and aquatic organisms during periods of high water, and only lead to a discontinuity in water levels during periods of low water. Alternative D13R is preferable to Alternative D in that it includes removal of the western portion of L-28 and all of L-29.

In addition to the environmental costs of an actively managed system, the questions of maintenance cost, energy consumption, and vulnerability to natural disasters should be considered. Depletion of fossil fuels may play a role in increasing energy costs in the future unless new power generation technologies become available. The additional energy costs of pumping water from one area to another, backpumping into reservoirs and into Lake Okeechobee, and pumping into and recovery from ASR wells, are large and should be evaluated and reduced whenever possible. Adverse weather conditions (e.g. hurricanes, intense thunderstorms, and tornados) may impair the ability to operate pumps and may result in severe damage to ecosystems if maintenance of these ecosystems is highly dependent on pumping operations.

Among the evaluated alternatives, Alternative D13R appears to provide a better balance between our attempts to remove structures from the C&SF system and the avoidance of the unintended consequences of full decompartmentalization (periods of extreme high and low water in some portions of the Everglades Protection Area). However, the COE should reassess these issues as each portion of the C&SF Restudy enters detailed design. Design plans should be chosen based upon the ability to achieve the most environmentally beneficial patterns of inundation with the lowest practical level of active control.

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CHAPTER XXIII -- SUMMARY OF THE DOI's POSITION

The DOI has cooperated closely in this multi-agency, multi-disciplinary effort to meet ecological targets throughout the C&SF system. Alternative D13R has shown significant progress towards achieving ecological restoration throughout the C&SF project and we endorse the majority of the elements in the Initial Draft Plan. However, Alternative D13R needs improvement to fully reach restoration goals. The DOI recommends further refinement of the Initial Draft Plan prior to the release of the Final PEIS in the spring of 1999.

The DOI concurs with the South Florida Ecosystem Restoration Task Force's appraisal of the issues most in need of continued analysis and refinement in the Restudy:

1. Total overland flow volumes to Florida Bay, through Shark River Slough, and Taylor Slough should be increased to reach NSM targets.

2. While accomplishing the above, the hydrologic characteristics in Water Conservation Area 3 (particularly northeastern WCA 3A, all of WCA 3B, and WCA 2B) should also reach ecological targets. Alternative D13R was not able to entirely eliminate potentially damaging high water and low water conditions in those areas. We should continue to seek full restoration of hydrologic characteristics in Florida Bay, Shark River Slough and Taylor Slough without compromising full restoration of WCA 3. Water flow should be delivered as naturally as possible in the remaining Everglades.

3. Whether or not wastewater reuse on the scale proposed by the Restudy is feasible for Dade County, we should continue to seek opportunities that are not dependent on this technology to restore more natural flows to Biscayne Bay. Chapter VI of this report describes two Other Project Elements (OPEs) that would benefit Biscayne Bay with or without the additional water that may be available through reuse facilities. These two OPEs are entitled: South Dade Agriculture Rural Land Use and Water Management Plan and Biscayne Bay Coastal Wetlands. The DOI believes that these projects and any others developed to improve ecological conditions in Biscayne Bay should be given priority. Under any future circumstances, total flow volumes to Biscayne Bay should be no less than those simulated in the 1995 Base.

4. Restoration goals for minimum flows of fresh water to the St. Lucie estuary and the elimination of regulatory releases to the estuary from Lake Okeechobee would be generally met in the Initial Draft Plan. However, the runoff generated within the St. Lucie drainage basin is still significantly greater than the restoration target. The DOI recommends that efforts to fully restore the St. Lucie estuary

5. The DOI understands that the Water Resources Development Act of 1996 authorized the protection of water quality as a project purpose of the C&SF Project. As such, water quality protection must be addressed throughout the entire Kissimmee/Okeechobee/Everglades watershed. The DOI remains concerned that the C&SF Restudy may not include adequate facilities for treatment of water destined to be returned to the natural system. The DOI recommends that specific pollutant loading targets be established and an implementation plan developed to reach those goals within the watershed. Finally, planning should not be limited to nutrient loading; a variety of water quality parameters and pollutants also need to be addressed (e.g. pesticides and mercury contamination).

Detailed findings and recommendations can be found throughout the preceding chapters of this report. The following general findings and recommendations provide a reference to the reader for the appropriate chapters:

1. The hydrologically restored wetland habitats of central and south Florida will not have the same distribution, abundance, and diversity of fish and wildlife as the pre-drainage Everglades. Given resolution of the issues presented above, we are reasonably certain that it will be sustainable in the long term and have the necessary structure and function **(Chapter II)**.

2. The Water Preserve Areas are an essential feature of the Restudy that should proceed rapidly to detailed design, preserving areas of existing high habitat value, and providing habitat enhancing features in others **(Chapter XII)**.

3. Water storage and treatment in other portions of the study area should also minimize impacts on fish and wildlife habitat. We have provided recommendations for relocation of the currently proposed storage location in the Caloosahatchee basin and for siting of storage and treatment in the Taylor Creek/Nubbin Slough basin **(Chapter XIII)**.

4. Land acquisition requirements are substantial in the Initial Draft Plan. We have provided a review of our current understanding of the issues. Although current activity is largely dependent on willing sellers, we find that eminent domain procedures will likely be required to complete the plan **(Chapter XI)**.

5. As the COE proceeds to detailed planning of components, we may find that some of the features are not feasible from technical, regulatory, or financial standpoints. Trade-offs will become more prominent in decision-making and fallback positions will need to be devised to address ecological problems that would be compromised by these trade-offs. Detailed design of all components should continually consider approaches that will promote passive systems over intensely active management **(Chapter XXII)**. Opportunities for removal of

structures that impede restoration should be a guiding principle; addition of structures must be clearly demonstrated to be unavoidable before being included in designs **(Chapter XXI)**. Proper sequencing of presently authorized projects and the components to be authorized in the Restudy must be determined and followed **(Chapter XV)**.

6. Policies governing authorization of wetland mitigation within the study area must be consistent with the goals of the Restudy. Enhancement of wetland functions and values attributable to the Restudy should not be credited to others. Information on the location of features proposed in the Restudy must be made accessible to reviewers of permit applications, and decisions must be compatible with the design of the Restudy **(Chapter X)**.

7. We have provided a review of the ecological benefits expected from implementation of the Other Project Elements. Many of these projects will provide ecological benefits at a regional scale **(Chapter VI)**.

8. We anticipate that the Restudy will promote recovery of several Federally-listed threatened and endangered species. Other listed species will either not be affected, or will be adversely affected, but not jeopardized, by implementation of the Initial Draft Plan **(Chapter XVI)**.

9. Recreational uses in the natural areas of south Florida must be considered in detailed project design and in policy development. Issues involved with access for hunting and fishing, management of fish and wildlife resources in the Water Conservation Areas, and the perception that federal lands are receiving restoration priority over state lands are issues that must be addressed with the Florida Game and Fresh Water Fish **(Chapter XVII)**.

10. Effective sequencing of actions proposed by the Restudy (relative to each other and to existing authorized projects) must be thoroughly analyzed and integrated in construction schedules. We strongly support the completion of the Water Preserve Areas, the Indian River Lagoon, and the Southwest Florida Feasibility Studies **(Chapter XV)**.

11. Control and management of invasive non-indigenous plants and animals is a critical aspect of ecosystem restoration in the central and south Florida. The South Florida Ecosystem Restoration Task Force and Working Group Exotic Pest Plant Task Team are developing a statewide strategic plan for managing and controlling exotic pest plants. This effort should be vigorously supported and implemented. We recommend that an equivalent Task Team for invasive exotic animals be established **(Chapter IX)**.

12. The DOI recommends that all progress toward achieving ecosystem restoration be continuously evaluated in a scientific forum. A peer-reviewed science-based adaptive management strategy, coupled with a sound monitoring program, is the recommended means for integrating all the past knowledge of the south Florida ecosystem with recent findings of the scientific community. Based on the monitoring information, the interagency adaptive management team will prepare annual reports and provide recommendations to decision-makers on how to proceed. This strategy will ensure that refinements to the Initial Draft Plan will be based on the best and most recent information. The annual reports will also be an avenue for keeping the general public informed on the progress of the restoration **(Chapter XIV**).

13. We have provided a review of some of the principal issues relating to water supply that have arisen during the Restudy **(Chapter VII)**.

14. We have provided recommendations regarding necessary studies on ASR **(Chapter XIX)** and on improvements to hydrologic models **(Chapter XX)**.

Without the actions proposed in the Restudy, we are certain that ecological conditions will continue to decline to a level where recovery will be improbable. Although no single plan has been shown to fully meet all targets, we support the Initial Draft Plan (Alternative D13R), with further refinements, as an effective conceptual strategy as we continue to refine and carry out the components of the Restudy.

ANNEX A2

FLORIDA GAME AND FRESH WATER FISH COMMISSION COORDINATION ACT REPORTS

ALLAN L. EGBERT, Ph.D., Executive Director
VICTOR J. HELLER, Assistant Executive Director

February 19, 1999

FARRIS BRYANT BUILDING
620 South Meridian Street
Tallahassee, FL 32399-1600
(850) 487-3796
TDD (850) 487-9542

Colonel Joe R. Miller
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Re: Central and Southern Florida Project Comprehensive Review Study (Restudy), Multiple Counties

Dear Colonel Miller:

The Florida Game and Fresh Water Fish Commission has reviewed the draft Integrated Feasibility Report and Programmatic Impact Statement ("integrated report") for the Central and Southern Florida Project Comprehensive Review Study (Restudy), dated October 15, 1998; and the scenario D13R4, which was developed after the draft integrated report was released. We have provided a series of three letters under the Fish and Wildlife Coordination Act (FWCA) of 1973 on the results of the Central and South Florida Project Comprehensive Review Study (Restudy). The first letter, dated August 6, 1998, addressed Alternative D13R; the second letter, dated January 19, 1999, addressed the draft integrated report; and this last letter addresses information (specifically, scenario D13R4) that has become available since the release of the draft integrated report. We have also received your letter dated February 19, 1999 in which you attempted to provide some level of assurance and commitment that the comprehensive plan would not further degrade Everglades habitats in the water conservation areas in the process of meeting other natural systems' restoration goals.

The preferred alternative, Alternative D13R, would partially alleviate flooding in southern WCA-3A and excessively dry conditions in northern WCA-3A; however, problems in some regions remain unresolved. Extreme high-water events would occur in eastern WCA-3A, and extreme high- and low-water events would occur in WCA-2B. Other sources of concern include increased water depths in WCA-3B, the frequency of extreme high-water events in northeastern WCA-3A, a shift toward long durations of marsh inundation throughout southern WCA-3A, and increased number and/or intensities of droughts in southern WCA-2A. Future development of this alternative must correct these deficiencies. We have addressed these issues in more detail in the first two parts of our FWCA report.

Effects of Scenario D13R4

Since the draft integrated report was released, the Alternative Evaluation Team developed scenario D13R4 to increase water deliveries to Everglades National Park and Biscayne National Park. This goal would be accomplished by capturing stormwater runoff from the basins that contribute to the C-51, C-13. C-14, C-15, C-16, Hillsboro, and North New River canals, and diverting it both west, through the Site 1 Reservoir/Stormwater Treatment Area (STA) and the Agricultural Reserve, into Water Conservation Area (WCA) 2A; and south, through the Water Preserve Areas and Lakebelt Reservoirs, to both parks. A number of other structural modifications were also modeled, including making WCA-2B more of a flow-through system and improving water delivery from Stormwater Treatment Area 3/4 into northern WCA-3A.

The result of developing scenario D13R4 was that Biscayne National Park and Everglades National Park (specifically, Shark River Slough) are predicted to receive water volumes that more closely approximate the target preferred by Everglades National Park than they would have received under the preferred alternative. In addition, very modest improvements would be made in the hydrologic regimes in eastern WCA-3A and in WCA-2B, although both areas still fall well short of their targets. On the other hand, these improvements would come at great cost to WCA-2A and WCA-3B, which would fare even worse than they do under the 1995 or 2050 Base Cases. In southern WCA-2A, scenario D13R4 would double the number of high-water events, while providing no relief from the increased drought frequencies predicted by the preferred plan. It would also double the frequency of high-water events throughout WCA-3B, and the frequency of extreme water depths would exceed that predicted by the Natural System Model for any portion of the Everglades characterized by a ridge and slough landscape. This effect in WCA-3B is of special concern to us, since this is one of the last parts of the WCA system that contains tree islands that have not been substantially damaged by flooding. The net result of scenario D13R4 is to increase the total area of the WCA system that is predicted to be worse off than if the project were not implemented. Clearly, this situation does not constitute "restoration" under any guise, and is not acceptable. The preferred alternative, Alternative D13R, is far superior in this respect.

In terms of the feasibility of implementing scenario D13R4, our conclusion is that it is problematic at best. One of the greatest areas of uncertainty is whether it would be possible to treat the stormwater captured through this scenario to a standard that would cause no "imbalance to flora and fauna." The water quality subteam of the Alternative Evaluation Team for the Restudy has calculated that the combined flow-weighted mean concentration of phosphorus in the water to be stored in the Site 1 Reservoir STA, and thence into WCA-2A, would be 166 ppb. Their calculations indicate that this STA would have to be enlarged from 2,160 to 6,892 acres in order to reduce this concentration to 50 ppb; no estimate is made as to the size required to meet the ultimate concentration that will be required by the Everglades Forever Act of 1994. Whether there is sufficient land available in this rapidly urbanizing portion of south Florida is highly uncertain. More importantly, by including urban runoff in the diversion of water to the natural system, chemical constituents (e.g., pesticides, oils, grease, and metals) other than phosphorus become a concern. While STAs appear to hold promise for reducing phosphorus loads, their efficacy at treating other contaminants is unknown.

A second significant source of uncertainty is the accuracy of the topographic information that led to the conclusion that substantially more water than that provided by the preferred alternative is needed in Shark River Slough, and that therefore led to the development of scenario D13R4. The Natural System Model assumes that no subsidence has occurred south of the Tamiami Trail, whereas lowered water levels in the northeastern portion (the "Expansion Area") of Everglades National Park, which had been drained for agriculture and development before its inclusion into the park and continues to be overdrained due to flood concerns to the east, would logically have caused some loss of soil to occur. If soil subsidence is factored into the model assumptions, then it is very possible that less water would be necessary to achieve desirable water depths in Shark River Slough. This issue is critical to the future of WCA-3B, and until it is resolved we would oppose any plan that includes maintaining extreme water depths in WCA-3B as a means to achieve restoration in other parts of the system.

Scenario D13R4 has been useful to the extent that it shows that the preferred alternative has the flexibility to capture 274,000 acre-feet of previously unused water in Palm Beach and Broward counties. If this water is to be shunted to natural areas (e.g., the WCAs or either national park), then it must be fully treated before it is discharged into them. Future efforts should (1) explore the possibility of reducing the negative effects in WCA-2A by incorporating a system to allow excess water to be moved south without passing it through WCA-2A and -2B when doing so would create flood events and a provision for using the Site 1 STA to deliver water to WCA-2A to alleviate the overly dry conditions that would otherwise occur; and (2) conduct an analysis to determine the extent to which topographic assumptions of the Natural System Model affect model outcome.

Conclusions

To summarize our major findings for this three-part FWCA report, we provide the following statements.

1. Alternative D13R remains the array of plan components that thus far has the most potential to be refined into a more detailed plan that could support the assemblage of fish and wildlife species that characterize south Florida. The exaggerated effects of dry and wet years in the

WCAs convince us that a "no-action" alternative would not be in the best interest of the state's fish and wildlife resources, and we believe that action needs to be taken as soon as possible to eliminate the conditions that have led to the unnatural pattern of water-level fluctuations that has been seen since the impoundment of the WCAs.

2. In its present form, Alternative D13R will require substantial refinements, particularly in portions of the WCAs, in order for it to realize its potential to provide adequate habitat for those fish and wildlife species, and to allow people to pursue recreational amenities that support a healthy Everglades.

3. Scenario D13R4 is troubling in that it continues a trend that has been in place since the conception of the Central and South Florida Project. This trend has consistently been one of ensuring water supply and flood control for agricultural uses and an ever-growing urban population at the expense of the natural system, and the part of the natural system that has borne the bulk of this cost has been the WCAs. To continue this trend in the name of restoration is unacceptable, particularly in light of the fact that these WCAs represent one-half of a system that itself has already been reduced by half. If true restoration of the Everglades as a whole is ever to occur, this trend must be reversed.

4. To ensure that the area affected by the Central and South Florida Project provides the kind of habitat that supports the fish and wildlife species of south Florida, we are committed to continue working with the U.S. Army Corps of Engineers and the South Florida Water Management District to develop the promise that we believe is contained in Alternative D13R. The challenge to you is to maintain your commitment to the Restudy's goal of enhancing ecologic values. To do so will necessitate maximizing benefits to the *entire* natural system. To do otherwise would result in an unacceptable loss to the future of Florida.

Sincerely,

Allan L. Egbert, Ph.D.
Executive Director

ALE/MAP/LH
ENV 2-16/5/1
fwcar4.let

cc: Ms. Patricia Beneke, Department of the Interior, Washington, D.C.
Mr. Michael Davis, U.S. Department of the Army, Washington, D.C.
Mr. Stephen Forsythe, FWS, Vero Beach
Mr. Samuel E. Poole III, SFWMD, West Palm Beach
Superintendent Richard Ring, ENP, Homestead

FLORIDA GAME AND FRESH WATER FISH COMMISSION

ALLAN L. EGBERT, Ph.D., Executive Director
VICTOR J. HELLER, Assistant Executive Director

January 19, 1999

FARRIS BRYANT BUILDING
620 South Meridian Street
Tallahassee, FL 32399-1600
(850) 487-3796
TDD (850) 487-9542

Colonel Joe R. Miller
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Re: Central and Southern Florida Project Comprehensive Review Study (Restudy), Multiple Counties

Dear Colonel Miller:

The Florida Game and Fresh Water Fish Commission (GFC) has reviewed the draft Integrated Feasibility Report and Programmatic Impact Statement ("integrated report") for the Central and Southern Florida Project Comprehensive Review Study (Restudy), dated October 15, 1998. This report is submitted under the authority of the Fish and Wildlife Coordination Act (FWCA) of 1973.

On August 6, 1998 we sent the U.S. Army Corps of Engineers (COE) the first portion of our FWCA report, which addressed concerns and made recommendations on the performance of the preferred alternative, D13R, which only covers hydrologic changes that can be modeled using the South Florida Water Management Model. At that time, we had expected that the issues that fell outside of the domain of the South Florida Water Management Model would be available in the draft integrated report for review. We had anticipated that we would address these other aspects through this letter, which constitutes the second and final portion of our FWCA report. Specifically, we had planned to provide input as to how water quality, the implementation plan, and the Other Project Elements would affect fish and wildlife. Although the draft integrated report contained sections on these topics, they are undergoing significant revision. In addition, even Alternative D13R is being revised. Even recognizing that a draft will likely be subject to some degree of revision, the work that is currently underway contains changes that are of sufficient magnitude that we cannot responsibly provide a FWCA report on what has become a moving target. Specifically, we will have to wait until the results of this month's revision of Alternative D13R, the five issue papers (adequacy of water deliveries to Shark River Slough, performance of Alternative D13R in portions of the Water Conservation Areas, discharges to the St. Lucie estuary, adequacy of water to Biscayne Bay, and the feasibility of water reuse), the revised implementation plan, and the white paper on water quality impacts are available for review. Although staff of the GFC have been involved with the development of some of these documents, their informal participation does not constitute a sufficient basis on which the GFC can provide a FWCA report.

In the meantime, we are providing you with a summary of some of our major concerns, most of which have been described in more detail in the August 6, 1998 section of our FWCA report.

Performance of Alternative D13R in Natural Areas. The performance of Alternative D13R is, at this point in the planning process, flawed with respect to the extent to which much of the Everglades is restored. We have supported this alternative in concept in that, of all of the alternatives, it appears to provide the array of hydrologic tools that will probably be necessary to improve the hydropatterns within the natural areas; however, much work remains to be done to determine how to best use these tools to approximate restoration. Of particular concern are the fates of portions of the Water Conservation Areas, Shark River Slough in Everglades National Park, and the St. Lucie estuary.

Our major concerns with the performance of Alternative D13R, with respect to the WCAs, include the extremely high and low water levels predicted to occur in WCA-2B; deep water in eastern and northeastern WCA-3A; and extended hydroperiods in much of WCA-3A, particularly south of Alligator Alley. Water Conservation Area 2B is particularly problematic, with conditions drying out in the northeastern corner (where the drier conditions have aided an invasion of melaleuca) and consistent ponding in the south.

Staff of Everglades National Park contends that Alternative D13R provides only 70% of the historic flow volumes to Shark River Slough, as predicted by the Natural Systems Model, and our rough calculations based on their data tend to agree with this conclusion. Since the slough is the major delivery route for fresh water to Florida Bay, the implications are on a larger scale than just the southern Everglades. We note, however, that Appendix B ("Hydrology and Hydraulics Modeling") cautions "against using NSM [Natural Systems Model] flow volumes as hydrologic restoration targets, and recommend[s] that it is more appropriate to use water depths and patterns as targets due to the relatively large uncertainty in NSM overland flow estimates compared to those from the [South Florida Water Management Model]" (Subsection B.3.2.4 "Proper Interpretation of Overland Flow," p. B-63). Since there is an intuitive link between flow and water depth, we are concerned that the reduction in flow cited by Park staff may indeed reflect a problem area, but the extent to which it is a problem in an ecological sense is not yet clear. Future efforts should be directed toward assessing the performance of Alternative D13R on Shark River Slough through indicators other than overland flow volume before actions are taken to adjust the plan. These assessment tools should not only be used to evaluate conditions within the slough, but also the timing and delivery of fresh water to Florida Bay.

Need to Treat Water through the New S-140 Structure. We have been concerned that immediately discharging a large amount of water directly into northern WCA-3A, where muck fires and oxidation have caused substantial soil subsidence, would result in the same situation as we have seen in Holey Land Wildlife Management Area, where cattails proliferated almost immediately after it was fully rehydrated. The expansion of the S-140 would allow the system to be operated so that some of the water that would eventually be discharged in to northern WCA-3A could be shunted, at least initially, to areas further south. This flexibility would allow northern WCA-3A to be rehydrated gradually, while still providing water to southern and central WCA-3A and Everglades National Park. This design comes at a price, however, in that it would involve the discharge of untreated water off of agricultural lands in the basin to be served by the new S-140 structure. Our preliminary review of the impacts of Alternative D13R led us to recommend a water-quality treatment facility be added to treat water that would be discharged through the new S-140 structure.

Key Information Needs for Planning in the Future. The single most important information need for future hydrologic restoration is accurate topographic information. During the Restudy process, there has been much debate over issues such as the "real" height of tree islands (which we define as the spectrum of islands of woody vegetation ranging from willow strands, islands dominated by swamp bay or dahoon holly, and islands with flood-intolerant native vegetation within a larger landscape of marsh and slough), the degree to which parts of the Water Conservation Areas have subsided, and whether there would be a sufficient hydraulic head to move water farther south. The information that exists may have been adequate for the conceptual level of planning that has gone on until now, but planning in the future will be severely hampered unless more accurate and detailed topographic information is obtained.

Other Project Elements. Although the list of Other Project Elements (actions that cannot be modeled through the use of the South Florida Water Management Model) do not appear to contain projects that would be detrimental to fish and wildlife, most of the individual project descriptions do not contain enough information on which to base an assessment of their potential impacts on fish and wildlife in any detail. The entire section of the draft integrated report dealing with the Other Project Elements lacks a critical review of the projects that have been proposed as "restoration" projects when various funding opportunities have arisen during the past several years. One of the projects appears to be mitigation for impacts already required under an existing permit, and another has value only as a demonstration project to determine if hardwood hammock vegetation can be reestablished on rock-plowed lands along two 200-foot-wide strips along the main road to Everglades National Park. Clearly, these projects must be investigated further if they are to be accepted as a restoration project on anything more than a conceptual level. The Other Project Elements will have to be reviewed under the FWCA individually as they are further developed.

Importance of Recreational Amenities. Societal values are the driving force behind the extent to which a project such as the Restudy can be carried out. It stands to reason, then, that it will be important to provide people with the opportunity to interact with the systems that we are restoring. Everglades National Park provides an excellent place where nature lovers can go to appreciate fish and wildlife in a way that minimizes disturbance to these resources, and we also have started a program, Watchable Wildlife, that promotes nature watching. The popularity of nature watching should not, however, eclipse the need to provide people with the opportunity to enjoy part of the system for the more traditional recreational activities of hunting and fishing, at least to the extent that they do not compromise restoration of the system as a whole. For instance, the L-67 canals support an enormously popular area for recreational fishing, including tournament fishing. We are concerned that not enough is known yet to support the contention that canals are a significant detriment to system-wide restoration, other than for hydrologic reasons. Because providing quality hunting and fishing opportunities consistent with restoration is an important mission of the GFC, it is important that canal removal be well justified in terms of hydrological and ecological results. Retaining public access to WCAs-2 and -3, which we manage as the Everglades Wildlife Management Area, is an integral part of this mission, so we are concerned about the potential to lose existing access points, particularly off the Tamiami Trail. We therefore oppose removal of existing access points without providing alternative suitable locations.

New Opportunities Provided by the Restudy. In addition to the benefits to the natural system and to water supply predicted by the integrated report, implementing the Comprehensive Plan may provide new opportunities for managing the Everglades Wildlife Management Area in ways that would benefit native wildlife. For instance, we recommend retaining portions of levees internal to the WCAs in such a manner that would not inhibit the restoration of sheetflow, and grading their sides to provide a gradual slope not unlike that of a natural tree island. This design would provide us with areas that we would then plant with appropriate native vegetation. Our aim would be to provide "tree island-like" habitat, particularly in areas where tree islands have disappeared. It would also provide an opportunity to test the hypothesis that the functions that lost tree islands provided can be restored by artificial means.

Authorization Process. The draft integrated report does not clearly address how the COE intends to request authorization of the Comprehensive Plan. Because it is expected to involve 50 years of construction and operational changes, we believe that it will be essential to obtain up-front Congressional endorsement, at least at a conceptual level, for the entire plan in order to provide the kind of support that will be needed if the Federal government is to ensure that it is committed to implementing the plan in full.

Although we strongly recommend that the COE request that the entire Comprehensive Plan be endorsed in concept, we would object if individual authorization packages resulted in a process that short-circuited the intent of the FWCA. Although we have no objection to the COE having the flexibility needed to implement the Comprehensive Plan, it will be important to maintain close coordination under the FWCA at all points during this large and complex project in order to ensure that intended benefits are indeed realized by native fish and wildlife communities.

We continue to support the restoration of the natural areas that the Restudy aims to accomplish, and look forward to continued coordination with the COE during the refinement and implementation of the Conceptual Plan.

Sincerely,

Allan L. Egbert, Ph.D.
Executive Director

ALE/MAP
ENV 2-16/5/1
rsdycar2.let
cc: Mr. Samuel Poole III, SFWMD, West Palm Beach
Mr. Stephen Forsythe, USFWS, Vero Beach
Superintendent Richard Ring, ENP, Homestead

FLORIDA GAME AND FRESH WATER FISH COMMISSION

ALLAN L. EGBERT, Ph.D., Executive Director
VICTOR J. HELLER, Assistant Executive Director

FARRIS BRYANT BUILDING
620 South Meridian Street
Tallahassee, FL 32399-1600
(850) 487-3796
TDD (850) 487-9542

August 6, 1998

Colonel Joe R. Miller
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Re: Central and Southern Florida Project Comprehensive Review Study (Restudy), Multiple Counties

Dear Colonel Miller:

The Florida Game and Fresh Water Fish Commission (GFC) has reviewed the description of the initial draft plan, Alternative D, for the Central and Southern Florida (C&SF) Project Comprehensive Review Study (Restudy), sent to us by the U.S. Army Corps of Engineers (COE) on 11 June 1998; and the description of the refined version (Alternative D13), sent to us in an undated letter (received in our Vero Beach office on 25 June 1998). Since we received the second letter, we understand that Alternative D13 has been further refined (Alternative D13R) to correct a modeling error that our staff had detected and in order to further improve the performance of the alternative with regard to the St. Lucie estuary. We have also reviewed the Alternative Evaluation Team's (AET) report (posted on the Restudy website on 24 July 1998) on the performances of Alternatives A, B, C, D, and D13R relative to the 1995 Base and the 2050 Base.

While Alternative D13R comprises an integral part of the Comprehensive Plan for the Restudy, as authorized by the Water Resources Development Acts of 1992 and 1996, it does not constitute the entire plan. For example, the Comprehensive Plan will also include a series of restoration projects, termed Other Project Elements (OPEs), that cannot be evaluated through the use of the South Florida Water Management Model (SFWMM) or its companion model, the Natural System Model (NSM). It is our understanding that a definitive list of these OPEs may not be available until the draft Programmatic Environmental Impact Statement (PEIS) is released on 15 October 1998. For that reason, this letter constitutes our Fish and Wildlife Coordination Act Report (FWCAR) for Alternative D13R, and we anticipate sending the COE a separate FWCAR once there is a definitive set and description of the OPEs. In addition, the AET's evaluation of water quality is not yet available; therefore, we will defer an assessment of the performance of Alternative D13R with regard to impacts of water quality on fish and wildlife to a later FWCAR.

This report is submitted under the authority of the Fish and Wildlife Coordination Act (FWCA) of 1973 (48 Stat. 401, as amended: 16 U.S. C. 661 et seq.). We intend to send additional reports as necessary to address significant changes to Alternative D13R resulting from the public review process.

Development of the Initial Draft Plan (Alternative D13R)

In October 1997, the COE and the South Florida Water Management District (SFWMD) began a planning process that was aimed at developing a broadly conceived Comprehensive Plan for the C&SF Project, intended for submission to Congress in July 1999. In order to accomplish this, they convened a multiagency team, composed of planners, modelers, hydrologists, biologists, and water-quality experts, that has met for the past year in an intensive, iterative process of developing and refining plans for hydrologic improvements to the C&SF Project to cover demands projected through the year 2050, with the assumption that the Everglades Construction Project, Modified Water Deliveries to Everglades National Park, and the C-111 Project would already have been implemented. It was also assumed that water conservation practices outlined by the Lower East Coast Regional Water Supply Plan would be in place. This team was divided into an Alternatives Development Team (ADT), made up primarily of modelers and hydrologists, and an Alternatives Evaluation Team (AET), made up primarily of biologists, water-quality experts, and water-supply planners. A starting plan was first developed by the modelers, and, ultimately, six alternatives were built upon it. Four of these plans were deemed worthy of further evaluation, and one, Alternative D, was chosen by the AET and the overall multiagency Restudy team as the one to be investigated intensively for refinement. The result of this refinement is Alternative D13R, also termed the “initial draft plan.”

Alternative D13R has approximately 50 components, which include both operational and structural changes to the present C&SF Project (excluding the Upper St. Johns River portion). It includes a massive amount of water storage through regional Aquifer Storage and Recovery (ASR) wells [1,665 million gallons per day (MGD)], regional surface reservoirs (1.5 million acre-feet), stormwater treatment areas (STAs; 60,000 acre-feet in addition to that supplied by the Everglades Construction Project), and the Water Preserve Areas (at least 42,400 acre-feet; these Water Preserve Areas will be more fully explored by a separate feasibility study due September 2001). It would partially decompartmentalize Water Conservation Area (WCA)-3 by filling in the Miami Canal and removing the L-67C, L-28, L-28 tieback, and L-29 levees and canals. The L-67A levee would remain, but three S-345 structures would be placed farther south than would the two now planned under Modified Water Deliveries to Everglades National Park. Eight fixed-crest weirs, six north of and two south of the S-345 structures, would be placed along the length of the

L-67A levee. The southern six miles of the L-67A canal would be filled, so that it would terminate at a control structure just upstream of the S-345 structures. The purposes of this design are to transport excess water from eastern WCA-3A and to avoid excessively deep water in WCA-3B, while delivering water to a point in southern WCA-3B where it could flow eastward to rehydrate northeast Shark River Slough. Alternative D13R is designed to route excess water from WCA-2B, WCA-3A, and WCA-3B, to the east of the L-30, L-33, and L-37 levees through the Water Preserve Areas into a proposed Central Lake Belt Reservoir, where it would be available for further improvements to the eastern part of Everglades National Park. It includes a rainfall-based operational plan for the entire system, except for the A.R.M. Loxahatchee National Wildlife Refuge.

Evaluation of Alternative D13R

This letter summarizes some key results of Alternative D13R in terms of ecological restoration of the south Florida ecosystem. Although the GFC is responsible for all of the wildlife and freshwater fish within the Restudy area, this letter focuses on the northern half of the remaining Everglades and Lake Okeechobee, for two reasons. First, these are areas where water supply and flood control have for many years taken precedence over the conservation of fish and wildlife. As a result, they have been significantly damaged by the C&SF Project, and they are at risk of continued deterioration unless their environmental needs receive sufficient priority as part of the Restudy effort. Second, because participating federal agencies have done an outstanding job advocating for the environmental restoration of federal trust lands within the A.R.M. Loxahatchee National Wildlife Refuge, Big Cypress National Preserve, Everglades National Park, and Biscayne Bay National Park, this letter focuses on issues confronting the other major parts of the Everglades ecosystem (i.e., the WCAs and Lake Okeechobee). An evaluation of Alternative D13R for all natural areas is attached to this letter (Attachment A).

The C&SF Project has caused a massive shift in water flows from their natural pattern. Flood waters were allowed to rise within Lake Okeechobee, and then were diverted in large releases to the east and west via the Caloosahatchee and St. Lucie canals. In the Everglades, the volume of water flowing through the watershed decreased; canals caused over-drainage of northern areas; levees created deep ponds at the lower elevations of the WCAs; and overall flows into Everglades National Park and Florida Bay were dramatically decreased. Alternative D13R makes substantial progress toward remedying this situation. The fundamental result of Alternative D13R for the overall natural system is that it restores an enormous amount of fresh water to a southward flow, using storage to achieve improvements in timing, while reducing unnatural flows to the east and west in the form of flood releases to the Caloosahatchee and St. Lucie estuaries. It accomplishes this without undue reliance on storage in Lake Okeechobee.

Northern and Central Everglades

The northern and central Everglades are composed of Holey Land and Rotenberger wildlife management areas (WMAs), A.R.M. Loxahatchee National Wildlife Refuge (WCA-1), and the Everglades and Francis S. Taylor WMA. Together, these areas constitute roughly 900,000 acres of Everglades landscape. The two most significant problems that have been caused by the C&SF Project in this region are (1) the loss of peat soils as a result over-drainage, followed by microbial oxidation and muck fires; and (2) the destruction of tree island vegetation as a result of a combination of muck fires in over-drained regions, such as northern WCA-3A, and prolonged high water in deeply ponded areas, such as southern WCA-2A. Overall, Alternative D13R appears to make major steps toward solving these two critical problems. Although all of the final alternatives developed by the Restudy team perform well in relieving drought conditions that could damage peat soils, Alternative D13R provides the best overall reduction in extreme high-water conditions that would flood tree island vegetation communities in southern WCA-3A and throughout WCA-3B.

Three physical features of the current Everglades make full hydrologic restoration difficult. First, the Everglades proper (i.e., the landscape composed of sawgrass plains, sawgrass ridge and slough, and shorter hydroperiod marl marshes) is much smaller than it was historically, with greater loss of extent as one proceeds northward. In order to restore historical flows and depths to the southern Everglades, it is therefore necessary to route more water through the smaller, narrower channel formed by today's northern portion of the Everglades. Second, current reconstructions of the predrainage system indicate that the portion of the Everglades now lost to development east of the Dade-Broward levee included some of the deepest areas, where substantial flow may have occurred (NSM 4.5 Final version, SFWMD). Third, the natural slope of the land directs water toward the eastern boundary of the remnant system in what is now WCA-3, and toward the southern boundary of WCA-2B. These changes in the landscape create a persistent problem in all the alternatives: a tendency for water to pond in WCA-2B and on the eastern sides of WCA-3A and -3B, while depths and inundation durations within Shark River Slough in Everglades National Park remain below NSM values. The Restudy team explored three basic methods of increasing conveyance so that excess water in the WCAs could be routed to Shark River Slough, where it was needed to restore the marsh and provide flows to Florida Bay: (1) use the existing L-67A canal to speed flow south; (2) remove levees that were impediments to flow, specifically the L-28, L-28 tieback, and L-29; and (3) develop a conveyance system (the Central Lake Belt reservoir component) east of the L-30 and L-33 levees in order to compensate at least partially for the lost eastern portion of deeper Everglades that fed Shark River Slough. Alternative A explored the first of these components, while Alternatives B, C, and D evaluated the second and third approaches in varying proportions. None of these alternatives managed to approach restoration goals sufficiently either north or south of Tamiami Trail. Only Alternative D13R has come close to providing hydrologic conditions that are more NSM-like throughout the northern, central, and southern Everglades, and it does this by using all three methods to move water from the ponded northern areas of eastern WCA-3A and WCA-2B toward the south.

A number of issues remain. One of the most serious issues is the potential ecological effect of the large hydrologic change predicted by Alternative D13R within WCA-3B. Water depths and inundation durations in WCA-3B will increase concomitant with restoring flows in Shark River Slough, through modification to L-67 structures and the removal of the L-29 levee. Overall, this would be a substantial deviation both from current conditions in WCA-3B and from NSM predictions of the predrainage hydrologic conditions. It would impose on WCA-3B an inundation and depth pattern that more closely matches NSM predictions for mid-Shark River Slough than for WCA-3B itself; therefore, WCA-3B is neither restored in an historical sense, nor are its current ecological values conserved under Alternative D13R. Only the compelling need to restore freshwater flows through Shark River Slough and Florida Bay and to provide more natural hydrologic conditions for the entire Everglades justifies tolerating this deviation from what would otherwise be suitable restoration objectives for this area. However, of all of the alternatives, only Alternative D13R manages to approximate restoration goals for the entire Everglades ecosystem with the least degradation of the ecological values in WCA-3B. At this time, Alternative D13R's performance appears to be at the limit of hydrologic change that could responsibly be advocated for WCA-3B in the near term, as any greater depths would push the region beyond the range of conditions currently predicted by NSM to have existed in *any* part of the historic River of Grass. Extreme caution will be needed in implementing changes that carry such a high degree of biological uncertainty. Maintaining even this minimally acceptable hydroperiod depends on the ability to move water to Shark River Slough through the Lake Belt system east of WCA-3B. The Lake Belt system is therefore an essential component of D13R.

A second major issue is the potential long-term biological effect of a shift in the overall hydrologic pattern toward longer periods of inundation with fewer drying events than those predicted by the NSM. The best overall match to NSM inundation patterns is Alternative A, where it appears that maintenance of the WCAs as compartments provides more control over water depths in different sections of the Everglades; however, what amounts to a highly controlled series of dammed pools is not consistent with the idea that one of the defining characteristics of a restored Everglades system is dynamic sheetflow. With partial decompartmentalization, such as modeled in Alternatives B and D13R, exact matches to local NSM predictions within WCA-3 no longer appear to be possible, given the reduced overall extent of the Everglades watershed north of Tamiami Trail. Hence, the benefits of decompartmentalization in promoting sheetflow and reducing the frequency and duration of flooding appear to conflict with the ability of water management to match local NSM targets. In considering this apparent trade-off, we believe that long-term sustainability of the northern and central Everglades marshes probably depends more on the avoidance of extremes of drought and flood than on exact restoration of local predrainage hydropatterns. Only Alternatives B and D13R manage to avoid extreme high water in southern and central WCA-3A, and only Alternative D13R accomplishes this in WCA-3B as well.

A third significant issue is the effect of altered hydrologic conditions within eastern WCA-3A on wading bird nesting and foraging areas. On the one hand, northeastern WCA-3A is predicted to become wetter and to experience an increased occurrence of depths in excess of 2.0 feet, as compared to the 1995 and 2050 bases. On the other hand, the area south of the 3A-3 gage and east of the Miami Canal will still remain deeper than the NSM values, but will have far fewer high-water events than would occur under the 1995 Base. Since both of these areas include important wading bird rookery sites, the changed conditions could be expected to improve breeding habitat in some areas (such as the Andytown rookery) but possibly damage it in others (such as Rescue Strand rookery). Furthermore, the distribution of suitable foraging areas for wading birds will undoubtedly be changed. Although overall restoration of the Everglades watershed is expected to improve habitat for nesting wading birds regionally, the timing of development of suitable breeding sites to the south, relative to changes in current nesting sites, could have significant effects on regional wading bird populations. We believe that improvement of performance measures that can evaluate the response of wading bird populations to changes in hydrologic conditions, combined with a plan for system-wide monitoring, will be extremely important components in implementing the plan.

In northwestern WCA-3A, as well as in Holey Land and Rotenberger WMAs, performance under Alternative D13R appears adequate to provide for sustainable marsh conditions. There is a beneficial decrease in the frequency of extreme drought conditions in northwestern WCA-3A and in Rotenberger WMA. Although hydrologic performance appears satisfactory at the level of resolution that can be provided by the SFWMM, it is not clear whether the structural components being considered in Alternative D13R are sufficient to (1) support a sufficiently natural hydrologic pattern, and (2) meet a 10-ppb phosphorus standard (the current default standard under the Everglades Forever Act). Specifically, it is our understanding from discussions with SFWMD staff that Rotenberger WMA is being modeled to receive dry-season water deliveries from the regional water supply system, as needed, via STA 5, and that Holey Land WMA includes additional discharge capacity to meet outflow operations aimed at minimizing depths above 1.5 feet (C. Neidrauer, pers. comm.). These structural and operation details are not formally documented in the descriptions of alternative components (Components DD5 and EE5). In addition, it is unclear as to whether or not STA 5, which discharges into Rotenberger, and the S-140 structure, which discharges into western WCA-3A, will be able to meet the 10-ppb phosphorus standard assumed by the alternative.

In conclusion, Alternative D13R provides inundation patterns within the WCA system that are similar to those thought to have occurred in the pre-drainage Everglades and that seem likely to promote a sustainable marsh ecosystem. There nonetheless remain many questions about the biological responses that will occur, and these uncertainties can only be overcome by a suitable plan for adaptive management that will allow timely and informed changes in water management that promote biological restoration goals.

Lake Okeechobee

The model results indicate that Alternative D13R would provide improvements to Lake Okeechobee, particularly for the littoral zone. It performs well due primarily to the addition of two types of water-storage strategies. First, storage and attenuation would be provided by the construction and operation of surface-water reservoirs (250,000 acre-feet; sites yet to be identified) and a stormwater treatment area in the Nubbin Slough/Taylor Creek basin (20,000 acre-feet). Second, and perhaps more significant, is heavy reliance on Aquifer Storage and Recovery (ASR) wells to achieve the benefits to the lake. The concept behind the use of ASR wells is to store water in the Floridan Aquifer when there is excess water in the system, and then to draw it back up for use when more water is needed. Alternative D13R proposes 200 ASR wells around the lake, each with a capacity of 5 MGD.

Recreation

One issue that merits attention is the potential impact of Alternative D13R on the recreational amenities provided by Lake Okeechobee, J.W. Corbett WMA, Rotenberger WMA, Holey Land WMA, Everglades and Francis S. Taylor WMA (WCAs-2 and -3), Big Cypress WMA, and Southern Glades Wildlife and Environmental Area. Please refer to the attached interim report (Attachment B) for a more in-depth description of the recreational values (hunting, fishing, and wildlife viewing) for which the GFC manages these natural areas. To our knowledge, the overall economic impact of the recreational uses, and in the case of Lake Okeechobee, commercial use, has not been fully evaluated; however, the growth of ecotourism would only escalate the economic benefits of fishing, hunting, and nature watching in the non-developed areas. To the extent that Alternative D13R approaches restoration, we anticipate benefits in recreational uses as well, since sustainable recreation depends on sustainable natural resources. For example, the elimination of extreme high-water events in WCA-3A may greatly reduce strandings of white-tailed deer, and allow them to move to and from higher ground in the Big Cypress National Preserve and other lands just west of WCA-3A. On the other hand, the removal of over 100 miles of canals would, without replacement of fishing opportunities elsewhere in Dade and Broward counties, eliminates much of the opportunity for this popular sport in southeastern Florida.

Concerns and Recommendations

1. <u>Concern:</u> The heavy reliance on ASR to meet performance goals for Lake Okeechobee is of concern for two reasons. First, although ASR technology is currently in use elsewhere in Florida, its use on a regional scale has not yet been tried. We understand that the PEIS will address a contingency plan should this solution fail to perform as modeled, and we are heartened to hear that the U.S. Environmental Protection Agency may be able to permit the use of ASR wells

without expensive treatment at the wellhead. Nevertheless, other obstacles (e.g., geological formations in the aquifer) may pose more technical problems. The implications of failure to identify a successful replacement for this technology are of grave concern with regard to the future of the lake.

Recommendation: Although we may have doubts as to the efficacy of regional-scale ASR facilities around Lake Okeechobee, we have no doubt as to how we want to see the lake look in the future. Both Alternative D and D13R perform very well for the lake; however, if regional ASR fails to perform adequately, we strongly recommend that the contingency plans avoid transferring the brunt of the storage lost to any part of the natural system.

2. Concern: We are concerned about the impact of impingement and entrainment of fish in pipelines and pumps used to move water from Lake Okeechobee to the reservoirs and ASR wells. Larval fishes, in particular, lack the ability to avoid entrainment. If there is at least one high-capacity connection to the lake for each reservoir and each ASR well, then their use could affect the fish communities in the lake.

Recommendation: We recommend that the COE work closely with staff of the GFC's Division of Fisheries to reduce or eliminate the potential for impingement and entrainment of fishes by new pumping facilities.

3. Concern: None of the alternatives manage to restore hydrologic conditions in WCA-2B to anything that approximates those that would sustain an Everglades-like landscape. During the course of the alternatives analysis, the reason for this poor performance was never well understood. We are concerned that continued dry-outs and high-water events that currently occur in WCA-2B will lead to further deterioration of this area to the extent that it no longer contributes to the overall populations of fish and wildlife that characterize the Everglades.

Recommendation: In order to rectify hydrologic problems in WCA-2B, every attempt must be made in the future to identify why the modeled alternatives, particularly Alternative D13R, have failed to provide hydropatterns that would be conducive to an Everglades landscape. We suggest that the first area to be investigated is the operations of WCA-2A and -2B.

4. Concern: Alternative D13R predicts hydrologic changes in northeastern WCA-3A that may harm nesting habitat for wading birds in areas that have been among the most productive nesting sites in the Everglades within recent years. The increase in extreme high water in this area can be credited, at least partly, to operational assumptions about STA 3/4.

Recommendation: Hydrologic performance in this area should be improved during further modeling efforts. It is possible that changes in STA3/4 operational rules alone could lead to improved performance. Additional storage to the north, or the development of structures that would provide a more balanced distribution of inflows to the WCAs during high rainfall periods, may also need to be included in the final plan.

5. Concern: One area of serious concern that remains with respect to Alternative D13R is the fact that approximately 6 miles of the southernmost end of the L-67A canal would be removed, as would the entire L-29 canal. We understand that the reason for the design of the L-67 system is to use the S-345 structures and the expanded weirs 7 and 8 to shunt water eastward into northeastern Shark River Slough, while avoiding extreme high-water events in the bulk of WCA-3B. On the other hand, the entire length of this canal is heavily used for recreational fishing, and in fact is one of Florida's premier recreational fishing areas. For example, in 1997 there were 106 organized fishing tournaments, with nearly 3,000 participants, held in WCA-3A. The catch rate for those tournaments was 0.67 largemouth bass per man-hour, as compared to the statewide goal of 0.5 (F. Morello, GFC, pers. comm.). The entire length of the L-67A canal is used, with a slightly higher observed use in the southern reaches. In addition, six GFC boat ramps associated with the L-29 canal and the southern end of the L-67 canals would be eliminated. Some of these ramps are quite popular. For example, during a six-month period from December 1996 though May 1997, GFC staff of the Division of Fisheries counted 2,900 boats launched from the boat ramp at the lower end of the L-67C canal.

We are aware of concerns that exotic fishes in canals may cause problems for native marsh communities, if not now, then possibly in the future. On the other hand, such impacts, specifically for the L-67A and L-29 canals, remain hypothetical, whereas the adverse effects of canal removal on recreational fishing would clearly occur. Thus, we cannot presently support the removal of these canals on the basis of the presence of non-native fish species alone. The GFC is prepared to support actions necessary for ecological restoration, but significant negative impacts to human use of these resources require clear justification.

Recommendation: While we fully support a design that would accomplish ecologic restoration, we recommend that the COE and the SFWMD run a sensitivity analysis to determine whether the L-67A canal can be extended farther south and still capture the hydrologic benefits that the currently proposed design is anticipated to accomplish. In addition, it is our understanding that the removal of the L-29 levee automatically included removal of the L-29 canal, as well. It does not appear that the effect of leaving in the canal, or parts of it, was investigated. Since the L-29 canal also provides a fishery resource with sufficient use that its elimination would pose a serious concern for our recreational fishing program, we recommend that the COE and SFWMD also model a scenario in which the L-29 levee is removed, but the L-29 canal is retained. In short, we would strongly support a design that clearly aids in restoring the overall hydrologic characteristics of the predrainage system; however, we would be opposed to removing canals that currently provide recreational fishing benefits when that removal provides little or no hydrologic restoration benefit. We recommend that the COE work in close cooperation with the GFC's Division of Fisheries during the detailed design phase in order to determine the degree to which recreational amenities can be maintained and to fully mitigate for any losses (e.g., by designing the Water Preserve Areas so that they support recreational fishing).

6. Concern: The northern and central Everglades are predicted under Alternative D13R to shift toward hydroperiods that are longer than those predicted by the NSM. The long-term ecological effects of such a change are not known. One significant uncertainty is the possibility of large scale cattail proliferation within the northern areas of WCA-3A.

Recommendation: Further modeling and design of the preferred alternative should include an effort to develop operational flexibility within the Everglades watershed. Operational and structural details should be explored that will allow hydroperiods within the remnant Everglades to be reduced in some regions without causing an overall loss of flow to more downstream parts of the system. The use of the S-140 structure and an associated spreader-canal system would be an example, as it might allow more water to be discharged into central WCA-3A, if it became desirable to send less water into northern WCA-3A as a means of discouraging cattail expansion.

7. Concern: An issue that continues to plague efforts to predict ecosystem response to hydrologic changes is that much of the SFWMM relies on topographic information that is derived from data collected before much of the subsidence and peat loss that has occurred over the past 40 years. Unless up-to-date information that captures the extent of subregional subsidence and local peat loss due to muck fires is utilized, we are concerned that the predicted flow vectors and extent of ponding may be inaccurate.

Recommendation: The COE and local sponsor should work with the U.S. Geological Survey and others to expedite the collection of high-resolution topographic data in Rotenberger and Holey Land WMAs and throughout the WCAs and Everglades National Park.

8. Concern: A variety of performance measures were used to evaluate the Restudy alternatives. These measures were deliberately designed to function as a minimal set of evaluation tools that could compare model results on the accelerated schedule of the Restudy alternative development process. These measures, therefore, cannot and should not be interpreted as management objectives for any or all parts of the Everglades ecosystem. Specific reasons why the AET performance measures should not be viewed as management criteria were detailed in a previous planning aid letter of 24 February 1998.

Recommendation: A concerted effort is needed to ensure that performance measures are developed that can more accurately predict the responses of peat soils, tree island vegetation communities, and wildlife (including wading birds) to hydrologic changes. Such measures should be scientifically supportable as best current estimates of ecological responses to changed hydrologic conditions, and they will need to be developed prior to detailed design of structures and operations that will alter hydrologic conditions within the Everglades watershed.

9. Concern: The Everglades has been subjected to hydrologic regimes that are far different than were the conditions under which they were originally formed. They have been drained to some extent for roughly 100 years, and have been even more intensively managed over the past 40 to 50 years. It is reasonable to hypothesize that, to some extent, today's landscape has adjusted to these changes. We are therefore concerned that abrupt changes to a more "restored" landscape may in fact result in unintended shifts in community structure. As an example, when the GFC, South Florida Water Management District, Florida Department of Environmental Regulation (now Florida Department of Environmental Protection), and the Board of Trustees of the Internal Improvement Trust Fund decided in 1983 to impound Holey Land Wildlife Management Area and restore it to a 0- to 2-foot water regulation schedule, the result was a proliferation of cattails, particularly in areas that had a history of muck fires.

Recommendation: The Comprehensive Plan should include two well-crafted sections: (1) an implementation plan that allows for careful staging of hydrologic changes so as to avoid large environmental "shocks" that could induce ecological damage to the marsh communities; and (2) an adaptive management strategy that ensures that monitoring is well designed and comprehensive over the total system. It will be crucial for monitoring results to be evaluated within an objective scientific framework, and to be acted upon expeditiously. Maintaining flexibility in water management actions in response to monitoring results will be critical during project implementation. Water management changes likely to be identified as part of an adaptive management process would generally take place on a time scale of months-to-years; hence, operational flexibility need not be incompatible with a system in which passive forms of water management play a dominant role.

10. Concern: No plan for adaptive management of the Everglades ecosystem can succeed unless it has the "teeth" that allow water management policy for the natural system to be responsive to input from the resource management agencies that would be responsible for much of the monitoring effort. We are concerned that, as the population of south Florida grows, there will be increasing conflict between the responsibilities of the agencies that manage water resources and those that manage natural resources.

Recommendation: We recommend that, if ecological restoration is to become a reality, a process be established to coordinate and balance the responsibilities and goals of the many resource- and water-management agencies responsible for different parts of the south Florida ecosystem.

Conclusion

The development of Alternative D13R has been the result of an intensive, multiagency planning process that has been underway since last October. The GFC has been very involved in this process, leading the AET subgroup that developed performance standards and evaluated model output for all of the Everglades landscape north of Tamiami Trail, an area that has been the most heavily impacted part of the natural system. Because the scope and complexity of the Comprehensive Plan that will be sent to Congress next July is unprecedented, we commend the COE and the SFWMD for taking this multiagency approach, which incorporates a wide spectrum of agency and government expertise.

In conclusion, the GFC finds Alternative D13R to be the alternative that shows the most promise for restoring the natural areas that lie within the SFWMM domain. We therefore support it as an alternative that merits further development during the detailed design phase. Concerns and issues expressed in this letter are intended to provide guidance for improvements during the future development of practical applications to effect restoration. We understand that the plan is still conceptual in nature, and we look forward to continuing our role in the Restudy team as it continues to design more detailed plans in order to turn the concept into actual restoration actions. To that end, we anticipate this FWCAR to be the first in an on-going series of FWCARs that we intend to provide the COE as it enters the detailed design phase.

Sincerely,

Allan L. Egbert, Ph.D.
Executive Director

ALE/MAP/LH
ENV 2-16/5/1
rstdycar.let
Enclosures
cc: Mr. Samuel Poole, III, SFWMD, West Palm Beach
Mr. Stephen Forsythe, USFWS, Vero Beach

ATTACHMENT A

SUMMARY OF THE PERFORMANCE OF ALTERNATIVE D13R IN THE NATURAL AREAS

Office of Environmental Services
Everglades Protection and Restoration Section
Florida Game and Fresh Water Fish Commission

This section provides a summary of the performance of Alternative D13R with respect to the natural system, since these are the areas that most directly pertain to fish and wildlife resources. The Alternatives Evaluation Team (AET) divided the domain of the South Florida Water Management Model into eight geographic subunits: the total system, Lake Okeechobee, the Lake Okeechobee Service Area, the Lower East Coast Service Areas, the northern and central Everglades [Rotenberger and Holey Land wildlife management areas (WMAs), WCAs-1, -2A, -2B, -3A, -3B, and the Pennsuco wetlands], southern Everglades (Everglades National Park, including Florida Bay; the Model Lands; and the C-111 basin), Big Cypress National Preserve, and the estuaries and bays (Caloosahatchee estuary, St. Lucie estuary, Lake Worth Lagoon, and Biscayne Bay). Our report is based in part on a review of the AET's report with regard to these regions, with the exception of the northern and central Everglades. For this critical portion of the Everglades, we have provided a much more in-depth analysis of the performance of Alternative D13R, since staff was deeply involved with its evaluation.

Total System (Decompartmentalization)

Because many of the effects of compartmentalization and fragmentation are at this time hypothetical, it is not possible to determine conclusively whether all of the benefits anticipated will be realized. For example, the extent to which canals play a role in the introduction of exotic fishes into "healthy" natural marshes, as opposed to remaining primarily in disturbed areas, is much debated [P. Shafland, Florida Game and Fresh Water Fish Commission (GFC), pers. com.]. On the other hand, exotic catfish have been well documented in Lake Okeechobee, where they disturb benthic habitat used by native fish species (G. Warren, GFC, pers. com.). The hypothesis that managing the WCAs as discrete pools such that "false cues" are given to wading birds in terms of when to initiate nesting is plausible, but as of this time, we are unaware of any definitive studies to support this concept.

On the other hand, much can be accomplished by the removal of some of the levees. For example, the removal of the L-29 levee has dramatically reduced dependence on WCA-3 for storage, and eliminates the damaging high-water events that have plagued southern WCA-3A during the past six years.

Lake Okeechobee

Alternatives B, C, D, and D13R all performed well in terms of nearly eliminating the number of undesirable events. These results are largely because all of these alternatives assumed that 200 regional-scale Aquifer Storage and Recovery (ASR) wells would be placed around the lake, although some lesser benefit is also accrued by incorporating above-ground reservoirs north of the lake. In addition, the inclusion of a large reservoir in the Everglades Agricultural Area would lessen its dependence on the lake, and therefore reduce the number of extreme drawdowns. All of the alternatives were improvements over the 1995 Base and the 2050 Base.

Alternative D13R would provide hydrologic conditions that would be beneficial to the littoral zone, particularly in the west and northwest. The littoral zone cannot be underestimated in terms of its importance to the fisheries of the lake. The littoral zone community of Lake Okeechobee includes most of the wading bird, waterfowl, and herpetofauna characteristic of the Everglades as a whole. One possible negative impact of Alternative D13R is the potential for impingement and entrainment of fishes in the pumps and pipelines used to move water from Lake Okeechobee to above-ground storage and ASR wells.

Southern Everglades

For the most part, Alternative D13R represented a significant improvement over the 1995 and 2050 bases. The overall performance of Shark River Slough indicated an 82% match with the NSM target, as opposed to 28% for the 1995 Base and 38% for the 2050 Base. The rockland marl marsh fared slightly less successfully, with an overall match of 76%, as opposed to 22% for the 1995 Base and 60% for the 2050 Base. The Florida Bay coastal basins showed an 80% match, as opposed to 20% for the 1995 Base and 50% for the 2050 Base. The overriding problem was the lack of sufficient water to fully meet the performance targets; however, the extent to which these shortfalls are ecologically significant is as yet undetermined.

The results for Model Lands were mixed, indicating that Alternative B performed better for lands west of U.S. 1, whereas Alternatives C, D, and D13R performed better for lands east of U.S. 1. As was the case for the rest of the southern Everglades, the issue was a lack of sufficient water, particularly of an adequate quality, to meet the restoration objectives. As a whole, however, the AET report deemed Alternatives C, D, and D13R to be preferable for the region as a whole, since all of these alternatives spread the available water across the region more equitably. Moreover, these three alternatives would provide the infrastructure to furnish the needed water, should a source be identified during the detailed design phase.

The ecological significance of the gap between the target performance measures is not clear at this time. Many other parts of the natural system likewise do not fully meet their targets. One thing that is certain is that it will not be possible to return the south Florida ecosystem, let alone the Everglades and Lake Okeechobee, to their predrainage condition. Since the first canals were dug in the late 1800s, roughly half of the spatial extent of the Lake Okeechobee-Everglades system has been lost; the system of levees that protect the developed and agricultural lands east of the Everglades has changed the shape of the natural flowage system, and therefore changed the range of possible flow vectors; peat has been lost, and whole regions have subsided; sea level appears to be rising over the long term; and exotics have invaded. Many of these changes are irreversible, while others are reversible only by restoring long-term processes. In general, any movement in the direction of meeting the performance measures beyond the performance of the 1995 Base and the 2050 Base would be expected to be positive for fish and wildlife. More problematic than the shortfalls predicted for hydrologic conditions within Everglades National Park are the long-term effects of shortened hydroperiods and water quality within the Model Lands. Invasion of exotic and brushy plants due to shortened hydroperiod may have to be approached aggressively through fire management and herbicidal treatment in order to maintain the relatively low, open plant community that supports the easternmost subpopulations of the endangered Cape Sable seaside sparrow. These issues will have to be sorted out at the detailed design stage.

Big Cypress National Preserve

The AET assessed the effects of the alternatives on the Big Cypress National Preserve by comparing the performance in each of the three regions (north Big Cypress, south Big Cypress, and southeastern Big Cypress) most likely to be affected by the changes being modeled with the SFWMM with the values predicted by the NSM. The results were not conclusive, possibly due in part to the use of an indicator region that did not adequately reflect the alternatives' performance in the north Big Cypress region, and also due to a disagreement as to how to interpret performance at the boundary with Everglades National Park (southeastern Big Cypress region). The summary results for the southern and southeastern Big Cypress regions, however, do indicate that Alternatives D and D13R perform the best of all of the alternatives, including the 1995 and 2050 bases. Due to uncertainties mentioned above, the impacts to fish and wildlife are not clear.

Estuaries and Bays

The greatly improved performance of the Caloosahatchee estuary under Alternative D13R would benefit all estuarine species. Reducing these freshwater pulses would stabilize seagrass beds, and would benefit members of the drum family (Sciaenidae), such as the seatrout. Damaging discharges to the St. Lucie estuary would be reduced, resulting in fewer stressful events on the estuarine fish species and productive seagrass beds; however, the Comprehensive Plan will have to defer to the results of the Indian River Lagoon Feasibility Study to fully address the St. Lucie estuary. Anticipating impacts to Lake Worth Lagoon and to Biscayne Bay are problematic at this time, due to the uncertainty in performance uncovered by both analyses of these coastal waterbodies.

Northern and Central Everglades

Holey Land and Rotenberger Wildlife Management Areas

Holey Land and Rotenberger WMAs constitute about one-half of the remnant sawgrass plains landscape of the Everglades, the remainder of which occurs in northeastern WCA-3A. The principle hydrological restoration needs for these areas are: the provision of clean water during both wet and dry seasons, in quantities suitable to provide natural hydropatterns; the avoidance of extreme high-water events that would drown remaining tree islands and promote cattail proliferation; and the prevention of extreme drought conditions that cause soil oxidation and risk of muck fires. Although the Restudy alternatives do no include significant structural alterations to these WMAs, Alternative D13R, like Alternatives A through D, contains some potentially beneficial components, including: (1) an inflow/outflow operational schedule that would deliver water to both Holey Land and Rotenberger WMAs during dry as well as wet seasons; (2) rainfall-based operational rules that provide for natural depth variations, but with high and low limits imposed to prevent extreme flood or drought conditions; and (3) improvement of additional outflow structures in Holey Land WMA as need to support the outflow operations (C. Neidrauer, pers. comm.).

The overall performance of Alternative D13R appears to be largely satisfactory in these areas. The model results for Rotenberger WMA show a reduced frequency of drought conditions relative to both the 1995 and 2050 bases. For Holey Land WMA, however, any comparison of Alternative D13R to the revised 1995 and 2050 bases is not realistic, because the revised bases modeled a 0- to 2-foot regulation schedule that has been abandoned and is unlikely ever to be re-implemented in the future. For this reason, we interpreted Alternative D13R for Holey Land WMA by comparing performance to the unrevised 1995 Base, which assumed a 0- to 1-foot regulation schedule more like that which is currently in use. When this comparison is made, the performance of Holey Land WMA in Alternative D13R is overall similar to the revised 1995 Base. Advantages of using the rainfall-based operations, as opposed to the fixed schedule in the 1995 Base, cannot be discerned at the level of resolution of the SFWMM.

Four concerns remain. First, the predicted quality of inflow water seems uncertain. Stormwater Treatment Area (STA) 5 may not be sufficiently large to meet a target of 10 ppb phosphorus, or even the 50-ppb interim standard, with the increased flows predicted for the Restudy. Second, it is not yet understood what exact operational limits on high and low water depths will provide the biologically best balance between the need protect peat soils and the need to discourage cattail proliferation. Current operational assumptions in Alternative D13R are only an estimate to support modeling of structural performance. It will be essential for the restoration of these areas that operational rules be evaluated with more detailed modeling, followed by monitoring and adjustment as needed. Third, one disadvantage of rainfall-based operations is that they can create higher water demands than do fixed regulation schedules because water is brought in and discharged more frequently in an attempt to emulate natural depth patterns. While this strategy may improve flow through the system, it may also increase overall phosphorus loading. Hence, it will be important to balance development of operational rules with possible constraints imposed by water quality. The fourth concern is that in both WMAs, drought conditions (when the water table drops to more than one foot below the ground surface) occur about 3-4% of the simulation period in Alternative D13R. The minimum depths and durations needed to protect peat soils are still not well understood; however, so long as the plan provides for dry season deliveries of adequately treated water via the STAs, it should be possible to adjust operational details so as to avoid further soil loss.

The hydrological performance of Alternative D13R for both Holey Land and Rotenberger WMAs is generally similar to that in the unrevised 1995 Base for Holey Land WMA. Predicted conditions are largely consistent with overall current management goals for these areas. Nonetheless, there remain uncertainties about the ability of the STAs to provide sufficient water quality, and these uncertainties raise concern about the potential for continued cattail expansion within these areas. The flexibility to adjust water management regimes in these areas will likely be the most important component for insuring long-term sustainability of marsh conditions favorable for wildlife.

Water Conservation Area 1 (A. R. M. Loxahatchee National Wildlife Refuge)

The current regulation schedule for A. R. M. Loxahatchee National Wildlife Refuge (LNWR) was used by all of the Restudy alternatives. Earlier examination of decompartmentalization scenarios had shown that removal of the L-39 levee would lead to severely damaging low water levels in Lake Okeechobee. Current refuge management goals are to maintain present conditions, comparable to the 1995 Base. For this reason, the only structural components included in Alternative D13R were weirs placed within the perimeter canal in order to reduce over-drainage of the northern part of the refuge.

Overall, LNWR would be expected under Alternative D13R to maintain marsh conditions favoring deeper-water species such as snail kites and waterfowl, as well as substantial populations of marsh fishes. However, it is possible that a continuation of the existing schedule, which maintains deeper water in the southern part of the refuge, could lead to adverse effects on tree island communities and the wildlife that depend on them.

Water Conservation Areas -2A and -2B

The marsh ecosystem in WCA-2A has suffered substantial damage as a result of past water management. In the south, most of its tree islands have been lost to prolonged high waters (Dineen 1974), while many acres of northeastern WCA-2A have been overtaken by cattails. The highest quality marsh occurs in central WCA-2A in the vicinity of the 2-17 gage and to the northwest of the gage, where a small number of intact tree islands persist. Principle hydrological restoration needs are a reduction in over-drainage in the north and in extreme high-water events that have drowned tree islands in the south.

Under all of the Restudy alternatives, WCA-2A exhibited problematic performance. In Alternatives A-D, southern WCA-2A experienced more frequent extreme high-water events than would occur under 1995 and 2050 bases while northern WCA-2A had durations of inundation that were much longer than those predicted by the NSM. Alternative D13R introduced operational changes that improved inundation patterns in the north, but in so doing increased the frequency of extreme drought conditions in the south. It appears that water management in WCA-2A imposes trade-offs between providing improved marsh conditions in some areas but worse conditions in others. It is also possible that restoration of a more natural hydropattern to this portion of the Everglades is hampered by constraints imposed by water management elsewhere, notably the fixed regulation schedule in LNWR, that may be amplifying high and low water conditions in WCA-2A. If LNWR adopts rainfall-based operational rules in the future, such unnatural fluctuations in depth may be alleviated.

Water Conservation Area-2B was one of the two most problematic regions in the northern and central Everglades from the standpoint of restoration to more natural hydrologic conditions. Although the overall hydroperiod in this area is similar to that in the NSM, all the alternatives exhibit too-frequent extremes of high water, low water, or both. In Alternative D13R, the occurrence of extreme high-water events is substantially less than it is in the 1995 and 2050 bases; however, there still remains a combination of frequent drought conditions and frequent extreme high-water events that occupy 16% of the total simulation period. Such frequent extremes imply that this area will not be able to function sustainably as either a shorter- or a longer-hydroperiod Everglades wetland.

The overall most significant component affecting performance in WCAs-2A and -2B is the Central Lake Belt storage facility, which takes water from southern WCA-2B (as well as from eastern WCA-3A and -3B) and routes it to the Central Lake Belt reservoir for later delivery to Everglades National Park or other areas. This design leads to continued flow-through and a very different set of water management issues than those of the present C&SF Project. Rather than exhibiting high water in the south combined with overdrainage in the north, as is currently the case in all of the WCAs, Alternative D13R predicts longer hydroperiods near the STA-2 input in the north, increased drying in the south, and accumulation of water at the “bottom” in WCA-2B. As a result, those areas that most closely match target hydrologic performance are those nearest to the locations of gages that trigger inflow/outflow operations. A more detailed study of the effects of different operational rules will be needed in order to identify the ecologically most beneficial method of water management for this region.

The ability of Alternative D13R to support appropriate densities of Everglades fish and wildlife within WCAs -2A and -2B will depend strongly on the results of detailed project design and the operational rules that accompany it. On the one hand, it is possible that water management could promote protection of remaining tree islands in northern WCA-2A along with recovery of previously damaged islands in southern WCA-2A. Such protection would provide nesting areas for wading birds and reptiles, as well as improved wading bird foraging habitat. On the other hand, it is also plausible that extremes of high and low water could result in soil loss in southern WCA-2A, deterioration of remaining tree islands, and spread of cattails throughout the north. Similarly, the deep water in WCA-2B might support fish and apple snail populations and provide refuges for aquatic organisms during all but the most extreme dry periods; however, if water management in this area allows WCA-2B to dry out for extended periods, it will not be able to serve such ecological functions.

Water Conservation Area-3A

A number of components in Alternative D13R lead to significant predicted changes in hydrologic conditions in WCA-3A. Those components having the most direct effects on the conservation area are (1) the changes in the location and magnitude of water deliveries along the northern and western boundaries; (2) the Central Lake Belt reservoir and its operation; (3) the L67-A canal and levee changes; and (4) the removal of the L-28, L-28 tieback, and L-29 levees. The hydrologic changes that result from these components fall into three general classes, corresponding to different sub-regions of the conservation area that differ both in their current restoration needs and in the changes predicted for Alterative D13R.

The first hydrologically distinct area is northwestern WCA-3A, north of Alligator Alley and west of the Miami Canal.   This area is within the part of the WCA that has been most affected by over-drainage, which in turn has led to substantial soil loss through oxidation and muck fires. A major restoration priority in this area is the protection of existing peat soils and the reinitiation of peat accumulation. Alternative D13R predicts improved hydrologic conditions in this respect, with a reduction in the frequency of extreme dry-outs (defined as groundwater depths in excess of 1.0 feet below ground) from 7-11% of time in the 1995 Base, and 4-5% of time in the 2050 Base, to 1-3% of time in Alternative D13R.

The second hydrologically distinct area in WCA-3A is the region south of Alligator Alley and west of the Miami Canal. This area includes some of the most deeply ponded parts of the WCA, where substantial damage to tree island vegetation has occurred as a result of flooding during the past 30 years (McPherson 1973). Southern WCA-3A also includes the portions of the central Everglades that have suffered the least damage as a result of C&SF Project operations (McPherson 1973; Schortemeyer 1980). Under Alternative D13R, southern WCA-3A is predicted to see a substantial reduction in the frequency and duration of extreme high-water events. The most dramatic improvement is in the southernmost part, corresponding to Indicator Region 14 in SFWMM output. Here the occurrence of extreme high-water events is reduced from 36% of time in the 1995 Base, and 6% of time in the 2050 Base, to only 1% of time in Alternative D13R.   These benefits are clearly owing to the removal of the L-29 levee along the southern boundary of WCA-3A, since significant reduction in the intensity of flooding occurs only in Alternatives D13R and B, the two alternatives in which this levee is removed. On the other hand, although extreme depths are largely eliminated from southern WCA-3A, the overall hydroperiod of the area is increased, with periods of inundation that are much longer than those predicted by the NSM. These extended hydroperiods are most pronounced in the area immediately to the south of Alligator Alley, corresponding to Indicator Region 18 in SFWMM output. Here the model predicts only 11 marsh dry-outs during the 31-year simulation, as compared with 18 events in the 1995 Base and 24 events in the NSM. This lengthening of hydroperiods is a result of the relocation and increased operational capacity of the S-140 structure, which leads to greatly increased discharges directly northwest and upstream of Indicator Region 18. Hence, although the reduction in predicted tree island flooding would be a dramatic step toward ecological restoration of southern WCA-3A, the ecological effects of a general shift toward longer hydroperiods is uncertain.

The third hydrologically distinct area in WCA-3A is the region to the east of the Miami Canal. This is the area in which the most successful wading bird nesting has occurred in recent years, although rookery vegetation was substantially damaged by the high-water event of 1994-95 (T. Towles, GFC, pers. comm.). The performance of Alternative D13R is problematic in this area. In the northeastern region, north of Alligator Alley, the frequency of extreme high-water events is larger than it is in either the 1995 or 2050 bases, and simulated depths and durations during the high-rainfall years of 1994-95 are predicted to be worse than in the 1995 Base. This increase in predicted flooding raises concerns about potential negative effects on wading bird nesting habitat in this region, which already suffered damage during the 1995-96 high-water event. The problem in Alterative D13R appears to result from excess discharges from STA 3/4 during high rainfall years. In contrast, to the south of the 3A-3 gage, northeastern and eastern WCA-3A are predicted to experience reduced depths and flooding compared to the 1995 Base. Since eastern WCA-3A has suffered from extreme high-water events in recent years, rookery sites in eastern WCA-3A might be expected to do better under Alternative D13R than under current conditions. In addition to uncertainty about the effect of hydrologic changes on rookery vegetation in this region, Alternative D13R also predicts that northeastern WCA-3A will continue to experience drought conditions frequently enough to raise concern about continued impacts to peat soils.

Alternative D13R makes substantial progress toward remedying the two most significant causes of habitat degradation for wildlife within WCA-3A. The first of these is flood damage to tree islands, with attendant loss of upland tree species, willow strands that serve as wading bird nesting sites in northeastern WCA-3A, tropical hardwood hammocks in southwestern WCA-3A, and habitat throughout the WCA for island-dependent organisms such as nesting reptiles, white-tailed deer, and migratory and nesting songbirds. The second major cause of habitat degradation has been the destruction of peat soils, marsh vegetation, and tree islands as a result of wildfires brought on by drought conditions in the north. Together, the reduction in the frequency and intensity of these two sources of environmental damage should be expected to lead to substantial restoration within this large portion of the remnant Everglades ecosystem.

Nevertheless, there continues to be uncertainty about several aspects of the predicted hydrologic change. First, the ecological effect of prolonged inundation periods on the overall functioning of the Everglades ecosystem is not known. Comparison of predicted hydroperiods for the overall WCA-3A and -3B region indicates that the entire landscape will, on average, be shifted toward inundation durations that are longer than those predicted by the NSM. Second, it is uncertain whether hydropattern restoration will lead to cattail proliferation in the north, as a possibly inevitable consequence of antecedent soil conditions and changed topography. Third, it is difficult to predict how wading bird nesting and foraging will be affected by changes in depth patterns in northeastern WCA-3A. The more northerly parts of this area (represented by model output for the 3A-4 gage and Indicator Region 21) are predicted to become wetter, while to the south, areas east of the Miami Canal will remain deeper than the NSM values, but will have much reduced high-water frequencies compared to the 1995 Base. These conditions could be expected to improve suitable rookery sites in some areas but, possibly, damage others; and the distribution of suitable foraging areas will undoubtedly be changed. Although overall restoration of the Everglades watershed is expected to improve nesting habitat for wading birds regionally, the timing of development of suitable breeding sites to the south, relative to changes in current nesting sites, could have significant effects on regional wading bird populations. A more detailed analysis of anticipated effects of Alternative D13R on wading bird breeding and foraging habitat, combined with a plan for system-wide monitoring, will be important components in implementing the plan.

A final area of uncertainty is water quality. The alternatives modeling process has assumed that all environmental water deliveries would meet a 10 ppb phosphorus standard; however, given the large inflows into and through the WCA system, it is not clear that this goal will be achieved. As currently modeled, most inflows into WCA-3A involve water that will be coming through the STAs (those currently under construction under the Everglades Construction Project and additional STAs proposed by Alternative D13R). However, an area of concern is the water entering WCA-3A South via the relocated S-140 structure. There is a possibility that the plan may not include adequate STA treatment capacity for flows of this magnitude in this area.

Water Conservation Area-3B

Water Conservation Area-3B is the second of two remaining high-quality marsh areas within WCA-2 and -3, the other being central WCA-3A. Although generally drier than it was prior to construction of the C&SF Project, the area is characterized by good water quality, intact wet prairie and sawgrass communities, and hardwood hammock and bayhead tree islands that are largely undamaged by flood, fire, or modern human activity. Southeastern WCA-3B is part of the predrainage channel of Shark River Slough. Overall, the area is slated to receive increased depths as part of the effort to restore natural hydropatterns to Shark River Slough and freshwater flows to Florida Bay.

Achieving acceptable Everglades conditions within WCA-3B has been a major planning challenge for the Restudy. Water Conservation Area-3B exhibits increased depths in all four alternatives, with weekly mean depths that exceed the NSM values by 0.5-0.75 feet year round. Of greater concern than the increased average depth pattern, however, has been the predicted high occurrence of prolonged depths in excess of 2.5 feet. Alternative B had the most extreme high water, with 12% and 17% of the simulation period having depths greater than 2.5 feet in western and eastern WCA-3B, respectively. These values for duration of high-water events range from 25% to 76% larger than those predicted by the NSM for northeast Shark River Slough, historically the deepest part of the natural system. Hence, Alternative B actually pushes WCA-3B not only well beyond the range of the predicted predrainage depths for that area, but outside the maximum depths and durations estimated to have occurred anywhere predicted within the historical River of Grass.

Alternatives D13R and A were the only alternatives that succeeded in holding the frequency of extreme high-water events within the bounds defined for the natural system, overall, by the NSM. In both alternatives, this performance can clearly be credited to the barrier provided by the L-67 levee, which prevents excess build up of water within the northern and central sections of the WCA. Alternative D13R was the only "decompartmentalization" alternative that avoided excessive flooding in WCA-3B. In addition, Alternative D13R predicts a lower frequency of extreme high-water events than that predicted for the 2050 Base, although 2050 Base conditions in northeast Shark River Slough are far drier than their restoration targets.

Under Alternative D13R, WCA-3B is neither restored in an historical sense, nor are its current ecological values conserved. Overall, D13R leads to an inundation and depth pattern in WCA-3B that more closely matches NSM predictions for mid-Shark River Slough than it does for WCA-3B itself. This pattern represents a substantial deviation from both current conditions in WCA-3B and from NSM predictions of the pre-drainage hydrology. The rationale for this deviation from what would otherwise be the defined restoration targets for WCA-3B is the need to restore freshwater flows through Shark River Slough to Florida Bay, and to provide more natural hydrologic conditions for the entire Everglades landscape. The long-term effect of increased depths in WCA-3B is uncertain.

Water Conservation Area-3B is one of the least impacted portions of the northern and central Everglades. Although it is substantially drier, at least in its southeastern reaches, than in predrainage estimates, and has suffered significant soil loss in this area, it has good water quality and tree islands that have been largely unimpacted by flood, drought, or human activity. Hence, although Alternative D13R appears likely to prevent damage to higher hammock tree islands in WCA-3B, impacts on less-elevated tree islands still may occur. It is doubtful that WCA-3B could tolerate much deeper conditions than those seen in Alterative D13R without causing a net degradation in fish and wildlife resources in this area.

Pennsuco Wetlands

The Pennsuco wetlands lie in a region that once included some of the deepest parts of the predrainage Everglades. Today the area supports a drier marsh with extant tree islands. Under Alternative D13R, extreme low-water and extreme high-water conditions occur relatively rarely, and the reduction in drought conditions is dramatically improved over the 1995 and 2050 bases. Overall hydroperiods are longer than under the base models, and the hydrologic conditions appear likely to support "NSM-like" ridge and slough conditions, with reduced drought frequencies. These hydrologic conditions would be expected to protect marsh soils and provide for a sustainable marsh in the area, even though it would not return this area to its historical condition.

Given the increased depths predicted in Alterative D13R for both Shark River Slough and WCA-3B, an important potential function of the Pennsuco marsh might be to provide shallower water suitable for wading bird foraging during periods when both Shark Slough and WCA-3B are too deep.

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ATTACHMENT B

RECREATION AND THE INITIALLY PREFERRED ALTERNATIVE (ALTERNATIVE D13R)

In-House Interim Report

D. Timothy Towles
Office of Environmental Services
Everglades Protection and Restoration Section
Florida Game and Fresh Water Fish Commission

Introduction

The C&SF Restudy encompasses a very large geographic area delimited by the South Florida Water Management District (SFWMD) boundary and includes a number of public properties that are managed by the Florida Game and Fresh Water Fish Commission (GFC) for their recreational value related to fish and wildlife. Those areas that are presently thought to be little affected, if at all, by the initially preferred alternative (Alternative D13R), but which lie within the drainage basin, include six Type I wildlife management areas consisting of Three Lakes Wildlife Management Area (WMA) and Kicco WMA in Osceola County, Arbuckle WMA in Polk County, Kissimmee River WMA in Highlands and Okeechobee counties, Fred C. Babcock/ Cecil M. Webb WMA in Charlotte County, and Frog Pond WMA in Dade County; and one Type II wildlife management area (Avon Park Air Force Base) in Polk and Okeechobee counties. Type I wildlife management areas are public hunting and recreation areas operated by the GFC in cooperation with private, state, and federal landowners. Type II wildlife management areas are public hunting and recreation areas operated by the landowner in cooperation with the GFC. Those wildlife and environmental areas (WEAs) that are presently not expected to be affected include the John G. and Susan H. Dupuis WEA in Palm Beach and Martin counties and the CREW WEA in Lee and Collier counties. Other areas managed by the GFC that are not expected to be influenced by the C&SF Restudy include the Lake Harbor and Terrytown Public Waterfowl Areas (PWA). Nevertheless, the use of Terrytown as a Public Waterfowl Area may be temporary since this area was acquired by the SFWMD for use as a stormwater treatment area as part of the Everglades Forever Act. The remaining wildlife management areas detailed in this report are the ones that we thought had the most potential for being affected if Alternative D13R were implemented.

A measure of the amount of recreational hunting in each of those wildlife management areas that are anticipated to change under the C&SF Restudy is portrayed in Table 1. The level of monitoring harvest pressure varies between wildlife management areas due to budgetary and staffing constraints, and to differences between areas in check station operation and amount of hunter use. For example, the highest 5-year mean (13,306 man-days) for harvest pressure recorded in the Everglades region was for the Big Cypress Wildlife Management Area (Big Cypress WMA) (Table 1). Harvest pressure information for this area was derived from vehicle counts on Saturdays of every weekend during the 93 days comprising the archery, muzzle-loading, and general gun seasons. By contrast, harvest pressure data was not collected in the Holey Land and Rotenberger WMAs during portions of some hunting seasons. For instance, during the 1997-98 season, harvest-pressure data were gathered only on the opening weekends of muzzle loading and general gun-walk seasons. Consequently, the 5-year mean figures for harvest pressure in the Holey Land (635 man-days) and Rotenberger (766 man-days) WMAs should be viewed as minimal estimates of harvest pressure that are not directly comparable to wildlife management areas such as the Big Cypress WMA, where the hunting pressure is more consistently measured.

Everglades and Francis S. Taylor Wildlife Management Area

The Everglades and Francis S. Taylor Wildlife Management Area (EWMA) is a Type I wildlife management area located in southwestern Palm Beach, western Broward, and northwestern Dade counties. The EWMA consists of Water Conservation Areas (WCA)- 2 and -3, and encompasses approximately 671,831 acres (Figure 1). Different hydrological regimes exist due to the division of WCA-2 into two compartments forming WCA-2A and WCA-2B, and the division of WCA-3 into two compartments forming WCA-3A and WCA-3B. Consequently, wildlife populations and associated recreational opportunities vary considerably between these compartments, necessitating the implementation of an array of management strategies that also varies with regional weather patterns and water management operations. The principal landowners of the EWMA are the SFWMD and the State of Florida's Board of Trustees, with the remainder owned by other public agencies and private individuals. Water Conservation Areas-2 and -3 were designated as the EWMA in 1952, and are operated by the GFC under the terms of a cooperative management agreement with the SFWMD.

The EWMA has traditionally been used by the public for a variety of recreational activities including hunting, fishing, frogging, airboating, camping, and nature appreciation. Utilization of the interior marsh is limited due to physical constraints and lack of access. Airboats are the primary mode of transportation into the marsh when surface water is present, whereas all-terrain vehicles (ATV), tracked vehicles, and swamp buggies are used to access the area when water levels approach ground level.

There are several recreation areas located along the boundary of the EWMA: Loxahatchee Recreation Area, Sawgrass Recreation Area, Everglades Holiday Park, and Mac's Fish Camp. These facilities, along with three regularly operated concessions by the Miccosukee Tribe on the Tamiami Trail, provide amenities such as boat ramps, camping facilities, boat rentals, airboat tours, fishing guides, bait and tackle supplies, and food to the general public. During 1997, commercial airboat tours out of Everglades Holiday Park transported 116,306 tourists into nearby Everglades canals and marsh.

Frogging is permitted throughout the year. This is a favorite pastime of many airboaters. Although frogging occurs throughout the EWMA, the southwestern and central portions of WCA-3A have traditionally harbored the best frog populations, and consequently have received the most use (Ligas 1960).

Hunting for selected game species is allowed during the fall-winter period; however, check stations erected to monitor harvest pressure and collect biological information are only operated during the fall deer season. Consequently, there is no information as to the hunting pressure on other game species. The mean time spent on deer hunting in the EWMA, based on the five-year period of 1989-93, was 1,984 man-days (Table 1); however, this level of hunting pressure declined precipitously following the unprecedented high water event of 1994-95 that practically eliminated the area's deer herd and necessitated the complete closure of the deer season for three years (Table 1). Other game species that are often sought by hunters in the EWMA, when hydrological conditions are favorable, include waterfowl, snipe, and wild hogs.

The canal system of the EWMA supports an important recreational fishery, with fishing permitted throughout the year. Two of the areas that have traditionally supported some of the best fishing and consequently have been monitored by the GFC through creel surveys are the L-35B/L-38E canals and the L-67A canal. Creel survey data collected for the 5-year period of 1985-89 in the L-35B/L-38E canals yielded a fishing effort ranging from 55,659 hours in 1985-86 to 128,430 hours in 1986-87, with an annual mean of 81,665 hours. A five-year mean total of 79,755 fish were harvested with a harvest success rate of 0.91 fish per hour (Table 2). There is a no-consumption advisory on bass due to high levels of mercury in the EWMA. Consequently, anglers routinely release their fish, which has resulted in high populations of 2- to 5-pound bass (Jon Fury, pers. com.).

Fishing effort in the L-67A canal for the seven-year period of 1990-97 ranged from 25,848 hours in 1992-93 to 58,150 hours in 1995-96, with an annual mean of 43,167 hours. The seven-year mean total recorded harvest was reported to be 41,765 fish, with a mean success rate of 0.98 fish per hour. The results from these creel surveys are derived from a six-month sampling period during each of the years, so these data do not include fishing effort expended during the remainder of these years. Although creel surveys were discontinued for the L-35B/L-38E canals in 1990, observations by staff of the Division of Fisheries indicated that the fishing effort in this canal system appeared to be comparable to that expended for the L-67A for the time period of 1992-97. High water levels in the EWMA since 1993, however, have contributed to below-normal fishing effort due to the dispersion of fish into the adjoining marsh, resulting in lower catch rates. It should also be noted that even though the year 1995-96 experienced the highest amount of fishing effort in the L-67A canal over the past seven years (Table 2), access was greatly curtailed due to the closure of the boat ramps at the primary access site of Everglades Holiday Park for about three months and the closure of the canal itself for about one month. Although these two canal systems represent no more than 16% (assuming about 330 miles total) of the total canal mileage within the EWMA, they receive a disproportionate amount of the fishing pressure from boats. Due to staffing and budgetary constraints, no recent creel survey data have been collected for the rest of the canal system within the EWMA. There is also a considerable amount of bank fishing in the canals adjacent to S.R. 27, I-75, and the Tamiami Trail (Tim Towles, pers. com).

Due to the institution of slot possession limits on largemouth bass in 1996, it became necessary to issue regulation exemption permits for bass tournament participants. Outside of Lake Okeechobee, the canal system within the EWMA has proven to be the most popular location for holding bass tournamentsin south Florida. There are approximately 65 fishing clubs in the Everglades region, many of which periodically host tournaments. In the fiscal year 1996-97, 91 of the 116 (or 78%) bass tournaments in the Everglades region (excluding Lake Okeechobee) were held in the EWMA. During this year, 3,202 participants landed 5,061 bass, with a combined weight of 13,906 pounds. Also, 37 of these bass caught in WCA-3A weighed more than 8 pounds, and the largest weighed almost 10 pounds. During the fiscal year of 1997-98, 117 of the 180 (or 65%) bass tournaments in the Everglades region (excluding Lake Okeechobee) were conducted within the canal system of the EWMA. In this fiscal year, 4,312 anglers landed 6,759 bass, with a combined weight of 16,920 pounds. Of these bass, 54 caught in WCA-3A weighed more than 8 pounds, and the largest weighed in at nearly 11 pounds. It is estimated that approximately 95% of the WCA-3A tournaments originate at Everglades Holiday Park, with most of the fishing pressure concentrated in the L-67A canal (Jon Fury, pers.com).

There are currently more than 65 privately constructed camps scattered throughout the EWMA. These camps consist of permanent buildings constructed by private individuals on tree islands or on pilings over the water. These camps are primarily used as weekend retreats and hunting camps.

Holey Land Wildlife Management Area

The Holey Land Wildlife Management Area (Holey Land WMA) is a tract of Everglades marsh encompassing approximately 35,350 acres in the southwest corner of Palm Beach County (Figure 2). Title to this tract is held by the State of Florida's Trustees of the Internal Improvement Trust Fund, and the area is leased to the GFC for fish and wildlife management purposes.

The Holey Land WMA was a popular deer hunting area prior to rehydration under the Holey Land Restoration Project. Since hydrological restoration was begun in 1991, the Holey Land WMA has undergone a transition in recreational use that has been more strongly oriented towards fishing in the perimeter canal and waterfowl hunting (GFC 1997g). Recreational access to the marsh areas may be achieved by airboat, ATVs, or tracked vehicles. Vehicle use is permitted in the Holey Land WMA from May 1 to the end of the duck season, except during specified big game hunts when further restrictions apply. Tracked vehicle deer hunts may be conducted under appropriate hydrological conditions if deer population indices indicate a sufficient population level.

The hunting pressure on the Holey Land WMA has ranged from 214 to 972 man-days during the time period extending from the 1993-94 through the 1997-98 seasons (Table 1). However, due to a severe reduction in the deer herd as a result of the higher water-regulation schedule adopted for the Holey Land WMA and above-average amounts of rainfall, the gun-vehicle hunt season was closed from the 1993-94 through the 1996-97 seasons. Also, only the archery season was open during the 1994-95 season. Consequently, the annual mean hunting effort for the years 1993-98 in the Holey Land WMA, using only the figures for those hunts that were open each season, was calculated to be 635 man-days.

Although waterfowl hunting has become popular in the Holey Land WMA since hydroperiod restoration began in 1991, no data on duck hunter use were collected until the 1996-97 season. During this season, a minimum of 266 man-days of hunting pressure was estimated for duck hunters, which surpassed the minimum estimate of 156 man-days expended by deer hunters during that season. During the 1997-98 season, man-days attributed to hunting in Holey Land WMA were 392, with a reported harvest of 382 ducks and two deer. Although frogging is permitted in the Holey Land WMA, the hydrological regime and vegetative structure is not conducive to an exploitable frog population; the area therefore receives little pressure from recreational froggers (Blake Sasse, pers. com).

No creel surveys have been conducted in the Holey Land WMA by the GFC's Division of Fisheries; however, an attempt was made in 1996 by staff of the Division of Wildlife to estimate fishing pressure by counting vehicles at boat ramps whenever they visited the management area. Fishing pressure was estimated to be 5,054 angler-days in 1996, with the majority of fishers using the G-200 and G-201 boat ramps. From this survey, it was concluded that fishing had apparently become the primary recreational use in the Holey Land WMA (GFC 1997g).

Rotenberger Wildlife Management Area

The Rotenberger Wildlife Management Area (Rotenberger WMA) is a tract of Everglades marsh comprising approximately 27,810 acres in the southwest corner of Palm Beach County, and is bordered to the east by the Miami Canal and to the south by WCA-3A (Figure 3). The area is owned by the State of Florida under fee-simple title to the Trustees of the Internal Improvement Trust Fund and leased to the GFC for fish and wildlife management purposes (GFC 1997e).

The primary public use of the Rotenberger WMA has been deer hunting. Other game species that are commonly sought include wild hogs and snipe. Although frogging and fishing are also permitted, these resources are in limited supply due to the short hydroperiods that presently exist in the area (GFC 1997e). Recreational access to the area can be achieved by ATVs, airboats, swamp buggies, or tracked vehicles during designated times of the year (May 1 to the end of the waterfowl season) when hydrological conditions are appropriate for that particular mode of transportation.

The hunting pressure on the Rotenberger WMA has ranged from 106 man-days during the 1994-95 deer hunting season to 944 man-days during the 1997-98 season. The low hunting pressure during 1994-95 could be attributed to the combined effects of extremely high water levels in the adjacent EWMA, a low deer population index, and the closure of all big game seasons except the archery season. The mean hunting effort for the five-year period from 1993-98 was reported as 766 man-days, using only those figures for the hunts that were open during that particular season (GFC 1998b).

Big Cypress Wildlife Management Area

The federally owned Big Cypress Wildlife Management Area (Big Cypress WMA) comprises approximately 565,848 acres in northwestern Dade, eastern Collier, and northwestern Monroe counties (Figure 4), with the game animal populations managed by the GFC under a cooperative agreement with the Big Cypress National Preserve. The Big Cypress WMA is subdivided into six different management units (Figure 4), where the amount of hunting pressure is regulated based on deer population indices, hydrological conditions, and the maintenance of a food base for the Florida panther. Of these management units, the Corn Dance, Loop Road, and Stairsteps units are more likely to be influenced by hydrological changes due to their close proximity to WCA-3A.

Due to the great diversity of both upland and wetland habitats in the Big Cypress WMA, a wide array of game species is harvested from the area. A significant amount of the hunting pressure within the Big Cypress WMA takes place in the Corn Dance, Loop Road, and Stairsteps units, which, since 1991, have together accounted for almost half of the total hunting pressure during those years when all units are open to hunting (Table 3). Due to the high level of interest in the big game general gun hunting season, this hunt is regulated by a weekly quota that has been consistently reached during the past six years for the Corn Dance and Loop Road units, but not in the Stairsteps unit (Eddie White, GFC, pers. com.). The number of permits allocated to the Stairsteps unit, however, is also usually three to four times the number issued to either the Corn Dance or Loop Road units. Although deer and hog hunting constitutes a significant component of recreation in the Big Cypress WMA (Jansen 1986), wild turkey, waterfowl, and small game (including doves, snipe, quail, marsh rabbits, grey squirrels, and raccoons) provide additional recreational opportunity. Fishing and frogging are permitted throughout the year. Fishing is a popular activity in the canals accompanying roadways through the Big Cypress WMA (U.S. 41, SR 94, and Turner River Road) (Jim Schortemeyer, pers. com.) although the use of outboard motor boats is limited due to the narrowness and generally densely vegetated nature of the canals (Deuver et.al 1986). Most frogging activity occurs in the wet prairie and dwarf cypress forest habitats in the Stairsteps unit south of US 41 (Deuver et.al 1986).

There are several established seasons for different user groups for the harvest of deer and wild hogs. These include a 30-day archery season extending from early September until early October that has been in effect since 1990, a 16-day muzzleloading gun season in the latter half of

October, and a 47- to 51-day general gun season extending from mid-November through the first of January (GFC 1997b). Access to the interior of the preserve is attained by the use of wheeled swamp buggies, ATVs, and airboats, depending on hydrological conditions and the regulations for a particular management unit. Wheeled swamp buggies are the most commonly employed mode of transportation in most of the Big Cypress WMA including the Corn Dance unit. On the other hand, airboats are the preferred type of transportation into the Everglades type habitats of the Stairsteps unit (Deuver et.al 1986).

Southern Glades Wildlife and Environmental Area

The Southern Glades Wildlife and Environmental Area (Southern Glades WEA) consists of 30,080 acres of Everglades marsh in southeastern Dade County and is bisected by the C-111 and C-109 canals and associated levees (Figure 5). Most of the area was acquired by the SFWMD through the Save Our Rivers program, although small, private in-holdings do occur, with the GFC given the responsibility of managing the fish and wildlife resources of the area. The Southern Glades WEA is divided into four management units. Unit 1 is that portion of the area lying west and south of the C-111 canal; Unit 2 is that portion of the area located between the C-111 canal and the C-110 canal; Unit 3 is that portion of the area located between the C-110 canal and the C-109 canal north of the C-111 canal; and Unit 4 is that portion of the area north of the C-111 canal that is located between the C-109 canal and U.S. 1. All motorized vehicles are prohibited, except airboats in units 1 and 4 from December through March 1 and outboard motor boats within the canals.

Fishing, primarily within the C-111 canal, is the primary recreational use within the Southern Glades WEA. A public-use survey conducted from September through November in 1997 revealed a weekend use that averaged 7 people per day (GFC 1997h). Fishing was shown to be the most common use, followed by sightseeing, then hunting, and biking. A foot trail has been established along the area's levees, and horse gates have been installed to improve access for equestrian groups that wish to use the trail system.

Fishing is permitted throughout the year within the Southern Glades WEA, while frogging is restricted to the period of December 1 through March 1. An annual deer season is open 30 days from early September through early October for archery hunters; 3 days in mid-October for muzzle loaders, and approximately 35 days from late October to late November for general gun hunting participants. Due to low deer populations and limited access, however, hunter participation has been low (Table 1). Waterfowl hunting is limited because of low densities and wide year-to-year variation in the local populations (GFC 1997f).

J.W. Corbett Wildlife Management Area

The J.W. Corbett Wildlife Management Area (Corbett WMA), a Type I wildlife management area located northwest of West Palm Beach (Figure 6), comprises only 60,224 acres but receives a disproportionately high amount of recreational use for the Everglades region. Most popular among hunters is the big game season, which consists of an archery season that begins the end of August and lasts for about 22 days, followed by a muzzleloading gun season that lasts for about 16 days, and a general gun season that extends from early November into early January. Although deer and wild hogs are the favored big game species, the Corbett WMA possesses a relatively good mixture of habitat types that support a wide array of other game species. The Corbett WMA is one of the most popular management areas in the Everglades region for snipe hunting (GFC Florida wildlife management area harvest data report, 1997). Other species that are sought on the Corbett WMA include grey squirrels, wild turkeys, puddle ducks, bobwhite quail, rabbits, and raccoons. Since low flatwoods swamp is poor habitat for terrestrial species, populations of upland species like wild turkeys, bobwhite quail, and grey squirrels are low; consequently, hunting pressure on these species is also low (GFC 1997c). There is a raccoon night-hunting season during which raccoons may be pursued with dogs for about 40 days during the winter small game season. Fishing and frogging are permitted throughout the year. Due to the seasonal nature of most natural ponds on Corbett WMA, fishing is limited to drainage canals, some of the deeper marshes, and six ponds excavated for fishing purposes.

Access to hunting areas in the Corbett WMA is attained most commonly by swamp buggies and ATVs. Vehicular recreational access is also allowed on designated grades from late April through mid-August. Tracked vehicles, airboats, motorcycles, and ATVs having a wheelbase less than 60 inches are not permitted in the management area at any time. Primitive camping is allowed at designated campsites both during the big game season and on weekends following the end of the general gun season.

The Corbett WMA provides other nature-based recreational opportunities such as bird watching, horseback riding, hiking, and nature study (GFC 1997c). The Hungryland Boardwalk and self-interpretive nature trail is used by those who wish to become better educated about the natural history of the area. Those hiking the Florida Trail also pass through the Corbett WMA. Prior to fiscal year 1997-98, there was no way to track use of the Corbett WMA by users in the non-hunting season; however, with the institution of a daily-use permit in July of 1997, the area has been estimated to receive on average about 30 to 40 people per week. Most of these users are reported to be interested in either observing or photographing wildlife (James Schuette, GFC, pers. com.).

Although the John G. and Susan H. Dupuis Jr Wildlife and Environmental Area lies to the west of the Corbett WMA within the L-8 basin, no impacts on recreation have been predicted at this time, and no analyses were conducted for this area.

Lake Okeechobee

Lake Okeechobee is nationally recognized as supporting high-quality largemouth bass and black crappie fisheries (Bell 1987). For the four years from the 1992-93 creel survey period through the 1995-96 period, creel estimates of fishing effort ranged from 742,347 angler hours in 1992-93 to 1,003,508 hours of effort in 1995-96 (Table 4). This estimate equates to an annual mean fishing effort of 879,616 hours for this four-year period. Creel surveys were conducted each year during the peak six-month period extending from December through May. During this four-year period, the black crappie fishery received the most use, with an annual mean creel estimate of fishing effort of 510,403 hours, followed by largemouth bass with an estimated annual mean fishing effort of 312,722 hours, and bream with an estimated annual mean fishing effort of 56,492 hours. It should be noted that these creel survey data are based on four high-use areas, with each area covering approximately 20,000 acres, for a total creel survey area of 80,000 acres. This creel survey area thus amounts to only about 10% of the areal extent of the lake; but it is estimated that these areas receive approximately 70% of the fishing pressure on the lake (Don Fox, GFC, pers. com.). If the summer-fall months were included, the estimated annual fishing effort would undoubtedly be greater. Bell (1987) used creel survey data collected during the summer-fall period in the late 1970s, and found the season fishing pressure to constitute approximately 23.8 % of the total annual fishing effort. Assuming that this trend has continued until the present, the four-year period from 1992 to 1996 would have had an annual mean fishing effort equating to 1,088,965 hours.

Bass fishing tournaments have also become very popular events on the lake, but prior to 1996, no permitting system existed for conducting bass tournaments on Lake Okeechobee and, consequently, no monitoring of this activity occurred. During the year extending from April 1996 through March 1997, however, a total of 520 bass tournaments consisting of 28,128 anglers were permitted through the GFC's Division of Fisheries. These anglers caught 25,164 bass, yielding a total weight of 55,486 pounds, with an average weight of 2.2 lb/ fish. During the past year extending from April 1997 through March 1998, there was a total of 484 bass tournaments on Lake Okeechobee consisting of 33,021 anglers. Angler success during these two years was considered to be low due to extremely high water levels that reduced fish vulnerability to capture (Don Fox, GFC, pers. com.).

Lake Okeechobee is probably the most important fresh water recreational fishery in the State of Florida, with an asset value assessed at nearly $100 million in 1987 dollars and an annual economic impact of approximately $28 million for the local economy (Bell 1987). It was also estimated that tourists spend $65.51 per fishing day compared to $24.23 for residents of Lake Okeechobee counties on largemouth bass fishing based on 1986 dollars (Bell 1987).

Pleasure boating (including airboats) on Lake Okeechobee is also a popular activity. As of 1987, there were 18 marinas on Lake Okeechobee supplying a total of 705 wet slips and 315 dry slips. Boat access to the lake is achieved through the use of 40 boat ramps with 65 lanes

(Bell 1987). In addition to recreational fishing and boating, Lake Okeechobee serves as a popular duck hunting and frogging area.

The lake is divided into four different alligator management units, and a set number of alligator harvest permits, based on annual alligator population survey data, is issued for the lake each year. Interest for participating in the alligator harvest program remains high and, statewide, only about 5% of the applicants are randomly selected to participate each year. During the most recent alligator harvest in 1997, 1,256 permits were issued to 251 participants, resulting in the harvest of 981 alligators on Lake Okeechobee (Table 5). The number of alligator harvest permits issued for Lake Okeechobee in 1997 accounted for approximately 40% of all permits issued for the entire state of Florida. The only other public body of water in the Everglades region where regulated alligator harvests still occur is on Lake Trafford, a relatively small lake located near Immokalee. This lake has had a rather modest annual harvest quota ranging from 30 to 70 permits over the last five years (Table 5).

Waterfowl

[This section was provided by Robert Pace, U.S. Fish and Wildlife Service, Vero Beach, FL]

Waterfowl hunting is an important outdoor recreational activity in central and southern Florida with a significant economic impact. A Midwinter Waterfowl Inventory is conducted by the GFC, and data have been compiled from the years 1994-1997 for those survey routes within the scope of the C&SF Restudy and which were consistently covered in those years (Table 6). Although these data should not be interpreted as representing a comprehensive count of waterfowl in central and southern Florida, they provide useful comparisons of the relative abundance of different species (or groups of species) in a particular area and their relative abundance among areas. The data could also be used to identify inter-annual variability in waterfowl abundance, and if consistently surveyed and analyzed over many years, might indicate long-term trends. The most abundant species found on the surveys were the American coot (*Fulica americana*); ringnecked duck (*Aythya collaris*); either blue-winged (*Anas discors*) or cinnamon (*Anas cyanoptera*) teal, which were counted together; and mottled duck (*Anas fulvigula*). The survey routes with the highest total waterfowl counts, averaged over the four years, were, in order of decreasing abundance: Lake Okeechobee, Lake Weohyakapka, Lake Hatchineha, Lake Istokpoga, and Fisheating Bay in Lake Okeechobee (Figure 7). Migratory bird hunting stamp sales data (Table 7) and harvest data (Table 8) for counties within the scope of the Restudy were obtained from the Office of Migratory Bird Management, Laurel, Maryland. These data demonstrate the economic importance of waterfowl hunting in central and southern Florida.

Potential Impacts of the Initially Preferred Alternative (D-13R) on Recreation

Everglades Wildlife Management Area

The unauthorized construction and augmentation of camps on tree islands in WCAs- 2 and -3 has been a controversial issue almost since the inception of the original C&SF Project in 1949 (GFC 1958). Prior to the construction of the eastern perimeter levees, hydroperiods were relatively short, and airboat access to interior portions of much of the Everglades was limited primarily to the rainy season and no camps existed. However, wetter conditions following levee construction led to longer periods of accessibility by airboat and camps started to appear in the EWMA in the mid 1950s with greater than 20 camps present by 1958 (Wallace 1958). Similarly, there has been a resurgence of new camp construction on tree islands over the last five relatively wet years (1993-97). Under Alternative D13R, WCA-3B and northern WCA-3A will be wet for a greater proportion of the year; thus airboat access would probably be increased in these areas. The increased accessibility of tree islands in this area may lead to an increase in privately constructed camps. Although the construction of permanent structures is prohibited in all wildlife management and environmental areas in the Everglades region, the continued erection of hunting camp structures in the EWMA remains a problematic issue.

Although airboat activity may increase as a result of the longer hydroperiods predicted by Alternative D13R, the use of vehicles that require relatively little or no surface water for operation (tracks, swamp buggies, ATVs, etc) would be expected to decline. The use of tracked vehicles in the Everglades appears to be steadily declining due to the high maintenance requirements of these vehicles; a decline in operator opportunities to use them for hunting because of higher water levels in recent years; and lower deer densities, which in turn resulted in the closure of the area to vehicle hunting seasons. During the 1997-98 hunting season on Rotenberger WMA, only 64 track permits were issued, with 50 tracks reportedly participating in the hunt (Blake Sasse, GFC, pers. com). Information derived from hunter questionnaires revealed that an average of 4 hunters occupied a track on any one occasion (GFC 1998a). In the last big track hunt that occurred in WCA-3A north of I-75 in 1990, 109 track permits were issued. The number of tracks for which hunting applications have been submitted in the Everglades during the past six years has ranged from as few as 83 in 1996 to as many as 165 in 1992 (Eddie White, GFC, pers.com.). It is evident, however, that not all track owners have decided to participate in the vehicle hunts during recent years, perhaps because of limited opportunities due to the continued closure of the northern part of WCA- 3A to track hunting because of depressed deer population levels. During the 1996-97 season, only 83 of the 123 tracks that had their tags renewed applied for a hunting permit. At the current time, it has been estimated that there are probably no more than between 100 and 200 tracked vehicles (although many are in various stages of disrepair) still remaining in South Florida (Blake Sasse, GFC, pers. com.) The number of tracks has probably dwindled even more since the track hunting season has remained closed in WCA-3A since 1994, and in Holey Land WMA from 1993 through 1996. Although tracked vehicle use may continue to decline, hydrological conditions in Holey Land WMA and Rotenberger WMA, and perhaps the northern portion of WCA-3A in drier years would probably still be suitable for tracked vehicle operation. The use of swamp buggies is currently minimal on Everglades mucky soils, and would likely disappear altogether under the elevated water table proposed under the 2050 Base (which assumes that the Everglades Forever Act and Modified Water Deliveries to Everglades National Park are fully implemented). Thus, the use of swamp buggies is not expected to be affected under the current preferred Restudy alternative.

The adoption of Alternative D13R would result in a very large decline in the mileage of canals available to fishermen. The decrease in canal mileage as modeled in the SFWMM was by 19 miles for the 2050 Base, but with the increased decompartmentalization under Alternative D13R, an additional 127 miles of canals would be backfilled. Although many of these canals may not be easily accessible with an outboard motorboat, or provide good fishing opportunities, other more accessible canals do receive a considerable amount of fishing pressure. This projected decline in the mileage of canals available to fishermen will most definitely have an impact on recreational fisheries in South Florida. However, the planned addition of 6,977 acres of water preserve areas with maximum water depths of 4 feet; 9,700 acres of above-ground water-storage areas with variable depths in the Lakebelt region; and a 1,600-acre stormwater treatment area of an unspecified depth in Broward and Dade and counties may offer some potential for the development of new fisheries resources in this region.

Of particular concern is the L-67A canal. Alternative D13R proposes to backfill approximately six miles of the southern end of this canal. The “three pines” area, located near the proposed end of the canal, has been a particularly productive fishing spot, and may be eliminated if this portion of the canal is backfilled. In general, the southern half of the L-67A canal receives the most fishing pressure, probably due in part to the prolonged hydroperiod that normally exists in the southern portion of WCA-3A (Jon Fury, GFC, pers. com.) Although access to the remaining portion of the L-67A canal would be reduced due to a loss of access from the Tamiami Trail, this effect may not be as pronounced as it could be. Due to a lack of security at the somewhat isolated boat ramp on the L-67 canal off the Tamiami Trail, most fishermen prefer to launch out of Holiday Park, at the northern end of the L-67A canal, and motor south to their favorite fishing holes. Information gathered by GFC Everglades Fisheries personnel while conducting creel surveys on the L-67A canal during the time period of 1991-97 found that 75% of those anglers interviewed launched their boat at Holiday Park with the remaining 25% launching their boat at the southern end of the L-67A levee (Jon Fury, GFC, pers. com.). Regardless of what access problems may exist, modeled hydrological conditions for the WCA-3A marsh adjacent to the L-67A canal predict somewhat lower mean water depths than would exist under the 2050 Base and considerably lower mean depths (> 1 ft.) than would occur under the 1995 Base. Consequently, the areal extent and duration of water depths in WCA-3A sufficient to maintain a productive marsh/canal bass fishery is expected to decline dramatically with implementation of Modified Water Deliveries in the 2050 Base, and even further under Alternative D13R. At this time, it is not clear how the weir design and operations across the L-67A levee will affect the fishery of the L-67A canal.

The L-67C canal, although not as popular a fishing area as the L-67A canal, also receives fishing pressure, especially when marsh water levels recede during the dry season. A count of the boat trailers parked at the L-67C boat ramp during the 6-month period extending from December 1996 through May 1997 yielded a total count of 2,900 boats using this canal, with an average of two persons per boat (Jon Fury, GFC, pers. com.). This canal would be backfilled entirely in Alternative D13R, and this fishery would be lost as well.

Under Alternative D13R, the areal extent of upland refugia in the form of tree islands and levees is expected to decline in WCA-3B. The removal of the entire length of the L-67C levee and portions of the L-67A levee would significantly reduce the areal extent of high elevation habitats that exist in this portion of the Everglades. Such habitats in the current remnant Everglades, where suitable upland refugia have been lost to development east of the L-30 levee and to devastating muck fires in the northern portion of WCA-3A and in WCA-2, have high wildlife value and function. For example, following the recent high water episode of 1994-95 in WCA-3B, the deer population was essentially eliminated from the marsh interior, with the only known survivors persisting on the levee system. The L-67C was one of the most used levees by the deer seeking relief from high water levels, which may have been due in part to the movement of deer to the northwest along the natural elevational gradient and to the relatively close proximity of several "low" elevation tree islands that were vacated when submergence occurred. The L-67C also serves as a corridor for expediting deer immigration from the levee back to tree island habitats following water level recession in the area.

Due to increased water levels in WCA-3B, recreational opportunities in terms of huntable deer populations are likely to decline in this area, where tree islands occur at lower densities and many are at relatively low elevations. Conversely, the areal extent and duration of emergence of tree islands above ambient water levels is expected to increase in the southern portion of WCA-3A upon the removal of the impounding effects of the L-28, L-29, and partial removal of the L-67 levees, and this situation would allow a relatively large number of tree islands to remain above ambient water levels for much longer periods of time. The greater density of tree islands in southern WCA-3A and a considerable reduction in the length of time that slough water levels remain above 30 inches deep in Alternative D13R may permit a more stable environment for upland game animals. Hence, deer hunting opportunities should improve in the southern portion of WCA-3A. Although the removal of the L-28 levee would result in the loss of dry habitat that has served as relief for deer and other upland-dependent wildlife in the past, lower water levels and reduction in prolonged high-water events predicted by Alternative D13R would make this levee less critical as an upland refugium. In addition, the removal of the L-28 levee and its associated borrow canal will help to recreate the natural hydrological gradient based on the region's topography and allow deer longer periods of time to move "upslope" to areas of higher elevation in the Big Cypress WMA during times of high water.

The removal of the L-29 levee and canal by Alternative D13R could have negative impacts on recreational access into WCA-3A and WCA-3B from U.S. 41, since the roadway would have to be elevated in some way. There are three public boat ramps providing airboat access into WCA-3B and three public boat ramps providing airboat and jon boat access into the L-29 canal and marsh of WCA-3A. One of the boat ramps for WCA-3B also provides jon boat access into the L-67C canal, which would be back-filled in Alternative D13R. Therefore, it will be necessary to construct on and off ramps to these recreational areas and provide ample parking space for vehicles and boat trailers.

Big Cypress Wildlife Management Area

The summary evaluation of those geographic regions encompassing the Stairsteps and Loop Road units suggests that these areas would most closely resemble NSM conditions under Alternatives D and D13R. Under the ATLSS Cape Sable Seaside Sparrow Model and Index output for Alternative D13R versus the 2050 Base, the hydroperiod length was shown to decrease somewhat in the Stairsteps and Loop Road units. Ponding depths in the eastern portion of the Stairsteps unit also appeared to be slightly less in Alternative D13R than under the 2050 Base. Although no ATLSS output for the White-tailed Deer Breeding Potential Index was generated for Alternative D13R, output was available for Alternative B, which was structurally similar to Alternative D13R in that both the L-28 and L-29 levees were removed. Under this modeled output, the overall deer breeding potential mean was slightly higher in the Stairsteps and Loop Road units under Alternative D13R when compared to the 2050 Base, but remained relatively unchanged in the Corn Dance unit. In conclusion, these evaluations tend to suggest that somewhat more favorable hydrological conditions will exist for deer and upland game animals in the Stairsteps and Loop Road units of the Big Cypress WMA with the adoption of Alternative D13R than would occur in the 2050 Base, and that deer populations in the Corn Dance unit will probably remain relatively stable.

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Figure 1.

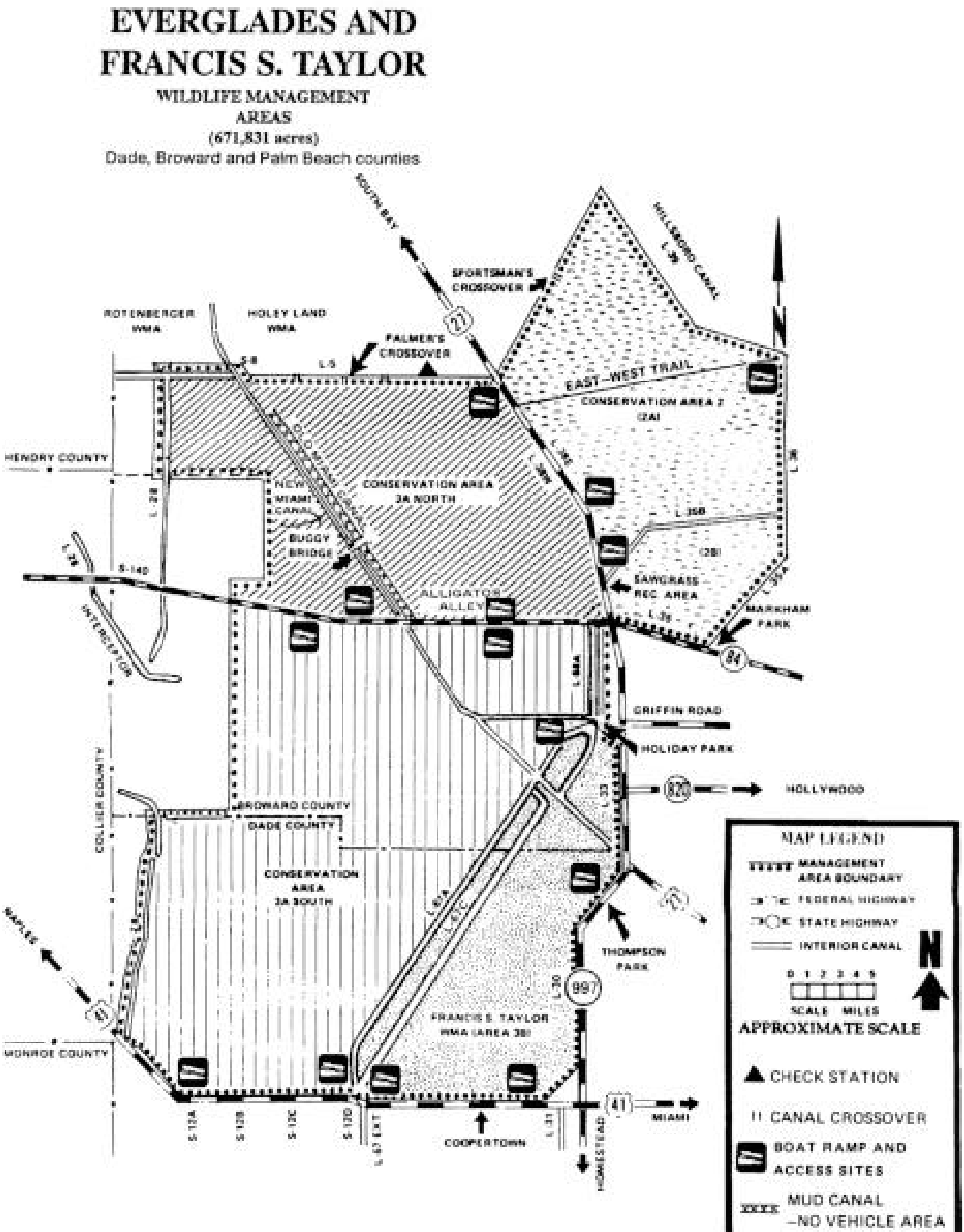

EVERGLADES AND
FRANCIS S. TAYLOR
WILDLIFE MANAGEMENT
AREAS
(671,831 acres)
Dade, Broward and Palm Beach counties
SOUTH BAY
SPORTSMAN'S CROSSOVER
HILLSBORO CANAL
ROTENBERGER WMA
HOLEY LAND WMA
PALMER'S CROSSOVER
EAST-WEST TRAIL
CONSERVATION AREA 2 (2A)
HENDRY COUNTY
CONSERVATION AREA 3A NORTH
NEW MIAMI CANAL
BUGGY BRIDGE
(2B)
SAWGRASS REC. AREA
ALLIGATOR ALLEY
MARKHAM PARK
INTERCEPTOR
GRIFFIN ROAD
HOLIDAY PARK
HOLLYWOOD
BROWARD COUNTY
DADE COUNTY
COLLIER COUNTY
CONSERVATION AREA 3A SOUTH
THOMPSON PARK
NAPLES
FRANCIS S. TAYLOR WMA (AREA 3B)
MONROE COUNTY
COOPERTOWN
MIAMI
HOMESTEAD
MAP LEGEND
MANAGEMENT AREA BOUNDARY
FEDERAL HIGHWAY
STATE HIGHWAY
INTERIOR CANAL
SCALE MILES
APPROXIMATE SCALE
CHECK STATION
CANAL CROSSOVER
BOAT RAMP AND ACCESS SITES
MUD CANAL -NO VEHICLE AREA

Figure 2.

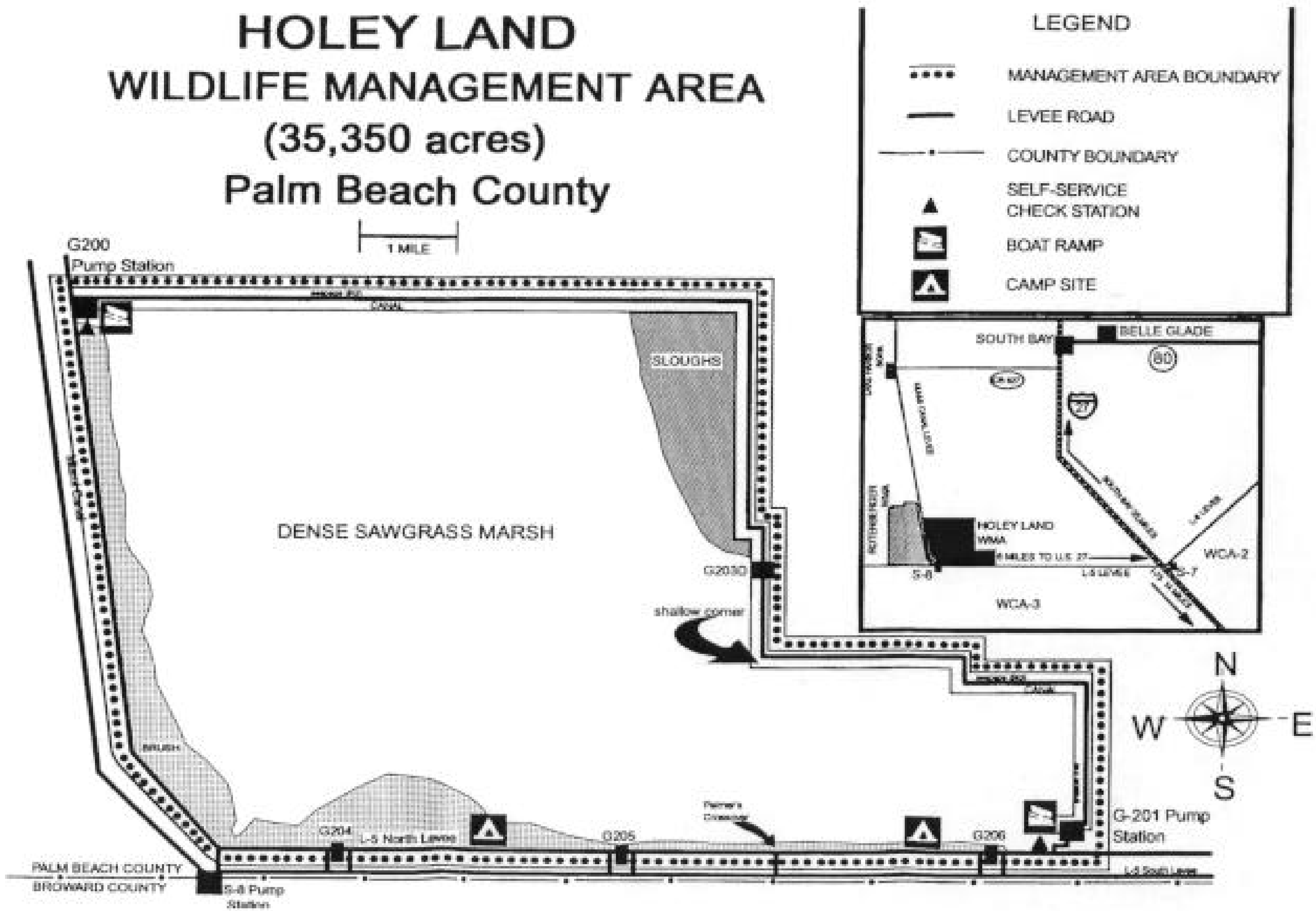
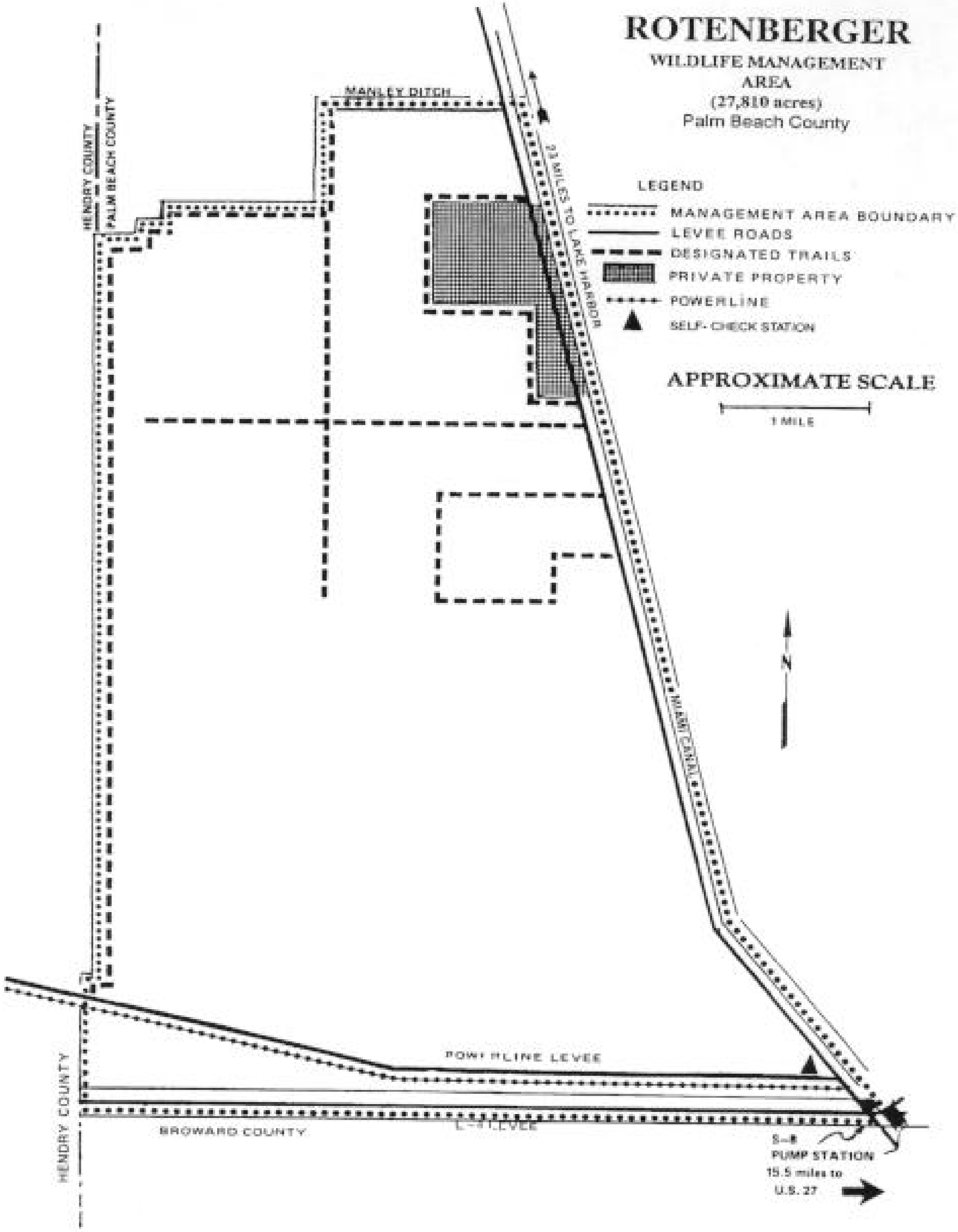

HOLEY LAND
WILDLIFE MANAGEMENT AREA
(35,350 acres)
Palm Beach County
1 MILE
LEGEND
MANAGEMENT AREA BOUNDARY
LEVEE ROAD
COUNTY BOUNDARY
SELF-SERVICE CHECK STATION
BOAT RAMP
CAMP SITE
G200 Pump Station
CANAL
SLOUGHS
DENSE SAWGRASS MARSH
G203D
shallow corner
BRUSH
G204
L-5 North Levee
G205
G206
G-201 Pump Station
PALM BEACH COUNTY
BROWARD COUNTY
S-8 Pump Station
SOUTH BAY
BELLE GLADE
80
27
HOLEY LAND WMA
S-8
S-7
WCA-2
WCA-3
N
W
E
S

Figure 3.



ROTENBERGER
WILDLIFE MANAGEMENT
AREA
(27,810 acres)
Palm Beach County
LEGEND
MANAGEMENT AREA BOUNDARY
LEVEE ROADS
DESIGNATED TRAILS
PRIVATE PROPERTY
POWERLINE
SELF-CHECK STATION
APPROXIMATE SCALE
1 MILE
MANLEY DITCH
HENDRY COUNTY
PALM BEACH COUNTY
MIAMI CANAL
POWERLINE LEVEE
BROWARD COUNTY
HENDRY COUNTY
S-8
PUMP STATION
15.5 miles to
U.S. 27
N

Figure 4.

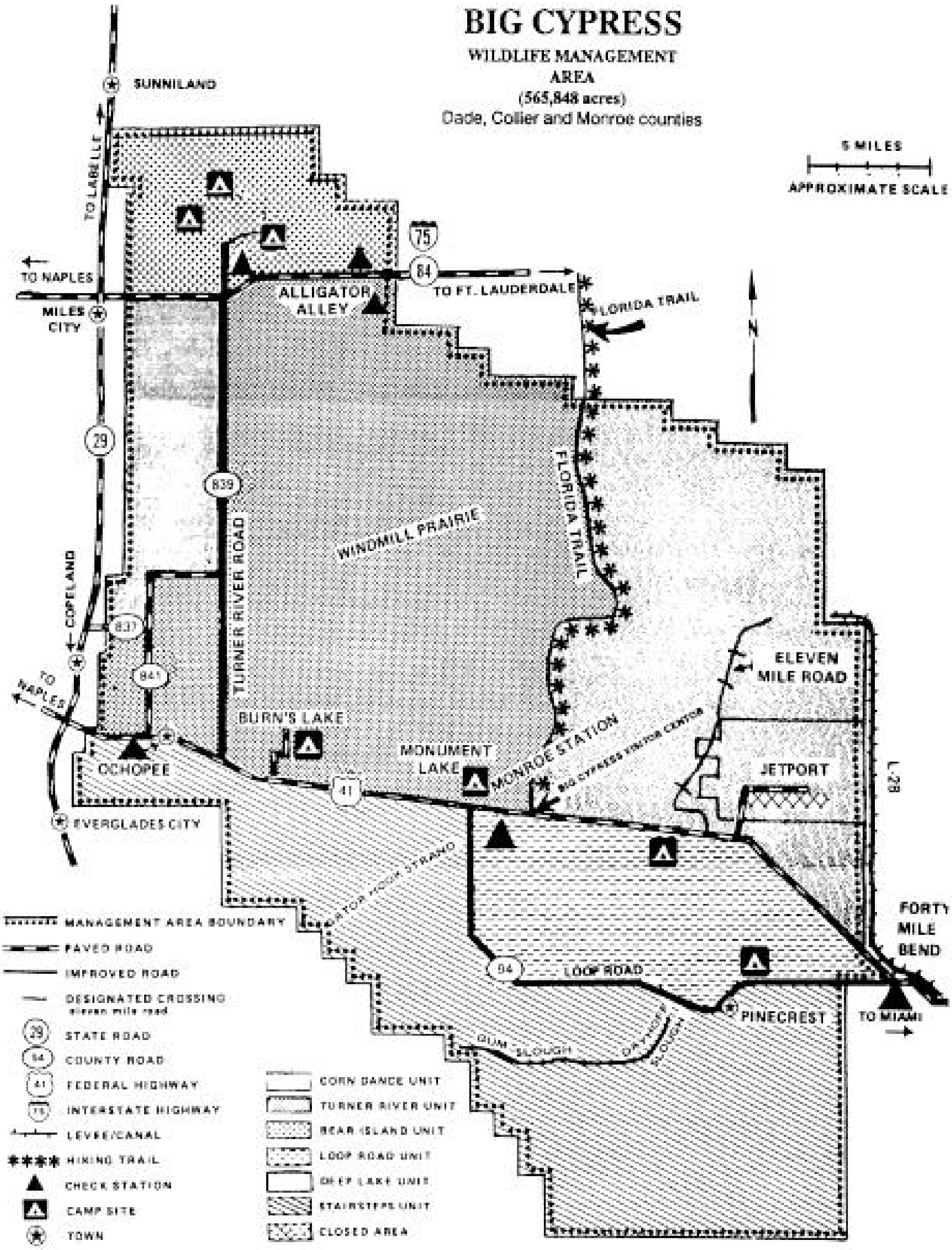

BIG CYPRESS
WILDLIFE MANAGEMENT
AREA
(565,848 acres)
Dade, Collier and Monroe counties
5 MILES
APPROXIMATE SCALE
SUNNILAND
TO LABELLE
TO NAPLES
MILES CITY
75
84
TO FT. LAUDERDALE
FLORIDA TRAIL
ALLIGATOR ALLEY
N
29
839
WINDMILL PRAIRIE
TURNER RIVER ROAD
FLORIDA TRAIL
COPELAND
837
841
TO NAPLES
ELEVEN MILE ROAD
BURN'S LAKE
MONUMENT LAKE
MONROE STATION
BIG CYPRESS VISITOR CENTER
OCHOPEE
41
JETPORT
L-28
EVERGLADES CITY
GATOR HOOK STRAND
FORTY MILE BEND
94
LOOP ROAD
PINECREST
TO MIAMI
GUM SLOUGH
MANAGEMENT AREA BOUNDARY
PAVED ROAD
IMPROVED ROAD
DESIGNATED CROSSING
STATE ROAD
COUNTY ROAD
FEDERAL HIGHWAY
INTERSTATE HIGHWAY
LEVEE/CANAL
HIKING TRAIL
CHECK STATION
CAMP SITE
TOWN
CORN DANCE UNIT
TURNER RIVER UNIT
BEAR ISLAND UNIT
LOOP ROAD UNIT
DEEP LAKE UNIT
STAIRSTEPS UNIT
CLOSED AREA

Figure 5.

SOUTHERN GLADES

WILDLIFE AND ENVIRONMENTAL AREA

(30,080 acres)

Dade County

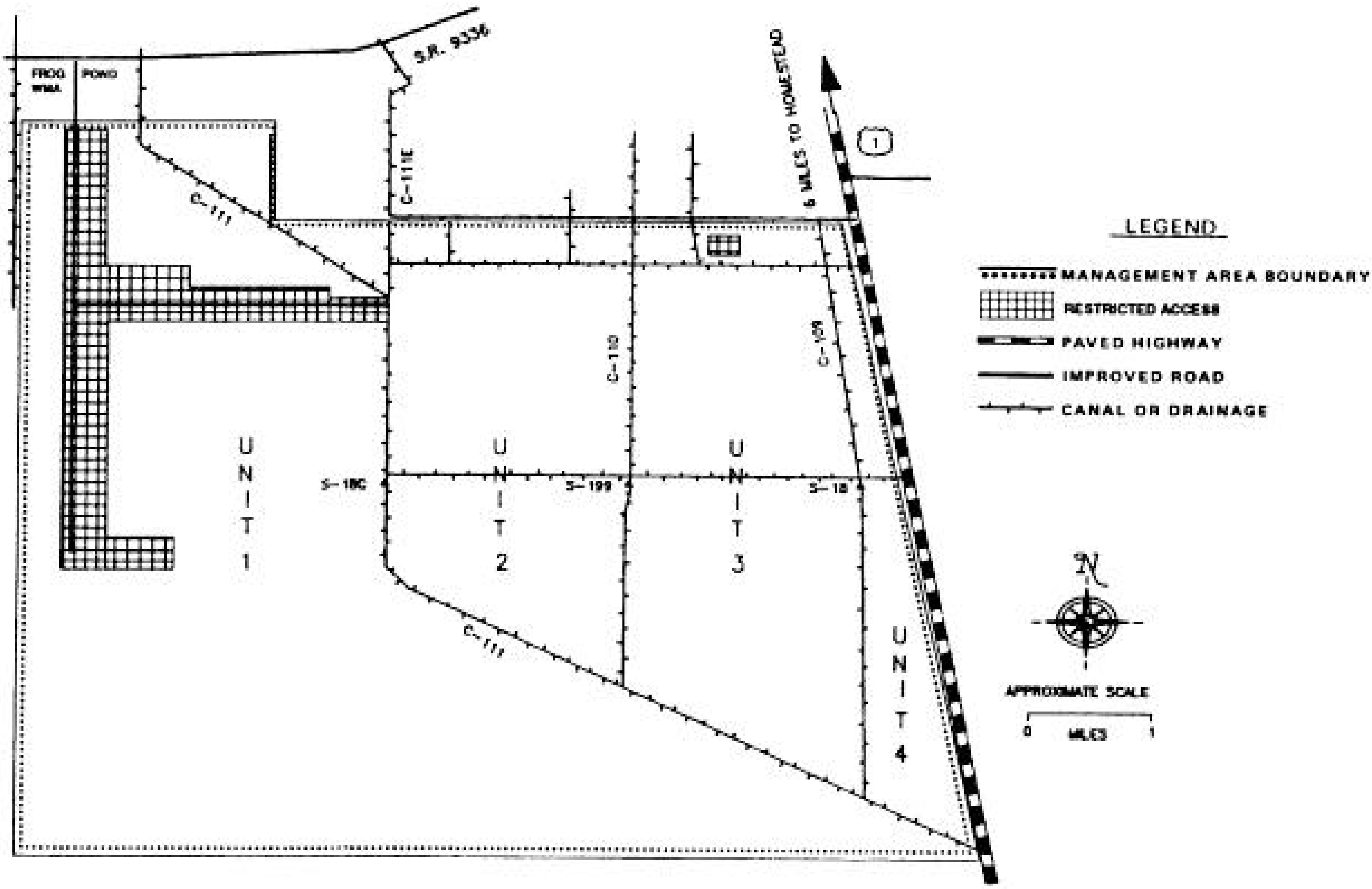
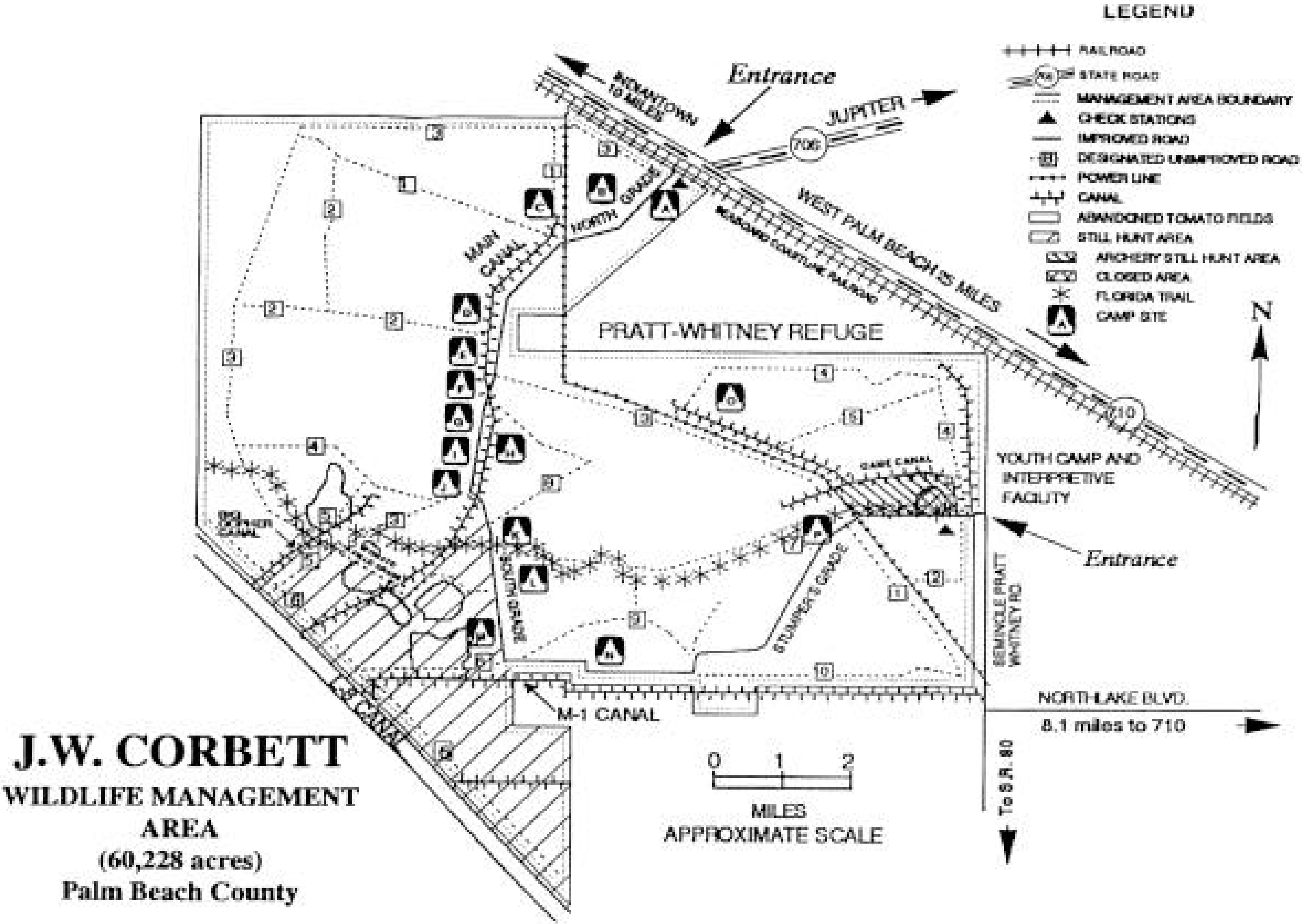


Figure 6.


LEGEND
RAILROAD
STATE ROAD
MANAGEMENT AREA BOUNDARY
CHECK STATIONS
IMPROVED ROAD
DESIGNATED UNIMPROVED ROAD
POWER LINE
CANAL
ABANDONED TOMATO FIELDS
STILL HUNT AREA
ARCHERY STILL HUNT AREA
CLOSED AREA
FLORIDA TRAIL
CAMP SITE
N
Entrance
INDIANTOWN 10 MILES
JUPITER
706
WEST PALM BEACH 25 MILES
SEABOARD COASTLINE RAILROAD
NORTH GRADE
MAIN CANAL
PRATT-WHITNEY REFUGE
710
YOUTH CAMP AND INTERPRETIVE FACILITY
Entrance
SEMINOLE PRATT WHITNEY RD
STUMPER'S GRADE
SOUTH GRADE
M-1 CANAL
C-18 CANAL
NORTHLAKE BLVD.
8.1 miles to 710
To S.R. 80
0 1 2
MILES
APPROXIMATE SCALE
J.W. CORBETT
WILDLIFE MANAGEMENT AREA
(60,228 acres)
Palm Beach County

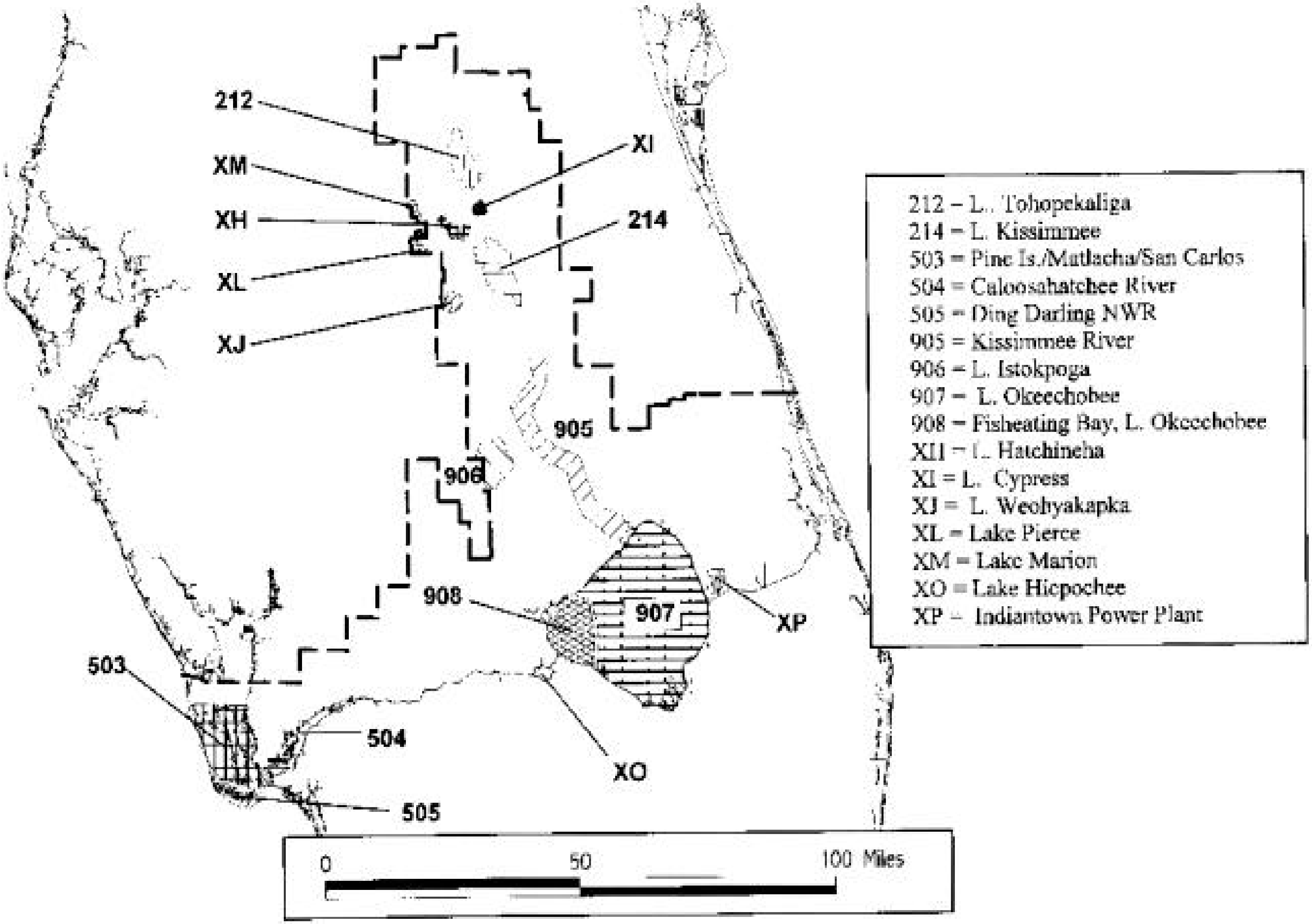


Figure 7. Location of the Midwinter Waterfowl Inventory survey routes that were consistently surveyed in central and south Florida in the years 1994-1997.

Table 1. Wildlife Management Area harvest pressure data for the years 1993 to 1998 in those areas that could be affected by the Restudy.

HARVEST PRESSURE (Man-Days)

Harvest Season	Big Cypress	Corbett	Rotenberger	Holey Land	Everglades	Southern Glades
1993-94	15,910	11,431	800	972	2,232	6
1994-95	9,735[a]	10,801	106	214	0	15
1995-96	11,290[a]	10,280	416	294	0	27
1996-97	15,185	10,961	907	274[c]	0	4
1997-98	14,410	11,298	944	281[c]	294[e]	8
5-Year Mean	**13,306**	**10,954**	**766**[b]	**635**[d]	**1,984**[f]	**12**

Total Mean Harvest Pressure = 28,030 Man-Days

[a]Hunting seasons were shortened during these years due to the closure of some units because of high water.

[b]Those hunting seasons closed during 1994-95 were omitted from the 5-year mean.

[C] Includes opening weekend of the regular waterfowl hunting season

[d]All closed hunts were omitted when calculating the 5-year mean.

[e]The 1997-98 season was open for only 15 days as a gun-vehicle season in WCA- 3A south of Alligator Alley.

[f]The five-year average for the EWMA was based on the years 1989-93, since the area has remained closed since the 1994 season due to low deer population levels resulting from the 1994-95 flood event.

Table 2. Expanded harvest, effort, and harvest success estimates for all fish categoriesobtained from the roving angler use surveys in WCA- 2A (L-35B and L-38E canals) and WCA-3A (L-67A canal) between 1985 and 1997 (GFC 1992, 1993, 1994, 1998c).

Area	Year	Harvest (# of Fish)	Effort (Hours)	Harvest Success (Fish Per Hour)
WCA-2A	1985-86	46,698	55,659	0.84
	1986-87	167,444	128,430	1.30
	1987-88	90,115	90,925	0.99
	1988-89	59,129	77,617	0.76
	1989-90	35,389	55,693	0.64
WCA-3A	1990-91	51,312	49,536	1.04
	1991-92	82,176	52,414	1.54
	1992-93	24,471	25,848	0.95
	1993-94	37,475	28,709	1.31
	1994-95	33,520	41,244	0.81
	1995-96	30,846	58,150	0.53
	1996-97	32,557	46,265	0.70

Table 3. Six-year comparison of documented hunter pressure on Big Cypress National Preserve, 1991-1997. - and *, indicate areas closed and partially closed, respectively, within a season (GFC 1997b).

	HUNTER PRESSURE (MAN-DAYS)					
	91-92	92-93	93-94	94-95	95-96	96-97
ARCHERY						
Bear Island	595	675	810	630	415	480
Deep Lake	-	10	10	40	35	25
Corn Dance	195	260	260	330	230	290
Turner River	445	285	365	540	530	525
Stairsteps	440	205	335	495	345	370
Loop	170	60	110	155	140	125
Total	1845	1495	1890	2190	1695	1815
MUZZLELOADING						
Bear Island	570	590	520	470	275*	575
Deep Lake	-	-	-	-	-	-
Corn Dance	265	265	295	405	-	300
Turner River	570	735	530	605	475*	650
Stairsteps	480	395	470	635	335*	565
Loop	145	100	140	155	145*	125
Total	2030	2085	1955	2270	1230	2215
GENERAL GUN						
Bear Island	2538	2571	2175	3635	1635	2720
Deep Lake	108	89	100	105	85	70
Corn Dance	1591	1689	1415	560*	735*	1235
Tuner River	4044	4107	3415	975*	3070	3320
Stairsteps	4078	3880	4270	-	2605*	3385
Loop	849	618	690	-	235*	375
Total	13208	12954	12065	5275	8365	11155
COMBINED						
Bear Island	3703	3836	3505	4735	2325	3775
Deep Lake	108	99	110	145	120	95
Corn Dance	2051	2214	1970	1295	965	1825
Tuner River	5059	5127	4310	2120	4075	4495
Stairsteps	4998	4480	5075	1130	3285	4320
Loop	1164	778	940	310	520	625
Total	17083	16534	15910	9735	11290	15185
% of BICY[a]	48.1%	45.2%	50.2%	28.1%	42.2%	44.6%

[a]Percent of total BICY hunting pressure contributed by the Corn Dance, Stairsteps, and Loop Road units

Table 4. Creel estimates of effort, catch and success by species and for four winter-spring seasons on Lake Okeechobee from data collected December 4, 1992, through May 30, 1996 (GFC 1995, 1996).

EFFORT (Angler hrs):	1992 - 93 SEASON	1993 - 94 SEASON	1994 - 95 SEASON	1995 -96 SEASON
Largemouth Bass	283,814	323,408	296,457	347,211
Black crappie	412,890	538,617	487,719	602,385
Bream	45,643	69,514	56,896	53,912
Total	**742,347**	**931,539**	**841,072**	**1,003,508**
HARVEST (Numbers):				
Largemouth bass (Caught)	230,321	213,810	225,951	226,855
Black crappie	714,454	889,161	1,033,205	997,854
Bream	152,936	260,779	201,402	159,287
Total	**1,097,711**	**1,363,750**	**1,460,558**	**1,383,996**
SUCCESS (Fish/Hr):				
Largemouth bass	0.82	0.68	0.78	0.67
Black crappie	1.71	1.60	2.08	1.64
Bream	3.60	3.88	3.48	2.89
Total	**1.49**	**1.45**	**1.72**	**1.37**

Table 5. Harvest quotas and harvest levels for American alligators harvested from Lake Okeechobee Alligator Management Units (AMU's) and Lake Trafford in Florida, 1993 through 1997 (Data compiled by GFC's Alligator Management Section).

	Harvest Quotas						Number Harvested				
AMU	1993	1994	1995	1996	1997		1993	1994	1995	1996	997
601 Lk Okeechobee (west)	475	432	570	510	561		286	353	512	429	450
602 Lk Okeechobee (north)	160	246	384	310	330		97	183	339	254	226
603 Lk Okeechobee (east)	45	48	48	50	65		39	44	43	49	49
604 Lk Okeechobee (south)	220	252	258	280	300		138	193	234	254	256
Lake Okeechobee Totals	**900**	**978**	**1260**	**1150**	**1256**		**560**	**773**	**1128**	**986**	**981**
741 Lake Trafford	60	36	42	30	70		40	27	42	27	49
TOTALS	**960**	**1014**	**1302**	**1180**	**1326**		**600**	**800**	**1170**	**1013**	**1030**
Percent of Quota Harvest							62%	79%	90%	86%	78%

Table 6. Four-year (1994-1997) average annual count of waterfowl in South Florida aerial survey routes. Averages are rounded to nearest whole number. Table includes only those routes consistently flown in the four-year period. Data are from the GFC's Midwinter Waterfowl Inventory. Figure 7 Shows the locations of the survey routes.

SPECIES	SURVEY ROUTE															
	212	214	503	504	505	905	906	907	908	XH	XI	XJ	XL	XM	XO	XP
Mallard	1	1	0	0	1	0	1	0	0	3	0	0	0	0	0	0
Mottled duck	98	110	15	0	18	73	26	49	1	27	10	1	0	5	7	0
Gadwall	0	0	0	0	0	0	4	4	0	0	0	0	0	0	0	0
Wigeon	49	30	0	0	70	0	39	29	44	5	0	40	0	0	0	3
G-W teal	13	23	12	0	11	198	0	13	0	8	0	0	2	0	1	0
BW/Cinn teal	116	791	14	0	242	451	60	308	46	46	8	0	0	0	4	1
Shoveler	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pintail	0	0	0	0	5	4	0	0	0	0	0	0	0	0	0	0
Wood duck	6	24	0	0	0	4	3	5	0	2	0	1	6	2	0	0
Whistling duck	107	206	0	0	0	0	4	243	5	0	0	0	0	0	0	0
Canvasback	1	0	0	0	0	0	343	16	15	0	25	112	0	2	0	0
Scaup	500	258	0	4,620	0	0	1	78,000	0	0	0	0	0	0	0	0
Ringneck	1,897	8,584	0	0	0	3	10,047	2,107	5,275	6,613	3,471	13,099	3,012	2,715	48	49
Ruddy duck	500	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0
Merganser	125	0	27	11	31	4	0	0	0	0	0	4	0	0	0	0
Unident ducks	0	4	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Canada goose	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Coot	12,224	9,461	0	75	73	15	13,320	8,256	15,985	20,090	6,704	25,934	4,611	3,693	75	2,321
TOTAL [1]	**15,638**	**19,491**	**68**	**4,705**	**450**	**751**	**23,847**	**89,030**	**21,371**	**26,792**	**10,218**	**39,221**	**7,630**	**6,418**	**134**	**2,373**

[1]The four-year average of the total waterfowl count for each survey route

Table 7. Numbers of migratory bird hunting stamps sold by county within the C&SF study area, from 1991-92 through 1995-96, as reported by the U.S. Postal Service[2] .

COUNTY	1991-92	1992-93	1993-94	1994-95	1995-96	5-YEAR TOTAL FOR COUNTY	5-YEAR AVERAGE	PERCENT
BROWARD	1,373	1,153	872	1,068	1,284	5,750	1,150	13
CHARLOTTE	60	45	52	44	9	210	42	<1
COLLIER	173	199	170	140	5	687	137	2
DADE	477	3,193	224	1,174	25	5,093	1,019	11
GLADES	107	95	84	98	0	384	77	1
HENDRY	66	63	58	43	0	230	46	1
HIGHLANDS	61	75	77	69	4	286	57	1
LEE	2,299	1,858	2,215	2,159	1,718	10,249	2,050	23
MARTIN	225	248	252	179	18	922	184	2
MONROE	28	50	62	52	36	228	46	1
OKEECHOBEE	312	258	163	163	1	897	179	2
ORANGE	1,000	681	1,006	531	3,002	6,220	1,244	14
OSCEOLA	107	137	165	607	1	1,017	203	2
PALM BEACH	2,311	2,047	2,275	1,909	1,543	10,085	2,017	23
POLK	391	392	395	402	3	1,583	317	4
ST LUCIE	174	156	84	129	1	544	109	1
ANNUAL REGIONAL	9,164	10,650	8,154	8,767	7,650	44,385		

[2]Data provided by the Office of Migratory Bird Management, Laurel Maryland

TOTALS						

Table 8. Total duck harvest, by county, in the C&SF study area, during the 1991-1992 through 1996-1997 hunting seasons (data from Office of Migratory Bird Management, Laurel, Maryland)

COUNTY	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	6-YR TOTAL
BROWARD	4,058	2,087	548	44		156	6,893
CHARLOTTE	305	730	1,199		1,358		3,592
COLLIER	1,727	1,021	1,216	149	1,452	617	6,182
DADE	2,069	804		107			2,980
GLADES	19,588	23,490	9,586	9,863	24,893	38,525	125,945
HENDRY	640	2,549	941	43	1,035		5,208
HIGHLANDS	9,155	3,053	834	548	518	3,944	18,052
LEE	212	439	1,051				1,702
MARTIN	237	289	83				609
MONROE							0
OKEECHOBEE	10,767	13,865	5,268	1,408	1,055	2,286	34,649
ORANGE	1,355	328	462	1,006	8,421		11,572
OSCEOLA	494	581	5,561	879	13,346	9,449	30,310
PALM BEACH	2,868	2,753	3,710	1,347	3,149	10,311	24,138
POLK	6,358	3,170	7,360	1,655	6,528	4,273	29,344
ST LUCIE	634	217	82				933
ANNUAL TOTALS	60,467	55,376	37,901	17,049	61,755	69,561	

ANNEX B

U.S. FISH AND WILDLIFE SERVICE
PROGRAMMATIC BIOLOGICAL OPINION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecosystem Office
P.O. Box 2676
Vero Beach, Florida 32961-2676

August 7, 1998

Colonel Joe R. Miller
District Commander
Jacksonville District
U.S. Army Corps of Engineers
400 West Bay Street
Jacksonville, FL 32232

Project:	Central and Southern Florida Project Comprehensive Review Study Initial Draft Plan.
FWS Log No.:	4-1-98-F628
Agency:	U.S. Army Corps of Engineers

Dear Col. Miller:

This document transmits the U.S. Fish and Wildlife Service's (FWS) preliminary programmatic biological opinion based on our review of the Central and Southern Florida Project Comprehensive Review Study (C&SF Restudy) alternative D13R (Initial Draft Plan), and its effects on threatened and endangered species in accordance with section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq*.). Our analysis considered effects on the following species: the endangered West Indian manatee *(Trichechus manatus*), Florida panther (*Felis concolor coryi*), snail kite (*Rostrhamus sociabilis plumbeus*), wood stork *(Mycteria americana*), Cape Sable seaside sparrow *(Ammodramus maritimus mirabilis)*, American crocodile (*Crocodylus acutus*), Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), red-cockaded woodpecker *(Picoides borealis)*, Okeechobee gourd (*Cucurbita okeechobeensis)*, crenulate lead-plant (*Amorpha crenulata*), deltoid spurge (*Euphorbia deltoidea)*, Small's milkpea (*Galactia smallii*), and tiny polygala (*Polygala smallii*), and the threatened bald eagle (*Haliaeetus leucocephalus)*, Audubon's crested caracara (*Polyborus plancus)*, eastern indigo snake (*Drymarchon corais couperi*), Florida scrub jay (*Aphelocoma coerulescens*) and Garber's spurge (*Euphorbia garberi*). Our analysis also considered effects on designated critical habitats for the West Indian manatee, snail kite, Cape Sable seaside sparrow and American crocodile. We have assigned FWS log number 4-1-98-F628 to this consultation.

This preliminary programmatic biological opinion is based on information provided by the U.S. Army Corps of Engineers (COE), the South Florida Water Management District (SFWMD), Everglades National Park (ENP), the U.S. Geological Survey's Biological Resources Division (USGS-BRD), the Florida Game and Fresh Water Fish Commission (GFC), the Institute for Environmental Modeling at the University of Tennessee, and information available in our files on the C&SF Restudy and other published and unpublished sources of information. A complete administrative record of this consultation is on file in the FWS's South Florida Restoration Projects Office in Vero Beach, Florida.

CONSULTATION HISTORY

In a November 20, 1996, letter, the COE initiated informal section 7 consultation and requested a list of threatened and endangered species expected to occur in the C&SF Restudy project area.

On January 22, 1997, the COE and the FWS met to discuss how to proceed with section 7 consultation for the C&SF Restudy and agreed to integrate section 7 consultation with preparation of a Fish and Wildlife Coordination Act report and programmatic Environmental Impact Statement.

In a February 20, 1997, letter, the FWS provided the COE with a list of 17 threatened and endangered species that occur in the project area that may be affected by the C&SF Restudy.

On November 24, 1997, the COE and the FWS met to further discuss how to proceed with section 7 consultation. The FWS presented several alternative consultation methods and explained the relative benefits of each.

In a December 19, 1997, letter, the FWS provided the COE with a written summary of the options for section 7 consultation that were discussed in the November 24th meeting, and asked the COE to notify the FWS of their preferred course of action.

In a February 2, 1998, letter, the COE notified the FWS that they would continue informal consultation at present and that they would initiate early programmatic consultation when an Initial Draft Plan for the C&SF Restudy had been chosen.

From November 1997 - June 1998, the FWS provided technical assistance and recommendations regarding listed species impacts during the COE's C&SF Restudy alternatives development process through participation in the COE's interagency C&SF Restudy Alternatives Evaluation Team.

In a February 24, 1998, letter, the FWS provided extensive recommendations for maximizing benefits to threatened and endangered species resulting from the C&SF Restudy that would fulfill the COE's affirmative conservation obligations in accordance with section 7(a)(1) of the ESA.

In an April 8, 1998, letter, the FWS informed the COE that, due to new information on possible impacts resulting from the C&SF Restudy, the FWS had determined that an additional threatened species, the Florida Scrub Jay, may be affected by the C&SF Restudy.

In an June 11, 1998, letter, the COE initiated formal consultation on the C&SF Restudy for the 18 threatened and endangered species referenced in the FWS's February 20, 1997, and April 8, 1998 letters. This letter indicated that Alternative D had been chosen as the official Initial Draft Plan. However, a significantly refined alternative, Alternative D13R, was developed and endorsed by the C&SF Restudy Alternatives Evaluation Team after June 11, 1998.

In a June 22, 1998, letter, the COE confirmed that Alternative D13R had been selected as the Initial Draft Plan.

PRELIMINARY PROGRAMMATIC BIOLOGICAL OPINION

DESCRIPTION OF PROPOSED ACTION

C&SF Restudy components can be divided into those that have been modeled using the SFWMD's South Florida Water Management Model (WMM), and those that could not be modeled in this way for various reasons. <u>This biological opinion addresses the first group of components only</u>. The second group, called Other Project Elements, will be addressed in separate section 7 consultations, as necessary. In this document, the phrase "proposed action" means those C&SF Restudy components modeled by the WMM as part of the C&SF Restudy Initial Draft Plan. Critical Projects and other Feasibility Studies associated with the C&SF Restudy will also require separate section 7 consultation.

In general, the proposed action seeks to restore the biological integrity of the remaining natural areas within the project boundaries through modifications to the existing C&SF Project while also providing for the water supply and flood control needs in this area. A detailed description of the means for accomplishing these goals contained in the proposed action is available on the C&SF Restudy World Wide Web Site (http://www.sfwmd.gov/org/pld/restudy) as of this writing, and will be contained in the Draft Programmatic Environmental Impact Statement (DPEIS) for the C&SF Restudy, which is currently scheduled to be published and available to the public by late October 1998.

Because the current proposed action, despite its complexity, provides only a conceptual description of individual project features, detailed analyses of impacts associated with each project feature will be conducted in the future when detailed design and engineering information has been developed. This means that the COE will likely need to reinitiate section 7 consultation on this action many times as detailed planning and implementation progress. A general description of some of the major features of the proposed action is provided below and this biological opinion will analyze and address the effects the proposed action may have on threatened and endangered species in general terms wherever possible. This is appropriate because of the programmatic nature of the proposed action and is consistent with FWS policy governing programmatic section 7 consultations. Figures 1, 2 and 3 illustrate the major features of the action area.

Water Storage Areas: New water storage reservoirs are proposed in the following general areas: 20,000 acres in the Kissimmie River Basin near Lake Okeechobee; 10,000 acres in the St. Lucie River Basin near Lake Okeechobee; 20,000 acres in the Caloosahatchee River Basin near Lake Okeechobee and 60,000 acres in the Everglades Agricultural Area. These reservoirs will store excess water when it is not needed in the natural system or for water supply, so that it may be used later. Currently, much of this excess water is discharged to the Atlantic Ocean and Gulf of Mexico where it often causes adverse impacts to estuarine environments. Other new water storage areas, called Stormwater Treatment Areas and Water Preserve Areas, would help to improve water quality and improve water supply and flood control.

Additional Water Control Structures: Several new water control structures are proposed in the Initial Draft Plan. These structures provide additional flexibility in the control of timing, direction and volume of water flow necessary to improve and maintain natural habitats and water supply and flood control. For example, new structures proposed for the southern border of Water Conservation Area (WCA) 2B and eastern border of ENP will allow the movement of excess water from WCA 2B to the Taylor Slough area in ENP where it is needed to restore natural conditions. Another example is a new weir that would partially replace the existing L-67A canal and levee, allowing more natural free flow of water from WCA 3A to WCA 3B.

Removal of Existing Structures: The proposed action would remove several existing water control structures, including large portions of the L-28 and Tamiami Trail canals and levees. This would provide more natural free flow of water between large areas that are currently separated and would allow many fish and wildlife species to move more freely between habitats.

Operational Changes: Numerous changes are proposed for the way new and existing water control structures are operated. Examples include different rules for opening and closing gates and different rules for turning pumps on and off. Each of the proposed changes would help to make the timing, distribution and volume of water flow more like natural conditions and/or would help provide for water supply and flood control.

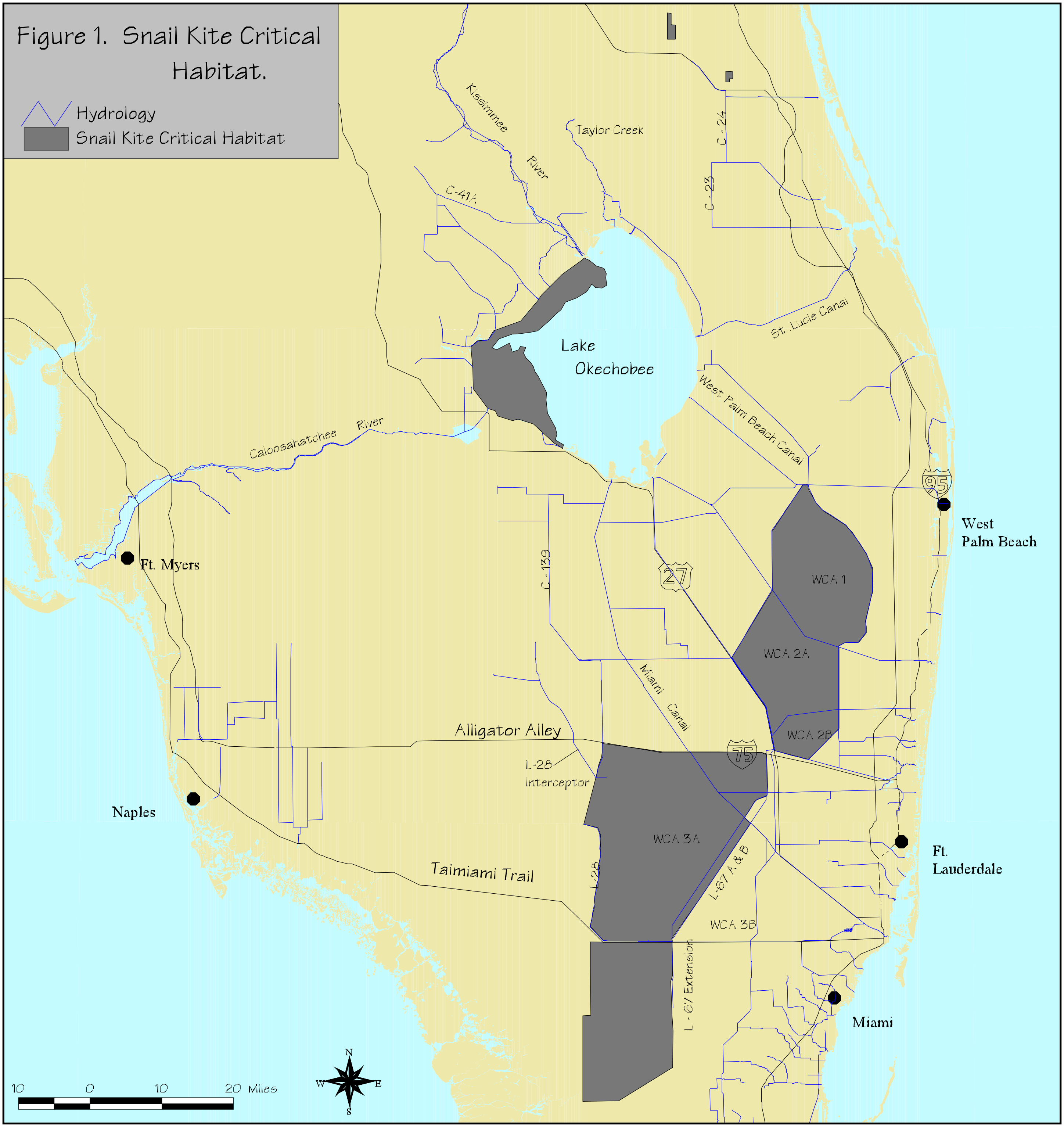


Figure 1. Snail Kite Critical Habitat.

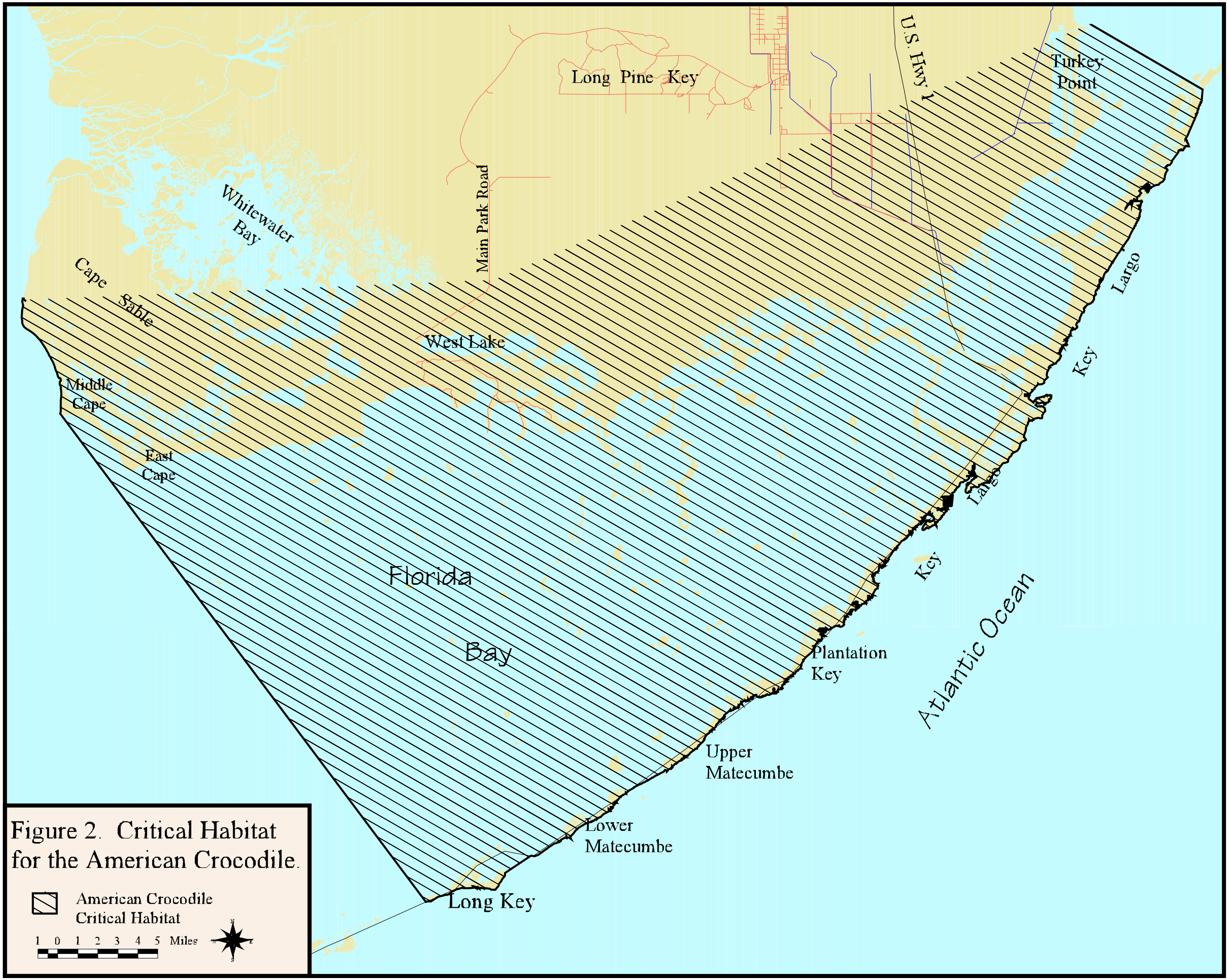


Figure 2. Critical Habitat for the American Crocodile.

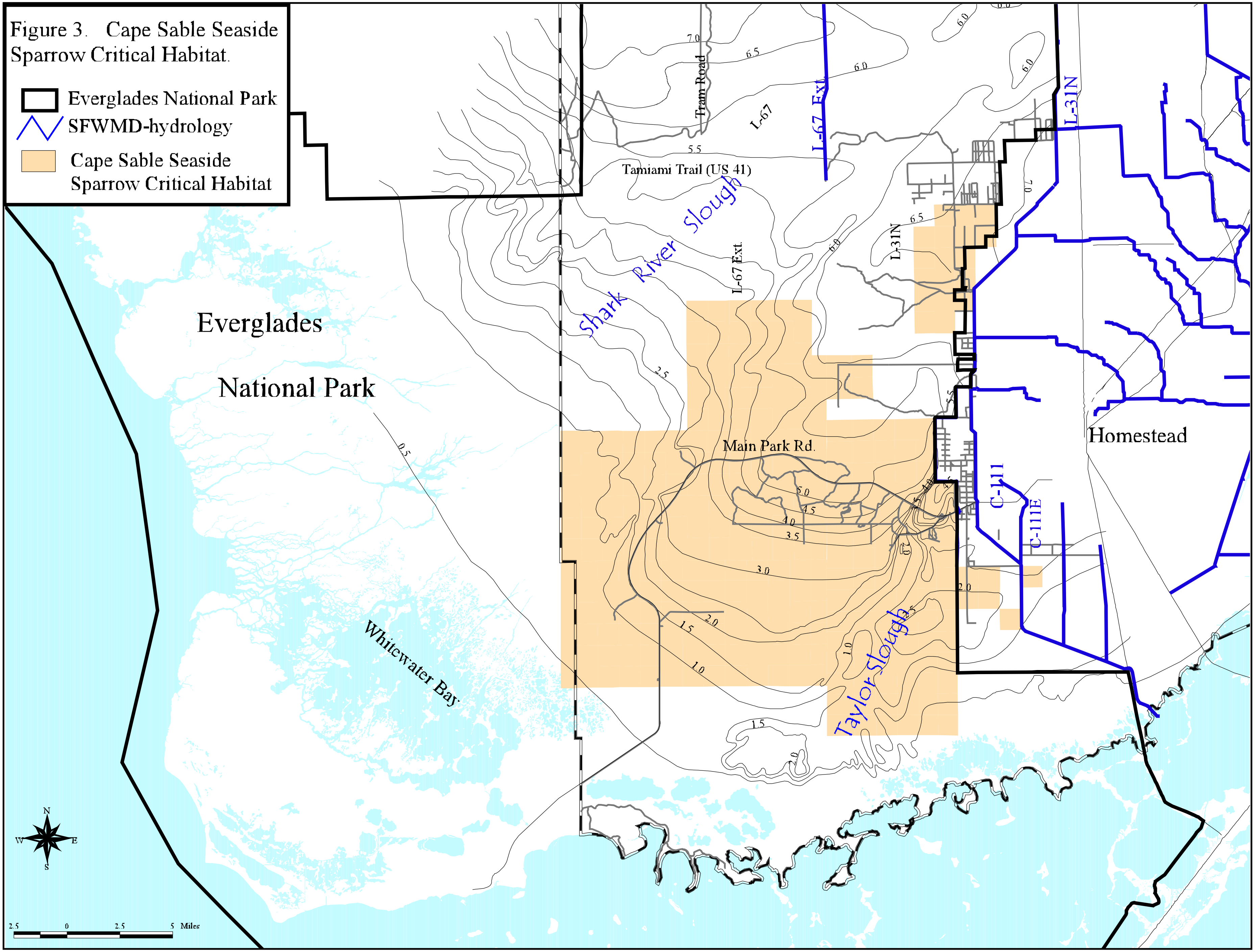


Figure 3. Cape Sable Seaside Sparrow Critical Habitat.

Timing of Implementation: Another important aspect of the proposed action is its expected timing. Currently, the planning process for the C&SF Restudy is in its earliest stage, and several years of additional planning will be necessary before any part of the proposed action can be implemented. Detailed timelines for implementation of project features have not yet been developed. The best information on timing of implementation that is currently available indicates that the initial components of the proposed action may be implemented no sooner than 10-15 years from now, and that full implementation of all components would not be expected any sooner than the year 2050.

Action Area: The action area for this consultation includes all areas within the boundaries of the SFWMD's Water Management Model. This includes Lake Okeechobee, the Everglades Agricultural Area, the Water Conservation Areas, the majority of Everglades National Park, Coastal Estuaries, Florida Bay, the majority of Big Cypress National Preserve and urban and agricultural areas along Florida's east coast south of the St. Lucie Canal.

STATUS OF THE SPECIES/CRITICAL HABITAT

Detailed biological information for listed species that may be affected by the C&SF Restudy is available in the Multi-species Recovery Plan for the Threatened and Endangered Species of South Florida, Volume I - Technical/Agency Draft (USFWS 1998).

Analysis of the species/critical habitat likely to be affected

In letters dated February 20, 1997, and April 8, 1998, the FWS initially determined that the 18 threatened and endangered species and four designated critical habitats listed on page 1 of this document may be affected by the C&SF Restudy. After review and analysis of the additional information on the proposed project and its expected impacts on these 18 threatened and endangered species and their habitats presented in the COE's June 22, 1998, Initial Draft Plan, the FWS concludes that the C&SF Restudy will not affect the Florida panther, Florida grasshopper sparrow, red-cockaded woodpecker, crenulate lead-plant, deltoid spurge, Small's milkpea, tiny polygala and Garber's spurge because the preferred habitats of these species will not be impacted by structural or hydrological changes expected to result from C&SF Restudy features modeled by the WMM. Therefore, these eight species will not be further addressed in this biological opinion.

However, as stated above, this biological opinion does not consider effects to these or other species that may result from the Other Project Elements, Critical Projects and other Feasibility Studies that are part of the C&SF Restudy, but were not modeled by the WMM. Effects to these and other listed species that may result from the Other Project Elements, Critical Projects and other Feasibility Studies will be addressed through separate informal and, if necessary, formal section 7 consultations. Additionally, if future, additional information indicates that C&SF Restudy features modeled by the WMM may affect these or other listed species in a manner or to an extent not considered in this preliminary programmatic biological opinion, the COE may need to reinitiate this section 7 consultation.

ENVIRONMENTAL BASELINE

For most section 7 consultations, the environmental baseline includes the effects of past and ongoing human and natural factors leading to the current status of the species and their habitats. For an action such as the C&SF Restudy, which is scheduled for implementation many years in the future, determination of the environmental baseline is less intuitive, and requires some assumptions regarding the expected status of the species and their habitats in the future when the proposed action will be implemented. The best information on timing of implementation that is currently available indicates that the initial components of the proposed action may be implemented no sooner than 10-15 years from now and that full implementation of all components would not be expected any sooner than the year 2050. An additional complicating factor is the need to include in the environmental baseline several other large, conceptual, projects that are planned for this area and that have already undergone section 7 consultation.

Status of the species within the action area and factors affecting species environment within the action area

Information on the current status of the species and the factors leading to their current status within the action area appears in Volume I of the Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida, Technical/Agency Draft. Light and Dineen (1994) provide an excellent discussion of factors affecting species environment within the action area up to and including current conditions.

During the C&SF Restudy alternatives development process, the COE and SFWMD anticipated the need to compare the alternatives to expected future conditions without the proposed action, and used the WMM to develop a characterization of expected future conditions without implementation of the C&SF Restudy called the 2050 Base Condition (2050 Base). A detailed technical description of all the features and assumptions included in the 2050 Base is available on the C&SF Restudy web site and will be included in the DPEIS for the C&SF Restudy. In general, the 2050 Base characterizes expected hydrological conditions in the action area taking into account implementation of the COE-sponsored Modified Water Deliveries to Everglades National Park, Canal C-111, Headwater Lakes Revitalization Project, Kissimmee River Restoration and Lower East Coast Regional Water Supply Plan projects as well as increased water supply demands resulting from projected growth in South Florida's human population.

The FWS recognizes that there is a large amount of uncertainty and difference of opinion regarding what factors were and were not included in the 2050 Base and regarding the details of how the included features were characterized. In addition, the FWS recognizes that the 2050 Base is likely to change almost continuously over the life of the proposed action due to new information resulting from ongoing planning and monitoring efforts associated with many of its features. However, the FWS has determined that the 2050 Base reasonably represents the best scientific and commercial information currently available and that it is the best currently available characterization of the expected status of species' habitats in the future when the proposed action will be implemented. Therefore, this biological opinion will use the 2050 Base as the environmental baseline.

Because the 2050 Base provides only the expected future hydrological conditions in the action area, the expected status of the species themselves in the future must be derived from this hydrological information. A sophisticated biological modeling effort for the C&SF Restudy and other restoration projects, called Across Tropic Level System Simulation (ATLSS), has been begun and provides information on the expected future status of some of the species (Institute for Environmental Modeling and USGS-BRD 1998a). The descriptions of known responses of listed species to various hydrological conditions in Volume I of the Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida, Technical/Agency Draft provides additional information on the expected future status of listed species within the action area.

EFFECTS OF THE ACTION

This section includes an analysis of the direct and indirect effects of the proposed action on the species and critical habitats and its interrelated and interdependent activities. To determine whether the proposed action is likely to jeopardize the continued existence of threatened or endangered species in the action area, the FWS focuses on consequences of the proposed action that effect rates of birth, death, immigration, and emigration, because the probability of extinction in plant and animal populations is most sensitive to changes in these rates.

Possible effects have been divided into three categories - hydrological effects, construction effects and sequencing effects. Hydrological effects are those caused by changes in the timing, volume and distribution of water flows resulting from proposed structural and operational changes in the water management system. Construction effects are those caused by construction activities necessary to install new structures or to modify or remove existing structures. Sequencing effects are those temporary effects resulting from the order in which components are constructed and put into operation. A final section summarizes expected effects on each listed species that will be affected.

1. Hydrological Effects

A. Hydrological changes in the natural system

The proposed action will alter many features of the timing, volume and distribution of water flows through the remaining Everglades system including Lake Okeechobee, the Water Conservation Areas, Everglades National Park including Florida Bay, and the eastern portion of Big Cypress

National Preserve. These alterations will be described generally here by first describing the general hydrological features of the 2050 Base (environmental baseline conditions) and then describing how the proposed action will change those features. Detailed descriptions and documentation of hydrological changes expected to result from the proposed action are available in the C&SF Restudy DPEIS.

Under 2050 Base conditions, several features of the water management system limit the system's ability to provide natural timing, volume and placement of water flows as defined by the SFWMD's Natural Systems Model (NSM), as follows: 1) the overall volume of water available to the remaining Everglades system falls far short of volumes expected under NSM conditions in most years, causing reduced depths and shorter hydroperiods over large parts of the project area. This reduced volume is due in large part to the release of excess water to the ocean during high water periods in order to avoid flooding; 2) the effects of a reduced volume of water are exacerbated by the system of canals and levees that provides unobstructed flow paths that allow much of the available water to flow quickly from Lake Okeechobee, through the WCAs and into ENP, reducing hydroperiods. Under natural conditions, water flowed much more slowly through unbroken stretches of marsh so that water was retained within the Everglades system for longer periods, increasing hydroperiods in many areas; 3) the levee system also provides barriers to natural flow paths, creating unnaturally deep and long-lasting pools of water upstream (north) of the levees separating the WCAs; and, 4) the historical flow path of Shark River Slough, the main path of drainage through the remaining Everglades system, has been re-routed from east to west in order to protect eastern urban and agricultural areas from flooding and a significant portion of the historical flow path has been permanently eliminated due to urbanization. Under natural conditions, the majority of water passing into what is now ENP entered to the east of today's L-67E levee. Under 2050 Base conditions, most water enters ENP to the west of this levee, producing unnaturally increased hydroperiods to the west and unnaturally reduced hydroperiods to the east.

The proposed action will make significant progress towards removing each of these limits to natural hydropatterns: 1) several very large Water Storage Areas and numerous Aquifer Storage and Recovery wells would capture and store much of the excess water available during wet periods. This makes more water available to the remaining Everglades system when it is needed to provide natural flow volumes, reduces damaging freshwater releases to estuaries, and reduces damage to Lake Okeechobee littoral zone habitats though attenuation of extreme high and low lake levels; 2) the rate of water flow through the remaining Everglades system is reduced through backfilling of canals including much of the Miami Canal and parts of the L-67 A and C canals, and removal of parts of the L-67 A and C levees, allowing water to travel through additional marsh areas; 3) the unnaturally deep pool of water in the southern part of WCA 3A is reduced through removal of parts of several levees, allowing water to flow more freely through this area; and, 4) the historical flow path of Shark River Slough is partially restored through removal of part of several levees, allowing large volumes of water to pass through WCA 3B and into northeast

Shark River Slough. This reduces unnaturally long hydroperiods in the area of northwestern ENP and southeastern Big Cypress National Preserve, and increases unnaturally short hydroperiods in northeastern Shark River Slough.

These more natural hydropatterns expected to result from the proposed action will have beneficial effects on several listed species. The overall increased volume of water flow though the remaining Everglades system provides greater volumes of freshwater flow into Florida Bay and Shark River Slough estuaries, reducing salinities in these areas. Since West Indian manatees prefer habitats that include sources of freshwater, the proposed action may increase the area of habitat suitable for manatees in Florida Bay. Decreased salinities and decreased temperatures associated with increased freshwater inflows may cause a shift in seagrass composition. However, manatees eat all species of seagrasses and are not thought to be food limited in this area (USFWS 1998). Consequently, implementation of the proposed action is likely to benefit the West Indian manatee. Similarly, adult American crocodiles prefer low salinity habitats and hatchling crocodiles experience increased growth rates and decreased predation when low salinity nursery habitats are available (USFWS 1998). The proposed action would increase the number of months that salinities in crocodile habitats are low and decrease the number of months that salinities in crocodile habitats increase to poorly tolerated levels. Therefore, implementation of the proposed action should benefit the American crocodile through decreased salinities in Florida Bay and Shark River Slough estuarine habitats, including designated critical habitat (Figure 2), resulting from increased freshwater flow volumes through the remaining Everglades system.

The Okeechobee gourd is also expected to benefit as a result of the proposed action. 2050 Base conditions produce periods of extreme high water in Lake Okeechobee that would flood Okeechobee gourd habitats and would be expected to cause some Okeechobee gourd mortality and reduce surrounding vegetation necessary to support mature plants (USFWS 1998). The 2050 Base also produces extreme low lake levels that overdry Okeechobee gourd habitats, reducing seedling survival rates (USFWS 1998). The proposed action would improve habitat conditions for this species through attenuation of extreme high and extreme low water levels in Lake Okeechobee.

Snail kites use many areas of the remaining Everglades system and large parts of this area have been designated as snail kite critical habitat (Figure 1). The proposed action would provide improved habitat conditions for snail kites in several ways: 1) attenuation of extreme high water levels in Lake Okeechobee would reduce flood induced die-off of woody vegetation that provides nesting substrate for snail kites, increasing available nesting habitat; 2) attenuation of extreme low water levels in Lake Okeechobee would increase availability of suitable snail kite foraging habitat in the littoral zone, particularly during drought periods when snail kite habitat in other areas is limited; 3) reduction of the deep, impounded pool areas in southern WCA 3A would reduce losses of snail kite nesting habitat due to drowning of woody vegetation (Bennetts and Kitchens 1997) and improve foraging conditions in many years, but would slightly increase the severity of drydowns during dry years (Institute for Environmental Modeling and USGS-BRD 1998b);

and, 4) more natural depths and hydroperiods in WCA 3B and along the flanks of Shark River Slough would provide improved snail kite foraging habitat in these areas during average to wet years (Institute for Environmental Modeling and USGS-BRD 1998b). During very dry years, the FWS expects a slight shift in snail kite habitat usage from WCA 3A to Shark River Slough and other habitats outside the project areas. No significant change in habitat conditions is expected for snail kite habitats in other areas of the remaining Everglades system.

The proposed action would improve habitat conditions for wood storks through reversal of factors that are thought to have caused the historic decline of nesting wood stork numbers in the remaining Everglades system. Ogden (1994) proposes that the substantial reduction in freshwater flow into Florida Bay and Shark River Slough estuaries seen under current and 2050 Base conditions reduces the production and availability of fish suitable for wood stork consumption to the point that these areas can no longer support nesting wood stork populations. Ogden (1994) further suggests that wood storks have responded by shifting their nesting attempts to parts of the WCAs and areas outside the southern Everglades that provide appropriate concentrations of fish. However, appropriate concentrations of fish are generally available in the WCAs several months later than they would be in the estuarine areas, causing wood storks to initiate nesting later in the year and increasing wood stork nest failure rates when wet season rains disperse fish concentrations before nestlings have fledged.

The proposed action would restore suitable wood stork foraging and nesting habitats in the Shark River Slough and Florida Bay areas by providing volume and timing of freshwater flows to these areas that more closely match natural conditions. Through an analysis of expected hydroperiods and flow volumes in the Shark River Slough and Florida Bay estuarine areas, Ogden (SFWMD, personal communication 1998) estimates a significant improvement in wood stork habitat suitability under the proposed action. ATLSS modeling of expected foraging conditions for long-legged wading birds and expected fish abundance also suggests that the proposed action will improve habitat conditions for wood storks (Institute for Environmental Modeling and USGS-BRD 1998b).

Cape Sable seaside sparrow habitat conditions, including designated critical habitat (Figure 3), would also be improved through reversal of factors that are thought to have caused the historic declines of this species. As described above, current delivery of the majority of water entering ENP to the west of the L-67E levee has resulted in artificially increased water levels west of Shark River Slough and artificially reduced water levels east of Shark River Slough. Nott *et al.* (1998) and Curnutt *et al.* (1998) documented the detrimental effects of current water management practices that flood Cape Sable seaside sparrow habitat west of Shark River Slough (Figure 3, ENP border area), through analysis of the various sources of water in this area and their correlation with observed Cape Sable seaside sparrow population declines and detrimental alteration of Cape Sable seaside sparrow habitat. Nott *et al.* (1998) and Curnutt *et al.* (1998) also document declines in the eastern Cape Sable seaside sparrow subpopulations (Figure 3, northern and eastern critical habitat areas) and detrimental alteration of eastern Cape Sable seaside sparrow habitats under current conditions, which they attribute to overdrainage and resultant increased fire frequencies in these areas. ATLSS modeling results indicate that 2050 Base conditions would not significantly reduce flooding in the sparrow's western population habitat, and would increase damaging overdrainage in the sparrow's eastern habitat as compared to current conditions (Institute for Environmental Modeling and USGS-BRD 1998c).

ATLSS hydroperiod modeling suggests that the proposed action will make significant progress toward reversing hydrological factors causing declines in Cape Sable seaside sparrow populations (Institute for Environmental Modeling and USGS-BRD 1998b). Increased water levels and hydroperiods in eastern marl prairie habitats utilized by the sparrow should improve habitat conditions through a reduction in woody vegetation encroachment and a reduction in fire return frequencies (Curnutt *et al*. 1998, Nott *et al*. 1998). Decreased water levels in the western marl prairie habitats would reduce the number of years in which successful sparrow breeding is reduced or precluded by flooding. ATLSS individual-based sparrow modeling and population viability analyses for the western sparrow sub-population provide further evidence that productivity and probability of persistence of this population would be improved (Institute for Environmental Modeling and USGS-BRD 1998b).

Although the proposed action would improve both western and eastern Cape Sable seaside sparrow habitats overall, some small adverse effects are also likely to result. Part of the sparrow's eastern habitat lies along the eastern flank of Shark River Slough at a lower elevation than other eastern habitat areas (Figure 3). With expected increases in water depths in Shark River Slough under the proposed action, part of this sparrow habitat would be likely to experience hydroperiods long enough to cause a shift in vegetative composition. Such a shift would increase densities of water tolerant vegetation, rendering part of the existing habitat unsuitable for Cape Sable seaside sparrows (S. Pimm, University of Tennessee and S. Bass, Everglades National Park, personal communications 1998). The FWS expects that the effect of this small loss of habitat would be minor given the overall beneficial effects in other habitat areas. However, the sequence in which components of the proposed action are implemented may influence the effect of this habitat shift on the overall sparrow population. This concern is discussed further below.

B. Hydrological changes in the new water storage and treatment areas

The proposed action includes approximately 125,000 acres of new Water Storage Areas, 60,000 acres of Water Preserve Areas and approximately 10,000 acres of new Stormwater Treatment Areas. This represents a large and significant part of South Florida's remaining natural habitats, including upland habitats, that will be hydrologically altered by the C&SF Restudy. Although the exact locations of the new Water Storage Areas and Stormwater Treatment Areas have not been determined, the COE has provided some preliminary information on possible locations. An analysis of wildlife habitats occurring in these possible locations is provided in the accompanying Draft Fish and Wildlife Coordination Act Report for the C&SF Restudy (FWCA Report).

The FWCA Report analysis reveals that habitats of several listed species occur in the possible storage and treatment area locations. The Everglades Agricultural Area storage area and Water Preserve Area locations include areas used for foraging by the wood stork, particularly during high water periods. Both possible locations for the storage area north of Lake Okeechobee include current and past bald eagle nesting sites, and the Audubon's crested caracara is present within and around both sites. Caracaras and active Florida scrub jay territories are present in the Caloosahatchee storage area site, and although there are currently no records of bald eagle nesting in this area, bald eagle nesting patterns shift over time and this species may be present in the Caloosahatchee site at the time of construction. Possible storage area locations in the St. Lucie drainage do not contain habitats of particular significance to listed species. However, records of caracara use exist for one of the areas and a wood stork nesting site occurs just outside one of the proposed areas. The COE has not provided possible sites for the storage and treatment sites in the Taylor Creek/Nubbin Slough area. However, FWS files indicate that caracaras use this general area and the COE is encouraged to avoid caracara habitats as much as possible during the siting process. Although detailed records of eastern indigo snake occurrences are not available for the proposed storage and treatment area locations, the FWS believes that eastern indigo snakes are very likely to occur in all of these areas.

It is difficult to predict what vegetative communities will be present in the new water storage areas due to the unusual hydrologic patterns they will experience. These areas will act primarily as "surge tanks", storing large amounts of excess water during wet periods and drying out completely during dry times. These alternating wet and dry conditions may last only a few days or may last for many months to more than a year, and water depths will vary widely, from as deep as 10 feet to only a few inches, depending on rainfall conditions and operational demands. These irregular hydrological patterns will certainly cause profound and widespread changes in wildlife habitats existing in these areas at the time of construction. Long periods of flooding would be expected to kill trees used as nesting sites by bald eagles, caracaras and many other species, eventually destroying the nests and reducing available nesting substrates.

Under some conditions, large areas of habitat suitable for foraging wood storks, snail kites, bald eagles, and Audubon's crested caracaras may be created and may provide some benefits to these and other wildlife species. However, the FWS is concerned that these areas would become "attractive nuisances" when temporary favorable conditions are created, drawing in opportunistic wildlife species. Temporary favorable conditions could induce species such as wood storks, snail kites, bald eagles and others to nest nearby with nesting success dependent on continued favorable foraging conditions, and could produce artificially inflated populations of some species. When storage area operations then cause a rapid change in conditions, widespread nesting failures and direct mortality of adult individuals due to loss of foraging resources could result. In addition, the rapid filling of storage areas that have been dry for extended periods would likely result in direct mortality due to drowning of less mobile species such as the eastern indigo snake.

Clearly, xeric habitats within the new water storage areas, such as oak scrub habitat used by Florida scrub jays, would be destroyed by periodic flooding. Florida scrub jays are habitat limited and the FWS expects that any scrub jay individuals residing in habitats that are subsequently destroyed by flooding would die due to starvation or predation while searching for new, unoccupied habitat unless new suitable scrub habitat is created nearby (USFWS 1998).

Expected vegetative patterns in the new Stormwater Treatment Areas are more predictable since water levels would be more stable and there are several currently operating Stormwater Treatment Areas that provide examples of expected conditions. However, uncertainty still exists because even when water levels are suitable for wildlife habitats, the high nutrient levels in the incoming water and soils tend to produce large numbers of cattails and other nutrient tolerant species that provide poor habitat for snail kites, wood storks and many other wildlife species. Stormwater Treatment Areas with water levels less than 4 feet deep, and that are not in a stage in their maintenance when high densities of cattails are present, would be expected to provide some foraging habitat for snail kites, wood storks and other wildlife species.

Detailed surveys of all proposed storage and treatment area locations will be necessary during future detailed siting and planning in order to provide up to date information on expected impacts to wildlife habitats at the time of construction. If these surveys suggest that listed species may be affected in a manner, or to an extent not analyzed above, the COE will need to reinitiate consultation on these components.

2. Construction Effects

Information on the precise location, seasonal timing and duration of C&SF Restudy construction activities will be developed during future detailed planning and design phases of the project. Therefore, analyses of the precise effects of construction activities on listed species will be conducted in the future as detailed designs and scheduling are completed. However, the general information now available suggests that these construction activities will have adverse effects on some listed species and their habitats, although the exact extent and magnitude of these adverse effects can not be determined at this time.

Construction of five very large Water Storage Areas and several smaller storage, Water Preserve Areas and Stormwater Treatment Areas may adversely affect several listed species. These water storage and treatment areas total more than 100,000 acres as currently designed. Impacts to wildlife resulting from construction of perimeter levees and control structures would include disturbance due to prolonged use of heavy construction equipment and disruptive construction techniques such as blasting. In addition, although exact design specifications have not yet been developed, the area of habitat destroyed within the footprint of these new structures could be significant. The COE has provided some preliminary data on possible locations for these water storage and treatment areas and an analysis of wildlife habitats occurring in these locations is provided in the accompanying FWCA report. Based on this analysis, the FWS concludes that construction locations are likely to include habitats of the bald eagle, Audubon's crested caracara, wood stork, eastern indigo snake and Florida scrub jay. An analysis of the nature and extent of any adverse effects to these species resulting from construction of these water storage and treatment areas will not be possible until exact siting and construction schedule information is available. The COE will need to reinitiate consultation on these components when such information has been developed. The FWS encourages the COE to carefully consider impacts to wildlife habitats during the siting process in order to avoid and minimize possible adverse effects. Thorough surveys of these areas will need to be conducted during the siting process in order to provide timely information on species locations at the time of construction.

Removal/redesign of several existing C&SF project features is likely to adversely affect several listed species. Removal of portions of the L-28 and Tamiami Trail levees and their associated canals, backfilling part of the Miami Canal and removal/redesign of the L-67 A and C levees will require prolonged use of heavy construction equipment and may require potentially disruptive construction techniques such as blasting. Several known snail kite and wood stork nesting areas occur immediately adjacent to portions of these levees slated for removal (Bennetts *et al*. 1994, Bennetts and Kitchens 1997, Ogden 1994) and the FWS believes that wood stork and snail kite individuals could be harassed and could abandon nesting activities as a result of physical disturbance and/or noise disturbance resulting from these construction activities if they occur during the breeding season and birds are actively engaged in breeding activities nearby. Such harassment could cause nesting individuals to flush from their nests, increasing the likelihood that eggs or nestlings would be lost to predation. In addition, eastern indigo snakes are known to occur along canal banks in South Florida, where they use crab holes in lieu of gopher tortoise burrows (Lawler 1977). Therefore, removal of large portions of these existing levees would destroy potential eastern indigo snake habitat and would likely result in death or injury of eastern indigo snake individuals present during construction.

Many other construction activities, such as new canal/levee construction for the Water Preserve Areas, construction of additional water control structures along the eastern perimeter levees, and installation of Aquifer Storage and Recovery wells, are also included in the proposed action. The FWS believes that these construction activities will generally have only discountable effects on the wood stork, snail kite, Cape Sable seaside sparrow and other listed species that may avoid using foraging and/or resting habitats immediately adjacent to construction sites during active construction due to physical and/or noise disturbance. However, if future detailed design and construction schedules for these components reveal that construction activities will occur immediately adjacent to snail kite, wood stork, Cape Sable seaside sparrow or bald eagle nesting areas during the nesting season, or that additional listed species may be affected, the COE should enter into consultation with the FWS to determine whether adverse effects to listed species are likely. All new water control structures will include devices designed to avoid trapping or otherwise injuring West Indian manatees (COE 1994); therefore, the FWS does not expect any adverse effects to manatees due to construction or operation of new water control structures.

The FWS recommends that the COE plan seasonal timing of construction activities to protect listed species whenever possible. This reflects the ongoing responsibility of all Federal agencies to minimize adverse effects to listed species, even when the cumulative effect of their actions do not reach the level of jeopardy. For example, if disturbance of a wading bird colony containing nests of the endangered wood stork can be avoided by scheduling construction activities outside the nesting season of the word stork, such scheduling changes are justified regardless of whether the long-term effects of the project will benefit the species as a whole.

3. Sequencing Effects

The above analysis includes expected effects of construction and implementation of the full complement of components included in the proposed action. Additional and possibly quite different effects are likely to occur as a result of the sequencing of component implementation. For example, implementation of the planned removal of part of the Tamiami Trail canal and levee starting at the eastern end and proceeding west would likely have very different effects on natural habitats during implementation than would a west to east progression. The east to west progression would remove one of the major impediments to restoring water flows to the main historic channel of Shark River Slough first, quickly relieving the overdrying of Northeast Shark River Slough and the flooding of marl prairie areas west of Shark River Slough. This broadly corresponds to improvements in eastern and western Cape Sable seaside sparrow habitats. A west to east progression would prolong limitations on our ability to alleviate these problems and may exacerbate flooding of western marl prairies due to loss of control over western water flows with levee removal. This may cause additional adverse effects to Cape Sable seaside sparrows prior to realization of any expected benefits, raising serious doubts as to the species ability to survive until these benefits could be realized. In addition, an east to west progression would allow development of improved foraging habitat for snail kites along the banks of Shark River Slough before removal of the western part of the Tamiami Trail levee reduces the snail kite habitat currently provided by artificial impoundment of water in southern WCA 3A.

Another example is the timing of land acquisition activities. Lands within the action area are undergoing development for residential and industrial uses every day, making acquisition of these lands for restoration purposes increasingly difficult. As options for placement of proposed water storage and treatment facilities are limited in this way, the likelihood increases that these limitations will force siting of facilities on ecologically sensitive lands, including listed species habitats. If land acquisition is scheduled and completed early in the implementation sequence, conflicts with other land uses in acquisition areas would likely be minimized, enhancing our ability to avoid sensitive natural areas.

Countless other sequencing considerations exist, and will best be addressed in the future detailed planning and design phases of the C&SF Restudy. However, guiding principles for minimizing adverse effects to listed species due to sequencing of component implementation can be outlined at this point and incorporated into future planning. First, sequencing should attempt to provide a smooth transition for those species that will lose habitat in some areas and gain it in others. The

Tamiami Trail levee removal example above illustrates this for shifts in snail kite habitats. Second, sequencing should attempt to implement actions that will benefit a species before those that will adversely affect it. The Tamiami Trail levee example illustrates this for the Cape Sable seaside sparrow. Third, when it is necessary to choose between sequences or other options that will differentially affect listed species, priority should be given to those species that are: 1) most imperiled; 2) most limited in their distribution to areas affected by the action; and, 3) least able to adjust to proposed changes. For example, higher priority should be placed on avoiding Florida grasshopper sparrow habitat during placement of storage reservoirs than on avoiding Audubon's crested caracara habitat because the grasshopper sparrow is more imperiled, more limited in distribution and less flexible in its habitat requirements.

4. Species Summary

A. West Indian Manatee and American Crocodile

The proposed action would improve habitat conditions for the West Indian manatee and American crocodile through decreased salinities in Florida Bay and Shark River Slough estuarine habitats resulting from increased volume and improved timing of freshwater flows to these areas.

B. Okeechobee Gourd

The proposed action would improve habitat conditions for the Okeechobee gourd through attenuation of extreme high and extreme low water levels in Lake Okeechobee.

C. Florida Scrub Jay and Audubon's Crested Caracara

Construction and operation of water storage and treatment areas is likely to destroy some Florida scrub jay and Audubon's crested caracara habitat.

D. Eastern Indigo Snake

Construction and operation of water storage and treatment areas, and removal of some existing levees is likely to destroy some eastern indigo snake habitat.

E. Bald Eagle

Construction and operation of water storage and treatment areas is likely to destroy some bald eagle nesting sites. Disturbance due to nearby construction activities may cause some additional adverse effects. Additional adverse effects are possible due to water storage and treatment area operations that may create "attractive nuisance" conditions.

F. Snail Kite

Snail kite habitats in Lake Okeechobee, southern WCA 3A, WCA 3B and Shark River Slough would be improved through more natural hydrology and a shift of snail kite habitat use from WCA 3A to Shark River Slough is expected during very dry years. Disturbance due to construction activities and possible temporary reductions in available habitats due to the sequencing of component implementation are likely to cause adverse effects. Additional adverse effects are possible due to water storage and treatment area operations that may create “attractive nuisance” conditions.

G. Wood Stork

Wood stork nesting habitats in Florida Bay and Shark River Slough estuarine areas would be improved by restoring more natural hydrology. Overall increases in fish availability may provide improved foraging in many areas. Disturbance due to construction activities and loss of foraging habitats to water storage areas are likely to cause adverse effects. Additional adverse effects are possible due to water storage and treatment area operations that may create “attractive nuisance” conditions.

H. Cape Sable Seaside Sparrow

Significant improvement in breeding habitat availability is expected in eastern and western sparrow habitats due to more natural hydrology. Minor adverse effects are likely due to expected vegetative shifts in a small area sparrow of habitat on the eastern bank of Shark River Slough.

Conflicts among the needs of listed species within the action area appear to be a concern for the proposed project as a whole only in the apparent need to eliminate or otherwise adversely affect some listed species habitat associated with new water storage facilities in order to provide benefits to many other species and habitats downstream. This tradeoff should be acceptable as long as the priority guidelines described above are adopted and any adverse impacts do not reach or exceed the jeopardy threshold. The proposed overall changes in the hydrology of the remaining Everglades do not appear to contain such conflicts - they benefit all listed species that would be affected.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, local or private actions that are reasonably certain to occur in the action area considered in this preliminary biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

All future actions that are reasonably certain to occur in the action area and would affect listed species are expected to be carried out, funded and/or permitted by the COE, NPS or FWS. Therefore, all future actions would require separate section 7 consultation and will not be included here in a cumulative effects analysis.

PRELIMINARY CONCLUSION

After reviewing the current status of the West Indian manatee *(Trichechus manatus*) and its designated critical habitat, snail kite (*Rostrhamus sociabilis plumbeus*) and its designated critical habitat, wood stork *(Mycteria americana*), Cape Sable seaside sparrow *(Ammodramus maritimus mirabilis*) and its designated critical habitat, American crocodile (*Crocodylus acutus*) and its designated critical habitat, Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), Okeechobee gourd (*Cucurbita okeechobeensis),* bald eagle (*Haliaeetus leucocephalus),* Audubon's crested caracara (*Polyborus plancus),* eastern indigo snake (*Drymarchon corais couperi*), and Florida scrub jay (*Aphelocoma coerulescens*), the environmental baseline for the action area, the effects of the proposed Central and Southern Florida Project C&SF Restudy and the cumulative effects, it is the Service's preliminary biological opinion that the C&SF C&SF Restudy alternative D13R, as proposed, is:

1) not likely to adversely affect and is likely to benefit the West Indian Manatee, American crocodile and Okeechobee gourd, and is not likely to adversely modify designated West Indian Manatee or American crocodile critical habitat;

2) is likely to adversely affect, but is not likely to jeopardize and, as a whole, is likely to benefit the snail kite, wood stork and Cape Sable seaside sparrow (this determination reflects minor, localized adverse effects that are expected to occur during the implementation of actions that will provide overall benefits to the species clearly outweighing the adverse effects) and is not likely to adversely modify designated snail kite or Cape Sable seaside sparrow critical habitat; and,

3) is likely to adversely affect, but is not likely to jeopardize the bald eagle, Audubon's crested caracara, eastern indigo snake and Florida scrub jay.

INCIDENTAL TAKE STATEMENT

INTRODUCTION

Sections 4(d) and 9 of ESA, as amended, prohibit taking (harass, harm, purse, hunt, shoot, wound, kill, trap, capture of collect, or attempt to engage in any such conduct) of listed species of fish or wildlife without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species b significantly impairing behavioral patterns such as breeding, feeding or sheltering. Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is any take of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or the applicant. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be implemented by the agency, if this preliminary biological opinion is confirmed, so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, in order for the exemption in section 7(o)(2) to apply. The COE has a continuing duty to regulate the activity covered by this incidental take statement. If the COE (1) fails to ensure that all implementing entities adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to permit, grant or other documents, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Sections 7(b)(4) and 7(o)(2) of the Act do not apply to the incidental take of listed plant species. However, protection of listed plants is provided to the extent that the Act requires a Federal permit for removal or reduction to possession of endangered plants from areas under Federal jurisdiction, or for any act that would remove, cut, dig up, or damage or destroy any such species on any State or in the course of any violation of a State criminal trespass law.

AMOUNT OR EXTENT OF TAKE ANTICIPATED

In meeting the provisions for incidental take in section 7(b)(4) of the ESA, the FWS has reviewed the biological opinion and other available information relevant to the proposed action. Based on our review, incidental take is anticipated as follows.

Audubon’s crested caracara

Incidental take of Audubon’s crested caracara individuals and habitat is likely during construction and operation of the large water storage areas that are part of the proposed action. The amount or extent of this incidental take cannot be anticipated at this time because a proposal for precise siting of these storage areas has not yet been developed. Therefore, this incidental take statement does not provide protection from liability under the taking provisions of section 9 of the ESA for take of Audubon’s crested caracaras associated with the proposed action.

Some preliminary recommendations for siting of water storage areas are provided in the accompanying FWCAR for the C&SF Restudy, and the FWS will provide detailed technical assistance during future development of siting proposals in order to minimize adverse effects to listed species. Reinitiation of formal consultation for Audubon's crested caracara will likely be necessary if final siting proposals include caracara habitat areas.

Bald eagle

Incidental take of bald eagle individuals and habitat is likely during construction activities, particularly construction of the large water storage areas, that are part of the proposed action. The amount or extent of this incidental take cannot be anticipated at this time because precise siting, engineering and construction activity schedule proposals have not yet been developed. Therefore, this incidental take statement does not provide protection from liability under the taking provisions of section 9 of the ESA for take of bald eagles associated with the proposed action.

Some preliminary recommendations for siting of water storage areas are provided in the FWS's FWCAR for the C&SF Restudy and the FWS will provide detailed technical assistance during future development detailed construction proposals in order to minimize adverse effects to listed species. The COE should refer to the FWS's Habitat Management Guidelines for the Bald Eagle in the Southeastern Region (USFWS 1987) during detailed planning. Reinitiation of formal consultation for the bald eagle will be necessary if final proposals include destruction of bald eagle nests or disruptive construction activity near bald eagle nests.

Cape Sable seaside sparrow

Incidental take of Cape Sable seaside sparrow individuals and habitat is likely during C&SF Restudy implementation, primarily through flooding and eventual loss of a small portion of habitat on the eastern bank of Shark River Slough. Current topographical and hydrological modeling information is not sufficient to determine the exact amount of this anticipated incidental take. Therefore, this incidental take statement does not provide protection from liability under the taking provisions of section 9 of the ESA for take of Cape Sable seaside sparrows associated with the proposed action.

Reinitiation of formal consultation for the Cape Sable seaside sparrow will likely be necessary when the availability of additional information allows a precise determination of anticipated incidental take.

Eastern indigo snake

Incidental take of eastern indigo snake individuals and habitat is likely during construction and operation activities, particularly construction and operation of the large water storage areas that are part of the proposed action. The amount or extent of this incidental take cannot be anticipated at this time because precise siting, engineering and construction activities and scheduling proposals have not yet been developed. Therefore, this incidental take statement does not provide protection from liability under the taking provisions of section 9 of the ESA for take of eastern indigo snakes associated with the proposed action.

Some preliminary recommendations for siting of water storage areas are provided in the FWS's FWCAR for the C&SF Restudy and the FWS will provide detailed technical assistance during future development detailed construction proposals in order to minimize adverse effects to listed species. Reinitiation of formal consultation for the eastern indigo snake will likely be necessary if final proposals include destruction and/or disturbance of eastern indigo snake habitat.

Florida scrub jay

Incidental take of Florida scrub jay individuals and habitat is likely during construction of the large water storage areas that are part of the proposed action. The amount or extent of this incidental take cannot be anticipated at this time because a proposal for precise siting of these storage areas has not yet been developed. Therefore, this incidental take statement does not provide protection from liability under the taking provisions of section 9 of the ESA for take of Florida scrub jays associated with the proposed action.

Some preliminary recommendations for siting of water storage areas are provided in the FWS's FWCAR for the C&SF Restudy and the FWS will provide detailed technical assistance during future development of siting proposals in order to minimize adverse effects to listed species. It should be possible to choose final sites that avoid all scrub jay habitat, thereby eliminating all adverse affects to this species. Reinitiation of formal consultation for the Florida scrub jay will likely be necessary if final siting proposals do include scrub jay habitat areas.

Snail kite

Incidental take of snail kite individuals and habitat is likely during construction and operation of the large water storage areas that are part of the proposed action and during other construction activities that occur near snail kite foraging and/or nesting areas while snail kites are present. The amount or extent of this incidental take cannot be anticipated at this time because proposals for precise siting and construction schedules have not yet been developed. Therefore, this incidental take statement does not provide protection from liability under the taking provisions of section 9 of the ESA for take of snail kites associated with the proposed action.

The FWS will provide detailed technical assistance during future development of siting and operations proposals in order to minimize adverse effects to listed species. Construction schedules should include provisions for surveys to determine if snail kites or other listed species are present near the construction site and measures to adjust the timing and/or location of construction activities to avoid disturbance. Reinitiation of formal consultation will be necessary if final proposals may adversely affect snail kites.

Wood stork

Incidental take of wood stork individuals and habitat is likely during construction and operation of the large water storage areas that are part of the proposed action and during other construction activities that occur near wood stork foraging and/or nesting areas while wood storks are present. The amount or extent of this incidental take cannot be anticipated at this time because proposals for precise siting and construction schedules have not yet been developed. Therefore, this incidental take statement does not provide protection from liability under the taking provisions of section 9 of the ESA for take of wood storks associated with the proposed action.

Some preliminary recommendations for siting of water storage areas are provided in the FWS's FWCAR for the C&SF Restudy and the FWS will provide detailed technical assistance during future development of siting and operations proposals in order to minimize adverse effects to listed species. Construction schedules should include provisions for surveys to determine if wood storks or other listed species are present near the construction site and measures to adjust the timing and/or location of construction activities to avoid disturbance. Reinitiation of formal consultation will be necessary if final proposals may adversely affect wood storks.

EFFECT OF THE TAKE

Based on the accompanying biological opinion, the FWS has determined that this level of anticipated incidental take is not likely to result in jeopardy to listed species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

When providing an incidental take statement the FWS is required to provide reasonable and prudent measures it considers necessary or appropriate to minimize the take along with terms and conditions that must be complied with, to implement the reasonable and prudent measures. The FWS believes the following reasonable and prudent measures are necessary and appropriate to reduce take:

1. Placement of water storage areas, water treatment areas and other impoundments should avoid listed species habitats as much as possible.

2. Construction schedules for all project features should avoid disturbance of listed species as much as possible.

3. Sequencing of component implementation should maximize benefits and minimize adverse affects to listed species as much as possible.

TERMS AND CONDITIONS

To implement the above reasonable and prudent measures, the FWS has outlined the following terms and conditions for incidental take. In accordance with the Interagency Cooperation Regulations (50 CFR 402), these terms and conditions must be complied with to implement the reasonable and prudent measures for incidental take.

1. The COE, in cooperation with FWS and other natural resources professionals, must design and implement a detailed monitoring and adaptive management program sufficient to provide information on the locations of listed species and the effects of C&SF Restudy components on listed species that can be used to maximize benefits and minimize adverse affects to listed species during detailed planning and implementation.

2. The COE must solicit advice from FWS and other natural resources professionals on options for siting of water storage areas, water treatment areas and other impoundments that minimize adverse effects to listed species during the detailed planning and implementation phases of the C&SF Restudy. Such advice must be implemented to the maximum extent possible within the basic scope of the C&SF Restudy.

3. The COE must solicit advice from FWS and other natural resources professionals on options for construction methods and schedules that maximize benefits and minimize adverse effects to listed species during the detailed planning and implementation phases of the C&SF Restudy. Such advice must be implemented to the maximum extent possible within the basic scope of the C&SF Restudy.

4. The COE must solicit advice from FWS and other natural resources professionals on options for sequencing of component implementation that maximize benefits and minimize adverse effects to listed species during the detailed planning and implementation phases of the C&SF Restudy. Such advice must be implemented to the maximum extent possible within the basic scope of the C&SF Restudy.

CONSERVATION RECOMMENDATIONS

In a February 24, 1998, letter the FWS provided the COE with an extensive list of recommendations for maximizing benefits to threatened and endangered species resulting from the C&SF Restudy in accordance with section 7(a)(1) of the ESA. This letter is incorporated herein by reference as conservation recommendations. Additional conservation recommendations are provided in the accompanying FWCAR on the C&SF Restudy.

REINITIATION - CLOSING STATEMENT

Because the proposed action is likely to have adverse effects on listed species, the FWS has included an incidental take statement pursuant to section 7(b)(4) of the ESA. However, because this is an early consultation on the initial draft plan, this incidental take statement does not eliminate the COE's liability under the taking prohibitions of section 9 of the ESA.

Instead, this statement provides your agency with foreknowledge of the terms and conditions that will be required if C&SF Restudy alternative D13R is formally submitted for Congressional authorization. These reasonable and prudent measures and implementing terms and conditions become effective only after the FWS confirms this preliminary biological opinion as a final biological opinion on the prospective action.

This concludes early consultation for actions modeled by the South Florida Water Management Model as part of C&SF Restudy alternative D13R. You may ask the FWS to confirm this preliminary biological opinion as a final biological opinion when the prospective action is ready for formal submission for Congressional authorization. The request must be in writing and the FWS is allowed 45 days from receipt of the written request to provide its response. If the FWS reviews the proposed action and finds that there are no significant changes in the action as planned or in the information used during the early consultation, it will confirm this preliminary biological opinion as a final biological opinion on the project and no further section 7 consultation will be necessary, except when one of the following criteria for Reinitiation is met: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect on listed species or critical habitat that was not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. When the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation. If the FWS does not confirm this preliminary biological opinion as a final biological opinion on the prospective action, the COE is required to reinitiate formal consultation with the FWS.

Thank you for the opportunity to comment on this project. If you have any questions, feel free to contact me at 561/778-0896.

Sincerely,

Stephen W. Forsythe
State Supervisor

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ANNEX C

PROGRAMMATIC
SECTION 404(b)(1) EVALUATION

ANNEX C

PROGRAMMATIC
SECTION 404(b)(1) EVALUATION

CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE RESTUDY

PREFACE This document is a programmatic Section 404(b)(1) Evaluation. As such it addresses, at a general level, the potential environmental effects of the wetland and aquatic ecosystem alterations expected from the construction of the structural components of the recommended comprehensive plan. Subsequent site-specific Section 404(b)(1) Evaluations will be done for individual project components, or groups thereof, in sufficient detail for final decision making and for full compliance with the Section 404(b)(1) Guidelines and National Environmental Policy Act requirements.

PROJECT DESCRIPTION

A. Location. The Central and Southern Florida (C&SF) Project area encompasses approximately 18,000 square miles from Orlando to Florida Bay with at least 11 major physiographic provinces: Everglades, Big Cypress, Lake Okeechobee, Florida Bay, Biscayne Bay, Florida Reef Tract, nearshore coastal waters, Atlantic Coastal Ridge, Florida Keys, Immokalee Rise, and the Kissimmee River Valley. The Kissimmee River, Lake Okeechobee and the Everglades are the dominant watersheds that connect a mosaic of wetlands, uplands, coastal areas, and marine areas.

B. General Description. The existing C&SF Project, which was first authorized by Congress in 1948, is a multi-purpose project that provides flood control; water supply for municipal, industrial, and agricultural uses; prevention of saltwater intrusion; water supply for Everglades National Park; and protection of fish and wildlife resources. The primary system includes about 1,000 miles each of levees and canals, 150 water control structures, and 16 major pump stations. The recommended Comprehensive Plan is the initial draft plan, alternative D-13R, along with Other Project Elements (OPEs). The plan consists of construction components, real estate requirements, a monitoring program, and operation and maintenance of the completed project. In addition, several feasibility studies are recommended to investigate additional improvements needed to support restoration, protection, and preservation of the South Florida ecosystem. A large number of components have been identified in the recommended Comprehensive

Plan. These components have been evaluated on a regional scale using the South Florida Water Management Model, an effective tool for analyzing regional hydrologic effects of the combined components. However, due to the scale of the model (four-square-mile grid cells), more site-specific analyses of components will be needed. Detailed planning and design will be necessary to determine the optimum size, depth and configuration, and management of various facilities which are proposed for construction. This will include collecting necessary physical data, finalizing performance targets, performing water quality evaluations, conducting refined modeling and pilot projects, and resolving regulatory issues. Upon resolution of outstanding issues, detailed design of the components and projects will occur. In a number of cases, water storage facilities have not been sited in the comprehensive plan, a cooperative effort with landowners in the areas where storage facilities are proposed will be used to identify suitable sites with willing sellers to the greatest degree possible.

C. Authority and Purpose. This study is authorized by Section 309(l) of the Water Resources Development Act of 1992 (P.L.102-580) which states:

> *"(1) CENTRAL AND SOUTHERN FLORIDA. -- The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as House document 643; 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation."*

This study is also authorized by two resolutions of the Committee on Public Works and Transportation, United States House of Representatives, dated September 24, 1992. The first resolution states:

> *"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes."*

The second resolution states:

"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes for Florida Bay, including a comprehensive, coordinated ecosystem study with hydrodynamic modeling of Florida Bay and its connections to the Everglades, the Gulf of Mexico, and the Florida Keys Coral Reef ecosystem."

The Water Resources Development Act of 1996 was enacted on October 12, 1996. Section 528 of the Act entitled "Everglades and South Florida Ecosystem Restoration authorizes a number of ecosystem restoration activities and also provides specific direction and guidance for the Restudy. The specific provisions of Section 528 concerning the Restudy are:

"(b) RESTORATION ACTIVITIES-

(1) COMPREHENSIVE PLAN-

(A) DEVELOPMENT-

(i) PURPOSE- The Secretary shall develop, as expeditiously as practicable, a proposed comprehensive plan for the purpose of restoring, preserving, and protecting the South Florida ecosystem. The comprehensive plan shall provide for the protection of water quality in, and the reduction of the loss of fresh water from, the Everglades. The comprehensive plan shall include such features as are necessary to provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project.

(ii) CONSIDERATIONS- The comprehensive plan shall--

(I) be developed by the Secretary in cooperation with the non-Federal project sponsor and in consultation with the Task Force; and

(II) consider the conceptual framework specified in the report entitled "Conceptual Plan for the Central and Southern Florida Project Restudy", published by the Commission and approved by the Governor.

(B) SUBMISSION- Not later than July 1, 1999, the secretary shall--

(i) complete the feasibility phase of the Central and Southern Florida Project comprehensive review study as authorized by section 309(l) of the Water Resources Development Act of 1992 (106 Stat. 4844), and by 2 resolutions of the Committee on Public Works and Transportation of the House of Representatives, dated September 24, 1992; and

(ii) submit to Congress the plan developed under subparagraph (A)(i) consisting of a feasibility report and a programmatic environmental impact statement covering the proposed Federal action set forth in the plan.

(C) ADDITIONAL STUDIES AND ANALYSES- Notwithstanding the completion of the feasibility report under subparagraph(B), the Secretary shall continue to conduct such studies and analyses as are necessary, consistent with subparagraph (A)(i).

(2) USE OF EXISTING AUTHORITY FOR UNCONSTRUCTED PROJECT FEATURES- The Secretary shall design and construct any features of the Central and Southern Florida Project that are authorized on the date of the enactment of this Act or that may be implemented in accordance with the Secretary's authority to modify an authorized project, including features authorized under sections 315 and 316, with funds that are otherwise available, if the Secretary determines that the design and construction--

(A) will accelerate the restoration, preservation, and protection of the South Florida ecosystem;

(B) will be generally consistent with the conceptual framework described in paragraph (1)(A)(ii)(II); and

(C) will be compatible with the overall authorized purposes of the Central and Southern Florida Project.

(3) CRITICAL RESTORATION PROJECTS-

(A) IN GENERAL- In addition to the activities described in paragraphs (1) and (2), if the Secretary, in cooperation with the non-Federal project sponsor and the Task Force, determines that a restoration project for the South Florida ecosystem will produce independent, immediate, and substantial restoration, preservation, and protection benefits, and will be generally consistent with the conceptual framework described in paragraph (1)(A)(ii)(II), the Secretary shall proceed expeditiously with the implementation of the restoration project.

(B) INITIATION OF PROJECTS- After September 30, 1999, no new projects may be initiated under subparagraph (A).

(C) AUTHORIZATION OF APPROPRIATIONS-

(i) IN GENERAL- There is authorized to be appropriated to the Department of the Army to pay the Federal share of the cost of carrying out projects under subparagraph (A) $75,000,000 for the period consisting of fiscal years 1997 through 1999.

(ii) FEDERAL SHARE- The Federal share of the cost of carrying out any 1 project under subparagraph (A) shall be not more than $25,000,000.

(4) GENERAL PROVISIONS-

(A) WATER QUALITY- In carrying out activities described in this subsection and sections 315 and 316, the Secretary--

(i) shall take into account the protection of water quality by considering applicable State water quality standards; and

(ii) may include in projects such features as are necessary to provide water to restore, preserve, and protect the South Florida ecosystem.

(B) COMPLIANCE WITH APPLICABLE LAW- In carrying out the activities described in this subsection and subsection (c), the Secretary shall comply with any applicable Federal law, including the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.).

(C) PUBLIC PARTICIPATION- In developing the comprehensive plan under paragraph (1) and carrying out the activities described in this subsection and subsection (c), the Secretary shall provide for public review and comment on the activities in accordance with applicable Federal law.

(c) INTEGRATION OF OTHER ACTIVITIES-

(1) IN GENERAL- In carrying out activities described in subsection (b), the Secretary shall integrate such activities with ongoing Federal and State projects and activities, including--

(A) the project for the ecosystem restoration of the Kissimmee River, Florida, authorized by section 101 of the Water Resources Development Act of 1992 (106 Stat. 4802);

(B) the project for modifications to improve water deliveries into Everglades National Park authorized by section 104 of the Everglades National Park Protection and Expansion Act of 1989 (16 U.S.C. 410r-8);

(C) activities under the Florida Keys National Marine Sanctuary and Protection Act (16 U.S.C. 1433 note; 104 Stat. 3089); and

(D) the Everglades Construction Project of the State of Florida.

(2) STATUTORY CONSTRUCTION-

(A) EXISTING AUTHORITY- Except as otherwise expressly provided in this section, nothing in this section affects any authority in effect on the date of the enactment of this Act, or any requirement of the authority, relating to participation in restoration activities in the South Florida ecosystem, including the projects and activities specified in paragraph (1), by--

(i) the Department of the Interior;

(ii) the Department of Commerce;

(iii) the Department of the Army;

(iv) the Environmental Protection Agency;

(v) the Department of Agriculture;
(vi) the State of Florida; and
(vii) the South Florida Water Management District.

(B) NEW AUTHORITY- Nothing in this section confers any new regulatory authority on any Federal or non-Federal entity that carries out any activity authorized by this section.

(d) JUSTIFICATION-

(1) IN GENERAL- Notwithstanding section 209 of the Flood Control Act of 1970 (42 U.S.C. 1962-2) or any other provision of law, in carrying out the activities to restore, preserve, and protect the South Florida ecosystem described in subsection (b), the Secretary may determine that the activities--

(A) are justified by the environmental benefits derived by the South Florida ecosystem in general and the everglades and Florida Bay in particular; and

(B) shall not need further economic justification if the Secretary determines that the activities are cost-effective.

(2) APPLICABILITY- Paragraph (1) shall not apply to any separable element intended to produce benefits that are predominantly unrelated to the restoration, preservation, and protection of the South Florida ecosystem.

(e) COST SHARING-

(1) IN GENERAL- Except as provided in sections 315 and 316 and paragraph (2), the non-Federal share of the cost of activities described in subsection (b) shall be 50 percent.

(2) WATER QUALITY FEATURES-

(A) IN GENERAL- Except as provided in subparagraph (B), the non-Federal share of the cost of project features to improve water quality described in subsection (b) shall be 100 percent.

(B) EXCEPTION-

(i) IN GENERAL- Subject to clause (ii), if the Secretary determines that a project feature to improve water quality is essential to Everglades restoration, the non-Federal share of the cost of the feature shall be 50 percent.

(ii) APPLICABILITY- Clause (I) shall not apply to any feature of the Everglades Construction Project of the State of Florida.

(3) OPERATION AND MAINTENANCE- The operation and maintenance of projects carried out under this section shall be a non-Federal responsibility.

(4) CREDIT- Regardless of the date of acquisition, the value of lands or interests in land acquired by non-Federal interests for any activity described in subsection (b) shall be included in the total cost of the activity and credited against the non-Federal share of the cost of the activity. Such value shall be determined by the Secretary."

D. General Description of Dredged or Fill Material. Many of the project components are expected to involve the discharge of dredged or fill material into wetlands or other aquatic resources. However, specific information is unknown at this time. The (1) **general characteristics**, (2) **quantities**, and (3) **sources** of dredged or fill material will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

E. Description of the Proposed Discharge Site. The (1) **locations** of many of the components are unknown at this time and therefore the associated discharge sites can not be described herein. The estimated cumulative (2) **size** of water storage areas and stormwater treatment areas in the recommended Comprehensive Plan is approximately 216,800 acres. This is not an estimate of the total wetland and aquatic area to be filled; rather it is the estimated acreage of the land needed for these components. Notwithstanding the current uncertainty regarding component locations, an analysis was conducted to determine the approximate extent of wetlands that could be encountered. Estimates of the wetland acreage to be affected by each of the water storage and treatment areas were made. For the known sites, the acreage estimates were based on available information, such as existing studies, aerial photography and other physiographic data. For those sites where only the conceptual location is known, estimates were made of the percent of wetland area expected to be encountered in the region. The total area of wetlands and that could be affected by these types of components is conservatively estimated to be approximately 34,000 acres. In addition to the estimates of wetland acreage that could be affected, habitat quality estimates were made for both the existing and with plan conditions. These habitat quality estimates were made using a scale of zero to one, with 0.0 representing very poor habitat quality and 1.0 representing optimum habitat quality. For the existing condition estimates, habitat quality was based on available data for project features with known locations and best professional judgement was used for project features with conceptual locations. To estimate the habitat quality for the with-project condition, operational details of the feature are needed. For example, the hydrologic operation and vegetative management of the Water Preserve Areas will dictate the effect on habitat quality as either beneficial or detrimental. Again, a conservative approach was taken and all features were assumed to produce an adverse impact. The total estimate of the potential adverse impacts of the Recommended Comprehensive Plan is a loss of approximately 10,000 “wetland habitat units”. These units were derived by multiplying the estimated area of affected wetlands by the difference between the existing and with plan habitat quality estimates. The (3) **types of sites**, (4) **types of habitats**, and (5) **timing and duration of the discharges** for many of the components are also unknown at this time. The pertinent information will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

F. Description of Disposal Method. Specific information is unknown at this time. The disposal method(s) for dredged or fill material will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

FACTUAL DETERMINATION

A. Physical Substrate Determination. Specific information is unknown at this time. The (1) **substrate elevation and slope**, (2) **sediment type**, (3) **dredge/fill material movement**, and (4) **physical effects on benthos** at the disposal sites for dredged or fill material will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

B. Water Circulation, Fluctuation and Salinity Determination. Specific information is unknown at this time. The (1) **water column effects**, (2) **current patterns and circulation**, and (3) **normal water level fluctuations and salinity gradients** at the disposal sites for dredged or fill material will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

C. Suspended Particulate/Turbidity Determinations.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site. Although site-specific information is unknown at this time, temporary increases in suspended particulates and turbidity levels can be expected during the construction of some of the components. All appropriate measures to reduce and contain turbidity will be employed so State Water Quality Standards will not be violated.

(2) Effects on the Chemical and Physical Properties of the Water Column. Specific information is unknown at this time. Effects on (1) **light penetration** (2) **dissolved oxygen**, (3) **toxic metals, organics, and pathogens** and (4) **aesthetics** of the water column will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

(3) Effects on Biota. Specific information is unknown at this time. Effects on (1) **primary productivity and photosynthesis**, (2**) suspension/filter feeders**, and (3) **sight feeders** will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

D. Contaminant Determinations. Specific information is unknown at this time. The presence of contaminants will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

E. Aquatic Ecosystem and Organism Determinations.

(1) Endangered and Threatened Species. It is the Biological Opinion of the U.S. fish and Wildlife Service that implementation of this project will either benefit, or not adversely affect, the continued existence of any endangered and/or threatened species which occur in the project area (see Annex B).

(2) Hardbottom Habitat. Currently, there are no project components proposed in marine ecosystems with known hardbottom habitat.

F. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination. Specific information is unknown at this time. The mixing zone will be determined during planning and design activities for each component. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

(2) Determination of Compliance with Applicable Water Quality Standards. Although specific information is unknown at this time, the construction and operation of the project components will comply with State water quality standards.

(3) Potential Effects on Human Use Characteristics.

(a) Municipal and Private Water Supplies. In addition to the primary goal of restoring the greater Everglades ecosystem, the project includes components that will improve urban and agricultural water supplies.

(b) Recreational and Commercial Fisheries. The project will benefit recreational and commercial fisheries.

(c) Water Related Recreation. Although specific information is unknown at this time, water related recreation may be reduced by some components and improved by others. Accordingly, this information will be addressed in subsequent Section 404(b)(1) Evaluations.

(**d)** **Aesthetics**. Although specific information is unknown at this time, it is expected that the components will be in keeping with general characteristics of the area.

(e) Parks, **National and Historic Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves.** The project will enhance environmental conditions at these types of sites within the project area.

G. **Determination of Cumulative Effects on the Aquatic Ecosystem.** The restoration of hydrology to the greater Everglades ecosystem and the increase in spatial extent of protected wetland acreage in the study area will produce extensive cumulative beneficial effects. These beneficial effects are expected to substantially outweigh the cumulative adverse effects produced by the aquatic ecosystem alterations that may be necessary to construct some of the project components.

3. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. No practicable alternative exists which meets the study objectives that does not involve discharge of fill into waters of the United States.

c. The discharges of fill materials will not cause or contribute to, after consideration of disposal site dilution and dispersion, violations of any applicable State water quality standards for Class III waters. The discharge operations will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. The placement of fill materials in the project area will not jeopardize the continued existence of any species listed as threatened or endangered or result in the likelihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended (See Annex B).

e. The placement of fill materials will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values will not occur.

f. Subsequent application of the Section 404(b) (1) Guidelines during planning and design activities for each component of the recommended Comprehensive Plan will ensure that the proposed disposal sites for the discharge of dredged material will comply with the requirements of these Guidelines.

ANNEX D

PROGRAMMATIC
FLORIDA COASTAL ZONE MANAGEMENT PROGRAM
FEDERAL CONSISTENCY EVALUATION PROCEDURES

ANNEX D

PROGRAMMATIC
FLORIDA COASTAL ZONE MANAGEMENT PROGRAM
FEDERAL CONSISTENCY EVALUATION PROCEDURES

CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE RESTUDY

PREFACE: This document is a programmatic evaluation of the overall project's consistency with the Florida Coastal Zone Management Program. As such it addresses, at a general level, the potential environmental effects expected from implementation of the recommended Comprehensive Plan. Subsequent site-specific evaluations will be done for individual project components, or groups thereof, in sufficient detail for final decision making and for full compliance with the Florida Coastal Zone Program and National Environmental Policy Act requirements.

1. Chapter 161, Beach and Shore Preservation.

The intent of the coastal construction permit program established by this chapter is to regulate construction projects located seaward of the line of mean high water and which might have an effect on natural shoreline processes.

Response: No work is proposed seaward of the line of mean high water in beach areas. The Florida Keys Tidal Restoration project included in the recommended Comprehensive Plan involves retrofitting several areas of the Overseas Highway (U.S. Highway 1) in the Florida Keys. This project will have beneficial effects on natural shoreline processes.

2. Chapters 186 and 187, State and Regional Planning.

These chapters establish the State Comprehensive Plan which sets goals that articulate a strategic vision of the State's future. It's purpose is to define in a broad sense, goals and policies that provide decision-makers directions for the future and provide long-range guidance for an orderly social, economic and physical growth.

Response: The proposed project will achieve the goals of this chapter by developing a long range master plan for South Florida's water resources which, will support the continued orderly social, economic and physical growth of the region.

3. Chapter 252, Disaster Preparation, Response and Mitigation.

This chapter creates a state emergency management agency, with the authority to provide for the common defense; to protect the public peace, health and safety; and to preserve the lives and property of the people of Florida.

Response: This statute is not applicable to this project.

4. Chapter 253, State Lands.

This chapter governs the management of submerged state lands and resources within state lands. This includes archeological and historical resources; water resources; fish and wildlife resources; beaches and dunes; submerged grass beds and other benthic communities; swamps, marshes and other wetlands; mineral resources; unique natural features; spoil islands; and artificial reefs.

Response: The proposed project contributes positively to the preservation of cultural, water, fish and wildlife, wetland and estuarine resources. The Everglades is a unique natural resource.

5. Chapters 253, 259, 260, and 375, Land Acquisition.

This chapter authorizes the state to acquire land to protect environmentally sensitive areas.

Response: The project has many components that require the acquisition of many types of land by the State. No encumbrance of the State's rights under this chapter is established under this project.

6. Chapter 258, State Parks and Aquatic Preserves.

This chapter authorizes the state to manage state parks and preserves. Consistency with this statute would include consideration of projects that would directly or indirectly adversely impact park property, natural resources, park programs, management or operations.

Response: The project will enhance environmental conditions at State parks or aquatic preserves within the project area.

7. Chapter 267, Historic Preservation.

This chapter establishes the procedures for implementing the Florida Historic Resources Act responsibilities.

Response: This project has been coordinated with the State Historic Preservation Officer (SHPO). Historic preservation compliance will be completed to meet all responsibilities under Chapter 267.

8. Chapter 288, Economic Development and Tourism.

This chapter directs the state to provide guidance and promotion of beneficial development through encouraging economic diversification and promoting tourism.

Response: The proposed project will achieve the goals of this chapter by developing a long range master plan for South Florida's water resources which, will support economic diversification and tourism.

9. Chapters 334 and 339, Public Transportation.

This chapter authorizes the planning and development of a safe, balanced and efficient transportation system.

Response: The proposed project will not adversely impact the existing public transportation systems in the long-term. Proposed modifications to existing major transportation infrastructure will include temporary bypasses during construction.

10. Chapter 370, Saltwater Living Resources.

This chapter directs the state to preserve, manage and protect the marine, crustacean, shell and anadromous fishery resources in state waters; to protect and enhance the marine and estuarine environment; to regulate fisherman and vessels of the state engaged in the taking of such resources within or without state waters; to issue licenses for the taking and processing products of fisheries; to secure and maintain statistical records of the catch of each such species; and, to conduct scientific, economic, and other studies and research.

Response: In addition to the primary goal of restoring the greater Everglades ecosystem, the project includes components expressly designed to improve ecological conditions in the downstream estuaries.

11. Chapter 372, Living Land and Freshwater Resources.

This chapter establishes the Game and Freshwater Fish Commission and directs it to manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions that provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits.

Response: The project has been coordinated with the U.S. Fish and Wildlife Service for compliance with Section 7 of the Endangered Species Act. No threatened or endangered species will be adversely affected. The proposed action will not adversely impact any resource under the management of the Game and Freshwater Fish Commission.

12. Chapter 373, Water Resources.

This chapter provides the authority to regulate the withdrawal, diversion, storage, and consumption of water.

Response: The project sponsor is the South Florida Water Management District, the State agency responsible for implementing this statute in the project area. Coordinated planning has been done with this agency to ensure compatibility with established policies.

13. Chapter 376, Pollutant Spill Prevention and Control.

This chapter regulates the transfer, storage, and transportation of pollutants and the cleanup of pollutant discharges.

Response: This project does not involve the transportation or discharging of pollutants. Environmental protection measures will be enforced during construction to avoid inadvertent spills or other sources of pollution.

14. Chapter 377, Oil and Gas Exploration and Production.

This chapter authorizes the regulation of all phases of exploration, drilling, and production of oil, gas, and other petroleum products.

Response: This project does not involve the exploration, drilling or production of gas, oil or petroleum products.

15. Chapter 380, Environmental Land and Water Management.

This chapter establishes criteria and procedures to assure that local land development decisions consider the regional impact nature of proposed large-scale development.

Response: The proposed project will achieve the goals of this chapter by developing a long range master plan for South Florida's water resources which, will support the continued orderly social, economic and physical growth of the region.

16. Chapter 388, Arthropod Control.

This chapter provides for a comprehensive approach for abatement or suppression of mosquitoes and other pest arthropods within the state.

Response: The project will not further the propagation of mosquitoes or other pest arthropods, and will foster high populations of insectivorous fishes.

17. Chapter 403, Environmental Control.

This chapter authorizes the regulation of pollution of the air and waters of the state of the Florida.

Response: An environmental assessment of project impacts has been prepared and will be reviewed by the appropriate resource agencies including the Department of Environmental Protection.

18. Chapter 582, Soil and Water Conservation.

This chapter establishes policy for the conservation of the state soil and water through the Department of Agriculture and Consumer Services. Land use policies will be evaluated in terms of their tendency to cause or contribute to soil erosion or to conserve, develop, and utilize soil and water resources both onsite or in adjoining properties affected by the project. Particular attention will be given to projects on or near agricultural lands.

Response: The proposed project is expected to impact agricultural land. The exact extent of agricultural land to be affected is unknown at this time. The project has been coordinated under the Farmland Protection Policy Act with the U.S. Department of Agriculture, Natural Resources Conservation Service. Project implementation will include appropriate erosion control plans and measures to ensure compliance.

APPENDIX A

PLAN FORMULATION

APPENDIX A
PLAN FORMULATION

This Appendix is a compilation of plan formulation documents. Below is a brief summary of each of these documents.

A1 PLAN FORMULATION DOCUMENT

The Plan Formulation Document was prepared during the component screening phase of the study. The document presents a range of components (ideas) that were screened during the initial phases of plan formulation. In the preliminary screening phase, information gained through a cost effectiveness analysis (Appendix A2) was joined with information from hydrologic modeling and information gained through previous studies to support best professional judgement in the selection of specific project components. This screening phase aimed to identify which components (from the initial list of potential project components) would be carried forward in the development of alternative comprehensive plans.

A2 COST EFFECTIVENESS SCREENING ANALYSIS

The Restudy Team used a cost effectiveness analysis as a tool in the preliminary screening phase. The results of this analysis are presented in this Appendix.

A3 SUMMARY DESCRIPTION OF ALTERNATIVES A-D

The Restudy Team evaluated a number of Alternatives. The description of the final array of alternatives is presented in the Appendix.

A4 DESCRIPTION OF ALTERNATIVE D13-R

Alternative D13-R is the plan selected by the Restudy Team as the Initial Draft Plan. This plan is comprised of forty-nine operational and structural features that the are referred to as components. Together, these forty-nine components make the Initial Draft Plan that addresses many of the water resources problems of south Florida. This Section of the Plan Formulation Appendix includes a description of each of the components that make up the Initial Draft Plan. At the end of this Section is a series of figures and maps to aid the reader in understanding the conceptual features of the Initial Draft Plan. However, not all components have been mapped due to uncertainty in site location.

A5 CRITICAL PROJECTS

Section 528 of the Water Resources Development Act (WRDA) of 1996 authorizes the Secretary of the Army to expeditiously implement restoration projects that are deemed critical to the restoration of the south Florida ecosystem. These projects are referred to as Critical Projects. This authority allows the Corps of Engineers to implement projects that are needed for restoration in advance of completion of the Comprehensive Plan. Thirty-five candidate Critical Projects were identified and prioritized by the Working Group of the South Florida Ecosystem Restoration Task Force through a process that utilized input from the Governor's Commission for a Sustainable South, project proponents, and the public. However, the cumulative cost estimate for all 35 candidate Critical Projects exceeds the current legislatively mandated funding limit. Therefore, it is anticipated that only the top priority candidates will be implemented under this authority. The Restudy addresses all of the Critical Projects nominated by the Working Group to ensure they will be implemented. This appendix briefly explains the Critical Project program, provides narrative summaries of each project and its expected benefits, and explains how each project is addressed in the Restudy.

A6 DESCRIPTION OF OTHER PROJECT ELEMENTS

The recommended comprehensive plan is comprised of the Initial Draft Plan (Alternative D-13R) and a select group of components that could not be evaluated during the iterative alternative plan formulation process. This group of components has been termed Other Project Elements (OPEs). An initial list of potential OPEs was developed by the Restudy Team from the Critical Projects list; the Governor's Commission Conceptual Plan, the Restudy Plan Formulation document, and nominations Restudy Team members. The list was screened against certain criteria and an interdisciplinary team evaluated the remaining OPEs. This Appendix describes the OPE screening and evaluation processes, the resulting conclusions, and the OPEs themselves.

APPENDIX A1

PLAN FORMULATION DOCUMENT

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APPENDIX A1
PLAN FORMULATION DOCUMENT

A1.1 INTRODUCTION

Plan formulation is an iterative planning process that identifies alternative plans to achieve a set of planning objectives and allows those plans to be modified as more information becomes available. Each iteration of this process provides an opportunity to refine and sharpen the planning focus. The reconnaissance phase of the Comprehensive Review Study (Restudy) and the South Florida Water Management District's Lower East Coast Regional Water Supply Planning process provides a foundation from which to begin reducing and refining the many ideas that have been proposed to a manageable set of ideas that deserve further evaluation during the ensuing feasibility study. This feasibility study will culminate in the selection of a Comprehensive Plan for the C&SF Project.

In February 1996, the Restudy Team began considering a vast array of ideas (components or options) that could be included in a comprehensive plan. These components were generated from a number of sources including the Restudy reconnaissance report and the Lower East Coast Regional Water Supply planning documents. The components were then used by the Governor's Commission for a Sustainable South Florida (GCSSF) to create their *Conceptual Plan for the Restudy*. This Conceptual Plan contains 13 Thematic Concepts that will be used during the Restudy as an organizing framework for developing and evaluating alternative components and generating the comprehensive plan that will be recommended to Congress by July 1999.

The 13 Thematic Concepts include:

1. Regional Storage Within the Everglades Headwaters and Adjacent Areas
2. Lake Okeechobee Operational Plan
3. Everglades Agricultural Area Storage
4. Water Preserve Areas
5. Natural Areas Continuity
6. Water Supply and Flood Protection for Urban and Agricultural Areas
7. Adequate Water Quality for Ecosystem Functioning
8. Spatial Extent and Quality of Other Wetlands
9. Invasive Plant Control
10. Aquifer Storage and Recovery
11. Protection and Restoration of Coastal, Estuarine, and Marine Ecosystems
12. Conservation of Soil
13. Operation and Management of the C&SF Project and Related Lands

The purpose of this paper is to present a refined set of alternative components to be considered and evaluated during the feasibility phase of the Restudy. This paper guides the reader from problem identification, development of goals and objectives, and the development of components through an initial screening of alternative ideas. After the initial screening of these components, alternative plans will be created and evaluated -- after which the final comprehensive plan will be selected and documented in a draft Feasibility Report and integrated Programmatic Environmental Impact Statement.

A1.2 PROBLEM IDENTIFICATION

The south Florida ecosystem encompasses more than 18,000 square miles from Orlando to Florida Bay and the Keys. Historically, the area sustained a mosaic of ecologic communities ranging from the uplands of the coastal ridge to the marshes of the Everglades to the near shore coastal waters of the Atlantic Ocean, Florida Bay, and the Gulf of Mexico. This complex system of inter-related communities was supported by distinct hydrologic characteristics.

Rain that fell on the northern reaches of this vast system collected in the lakes north of the Kissimmee River. This water would flow slowly south through meandering rivers and sheetflow through the prairies and floodplains to Lake Okeechobee. In its natural state, Lake Okeechobee was much larger and had no well-defined outlets. During the extremely wet years, Lake Okeechobee would over-top its southern rim, which was lined with huge pond-apple trees, where it would become the River of Grass and its water would mingle with the tremendous amount of standing rain water. The River of Grass, defined by the expansive spatial scale and dynamic patterns of storage and sheetflow, formed south of Lake Okeechobee, flowed slowly southward and escaped eastward through a few small rivers which flowed through the east-coast barrier ridge, or passed eventually to Florida Bay through marshes and tangled mangrove thickets. The dynamic hydrologic patterns combined with the mosaic of landscapes throughout the region organized and concentrated a sufficient biomass to support abundant animal populations, established relatively low salinity gradients in the estuaries, and created an extensive network of dry-season refugia for many species.

With the expansion of human activity within south Florida, the aerial expanse of the natural system has become significantly reduced and much of the remaining natural system has degraded. Drainage of the wetland systems within south Florida and the development of uplands have resulted in significant loss of natural values and brings into question whether south Florida can sustain continued social and economic growth. The Governor’s Commission for a Sustainable South Florida in their October 1995 *Initial Report* stated that “south Florida is not sustainable on its present course.”

To this end, the C&SF Project Comprehensive Review Study provides an opportunity to investigate and recommend short- and long-term solutions to address the system's hydrologic problems. Solutions to these hydrologic problems are not a panacea for all the problems hindering sustainability of the region. Other social, cultural, and economic issues must be resolved also.

The altered hydrologic characteristics of the region are now apportioned among often competing sub-regions. These sub-regions include: Kissimmee River Valley; Upper East Coast, consisting of Martin and St. Lucie Counties; Caloosahatchee River and estuary; Lake Okeechobee; Everglades Agricultural Area; Lower East Coast urban area (coastal metropolitan and agricultural areas of North Palm Beach, Palm Beach, Broward, Miami-Dade, and Southern Miami-Dade Counties); Holey Land Wildlife Management Area; Rotenberger Wildlife Management Area; Water Conservation Areas 1, 2A, 2B, 3A, and 3B; Big Cypress National Preserve; Everglades National Park; and coastal areas of Florida Bay, Biscayne Bay, Florida Keys and the Florida Reef Tract.

A1.3 HISTORIC AND PRESENT OBJECTIVES OF THE C&SF PROJECT

In the late 1800s and early 1900s, draining the Everglades was clearly the objective of the people of Florida. South Florida had tremendous natural resources that were subject to long periods of inundation, and the people of south Florida wanted to harness these resources in order to realize their economic potential. As a result, major drainage projects sponsored by the State of Florida were initiated in the late 1800s and continued into the 1920s. There were problems associated with many of these projects and following a series of hurricanes and significant loss of life, the State of Florida initiated a partnership with the Federal government, through the Corps of Engineers, to address the flooding and the other problems created by these drainage projects.

As this partnership embarked to control the hydrologic conditions that were hampering economic development, the project planners recognized a need to strike a balance among competing economic needs. However, the emphasis on economic goals clearly focused the design of the C&SF Project towards the economic development of the region with little understanding of the consequences for the natural system.

In 1948, a comprehensive plan was presented in a report to Congress to meet a set of objectives to promote economic development of the region. These objectives included: reducing flood damages and enhancing land use throughout the region; controlling ground water levels for healthy agriculture; storing excess flood-water for beneficial use; reducing salt water intrusion into coastal wellfields; preserving fish and wildlife; enhancing navigation through a cross-Florida waterway; and providing recreational opportunities. While the project has met and surpassed many of these objectives, it has also had unintended adverse environmental consequences. It is these consequences that have driven the need for the Restudy.

Table 1
HISTORICAL C&SF PROJECT OBJECTIVES (PURPOSES)

•Reduce flood damages and enhance land use throughout the region
•Control ground water levels for agriculture
•Store excess flood-water for beneficial use
•Reduce salt water intrusion into coastal wellfields
•Preserve fish and wildlife
•Enhance navigation
•Provide recreational opportunities

To meet these historical project objectives, the C&SF Project converted a significant portion of the natural system to other uses. The Kissimmee River was channelized. Lake Okeechobee was diked to prevent uncontrolled discharges from the lake. The Everglades Agricultural Area was drained and ground water levels managed to reduce flood damages. The flooding risk was also reduced in the Lower East Coast to allow for urban and suburban development and intensified agriculture. Central portions of the Everglades were diked to create areas in which water could be stored for human needs in the Lower East Coast and for deliveries to Everglades National Park. While some fish and wildlife value was expected to remain in the Water Conservation Areas, the only natural area intended to be preserved in pristine condition was Everglades National Park.

A1.4 RESTUDY GOALS AND OBJECTIVES

The purpose of the Restudy is to review how well the C&SF Project is functioning and determine what modifications may be needed to achieve a new set of objectives. The precursor to the feasibility phase of the study -- the reconnaissance study -- identified a set of regional-scale planning objectives. The Governor's Commission for a Sustainable South Florida also developed a set of regional-scale objectives for the Restudy. A synthesis of these has resulted in an inclusive set of objectives to achieve two general goals for south Florida's ecosystem: enhance ecologic values and enhance economic values and social well being.

Table 2
GOALS AND OBJECTIVES FOR THE C&SF RESTUDY

Goal: Enhance Ecologic Values
• Increase the total spatial extent of natural areas • Improve habitat and functional quality • Improve native plant and animal species abundance and diversity
Goal: Enhance Economic Values And Social Well Being
• Increase availability of fresh water (agricultural/municipal & industrial) • Reduce flood damages (agricultural/urban) • Provide recreational and navigation opportunities • Protect cultural and archeological resources and values

The Restudy planning objectives were developed as the result of public participation and scientific knowledge of south Florida. Through workshops conducted during the reconnaissance phase of the Restudy and subsequent technical evaluations, it is evident that the C&SF Project must continue to provide valuable services to developed areas as originally intended. Therefore, many of the economic and social objectives are similar to those of the original C&SF Project. However, unlike the original set of objectives for the C&SF Project, the Restudy includes objectives that recognize the importance of the natural system in achieving sustainability of the region.

A1.4.1 ENHANCE ECOLOGIC VALUES

Healthy natural systems are integral to the sustainability of south Florida. These systems provide numerous functions, such as plant and animal habitat, recreation and educational opportunities (photography, fishing, hunting, bird watching, etc.), water quality filtration including removal of nutrients and silt, ground water recharge, soil formation, hydrologic linkages, ground water quality protection, interception of airborne pollutants, shoreline stabilization, and protection against erosion. Wetlands, in particular, retard floodwater and provide surface water storage. Mangroves and estuarine areas provide critical breeding habitat for finfish and shellfish, including several of commercial interest. Upland natural systems function as noise buffers, urban green space, habitat for plants and animals (such as tree snails, deer, hundreds of species of birds, and the endangered panther and indigo snake), and travel corridors for these same animals. Thus, plant and animal habitat, although perhaps the most obvious benefit or function, is just one of many functions that natural systems provide. Collectively, these systems benefit the natural ecology and support agricultural, urban, and other human interests as well.

Two recent documents are particularly important in framing the Restudy's goal for enhancing *ecological* values. These documents, which were prepared by many of the leading experts on Everglades ecology, are *The Science Sub-Group Report, Federal Objectives for the South Florida Restoration* (Science Sub-Group, 1993), and *Everglades, the Ecosystem and Its Restoration* (Davis and Ogden, 1994). Another earlier publication, *Ecosystems of Florida* (Myers and Ewel, 1990) also contributed substantial input into the Restudy.

A1.4.1.3 Spatial Extent

Scientists have identified the large spatial extent of the south Florida wetlands as one of the defining physical characteristics of the pre-drainage ecosystem. The size of the south Florida wetlands, in combination with the complex mosaic of habitats, enabled multiple populations of plants and animals to persist over time. The size of the pre-drainage area made it possible for the natural ecosystem to: 1) support genetically viable numbers and sub-populations of species with large feeding ranges and/or narrow habitat requirements; 2) provide the aquatic production to support large numbers of higher vertebrate animals in a naturally nutrient-poor environment; and 3) sustain habitat diversity despite natural disturbances. The ability of populations to recover from disturbances decreases as the available habitat area decreases since habitat diversity, the amount of seasonal refugia, and the number of dispersal options also decrease.

Roughly 50 percent of the pre-drainage wetland area and 90 percent of pinelands have been lost to development. The resulting loss of these natural areas has caused wading bird, snail kite, and panther populations, for example, to be stressed. Assuring adequate spatial extent for natural systems, necessary to support the mosaic of habitats characteristic of the pre-drainage ecosystem, will provide for genetically viable numbers and populations of native species and habitat diversity.

The health of south Florida's ecosystem, and particularly the Everglades, is of important concern to the public. Most people recognize that the spatial extent of the ecosystem has been reduced in the wake of human development. Many people have also stated that they do not believe that the "natural" area of the ecosystem should be enlarged at the expense of communities, jobs, and businesses.

A1.4.1.4 Habitat and Functional Quality

The public has noted the adverse changes in natural habitats, such as sawgrass, mangroves, sea grass beds, and other native wetland habitats, as well as in many native fish and wildlife species, such as wading birds, alligators, shrimp, and lobsters, that depend on the native habitats for survival. The adverse effects of invasive non-native species, such as melaleuca, Brazilian pepper and Australian pine, are also of concern to many. The specific functions that a wetland or upland performs are closely associated with its condition or quality. A reduction in the quality of these areas results in the loss of many or all of the functions that these areas historically performed. Improving the functional quality of the remaining natural areas is important to system-wide restoration given the loss of spatial extent and, thus, function of the historic wetlands and uplands.

South Florida natural habitats have been physically and hydrologically altered and manipulated. Consequently, the south Florida ecosystem is now substantially less productive and diverse than the historic system. For example, although many of the historic short hydroperiod wetlands no longer exist, wetlands that were historically much wetter now have short hydroperiods. Another example is the alteration of wetlands in the Water Conservation Areas. These areas are managed as separate entities that are hydrologically different from historic conditions resulting in changed hydropatterns and quality of the wetlands. Aquatic productivity has been reduced or highly altered throughout the marshes of the central Everglades and the estuaries. Additionally, changes within interior and coastal wetlands have adversely influenced downstream commercial fish and other species in coastal ecosystems such as Florida Bay.

Invasive plant and animal species have also impacted the quality of the south Florida landscape. Invasive species include both native (i.e. cattails) and non-native species (e.g. melaleuca, Brazilian pepper, and Australian pine). The increasing dominance of any community by a single species ultimately reduces the habitat variability necessary to sustain a healthy community of both plants and animals. Water management has encouraged the spread of these invasive species by creating conditions under which they can out-compete the native habitat that existed under pre-drainage conditions. For example, high phosphorus loads and increased hydroperiods have contributed to cattails out-competing sawgrass; altered hydrologic regimes have increased the spread of melaleuca and Brazilian pepper; and the construction of levees has contributed to the spread of Australian pine and Brazilian pepper. Eliminating the invasive and exotic species and the conditions that favor these species will contribute to restoration of native plants and animal species and a more natural ecosystem hydrology and function.

A1.4.1.5 Species Abundance and Diversity

The changes that have taken place in the natural system have led to decreases in native animal and plant populations. One of the most obvious indicators that the Everglades has experienced an ecologically significant reduction in productivity is the decline in wading bird populations. Several species are now so reduced in numbers that their long-term existence is jeopardized unless measures are taken to ensure their sustainability. Other species have a naturally restricted range; these species are also vulnerable to extinction if their specialized habitats are altered. In addition to considering these species, it is important to recognize that maintaining balanced communities of the more abundant species is also essential to a sustainable ecosystem. It is also important to recognize that a balanced community is dynamic; population levels fluctuate widely from year to year as natural conditions fluctuate. Unnaturally small, isolated populations can be quickly extinguished by natural conditions.

Increasing spatial extent and improving habitat quality can provide a base for improving species abundance and diversity. However, compartmentalization caused by construction of physical barriers such as canals, levees, and roads, or even hydrologic barriers (such as the Water Conservation Areas) has fragmented the system by creating a series of poorly connected natural areas. These barriers have restricted the movement of many fish and consequently reduced their range. Fragmented communities are more likely to lose species because the number of individuals in each fragment may be too small to persist. The smaller the fragment, the higher is the likelihood of losing species, or favoring an imbalance in the species that do inhabit the areas. Moreover, fragmentation itself alters the landscape by breaking connections between the various habitat types that were distributed historically across the landscape. Therefore, improving the connectivity of habitats will improve the range of many animals and their prey-base and provide for a more natural balance of species within the system.

Many people have expressed concern about the ability of the south Florida ecosystem to maintain healthy populations of endangered species, including the Florida panther, the tree cactus, the manatee, the wood stork, and the snail kite, to name just a few. There is ample scientific evidence to support such concern; over 65 species in Florida have been listed as endangered or threatened under the Endangered Species Act of 1973, as amended. The State has also identified an additional 50 species of special concern (e.g. little blue heron, snowy egret). In addition to public and scientific concern, the Act directs Federal agencies to carry out programs to conserve endangered and threatened species, in consultation with the Secretary of the Interior (or the Secretary of Commerce in appropriate situations), and to protect the habitat of such species.

A1.4.2 ENHANCE ECONOMIC VALUES AND SOCIAL WELL BEING

The C&SF Project provides economic benefits through regional water supply, flood damage reduction, navigation, and recreation. While most people recognize the need for a healthy ecosystem to support the region's economy and jobs, there are others who are concerned that potential restoration projects will displace farms and other businesses, limit development, and reduce job opportunities. By contrast, continued degradation of the south Florida environment will inevitably adversely affect the tourism and recreational industry that are important to the regional economy.

Many people recognize the beneficial services provided by the C&SF Project. Public concerns about water supply and flood control generally center on preservation of the existing protection from relatively frequent flooding, and delivering water for aquifer recharge, as provided by the C&SF Project.

A1.4.2.3 Water Supply

Public comment and technical analysis both support the need for additional water supply for south Florida. Drainage has reduced the available water supply by sending stormwater to tide, while agricultural and urban development has greatly increased water demand. The 1990 base case developed by South Florida Water Management District planning studies indicates a limited number of water supply shortfalls. If no further action is taken, by the year 2010, the supply shortages will be quite severe and unacceptable to the public.

Drainage, water supply, and flood protection afforded by the C&SF Project have provided for the growth of south Florida's population, which by 1990 was 5.2 million. Local governments in south Florida are predicting that total population will reach 8 million by the year 2010 and will range from 12-15 million people by the year 2050. Approximately 88 percent of the region's current population are concentrated in the coastal urban counties of Miami-Dade, Broward, Palm Beach, Lee, and Collier; this distribution pattern is projected to continue. Urban water supply demands could increase from approximately 1 billion gallons of water per day (BGD) today to 3 BGD by 2050. The growing demand for dependable water for agriculture, industry, and a burgeoning population at a reasonable cost could rapidly exceed the limits of readily accessible sources. If the needs of the region's natural systems are factored in, conflicts for water among users will become even more severe.

In the study area, surficial aquifers supply the majority of water for urban use. These aquifers are vulnerable to salinity intrusion. In the Lower East Coast area, salinity intrusion has resulted from two major events. The first is the lowering of the ground water table in the area due to drainage and reduced recharge as well as the increased withdrawal of water by pumping. The second reason, which has had a more direct impact, is the construction of numerous drainage and navigation canals from inland areas to the coastal waters.

In order to prevent saltwater from entering the local surficial aquifer and contaminating nearby well fields, the water table in coastal areas should be maintained at the level needed to prevent the fresh and saltwater boundary from moving inland. Existing criteria to protect against saltwater intrusion requires maintenance of a one-foot mound of fresh water between the withdrawal point and the saline interface. This is accomplished by maintaining canal levels high enough so that the hydraulic interconnection of the canals and the aquifer maintains a fresh water gradient that is adequate to prevent intrusion of saltwater into the fresh surficial aquifer.

A1.4.2.4 Flood Protection

The C&SF Project was conceived and authorized to provide regional flood protection for all of central and south Florida. The system of canals, levees, water control structures and pump stations conveys and confines flood waters to regional storage facilities, such as Lake Okeechobee and the Water Conservation Areas, or to tidal receiving waters. Further, additional protection is afforded by the local systems operated by special districts, private property owners, and local governments. Public concerns about flood control generally center on preservation of existing flood protection provided by the C&SF Project and increased flood protection in specific areas of need.

The existing investment in flood protection infrastructure was never intended to totally eliminate flooding in developed areas and flooding does occur periodically. In addition, natural areas have also suffered damage as a result of operating the flood control system to benefit the developed areas. Florida's high vulnerability to flooding demands responses to protect the public health, safety, and welfare, the social and economic impacts of which can be staggering.

Flood protection needs have increased since the original flood control project was constructed. As agricultural and urban development continues, the volume, duration, and frequency of floodwaters may increase; the actual level of flood protection may have declined in some areas. There is an opportunity to further reduce the extent of damages from flooding through operational and structural changes to the C&SF Project.

A1.4.2.5 Recreation and Navigation

Public use has been an important consideration of the C&SF Project since it was first developed. The C&SF Project provides opportunities for a wide range of outdoor activities, including: fresh water and estuarine fishing, boating, hunting, camping, picnicking, nature watching, and photography. It also provides the public with access to areas where they can simply "get away from it all." The opportunity to pursue these activities is very important to the economy of south Florida and to the people who make use of these opportunities, including residents, visitors, eco-tourists, and the Native American Tribes. Restoration and protection of the remaining Everglades system, the Keys, south Florida estuaries (including Florida Bay), and reef tracts are essential to the economic base provided by these recreational and traditional uses.

A1.4.2.6 Social and Cultural

The developers of the C&SF Project recognized that a comprehensive plan could not be a panacea for all problems inherent in the development of the region. Management of local and regional growth issues, including changes in population and development, is the responsibility of state, county, city, and other local interests. Although, in this study, alternative plans will not be formulated to address public concerns about growth, the possible effects of alternative restoration plans on population, development, and other growth issues must be evaluated and displayed in the assessment of restoration plans' effects.

Societal sustainability requires the preservation of the rich cultural diversity of the region, such as the Native American communities and the multi-generational culture of the agricultural communities. The rapidly growing population of south Florida is decreasingly dependent directly on the environment for its sustenance, with the exception of water needs. Yet that population is increasingly dependent indirectly on a restored and sustainable environment, such as for support for the economic base of tourism as well as the heightened awareness of the environmental ethic to preserve and sustain this unique natural environment for the future generations to experience and value.

A1.5 PLAN FORMULATION STRATEGY

Alternative plans must be formulated for the Restudy such that they can be evaluated to reveal important effects, including effects that reflect progress toward meeting the objectives, as well as effects that are of interest for other reasons. Usually, plans are developed based on a particular strategy. A strategy defines the approach to a problem in terms of the means and the results that are sought. It is a process of translating the objectives to means to achieve them.

Numerous studies support the theory that the remaining natural system can be changed in the direction of its pre-drainage wetland character through modifications to the hydrologic features. The issue that remains is how to accomplish the ecologic restoration objectives while allowing the system to serve the economic and social needs of the region. The hydrologic characteristics that form this strategy, while not in themselves objectives, provide a basis to formulate alternative components as well as measure and evaluate how they will effect both ecologic and economic goals. They include:

- Regain lost storage capacity
- Restore more natural hydropatterns
- Improve timing and quantities of fresh water deliveries to estuaries
- Restore water quality conditions

A1.5.1 REGAIN LOST STORAGE CAPACITY

Historically, functioning of the natural system depended more on large storage capacity and slow rate of water flow than on the immediate effects of rainfall. Due to the storage and the slow rate of water flow throughout the natural system, wet season rainfall kept the wetlands flooded and maintained fresh water flow to the estuaries well into the dry season. The carry-over effect of the enormous storage capacity of the natural system was so great that a year of high rainfall maintained surface water in wetlands and fresh water flow to estuaries even into one or more subsequent drought years. Further, ground water seepage driven by hydraulic gradients provided the base flow of creeks, rivers, and possibly even surface runoff across the mangrove zone.

Human modifications to the Everglades ecosystem have resulted in the loss of roughly 6 million acre-feet of storage. In southeast Florida, approximately 2 million acre-feet is diverted to the sea on an average annual basis due to seepage from the Water Conservation Areas and drainage in the lower east coast. Increasing storage capacity in the system will provide sufficient quantities of water necessary to meet the needs of the Everglades, Florida Bay, urban, and agricultural areas, while reducing the adverse stormwater impacts to coastal estuaries.

Lake Okeechobee provides considerable storage capacity today and it could be managed in such a way as to maximize storage capability within the existing levee design while at the same time protecting the littoral zone. However, this increase is inadequate to provide for all the regional system demands; therefore, additional sources of water need to be developed with specific users in mind. Flood releases from Lake Okeechobee could be used to fill regional storage facilities prior to allowing discharges to the Caloosahatchee and St. Lucie Estuaries. Storage facilities could also be used to capture water prior to entering Lake Okeechobee.

Operational and structural modifications to existing project features, along with new reservoirs, Water Preserve Areas, seepage barriers, and aquifer storage and recovery (ASR) could enhance stormwater storage for environmental, urban, and agricultural uses. Increased water levels and stormwater storage adjacent to the Water Conservation Areas in Miami-Dade and Broward Counties could prevent excessive seepage from the Everglades and provide increased flows to both Shark River Slough and Florida Bay. Taking advantage of the seasonal nature of water availability from the regional system and greater use of local sources for meeting the demands of urban water supply could provide greater use of the regional water supply system for enhancing the ecologic health of the Everglades and Florida Bay.

A1.5.2 RESTORE MORE NATURAL HYDROPATTERNS

Water supply releases and flood releases involved in the management of stage levels in Lake Okeechobee, the Water Conservation Areas, and the East Everglades, have decoupled water flows from rainfall. Peak flows are higher following major rain events and flow rates decline more abruptly following the end of the wet season than in the natural system. Flows to the Everglades from Lake Okeechobee have shifted from primarily wet season flows in response to rainfall to controlled dry season deliveries in response to urban and agricultural water demands. Channelization and impoundment have disrupted the annual pattern of rising and falling water depths in the remaining wetlands of south Florida. In a few areas, such as the southern parts of the Water Conservation Areas, channelization, coupled with impoundment, has increased depth and hydroperiod. Regulatory water releases from the Water Conservation Areas have flooded alligator nesting sites in Everglades National Park causing nest failure. In addition, these releases have disrupted wading bird nesting, which depends upon lower seasonal water levels that concentrate food supplies.

The importance of hydrology to almost every aspect of Everglades ecosystem function, both in annual and pulse of wet and dry cycles and in stochastic deviations as they relate to disturbances, suggests that water delivery plans should be based on antecedent rainfall and natural system modeling for all major remnant Everglades marshland, including the Water Conservation Areas. The rainfall-based plan for water delivery to Everglades National Park is a first attempt to restore a natural hydrology pattern in the Everglades. Application of this approach to other undeveloped areas of marsh may represent the best strategy for ecosystem restoration. The Everglades system could be operated with rainfall driven targets triggering deliveries to the Water Conservation Areas and Everglades National Park with special attention to protecting tree islands from high water levels. These environmental deliveries could be made first from regional storage facilities if water is available, then from Lake Okeechobee as needed. However, Water Conservation Areas-2B and 3B could continue to function in a multi-purpose role as identified in the original federal authorization. Water storage areas are needed to recover some of the system flexibility originally considered in the C&SF Project (e.g. areas to receive backpumped storm water, sources of water for urban and agricultural consumption, wildlife conservation, etc.). These areas should be designed to reduce excessive seepage from the Everglades system into the coastal basin over and above the amounts desired to maintain a seaward groundwater flow gradient to prevent saltwater intrusion and provide appropriate fresh water flows to the estuaries along the Lower East Coast.

A1.5.3 IMPROVE TIMING AND QUANTITY OF FRESH WATER FLOWS TO ESTUARIES

Water management has altered the natural timing, quantity, and quality of fresh water flow into the coastal ecosystems in south Florida. Water management has resulted in increased short duration, high volume water flow to the St. Lucie and Caloosahatchee Estuaries and less life-sustaining base flows to these estuaries. Flood releases needed to control lake and ground water levels, causing large pulses of fresh water to enter the St. Lucie and Caloosahatchee Estuaries which have caused rapid, drastic decreases in salinity that stressed estuarine organisms. In addition, water flows have been diverted from one receiving basin to another that changed the long-term salinity regimes in both systems.

Areas that have experienced detrimental changes due to alterations in fresh water flows are: Florida Bay (impacted by reduced and untimely fresh water inflows), Manatee Bay (impacted by large fresh water discharges), Caloosahatchee Estuary (impacted by episodic large fresh water discharges and reduced minimum flows during dry seasons), St. Lucie Estuary (same as the Caloosahatchee), Lake Worth Lagoon (impacted by large flood discharges and water quality degradation), and Biscayne Bay (impacted by untimely fresh water inflows). Improving quality, quantity, and timing of fresh water flows to downstream waterbodies should improve the salinity, nutrients, turbidity, and other characteristics that impact the bays, estuaries and reef ecosystems offshore.

A1.5.4 RESTORE WATER QUALITY CONDITIONS

Human activities in south Florida have changed water quality parameters by altering flow characteristics and introducing urban and agricultural pollutants into storm water. The public has expressed particular concerns for six major areas: eutrophication of Lake Okeechobee, flood releases from Lake Okeechobee to the St. Lucie and Caloosahatchee Estuaries, flow into the Water Conservation Areas particularly from the Everglades Agricultural Area, salinity in Florida Bay, urban water quality, and system-wide mercury pollution. These public concerns are complex and varied but can be grouped into three categories: salinity changes, eutrophication, and contaminants.

Changes in salinity characteristics of estuaries have resulted from the alteration of flow throughout the study area. Flood releases from Lake Okeechobee as well as local basin runoff have been routed to the St. Lucie and Caloosahatchee Estuaries and result in short periods of too much fresh water. Similar effects have occurred in Barnes Sound as a result of C-111. Other areas, such as Florida Bay (via Taylor Slough) and the Ten Thousand Islands (via Shark River Slough), have received less fresh water than under historical conditions, which results in periods of hyper-saline conditions. In all cases, natural communities have suffered. Modifications in the timing and quantity of fresh water inflow to Florida Bay have had substantial impact including: more saline bay waters in more locations and for longer periods of time than under pre-managed conditions; reduced recruitment of pink shrimp, snook, and redfish; lowered reproductive success of ospreys and great white herons; shifts in distributions of West Indian manatees and American crocodiles; reduction in wading birds; and contribution to a complex series of factors in the mass mortality of sea grasses that have occurred in the bay since 1987.

Eutrophication, caused by watershed activities that have produced too many nutrients, caused dramatic changes in algal growth within Lake Okeechobee and resulted in shifts of plant communities within the Everglades from sawgrass to cattails. These changes have resulted in further degradation of natural conditions. Contamination problems are characterized by pesticide/herbicide residues and mobilization of mercury within the system. The cause of mercury contamination remains uncertain because not enough is known about the potential sources or the catalyst for mobilization.

Water quality treatment must be incorporated into the facilities that support hydrologic modifications. To date, uptake relationships in the Water Conservation Areas have focused on a rapid flow-through marsh system as a means to achieve an increment of water quality treatment (50 ppb of total phosphorus). But if detention time is as important as literature suggests, then some degree of water quality improvement can be expected from the components that regain lost storage capacity. Captured seepage from storage areas may prove to be a means through which water quality may also be significantly improved.

Different water quality standards apply to different uses, jurisdictional responsibilities, and criteria established by various regulatory agencies. For example, drinking water standards are much higher than water quality standards for agriculture. Furthermore, allowable phosphorus loadings vary among regions of the natural system. Water quality improvement features must specify the potential use of the treated water. The delivery of water for urban use occurs primarily through ground water recharge and subsequent well pumping. Due to the nature of aquifers, contamination would pose long term problems because clean up may be impractical. Any redistribution of water in the C&SF Project must account for movements of existing contaminants so that ground water sources are protected. In addition, the Water Preserve Areas could be designed to provide water quality treatment of captured stormwater prior to release into the Water Conservation Areas or to help meet Lower East Coast area demands.

A1.6 COMPONENTS

The Comprehensive Plan for the C&SF Project will consist of structural and operational changes to the C&SF Project. Individual project features have been termed components. Components have been developed by sub-regions and will be optimized at the sub-regional level, then grouped with other components to form a preliminary Comprehensive Plan. This plan will then be evaluated and trade-offs determined using the system-wide objectives stated previously. This evaluation will provide the Restudy critical data to determine what refinements to the plan are needed.

The components described below were developed based on knowledge gained from considerable public comment, research and analytical studies. However, further evaluation of a range of components is needed to test and verify our knowledge of the system before a comprehensive plan can be selected. Further, some components listed below have been proposed for the sake of gaining greater knowledge of how the system might respond to certain management actions. These components are not intended to be all inclusive of the options available to the Restudy. Public involvement activities and further design and optimization of these and other components will impact the final array of project features.

The components and general issues in ***Table 3*** are organized by sub-region. The left-hand column lists the Governor's Commission for a Sustainable South Florida (GCSSF) Thematic Concept(s) as they relate to the individual components.

Table 3
Initial List of Components

I. KISSIMMEE RIVER AREA

Issues/Problems

- Excess flood discharge to Lake Okeechobee.
- Water quality of inflows into Lake Okeechobee.
- Reduced spatial extent of natural areas and loss of habitat.

Concept		Components
1	1.	Storage reservoirs to reduce high Lake Okeechobee stages. These reservoirs will be designed for flood attenuation and water supply benefits.
1,7	2.	Wetland detention areas for tributaries along the Kissimmee River to improve timing of flows and reduce nutrient impacts to Lake Okeechobee.
1	3.	Additional storage in the Kissimmee Chain of Lakes (above Cypress Lake) through modification in regulation schedules and improved outlet capacities that would protect lake littoral zones while providing proper timing and volume to Kissimmee River and not worsen flood damages.
8	4.	Restore wetlands and aquatic habitat at Pool A along Kissimmee River.
8	5.	Restore wetlands and aquatic habitat at Pool E along Kissimmee River.
8	6.	Restore wetlands and aquatic habitat at Paradise Run along Kissimmee River.
1, 7	7.	Creation of a wetland detention area or stormwater treatment area at Taylor Creek/Nubin Slough to reduce

Phosphorus loading to Lake Okeechobee.

II. UPPER EAST COAST/ST. LUCIE AND MARTIN COUNTIES

Issues/Problems

- Excess local and Lake Okeechobee flood releases to estuary.
- Water quality of fresh water discharges to estuary.
- Base flow needed to maintain healthy estuary.
- Limited agricultural water supply sources.
- Increased dissolved organics and sediment entering the estuary.
- Degraded wetland values within remnant sloughs.
- Reduction of spatial extent of agricultural land due to urban development pressures or planned project modifications.

Concept		Components
1	1.	Storage reservoirs to capture runoff from C-44 and releases from Lake Okeechobee. These reservoirs will be designed for flood attenuation, water supply benefits, and water quality benefits to reduce nutrient impacts of runoff that is allowed to backflow to Lake Okeechobee or to the estuary.
1,7	2.	On-site detention facility to attenuate basin runoff to C-44 and provide water supply. Facilities will also reduce water quality impacts to the St. Lucie Estuary, Indian River Lagoon, and Lake Okeechobee through backpumping.
8	3.	Wetland restoration of remnant sloughs in western St. Lucie and Martin Counties to regain a portion of the habitat lost due to drainage. This is similar to the impoundments recently constructed in the Upper St. John's River Basin and could provide attenuation benefits.
1	4.	Conveyance feature (C-131) to Lake Okeechobee from C-23, 24, 25 to reduce quantity and quality impacts to the St. Lucie Estuary and Indian River Lagoon while providing an additional source of water for Everglades restoration. The quality of water and the stages of Lake Okeechobee must not be adversely effected by the backpumped water.
7	5.	Water quality treatment of existing flows from C-44 to Lake Okeechobee. A portion of the stormwater runoff that is presently discharged to C-44 from basins adjacent to the canal will be backpumped through a stormwater treatment facility and then backpumped to Lake Okeechobee.
2	6.	Backpumping and water quality treatment of additional flows from C-44 to Lake Okeechobee. This component is intended to capture local drainage within the C-44 Basin and

backpump through a stormwater treatment facility to Lake Okeechobee.

6,10	7.	Regional Aquifer Storage & Recovery for water supply.
8	8.	Flowway feature to divert excess treated water south through the J. W. Corbett Wildlife Management Area to the proposed Everglades Construction Project Divide Structure S-316 that is intended to divert flow to Water Conservation Area-1. The J. W. Corbett Wildlife Management Area must not be adversely effected by the backpumped water, necessitating a treatment facility to improve water quality before backpumping. Flowway will reduce quantity and quality impacts to the St. Lucie Estuary and Indian River Lagoon while providing an additional source of water for Everglades restoration.

III. CALOOSAHATCHEE

Issues/Problems

- Excess local and Lake Okeechobee discharges to estuary.
- Water quality of fresh water discharges to estuary.
- Maximum and minimum flow needed to maintain healthy estuary.
- Limited agricultural water supply sources.
- Reduction of spatial extent of agricultural land due to urban development pressures or planned project modifications.

<u>Concept</u>		Components
1, 7, 11	1.	Storage reservoirs to capture basin runoff and releases from Lake Okeechobee. These reservoirs will be designed for flood attenuation, water supply benefits, and water quality benefits to reduce nutrient impacts of runoff that is allowed to backflow to Lake Okeechobee or to the estuary.
1,7, 11	2.	On-site detention facility to attenuate basin runoff to C-43 and provide water supply. Facilities will also reduce water quality impacts to the St. Lucie Estuary, Indian River Lagoon, and Lake Okeechobee through backpumping.
7	3.	Water quality treatment of existing flows from C-43 to Lake Okeechobee. A portion of the stormwater runoff that is presently discharged to C-43 from basins adjacent to the canal will be backpumped through a stormwater treatment facility and then backpumped to Lake Okeechobee.
2	4.	Backpumping and water quality treatment of additional flows from C-43 to Lake Okeechobee. This component is intended to capture local drainage within the C-43 Basin and

backpump through a stormwater treatment facility to Lake Okeechobee.

6,10	5.	Regional Aquifer Storage & Recovery for water supply.
8	6.	Lake Hicpochee restoration as an environmental feature and potential attenuation of local runoff for water supply. The reservoir will provide water quality improvements through detention that will reduce nutrient impacts of runoff that is allowed to backflow to Lake Okeechobee or to the estuary.
1, 7, 11	7.	Additional storage in C-43 adjacent to Moore Haven. Will provide water supply and water quality benefits.
5, 11	8.	Restore natural flows under San Carlos Bay/Sanibel Island causeway. (Raise roadway, add culverts, etc.)

IV. LAKE OKEECHOBEE

Issues/Problems

- Prolonged high water levels impact littoral zone.
- Low lake levels for extended periods impact littoral zone.
- Quality of water flowing into Lake Okeechobee.
- High water supply demands on Lake Okeechobee.
- Unnaturally large fluctuations in lake stages.
- Navigation and public water supply intake problems with lower lake levels.
- Sedimentation of Lake Okeechobee and release waters.

Concept		Components
2	1.	New operating criteria for Lake Okeechobee that includes flood control, water supply and Everglades demand driven releases to the Water Conservation Areas to meet estimated natural system needs. This new criteria would need to be derived from an optimization based on rainfall and antecedent conditions. The regulation schedule would include:

- Additional storage capacity that would not result in long term impacts to the littoral zone (i.e. temporary higher stages that serves to avoid continuous periods of marsh inundation greater than two to three years).
- Operation for lake habitat and water quality improvement (lower stages during certain times of the year) and provide more natural fluctuations for the existing littoral zone.
- Maintain a minimum water level in the Lake for ecosystem health.
- Aquifer Storage & Recovery zone in schedule for withdrawal

of lake water for injection into Aquifer Storage & Recovery facilities.

- Regulatory (flood) discharges would be prioritized as follows;

Priority 1: Sends regulatory discharges to downstream storage facilities if capacity is available (Everglades Agricultural Area & Caloosahatchee storage, Water Preserve Areas, etc.)

Priority 2: Releases to Water Conservation Areas up to estimated natural system limits

Priority 3: Pulse releases to Caloosahatchee and St. Lucie Estuaries

Priority 4: Major releases to Caloosahatchee and St. Lucie Estuaries.

2,6,10 2. Lake Okeechobee regional Aquifer Storage & Recovery to reduce peak water stages for flood protection and water supply.

8 3. Restoration of Kreamer, Torry and Ritta Islands dependent on new operating criteria for Lake Okeechobee.

V. EVERGLADES AGRICULTURAL AREA

Issues/Problems

- Water quality of runoff degrading downstream ecosystem.
- High water demands and limited agricultural water supply sources.
- Limitations on conveyance through the basin.
- Continuing subsidence of organic soils.
- Reduction of spatial extent of agricultural land due to urban development pressures or planned project modifications.

<u>Concept</u> Components

3 1. Storage areas (reservoirs) to reduce flood releases to the Water Conservation Areas, to improve timing of environmental deliveries to the Water Conservation Areas and to meet agricultural water supply demands and flood protection within the Everglades Agricultural Area.

- Capture local runoff and Lake Okeechobee regulatory (flood) releases.
- Canal conveyance improvements as required to convey flood waters to storage and treatment areas.
- Modifications to Stormwater Treatment Areas as necessary for Everglades water deliveries to meet the appropriate water quality.

3,6,10 2. Regional Aquifer Storage & Recovery for storage of local stormwater and Lake Okeechobee water for water supply.

7 3. Water quality treatment facility (Stormwater Treatment

Area) within the northern reaches of the Everglades Agricultural Area to capture and treat water that is presently backpumped to Lake Okeechobee.

2, 3, 7 4. Backpumping additional water from the Everglades Agricultural Area to Lake Okeechobee with a water quality feature. The quality of water and the stages of Lake Okeechobee must not be adversely effected by this backpumping.

LOWER EAST COAST URBAN

VI. North Palm Beach County

Issues/Problems

- Limited surficial aquifer capacity for growing public water supply demand.
- Improved quantity and timing of fresh water flows to the Loxahatchee River and Slough, and West Palm Beach's Water Catchment Area.
- Improved continuity of natural areas needed including areas of Pal Mar, Corbett, West Palm Beach's Water Catchment Area, and Loxahatchee River and Slough.
- Urban flood protection needed in Indian Trail Water Control District, South Indian River Water Control District, and the C-18 Basin.
- Reduction of spatial extent of agricultural land due to urban development pressures or planned project modifications.
- Salt water intrusion.
- Lowering of groundwater table.

Concept		Components
4,6,8	1.	Southern L-8 Project, which will take local basin runoff, and if needed provide additional water quality treatment and store flood waters (reservoirs, e.g. western C-18 reservoir) for flood protection and for enhancing water supply to Loxahatchee River and Slough along with enhanced urban water supply for the City of West Palm Beach via the Water Catchment Area, and improved recharge to the Seacoast and Jupiter wellfields.
6	2.	Further expansion and utilization of reuse of reclaimed water and water conservation.
6	3.	Further expansion and utilization of the Floridan Aquifer as a water source.
6, 10	4.	Further expansion and utilization of utility Aquifer Storage & Recovery.

6,10	5.	Regional Aquifer Storage & Recovery for water supply.
4	6.	Link Lake Okeechobee with Water Preserve Areas and reservoirs by improving Lake Okeechobee outlet at the L-8 with enlarged canal to marshes and storage areas. L-10 / L-12 / L-8 / S-5A(E) conveyance improvement for improved water supply deliveries to the C-51 Basin (Lake Worth Drainage District) from Lake Okeechobee.
8	7.	Protect and enhance existing wetland systems including Pal Mar, Corbett, and Loxahatchee Sloughs by restoring hydropatterns. Some flood attenuation benefits may be achieved.
6	8.	Improved operation of secondary and primary canal systems in 298 Districts to enhance stormwater diversion while increasing ground water recharge.

VII. Palm Beach County

Issues/Problems

- Growing public water supply demand increasing potential for saltwater intrusion and demand on regional system.
- Drainage of area causing large flood discharges and water quality degradation in Lake Worth Lagoon.
- Wetlands east of Water Conservation Area-1 require hydropattern restoration.
- Quality of stormwater runoff.
- Limited availability of land with sufficient size to serve as water storage areas.
- Potential decrease in water supply available due to minimum flows and levels.

Concept		Components
6	1.	Further expansion and utilization of reuse of reclaimed water and water conservation.
6	2.	Further expansion and utilization of the Floridan Aquifer as a water source.
6, 10	3.	Further expansion and utilization of utility Aquifer Storage & Recovery.
6	4.	Further expansion and relocation of existing wellfields.
6, 10	5.	Regional ground water Aquifer Storage & Recovery adjacent to primary canal system.

VIII. Broward County

Issues/Problems

- Growing public water supply demand increasing potential for

saltwater intrusion and demand on regional system.
- Drainage of area causes large flood discharges to Intracoastal Waterway which previously flowed west to the Everglades.
- Limited spatial area for project features to control and manage the significant amount of seepage from the Everglades to the developed areas.

Concept		Components
6	1.	Further expansion and utilization of reuse of reclaimed water and water conservation.
6	2.	Further expansion and utilization of the Floridan Aquifer as a water source.
6, 10	3.	Further expansion and utilization of utility Aquifer Storage & Recovery.
6	4.	Further expansion and relocation of existing wellfields.
6,10	5.	Regional ground water Aquifer Storage & Recovery adjacent to primary canal system.
6	6.	Improved operation of secondary and primary canal systems in 298 Districts to enhance stormwater diversion while increasing ground water recharge and maximizing system storage.

IX. Miami-Dade County

Issues/Problems
- Growing public water supply demand increasing potential for saltwater intrusion and demand on regional system.
- Drainage of area causing large flood discharges to intracoastal waterway.
- Significant amount of seepage from the Everglades to the developed areas.
- Base flows needed for Biscayne Bay.
- Conversion or degradation of remaining natural areas.
- Excess discharge to Biscayne Bay

Concept		Components
6	1.	Further expansion and utilization of reuse of reclaimed water and water conservation.
6	2.	Further expansion and utilization of the Floridan Aquifer as a water source.
6, 10	3.	Further expansion and utilization of utility Aquifer Storage & Recovery.
6	4.	Further expansion and relocation of existing wellfields.
6,10	5.	Regional ground water Aquifer Storage & Recovery adjacent to primary canal system.

X. South Miami-Dade County and Biscayne Bay

Issues/Problems

- Significant amount of seepage from the Everglades to the developed areas.
- Altered hydropatterns causing negative impacts on Model Lands and East Everglades.
- Conversion or degradation of remaining natural areas.
- Water quality issue with south Miami-Dade County agriculture and in eastern portions (L-31E, Military Canal, etc.).
- Reduction of spatial extent of agricultural land due to urban development pressures or planned project modifications.

Concept		Components
11	1.	Environmental deliveries to Biscayne Bay.
4, 8,11	2.	Create additional water preserve areas in south Miami-Dade County by the addition of eastern Model Lands and Biscayne Bay Coastal wetlands. Preservation and/or restoration will increase the spatial extent of wetlands in southern Miami-Dade County.
6	3.	Create additional water preserve areas for urban/agricultural water supply storage. Water Preserve Areas can be used to capture wet season runoff for use in early dry season.
7	4.	Water quality treatment facilities.
5	5.	Backfill C-111 to increase hydropattern restoration and produce sheetflow across the Southern Glades; used in conjunction with other measures to provide flood control.

XI. HOLEY LAND WILDLIFE MANAGEMENT AREA

Issues/Problems

- Altered hydropatterns causing negative impacts to the ecosystem.
- Quality of water entering the area causing changes to the ecosystem.
- Nutrients in sediment may cause cattail proliferation even if water entering the area is clean.

		Components
5	1.	Rainfall driven schedule consistent with Florida Game and Fresh Water Fish Commission's management schedule recommendations.

8 2. Once the water entering the area is clean and the sediment is stabilized, structurally reconnect the area with the Water Conservation Areas to provide for more natural water flow.

XII. ROTENBERGER WILDLIFE MANAGEMENT AREA

Issues/Problems

- Altered hydropatterns causing negative impacts to the ecosystem.
- Quality of water entering the area causing negative impacts to the ecosystem.
- Water supply to the tribal lands.
- Antecedent soil conditions and topography.

Components

5 1. Rainfall driven schedule consistent with Florida Game and Fresh Water Fish Commission's Everglades Construction Project recommendations.

8 2. Once the water entering the area is clean and the sediment is stabilized, structurally reconnect the area with the Water Conservation Areas to provide for more natural water flow.

XIII. WATER CONSERVATION AREAS

Issues/Problems

- Altered hydropatterns causing negative impacts to the ecosystem.
- Quality of water entering the Water Conservation Areas causing negative impacts to the ecosystem.
- Water quality regulation of urban runoff.
- Large amounts of seepage from Water Conservation Areas to eastern developed areas.
- Must consider water supply impacts if seepage is reduced.
- Invasive plant and animal species causing negative impacts to the ecosystem.
- Reduced spatial extent and habitat loss.
- Antecedent soil conditions and topography.
- Connectivity between Water Conservation Areas.
- High water levels causing impacts to tree islands.

Concept Component

5 1. Rainfall driven schedule with NSM levels triggering deliveries with consideration to tree island impacts and minimum floor levels consistent with SFWMD's proposed minimum levels criteria. This type of operation would be contingent upon improved seepage management adjacent to developed areas, and may require a step down levee system consistent with Water Preserve Area components or seepage barriers. This schedule would be multi-objective and attempt to balance environmental, water supply, flood control, and water quality objectives. Coordinate rainfall-driven schedules between all the Water Conservation Areas.

6 2. Cross-Water Conservation Area aqueduct(s) that would convey water across the Water Conservation Areas (Everglades Agricultural Area to Lower East Coast and Lower East Coast to Everglades Agricultural Area) depending on locations of supplies and demands. The aqueduct would be designed to minimize impacts on the ability to restore desired overland flow and hydroperiods within the water conservation areas.

5 3. Decompartmentalization of natural areas through the removal of levees, in a phased approach, within and between all Water Conservation Areas.

5 4. Berms or low levees within the Water Conservation Areas to slow water flow and redirect it toward overland flow. These levees should be adjustable and removable and the process of constructing them should not cause major impacts. This should be viewed as an experimental project and should employ adaptive management strategies.

XIII(1). LOXAHATCHEE NWR (Water Conservation Area 1-Service Area 1)

5 1. Rainfall driven schedule with NSM levels triggering deliveries with consideration to tree island impacts and minimum floor levels consistent with SFWMD's proposed minimum levels criteria. This type of operation would be contingent upon improved seepage management adjacent to developed areas, and may require a step down levee system consistent with Water Preserve Area components or seepage barriers. This schedule would be multi-objective and attempt to balance environmental, water supply, flood control, and water quality objectives. Coordinate rainfall-driven schedules between all the Water Conservation Areas.

4, 8 2. Creation of Water Preserve Areas for wetland restoration and/or preservation. These areas would be outside the Refuge and would increase the spatial extent of wetlands in Palm Beach County.

6 3. Creation of Water Preserve Areas for water supply storage for urban, agricultural and environmental uses. Wet season runoff from western C-15 and C-16, eastern C-51 and Hillsboro Basins will be diverted to storage to serve as water supplies during the early dry season.

7 4. Creation of Water Preserve Areas for use as water quality treatment facilities. Wet season runoff from western C-15 and C-16, eastern C-51, and Hillsboro Basins will be treated and released to Water Conservation Area-1, Water Conservation Area-2, or adjacent wetlands for use in hydropattern restoration.

4 5. A seepage barrier or impervious underground barrier will be constructed along the eastern edge of the Refuge to prevent losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

6 6. A seepage collection system will be constructed along the eastern edge of the Refuge to recover losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

XIII(2A/2B). WATER CONSERVATION AREA 2A/2B (Service Area 2)

5 1. Rainfall driven schedule with NSM levels triggering deliveries with consideration to tree island impacts and minimum floor levels consistent with SFWMD's proposed minimum levels criteria. This type of operation would be contingent upon improved seepage management adjacent to developed areas, and may require a step down levee system consistent with Water Preserve Area components or seepage barriers. This schedule would be multi-objective and attempt to balance environmental, water supply, flood control, and water quality objectives. Coordinate rainfall-driven schedules between all the Water Conservation Areas.

5 2. New schedule for flood attenuation into 3A.

4 3. A seepage barrier or impervious underground barrier will be constructed along the eastern edge of the Water Conservation Area to prevent losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

6 4. A seepage collection system will be constructed along the eastern edge of the Water Conservation Area to recover losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

4 5. A step down levee system inside Water Conservation Area-2B to reduce seepage flows. Water reserved in the regional system will be used to achieve hydropattern restoration and regional water supply deliveries to the Lower East Coast.

XIII(3A/3B). WATER CONSERVATION AREA 3A/3B (Service Area 2)

5 1. Rainfall driven schedule with NSM levels triggering deliveries with consideration to tree island impacts and minimum floor levels consistent with SFWMD's proposed minimum levels criteria. This type of operation would be contingent upon improved seepage management adjacent to developed areas, and may require a step down levee system consistent with WPA components or seepage barriers. This schedule would be multi-objective and attempt to balance environmental, water supply, flood control, and water quality objectives. Coordinate rainfall-driven schedules between all the Water Conservation Areas.

4, 8 2. Sheetflow distribution system for flows into Water Conservation Area-3A.

4, 8 3. Creation of Water Preserve Areas for wetland restoration and/or preservation. These areas would be outside the Water Conservation Area and would increase the spatial extent of wetlands in Broward County.

6 4. Creation of Water Preserve Areas for water supply storage for urban, agricultural and environmental uses. Wet season runoff from western North New River and C-11 Basins will be diverted to storage to serve as water supplies during the early dry season.

7 5. Creation of Water Preserve Areas for use as water quality treatment facilities. Wet season runoff from western North New River and C-11 Basins will be treated and released to Water Conservation Areas-3A/3B or adjacent wetlands for use in hydropattern restoration.

4 6. A seepage barrier or impervious underground barrier will be constructed along the eastern edge of the Water Conservation Area to prevent losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

6 7. A seepage collection system will be constructed along the eastern edge of the Water Conservation Area to recover losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

XIII(3B). WATER CONSERVATION AREA 3B (Service Area 3 – Lake Belt Area)

4, 8 1. Creation of Water Preserve Areas for wetland restoration and/or preservation. These areas would be outside the Water Conservation Area and would increase the spatial extent of wetlands in Northwest Dade County.

6 2. Creation of Water Preserve Areas for water supply storage for urban, agricultural and environmental uses. Wet season runoff from western Miami Canal, C-4, C-9, and L-31N Basins will be diverted to storage to serve as water supplies during the early dry season.

7 3. Creation of Water Preserve Areas for use as water quality treatment facilities. Wet season runoff from western Miami Canal, C-4, C-9, and L-31N Basins will be treated and released to Water Conservation Area-3B or adjacent wetlands for use in hydropattern restoration.

4 4. A seepage barrier or impervious underground barrier will be constructed along the eastern edge of the Pennsuco Wetlands to prevent losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

6 5. A seepage collection system will be constructed along the eastern edge of the Pennsuco Wetlands to recover losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

4, 6 6. Creation of Water Preserve Areas or bathtub reservoirs in part of the excavated Lake Belt.

4, 8 7. Additional structures in western C-4 and C-6 Canals.

XIV. BIG CYPRESS NATIONAL PRESERVE

Issues/Problems

- Altered hydropatterns may cause negative impacts to the ecosystem over the long term.
- Hydrologic and physical barriers from roads/airport/levees/canals.
- Agricultural development north of the Preserve and potential effects from the loss of headwaters on the Mullet Slough watershed.
- Impacts from all terrain vehicles.

Concept		Components
5	1.	Rainfall driven deliveries triggered by gages with environmental deliveries consistent with NSM.
5	2.	Gap southern levee of L-28 interceptor to restore sheet flow within the Preserve in conjunction with a water quality feature north of tribal lands.
5	3.	Enhance sheetflow within Preserve (Loop Road and Tamiami Trail modifications).
1	4.	Reservoir off the Caloosahatchee to supply headwater to Mullet Slough.
8	5.	Restoration of Golden Gate Estates.
8	6.	Restoration of Belle Meade and Fakahatchee Strand

XV. TRIBAL LANDS

Issues/Problems

- Quality of water entering the area causing negative impacts to the ecosystem.
- High water levels inhibiting tribal land development.

Concept		Components
6	1.	Flood control improvements adjacent to I-75 between L-28 and L-28 interceptor.
7	2.	Water quality feature north of tribal lands (Feeder Canal).
6,7	3.	Seminole Water Conservation Project which will improve water quality of runoff into the Everglades and detain flows during high water events.

XVI. EVERGLADES NATIONAL PARK

Issues/Problems

- Altered hydropatterns causing negative impacts to the ecosystem.
- Large amounts of seepage from Everglades National Park to eastern developed areas.
- Unnatural distribution of flows entering the park.
- Physical and hydrologic barriers within Everglades National Park (roadways).
- Efforts must be linked to the 8.5 Square Mile Area and Southern Everglades Restoration Alliance (SERA).

Concept		Components
5	1.	Rainfall-driven deliveries with NSM levels triggering environmental deliveries.

5 2. Enhance distribution (east-west) of flows into the Park by operating 3B as a flow-through system; would favor Northeast Shark River Slough. Modified / additional structures in L-67 levees to "control" releases into Water Conservation Area-3B dependent on real-time ability to mitigate seepage losses and meeting water quality concerns.

5 3. Improve flow into and through the Park by elevating low sections Tamiami Trail (below 3B) and Flamingo Road with bridges.

5 4. Gap or remove L-67 extension (remove the function).

8 5. Creation of Water Preserve Areas for wetland preservation and/or restoration. Will increase spatial extent of wetlands in Miami-Dade County.

6 6. Storage reservoirs or water conveyance improvements to provide water supply capacity for use in hydropattern restoration within Everglades National Park and to augment urban/agricultural supplies. Excess water from northern Water Preserve Area facilities could be diverted south as an additional water supply source for the Everglades or to manage seepage losses from Everglades National Park. Wet season runoff from L-31N and C-11 Basins will be diverted to storage to augment urban and agricultural supplies during early dry season.

7 7. Water quality treatment facilities and water conveyance improvements to provide wet season water supply capacity for use in hydropattern restoration within Everglades National Park. Surplus wet season runoff from L-31N and C-11 Basins will be treated through water quality treatment facilities and released through a dedicated conveyance system to either the Park, Model Lands, or Biscayne Bay or adjacent wetlands for use in hydropattern restoration of the remnant Everglades to augment urban/agricultural supplies.

4 8. Divert Everglades National Park seepage losses at 8.5 Square Mile Area into Northeast Shark River Slough through development of an isolated seepage recovery plan, separate from the residential runoff treatment scheme.(see South Dade).

4 9. A seepage barrier or impervious underground barrier will be constructed along the eastern edge of the Park to prevent losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

6 10. A seepage collection system will be constructed along the eastern edge of Everglades National Park to recover losses due to seepage to the east coast. Additional water retained in the regional system will be used to restore hydropatterns and for water supply to the Lower East Coast.

XVII. FLORIDA BAY and FLORIDA KEYS

Issues/Problems

- Altered timing and distributions of flows to the bay may be negatively impacting the ecosystem.
- Reduced conveyance through the Keys (U.S. 1 and railroad).
- Persistent water quality contaminant problems.

Concept		Components
5,11	1.	Restoration of more natural flows to Taylor and Shark River Sloughs is expected to have beneficial affect on flows to Florida Bay. Further study of the Buttonwood embankment is needed.
5,7,11	2.	Restore sheet flow in Taylor Slough (C-111) and Northeast Shark River Slough by removal of causeways.
5, 11	3.	Restore natural flow into Florida Bay by removal of causeway at Adams Waterway, mile marker 103, Florida Keys.

A1.7 SCREENING

The purpose of the screening analysis is to create a range of components to be used by the Restudy Team in developing alternative comprehensive plans. The Restudy defines components as conceptual project features (or options) intended to achieve a particular planning objective or set of planning objectives. During the next phase of the Restudy, the team will develop alternative comprehensive plans, each consisting of different combinations of these components.

Presently, the Restudy Team is considering more than 100 components. Different alternative restoration plans could be developed by making different combinations of these components. To put this into perspective, if the team were to evaluate all the possible combinations of these components, the number of possible comprehensive plans would be approximately $6.72x10^{30}$. Therefore, the Restudy Team needs a process to allow the Team to select a smaller number of plans for the evaluation phase. Because screening is limited and the nature of assumptions made during the screening process are generalized, components are not being eliminated from further consideration at this point. Rather, the screening process organizes and prioritizes the components for consideration in alternative plans. Clearly, more detailed evaluations are necessary before the Restudy can recommend any particular component be included in, or excluded from, the Comprehensive Plan.

This screening process involves: (1) optimizing component design (such as size and configuration) based on hydrologic criteria, (2) comparing similar components in terms of costs and magnitude of output, and (3) applying best professional judgment to reduce the inordinate number of plans.

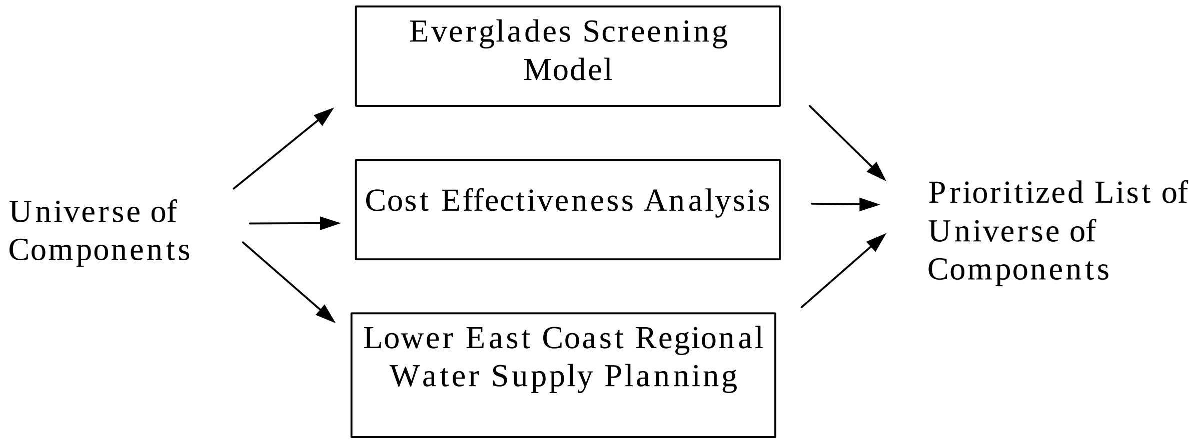
A1.7.1 COMPONENT SCREENING

Screening is a process for comparing alternative components or plan features against certain criteria. The screening process at this stage of the study provides a basis for identifying relative differences between components. The information gathered during the screening process will be used to combine components into alternative comprehensive plans. The alternatives will then undergo a more rigorous evaluation utilizing a system-wide hydrologic model and a suite of ecologic and water quality models.

The screening process involves three sets of screening criteria, including: hydrologic modeling using the Everglades Screening Model, a cost effectiveness analysis, and findings from the South Florida Water Management District's Lower East Coast Regional Water Supply Planning process, which utilized the South Florida Water Management Model for system-wide evaluations. Best professional judgment and findings from other studies such as the L-28 Feasibility Study and the Water Preserve Area Land Suitability Analysis also provide a basis from which screening conclusions can be drawn.

The component screening involves comparing the components against the three sets of screening criteria, not to eliminate components, but rather to identify which ones appear to be better than others in terms of their performance and financial investment.

Figure 1
Screening Criteria



A1.7.2 EVERGLADES SCREENING MODEL (ESM)

The Everglades Screening Model allows the Restudy Team an opportunity to evaluate and optimize particular hydrologic components at a broad level of detail relatively quickly. This hydrologic model is similar to the model used during the Reconnaissance Study to evaluate alternative plans. The model can be easily modified to compare system responses to changes in infrastructure or operations, such as adding a reservoir or comparing different sized reservoirs. This hydrologic model lets the Restudy Team look at a number of different component configurations in a short period of time.

As part of the screening phase, a number of components were investigated using this tool, including: storage reservoirs in the Everglades Agricultural Area, the Kissimmee River Basin, the Caloosahatchee Basin, and the St. Lucie Basin; Lake Okeechobee operation schedules; Lake Okeechobee aquifer storage and recovery systems; Water Preserve Area reservoirs and wetlands; seepage barriers; and seepage recycling.

The Everglades Screening Model helped identify optimal component designs based on hydrologic criteria such as evaporation-transpiration, seepage, and water demand. Findings from the Everglades Screening Model will guide the design of components that will be modeled and evaluated during the next phase of plan evaluation.

A1.7.3 COST EFFECTIVENESS ANALYSIS (CEA)

Cost effectiveness analysis is an evaluation tool that can be used to facilitate informed decision making. Cost effectiveness analysis is typically done near the end of a study to compare complete alternative plans. However, the analysis can also be used earlier to compare similar components to assist in the formulation of cost effective alternative plans. For screening, the cost effectiveness analysis was used to identify the least-cost component at each level of output, as well as to examine how cost varies as output levels increase. To do this, the components were first arranged into "functions." These functions are displayed in ***Table 4***.

Of the 112 components being considered by the Restudy, 47 of them had sufficient known detail to be grouped in the above categories and analyzed using the cost effectiveness analysis. In this way, only components with similar output were compared to identify cost effective features. The other 65 components were screened using findings from the Lower East Coast Regional Water Supply Plan, other studies, or best professional judgment.

The cost effectiveness analysis is conducted by first designing each of the components. The general nature of the description of each of the Restudy components provided the Restudy Team an opportunity to look at different designs for each component, resulting in nearly 175 designs which are referred to as *management measures*. For example, a component such as a storage reservoir could have a near infinite number of designs to achieve its desired effect. Based on previous system knowledge, a limited range of designs for this component was developed. In the case of Kissimmee River Storage Reservoirs, nine designs were developed ranging from 10,000 to 30,000 acres at 4, 8 and 12 foot depths.

For each management measure, cost estimates were developed for construction, real estate, and operation and maintenance. Outputs were also estimated for each design. The outputs were derived from a number of sources. Outputs for components designed to improve the quality of Lake Okeechobee inflows were obtained by applying the same design equations used for the Stormwater Treatment Areas for the Everglades Construction Project. The output for components designed to manage Lake Okeechobee water levels and provide additional water supply capability within Lake Okeechobee were calculated from the South Florida Water Management Model. The Everglades Screening Model was used to calculate outputs for the components designed to: (1) provide additional regional water sources within the Lower East Coast; (2) manage Everglades Protection Area inflows from the Everglades Agricultural Area; and (3) retain additional water in the regional system. Finally, spatial extent was measured by estimating the acreage of wetlands to be restored.

Table 4
Output Measurement Units

Function	Desired Effect (unit of measure)
Improve quality of Lake Okeechobee inflows	Reduction in Phosphorus load to Lake Okeechobee (tons)
Improve management of Lake Okeechobee water levels	Reduction in regulatory releases (acre-feet)
Additional Lake Okeechobee water supply capability (water otherwise lost to tide)	Increase in net inflows to Lake Okeechobee (acre-feet)
Additional regional water source (Lower East Coast)	Reduction in demand on existing regional system (acre-feet)
Increase spatial extent of wetlands	Restored or Preserved Wetlands (acres)
Improved management of Everglades Protection Area inflows from Everglades Agricultural Area	Increase in storage capacity within the Everglades Agricultural Area (acre-feet)
Additional water retained in the regional system	Increase in water retained in the Everglades Protection Area (acre-feet)

The cost effectiveness analysis provides the Restudy Team organized information about different levels of output and their associated cost which is useful both for making selections as to project scale and in describing the rationale for that selection.

A1.7.4 LOWER EAST COAST REGIONAL WATER SUPPLY PLAN

The South Florida Water Management District's Lower East Coast Regional Water Supply planning process modeled and evaluated five alternative plans. The South Florida Water Management Model (SFWMM) was used to help identify water supply problems in the Lower East Coast Region and to assist staff in the evaluation of the five plans.

The SFWMM is an integrated surface water – ground water model that simulated the hydrology and the existing and proposed water supply conditions in the region based on 26 years of historical climatic data (1965-1990) (Note: The model has now been updated to include a 31-year period of record from 1965 to 1995). The model encompasses: Lake Okeechobee, the Everglades Agricultural Area, the Water Conservation Areas, Everglades National Park, the Lower East Coast urban areas and parts of the Big Cypress National Preserve. The model also includes flows from the Kissimmee River, and Lake Okeechobee outflows to the Caloosahatchee and St. Lucie Estuaries. The model simulates the major components of the hydrologic cycle, which includes surface water flow, ground water flow, rainfall, and evaporation. The model also simulates the operation of the regional water management system, including pump stations, water control structures and canals.

A wide range of options (components) were modeled and evaluated in the five alternatives. These options can be divided into nine general categories:

- Facilities or operating procedures to modify storage in Lake Okeechobee
- Facilities to capture and use runoff from the Caloosahatchee Basin
- Facilities to capture and use runoff from the Everglades Agricultural Area
- Facilities and operational procedures to improve the timing and distribution of water released into the Everglades and move between locations in the Everglades
- Facilities to manage losses of water from the Everglades
- Facilities to protect and make better use of water resources in the coastal basins
- Facilities to capture and use excess water in the coastal basins
- Facilities and procedures to create and restore wetlands outside the Everglades
- Operational procedures to improve the timing and location of releases to tide

A number of options, which were considered in the first four alternatives, were found to be quite effective in meeting the planning objectives. However, it became apparent that the plans were not implementable within the year 2010 planning horizon and should be deferred to the Restudy for further evaluation.

Because of the use of the SFWMM and options considered in each alternative, important insight can be gained regarding the system-wide affects and interactions of a variety of water management options and strategies.

A1.7.5 SCREENING CONCLUSIONS

Screening conclusions for each component can be drawn from the Everglades Screening Model, cost effectiveness analysis, and/or the Lower East Coast Regional Water Supply Planning process. For the components that were analyzed with the Everglades Screening Model, the model provided an optimum component design based on hydrologic criteria. This optimum level, when applied to the cost effectiveness analysis, was used to determine if a cost effective component could achieve the same level of output as determined by Everglades Screening Model screening or if other or additional components should be considered.

The cost effectiveness analysis, when used by itself, provides a range of cost effective components with varying output levels. Without a target or optimal design from the Everglades Screening Model, the screening conclusion is limited to identification of the most cost-efficient component. That is, the component with the lowest cost per unit of output desired. If an output target is available, and the most cost-efficient component fails to meet its target, the analysis can be used to identify the next most cost-efficient component or group of components. This will give the Restudy Team a hierarchy for selecting components during the development of alternative comprehensive plans.

Finally, the Lower East Coast Regional Water Supply planning process provides a system-wide perspective on outputs that is lacking from the other analyses. The screening conclusions for each of the components is displayed in the attached matrix. The matrix displays each of the 112 components, the screening evaluation tool applied, and a brief summary of the findings. A summary of the major conclusions from screening is shown in ***Table 5***.

A1.7.6 APPLICATION OF FINDINGS

The screening analysis gives the Restudy team information to guide the order in which components are added together. The findings from the screening analysis allow the Restudy team to categorize the components based on hydrologic output and cost effectiveness. These findings are listed in ***Table 6***. The conclusions from screening will be used to create the first alternative comprehensive plan; but the power of this information extends well beyond the first alternative.

Consider this analogy: through screening, the components have been stocked and organized in a warehouse based on hydrologic output and cost effectiveness. Through the screening process, the components have, in a sense, gone through a “quality control” check. These components are available to the Restudy team to meet targets set forth during the next phase of plan evaluation. In developing alternatives, the team will be able to “order” an appropriate component from the warehouse with some certainty as to the effectiveness and efficiency of the component.

Each time the team must select a new component to achieve a desired effect, they will have the data from the screening analysis to help them choose from the warehouse. For instance, if a least cost alternative plan results in too many regulatory releases to the estuaries, then the team will have a basis to select (request from the warehouse) a component that may not be the least cost feature but is more effective (has greater output) at managing Lake Okeechobee water levels without impacting the estuaries.

Table 5

Restudy Components Screening Conclusions

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
I	KISSIMMEE RIVER AREA				
1	Storage Reservoirs	10,000 - 20,000 acre reservoir @ 10' optimum	20,000 acre reservoir @ 12' is cost effective Lake Okeechobee operation criteria more cost effective		
2	Wetland Detention Areas		Taylor Creek/Nubbin Slough most cost effective water quality treatment		
3	Additional Storage in the Kissimmee River Chain of Lakes				No conclusive findings - extensive lake-side development may preclude rise in Lake levels
4	Pool A Restoration		Not as cost effective as Paradise Run – would consider as next increment (quality not evaluated)		
5	Pool E Restoration		Not as cost effective as Pool A Restoration (quality not evaluated)		
6	Paradise Run		Most cost effective measure in sub-region to increase spatial extent (quality not evaluated)		
7	Taylor Creek/Nubin Slough		Most cost effective measure to reduce Phosphorus loading to Lake Okeechobee		
II	UPPER EAST COAST/ST. LUCIE AND MARTIN COUNTIES				
1	Storage Reservoirs (C-44)	10,000 acre reservoir @ 4' optimum	2,500 or 5,000 acre reservoir @ 8' (however, Backpumping C-44 to Lake (6) more cost effective)		
2	On-site Detention Facility (C-44)		Not cost effective compared to other components		

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
3	Wetland Restoration in western portion of counties		10,000 acres are most cost effective for sub-region (quality not evaluated)		Numerous opportunities to increase spatial extent in this sub-region
4	Backpump C-23, 24, 25 to Lake Okeechobee		C-44 Backpump (6) is more cost effective (Potential impact to littoral zone and estuaries)		
5	Water quality Treatment of existing flows from C-44 to Lake Okeechobee		Kissimmee water treatment options are more cost effective		
6	Backpump C-44 to Lake Okeechobee (additional flows)		Most cost effective in increasing water in Lake Okeechobee (Potential impact to littoral zone and estuaries not evaluated)		
7	Regional ASR		8 wells with 2,500 acre reservoir most cost effective storage option for this region		
8	Corbett WMA Flowway from C-44 to L-8				Impact to high quality wetlands - results in further fragmentation
III.	CALOOSAHATCHEE				
1	Storage Reservoirs	20,000 acres @ 8' optimum	Lake Hicpochee reservoir most cost effective – additional storage site needed to achieve target	20,000 acres provides water supply to meet a portion of demands in that basin	
2	On-site Detention		Not cost effective - may require site specific analysis		
3	Water quality treatment of existing flows from C-43 to Lake Okeechobee		Kissimmee water treatment options are more cost effective		
4	Backpump C-43 to Lake Okeechobee (additional flow)		Most Cost effective in increasing water to Lake Okeechobee (Potential impact to littoral zone and estuaries not evaluated)		

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
5	Regional ASR		Not as cost effective as storage or backpumping but should consider as the next increment		
6	Lake Hicpochee Reservoir	See Storage Reservoirs (1)	Most cost effective reservoir option for this sub-region - see Storage Reservoir (1)	See Storage Reservoirs (1)	
7	Additional Storage in C-43 adjacent to Moore Haven		Not cost effective		
8	Restore natural flows under San Carlos Bay/Sanibel Island causeway. (Raise roadway, add culverts, etc.)				No Conclusive findings - Bay circulation model needed to access impacts
IV	LAKE OKEECHOBEE				
1	New operating criteria	Limited opportunities for additional storage	Increasing Lake levels is most cost effective storage option (Potential impact to littoral zone and estuaries not evaluated)	Limited opportunities for additional storage	
2	Lake Okeechobee regional ASR	Limited benefits to Lake level management	Not cost effective compared to other Lake level management options		
3	Restoration of Kreamer, Torry and Ritta Islands		Middle of the road compared to increasing spatial extent in other sub-regions (quality not evaluated)		Possible HTRW contamination
V	EVERGLADES AGRICULTURAL AREA				
1	Storage Reservoirs	40,000 - 60,000 acres @ 6' optimum	20,000 acres @ 10 feet may give similar benefit as 40,000 @6' (However, Backpumping (4) more cost effective)	20,000 acres @ 8' modeled, storage option improves timing of flows to the Everglades and provided water supply benefits	

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
2	Regional ASR			Reservoir required to achieve benefit, technology at the scale proposed remains to be proven	
3	Water quality treatment facility to Lake Okeechobee (existing flows)		Kissimmee water treatment options more cost effective		
4	Backpump/treat additional EAA water to Lake Okeechobee		More cost effective than reservoir (Potential impact to littoral zone and estuaries not evaluated)		
VI	NORTH PALM BEACH COUNTY				
1	Southern L-8 Project			Effective in delivering water to North Palm Beach County and Loxahatchee Slough	
2	Re-use (M&I)				Should be considered with other local water utility options
3	Floridan Aquifer Blending (M&I)				Should be considered with other local water utility options
4	Utility ASR (M&I)			Maybe effective in meeting local needs but did not appear to have significant regional impact	
5	Regional ASR			Very effective in Palm Beach County on C-51 and Hillsboro (not evaluated North of C-51)	
6	New Lake Okeechobee Outlet and L-8 Improvements				Benefits uncertain - requires more detailed modeling
7	Wetland Enhancement of Pal Mar and Corbett				Pal Mar and Corbett are existing high quality wetlands that contribute to spatial extent

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
8	Improved operation of secondary and primary canal systems in 298 Districts			Requires site specific design	
9	C-17 Modifications				Project not defined - should improve water quality in Lake Worth Lagoon
VII	Palm Beach County				
1	Re-use (M&I)				Should be considered with other local water utility options
2	Floridan Aquifer Blending				Should be considered with other local water utility options
3	Utility ASR			Maybe effective in meeting local needs but did not appear to have significant regional impact	Very effective in Palm Beach County on C-51 and Hillsboro (not evaluated North of C-51)
4	Wellfield Expansion and Relocation			Very effective for coastal utilities with well fields at risk from salt water intrusion	
5	Regional ASR				
VIII	Broward County				
1	Re-use (M&I)				Should be considered with other local water utility options
2	Floridan Aquifer Blending				Should be considered with other local water utility options
3	Utility ASR			Maybe effective in meeting local needs but did not appear to have significant regional impact	
4	Wellfield Expansion and Relocation			Effective for coastal utilities with well fields at risk from salt water intrusion	

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
5	Regional ASR			North New River facility captures significant volume of water however, substantially exceeded basin demand	
6	Improved operation of secondary and primary canal systems in 298 Districts			Very effective in recharging aquifer near eastern wellfields in north and central Broward	
IX	Miami-Dade County				
1	Re-use (M&I)				Should be considered with other local water utility options
2	Floridan Aquifer Blending				Should be considered with other local water utility options
3	Utility ASR			Effective with large regional wellfields	
4	Wellfield Expansion and Relocation				May be needed to meet future demand
5	Regional ASR			L-31E facility effective but limited quantities of water to capture, should consider other basins (C-6)	
X	South Miami-Dade County and Biscayne Bay				
1	Environmental Deliveries to Biscayne Bay				No conclusive findings - more detailed analysis necessary
2	WPA - Model Lands and Biscayne Bay Coastal Wetland Preservation/ Restoration		Model Lands and Biscayne Bay coastal wetlands are most cost effective at increasing spatial extent (quality not evaluated)	Some benefit to south Dade utilities and overland flow to Biscayne Bay/Barnes Sound	Portions of Area K and M have high intrinsic value
3	WPA - Water Supply Storage				Potential impact to surrounding areas - need has not been identified

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
4	WPA - Water Quality Treatment Facilities				Must consider water quality treatment if runoff is used for restoration
5	Backfill C-111				Potential urban and agricultural flood impact - being revisited by SERA
XI	HOLEY LAND WILDLIFE MANAGEMENT AREA				
1	Rainfall driven schedule				No conclusive findings - more detailed analysis necessary
2	Reconnect with the WCAs				Must be evaluated with system-wide modeling
XI	ROTENBERGER WILDLIFE MANAGEMENT AREA				
1	Rainfall Driven Schedule				No conclusive findings - more detailed analysis necessary
2	Reconnect with the WCAs				Future "Without" project condition - Everglades Construction Project
XIII	WATER CONSERVATION AREA (General)				
1	Rainfall Driven Schedule			Very effective method to restoring more natural hydroperiod	
2	Cross-WCA aqueduct(s) (EAA to LEC and LEC to EAA)				No conclusive findings
3	Removal of Levees between WCAs				Must be evaluated with more detailed modeling
4	Overland Flow Berms (adjustable/ removable) within the WCAs				Must be evaluated with more detailed modeling
XIII(1)	LOXAHATCHEE NWR (Water Conservation Area 1 - Service Area 1)				
1	Rainfall Driven Schedule			Very effective method to restoring more natural hydroperiod	

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
2	WPA - Wetland Preservation/ Restoration	Retains water by reducing seepage from WCA	Not cost effective for spatial extent as compared to wetlands in other regions (quality not evaluated)		Area B has high intrinsic value, cypress dome (NAS)
3	WPA - Water Supply Storage	1639 acres @ 6' in Hillsboro Basin very effective – consider additional 900 acres in C-18 Basin (ASR could reduce acreage)	Area E most cost effective for sub-region – Area E and C may be needed to reach target	Significant amount of water could be captured and backpumped to Site 1 Reservoir	
4	WPA - Water Quality Treatment Facilities				Must consider water quality treatment if backpumping to WCAs or adjacent wetlands
5	Seepage Barrier	Effective at retaining water in WCA – potential impact to coastal wellfields & estuaries not evaluated	Not cost effective compared to seepage collection		
6	Seepage Collection		Cost effective at retaining water in regional system		
XIII (2A/2B)	WATER CONSERVATION AREA 2A/2B (Service Area 2)				
1	Rainfall Driven Schedule			Very effective method to restoring more natural hydroperiod	
2	New schedule for flood attenuation into 3A.				Unacceptable environmental impact - should be considered as a last increment
3	Seepage Barrier	Effective at retaining water in WCA – potential impact to coastal wellfields & estuaries not evaluated	Not cost effective compared to seepage collection		
4	Seepage Collection		Cost effective at retaining water in regional system		
5	Step-down levee system inside WCA 2B		Not as cost effective as seepage collection		

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
XIII (3A/3B)	WATER CONSERVATION AREA 3A/3B (Service Area 2)				
1	Rainfall Driven Schedule			Very effective method to restoring more natural hydroperiod	
2	Sheet Flow Distribution System for flows into WCA-3A			ECP addressing flows from EAA - flows from 2A require more detailed modeling	
3	WPA - Wetland Preservation/ Restoration	Retains water by reducing seepage from WCA	Area A most cost effective in sub-region – however, other spatial extent options are more cost effective (quality not evaluated)	Sites retain water by reducing seepage from WCA	Portions of A, B, C, H have high intrinsic value
4	WPA - Water Supply Storage	2,900 acres @ 4' in C-11 Basin effective	Area A most cost effective in sub-region – impact to high quality wetlands - Area D, H, I the next potential storage sites that would avoid impact		
5	WPA - Water Quality Treatment Facilities				Water quality treatment must be addressed in this sub-region - S-9 Critical Project under study
6	Seepage Barrier	Effective at retaining water in WCA – potential impact to coastal wellfields & estuaries not evaluated	Not cost effective compared to seepage collection	Effective at retaining water in WCA - impact to coastal wellfields & estuaries	
7	Seepage Collection	Effective at retaining water in WCA	Cost effective at retaining water in regional system		
XIII(3B)	WATER CONSERVATION AREA 3B (Service Area 3 - Lake Belt Area)				
1	WPA - Wetland Preservation/ Restoration		Area B (Pennsuco) most cost effective for sub-region – also cost effective compared to other regions (quality not evaluated)	Increasing hydroperiods in Pennsuco retains waters in WCA 3B	Portions of A, B and C have high intrinsic value

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
2	WPA - Water Supply Storage	2,900 acres @4' in C-6/C-4 Basin effective	Area B most cost effective (however, impact to wetlands) - A portion of Area A would be next most cost effective	Bath-tub concept in Lake Belt effective storage mechanism	
3	WPA - Water Quality Treatment Facilities				Must consider water quality treatment if backpumping to WCAs or adjacent wetlands
4	Seepage Barrier	Effective at retaining water in WCA – potential impact to coastal wellfields & estuaries not evaluated	Not cost effective	Effective at retaining water in WCA - impact to coastal wellfields & estuaries	
5	Seepage Collection	Effective at retaining water in WCA	Cost effective at retaining water in regional system		
6	WPA - Bathtub reservoirs in part of excavated Lake Belt.				May be only means of achieving storage in this sub-region
7	Additional structures in western C-4 and C-6 canals			Should be first increment to reduce seepage from Pennsuco and improving flows to ENP	
XIV	BIG CYPRESS				
1	Rainfall driven deliveries			Very effective method to restoring more natural hydroperiod	
2	Gap southern levee of L-28 interceptor				Water quality concerns - treatment needed for this drainage basin (see Tribal Lands)
3	Enhance sheetflow within Preserve (Loop Road and Tamiami Trail modifications)				Presently under study
4	Reservoir off the Caloosahatchee to supply headwater to Mullet Slough				No conclusive findings - project not defined

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
5	Restoration of Southern Golden Gate Estates		Most cost effective at increasing spatial extent (quality not evaluated)		High ecological values
6	Restoration of Belle Meade and Fakahatchee Strand				No conclusive findings - project not defined
XV	TRIBAL LANDS Adjacent to WCAs				
1	Flood control improvements adjacent to I-75 between L-28 and L-28 interceptor				Adverse impact on surrounding wetlands - area could be used as an STA for L-28 interceptor water
2	Water quality feature north of tribal lands (Feeder Canal)				Project needs to address high nutrient levels entering WCA 3
3	Seminole Water Conservation Project				Conceptual project needs further study
XVI	EVERGLADES NATIONAL PARK				
1	Rainfall-driven deliveries			Very effective method to restoring more natural hydroperiod	
2	Enhance distribution (east-west) of flows into ENP			Future "Without" Project condition - Mod Water Deliveries	
3	Elevate low sections Tamiami Trail (below 3B) and Flamingo Road (bridges)				Detailed modeling required to evaluate
4	Gap or remove L-67 extension (function)			Future "Without" Project condition - Mod Water Deliveries	
5	WPA - Wetland Preservation/ Restoration		Area E (Bird Drive Basin) most cost effective for this sub-region (quality not evaluated)		Portions of Areas F and G have high intrinsic value

	Geographic Area/ Components	Everglades Screening Model	Cost Effectiveness Analysis	Lower East Coast Regional Water Supply Plan	Other Analysis or Best Professional Judgment
6	WPA - Water Supply Storage and Conveyance Improvements	Conveyance and seepage management critical	Area G and F most cost effective		
7	WPA - Water Quality Treatment Facilities				Must consider water quality treatment if backpumping to ENP
8	WPA - Isolated Seepage Recovery Plan 8.5 Square Mile Area				Detailed evaluation underway
9	Seepage Barriers		As cost effective as seepage collection	Effective at retaining water in N.E. Shark River Slough - impact to coastal wellfields & estuaries	
10	Seepage Collection	As cost effective as seepage barriers			
XVII	FLORIDA BAY and FLORIDA KEYS				
1	Buttonwood Embankment modifications				No conclusive findings - insufficient data
2	Removal of causeways between Keys				No conclusive findings - need Florida Bay circulation model

Table 6
SCREENING FINDINGS

KISSIMMEE RIVER BASIN
• Storage reservoirs effective for Lake level management
• Water quality treatment very cost effective for improving Lake Okeechobee
• Paradise Run most cost effective way to increase spatial extent of wetlands in this basin
UPPER EAST COAST
• Storage reservoirs for C-44 Basin effective to improve estuary conditions
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, impacts to Lake's littoral zone were not evaluated
• Adding Aquifer Storage & Recovery to storage reservoirs should be considered
• Opportunities to increase spatial extent of wetlands in this basin
• C-23, C-24, and C-25 Basins being considered in detail as part of Indian River Lagoon Study
CALOOSAHATCHEE RIVER BASIN
• Storage reservoirs effective.
• Lake Hicpochee should be considered as first increment for storage
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, impacts to Lake's littoral zone were not evaluated
• Adding Aquifer Storage & Recovery to storage reservoirs should be considered
LAKE OKEECHOBEE
• Increases to Lake levels cost effective; however, impacts to Lake's littoral zone were not evaluated
• Regional Aquifer Storage & Recovery not cost effective in this area for lake level management
EVERGLADES AGRICULTURAL AREA
• Storage reservoirs effective
• Increased backpumping of treated water to Lake Okeechobee cost effective; however, impacts to Lake's littoral zone were not evaluated
WATER CONSERVATION AREAS
• Detailed modeling required to evaluate components to reconnect habitats
• Rainfall driven delivery schedules are needed to achieve hydropattern restoration
LOWER EAST COAST
• Southern L-8 project effective in delivering water to North Palm Beach County and Loxahatchee Slough
• Urban Water Supply: (depending on location) wellfield relocation/expansion, utility Aquifer Storage & Recovery, and secondary canal operations are effective
• Regional Aquifer Storage & Recovery is very effective on C-51 and Hillsboro canals
• Opportunities to increase spatial extent of wetlands in Northern Palm Beach County, Model Lands, and Biscayne Bay coastal areas
BIG CYPRESS
• Restoration of southern Golden Gate Estates very cost effective to increase spatial extent of wetlands
WATER PRESERVE AREAS
• Storage reservoirs adjacent to Water Conservation Areas effective in a number of basins
• Aquifer Storage & Recovery should be considered to reduce size of storage reservoirs
• Seepage collection and backpumping generally most cost effective seepage management component
• Water quality treatment needed if drainage water is backpumped to natural areas
• Opportunities to increase spatial extent of wetlands

APPENDIX A2

COST EFFECTIVENESS SCREENING ANALYSIS

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APPENDIX A2
COST EFFECTIVENESS SCREENING ANANLYSIS

A2.1 INTRODUCTION

The Restudy defines “components” as conceptual project features (or options) intended to achieve particular planning objectives. The plan formulation phase of the Restudy would look at combining these components into alternative comprehensive plans. At the Restudy’s start, the initial list of potential components numbered 112. If the Restudy were to develop every possible combination of these initial components, the number of possible alternative comprehensive plans would number approximately 5.19×10^{33}. Because it was impossible to look at that many plans, the preliminary screening phase was designed to provide information to support decisions regarding which components to include in a more discrete range of comprehensive plans.

Cost effectiveness analysis was used in the Restudy as a tool in the preliminary screening phase. In the preliminary screening phase, information gained through the cost effectiveness analysis was joined with information from hydrologic optimization modeling and information gained through previous studies to support best professional judgement in the selection of specific project components. This screening phase aimed to identify which components (from the initial list of potential project components) would be carried forward in the development of alternative comprehensive plans.

A2.2 DEVELOPMENT OF COMPONENTS AND MANAGEMENT MEASURES

The development of the initial list of components began in January 1996, when the Restudy Team met to review and discuss a broad range of ideas from the Reconnaissance Study and other related efforts such as the South Florida Water Management District’s Lower East Coast Regional Water Supply Plan. These ideas or “components” were listed, described, and linked to Restudy planning objectives. The list of potential components was then considered and refined by the Governor’s Commission for a Sustainable South Florida when they developed their Conceptual Plan for the Restudy. The Restudy Team met again in November 1996 to design a formulation and evaluation strategy for comprehensive plans. Subsequently, a draft document entitled *Restudy Plan Formulation* was produced, outlining the Restudy goals and planning objectives and listing the components to be evaluated with a brief description of each. The Restudy Plan Formulation document was reviewed by the Restudy Team and was the basis of a series of stakeholder focus group meetings. These meetings helped to ensure that most stakeholders were satisfied with the components to be considered and the strategy for formulating and evaluating the different comprehensive plans.

Of the 112 components in the initial list, 47 had sufficient known detail to compile cost and output estimates for cost effectiveness analysis. The other 65 components were screened using findings from other studies or best professional judgement. Considering different sizes and scales of the 47 components, 58 specific management measures were designed and modeled, providing the necessary data for their examination through cost effectiveness analysis.

Where the Restudy defined a "component" as a *conceptual* project feature intended to achieve a particular planning objective, a "management measure" was defined as a *specific* action, project feature or project modification intended to achieve a particular planning objective. Multiple management measures might address a single component. For example, the initial list of components included the component "Wetland Detention Areas"; specific management measures addressing this component included a "Detention Area at Yates Marsh", and a "Detention Area at Maple River Marsh". Management measures were further broken down into "scales", defined as ranges of specific designs for a management measure. For example, the management measure "Lake Okeechobee Regional ASR" included the scales "25 wells," "50 wells," "75 wells," and "100 wells." Components, management measures, and scales are summarized in ***Table 1***.

Table 1: Terminology

TERM	MEANING	EXAMPLE
Components	Conceptual Project Features	Water Storage Area
Management Measures	Specific Project Features	Storage Reservoir in the Everglades Agricultural Area
Scales	Specific Designs of Management Measure	20,000 acres at 6 and 10 feet 40,000 acres at 6 and 10 feet 60,000 acres at 6 and 10 feet

For the Cost Effectiveness Analysis, components of the Water Preserve Areas were identified by an alpha-numeric designation due to the sheer number of options and the range of possible sites. Refer to the site maps that follow on pages A2-4 through A2-7. This 5 digit designation is broken down as follows:

Example – SA1AC
The first three digits (SA1) represents a geographic region known as the Lower East Coast service areas. In this instance SA1 represents Service Area 1. The fourth digit (A) represents a specific site within the service area, as depicted on Figures 1-4. The fifth digit is the functional use of the site (A- wetland preservation/restoration, B- deep water storage, C- shallow water storage). Occasionally, partial areas were considered. These sub-areas were

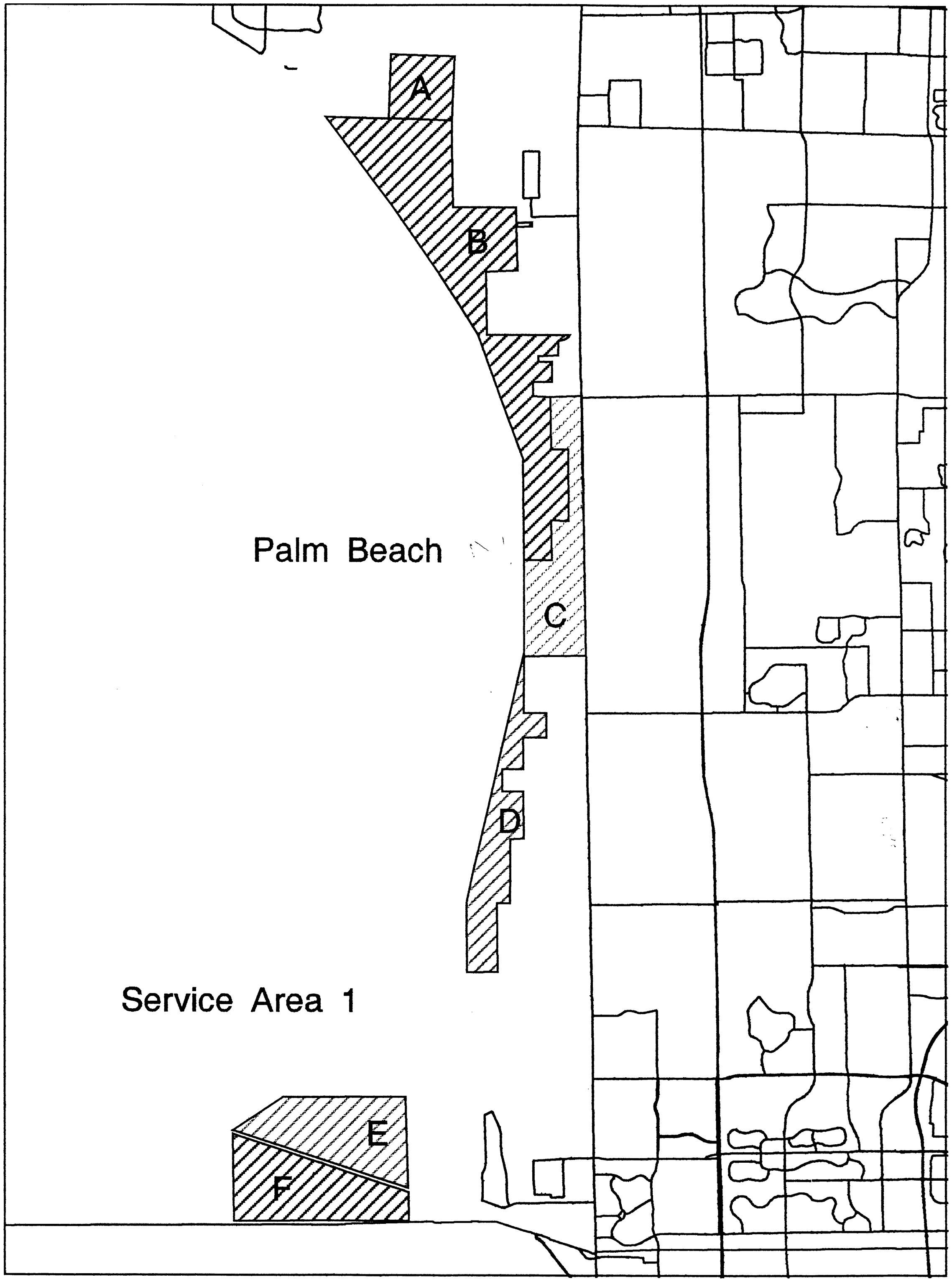
designated by an additional digit of .0 – .3; depending on the number of sub-areas considered.

Cost effectiveness analysis was chosen to compare and prioritize the management measures based upon both the cost and the output of each measure; and to look at the variations in cost and output across combinations of management measures. The Restudy examined 58 different management measures (with a total of 174 scales) through cost effectiveness analysis. All possible combinations of these measures numbered 6.2 $X10^{27}$. Because it was impossible to look at this many combinations in the screening phase, all measures were grouped into functional categories and cost effectiveness analyses were conducted for each functional category. Each functional category had a different objective or "desired effect". The seven functional categories and their respective desired effects are listed in ***Table 2.***

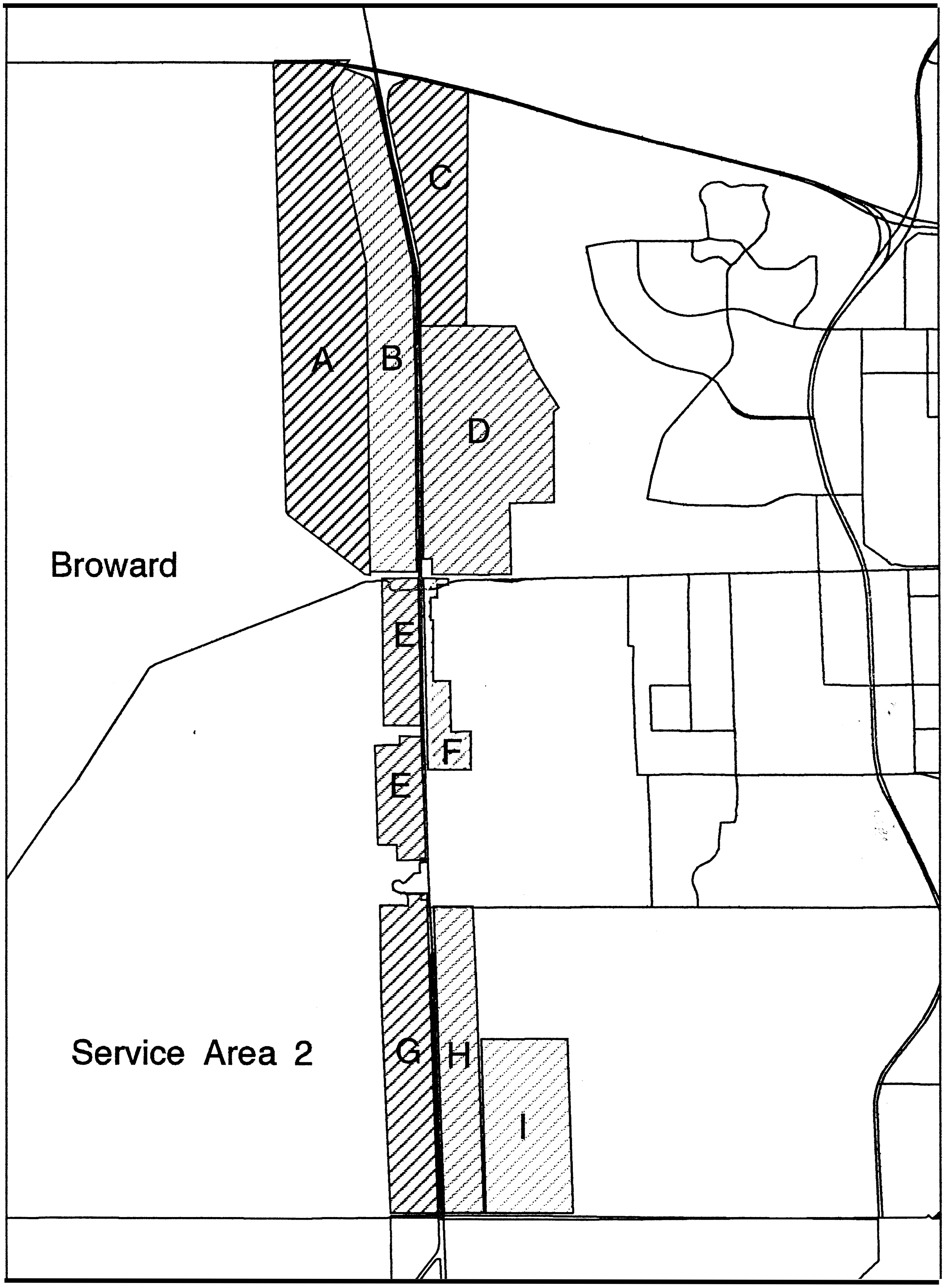
A2.3 INFORMATION FOR DECISION MAKING

Grouping the management measures into functional categories allowed the cost effectiveness screening to compare "apples to apples". For example, Table 1 shows that in "Function A – Improve Quality of Lake Okeechobee Inflows" the desired effect is "reduced phosphorous loading" which is measured in the unit "tons of phosphorous". By passing all measures aimed at reducing phosphorous loading into Lake Okeechobee through a common cost effectiveness analysis, information was identified to support selecting, or not selecting, particular Function A measures for inclusion in the development of comprehensive (multi-functional area) plans. The information gained through the analysis identified the relative efficiency and effectiveness of different measures (and combinations of measures) aimed at reducing phosphorus loading.

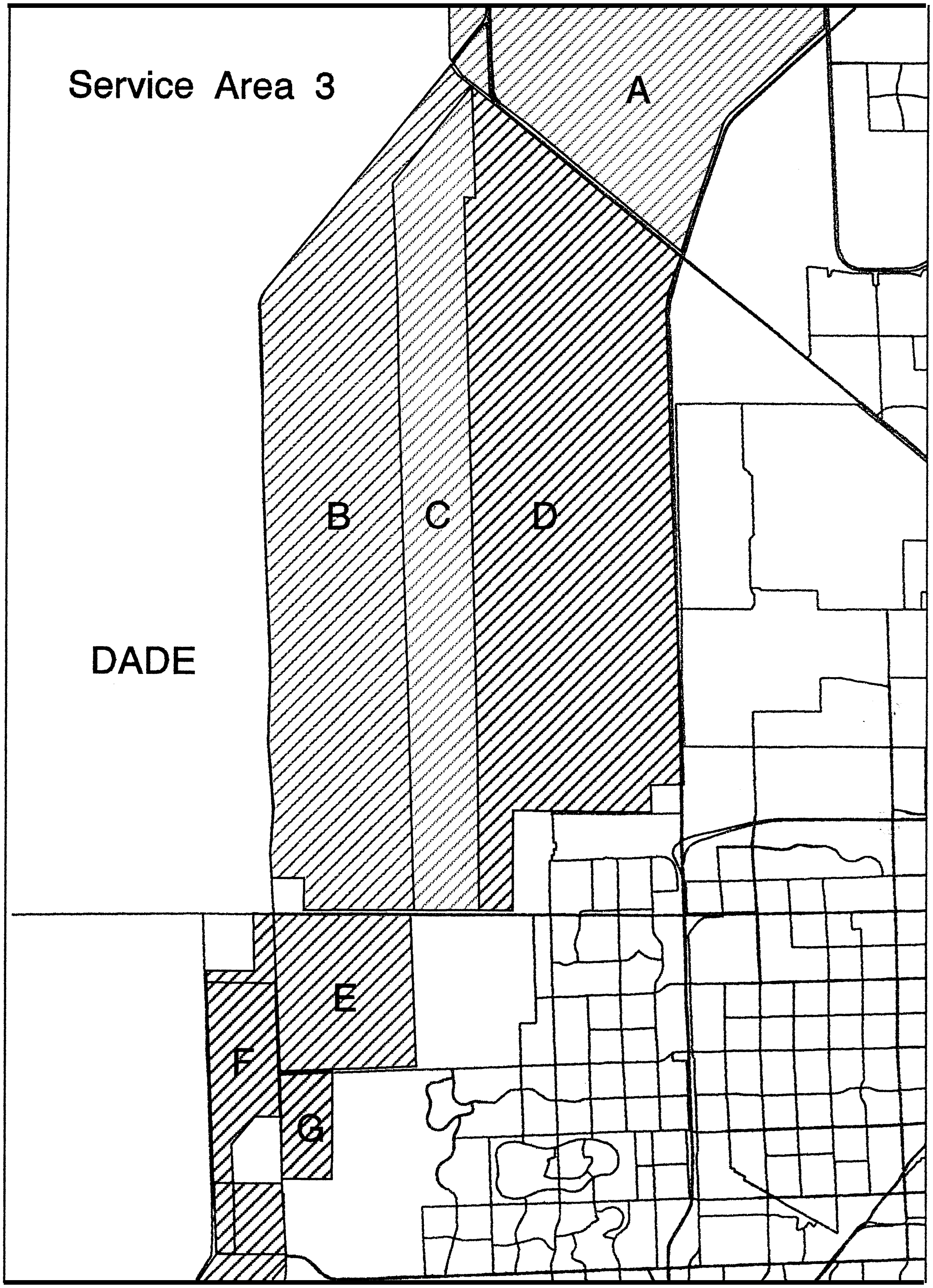
A similar analysis was applied in each remaining functional category. The results of these analyses provided information to support the selection of individual measures (and combinations of measures) for further evaluation, helping to assure the development of alternative comprehensive plans that are good financial investments.



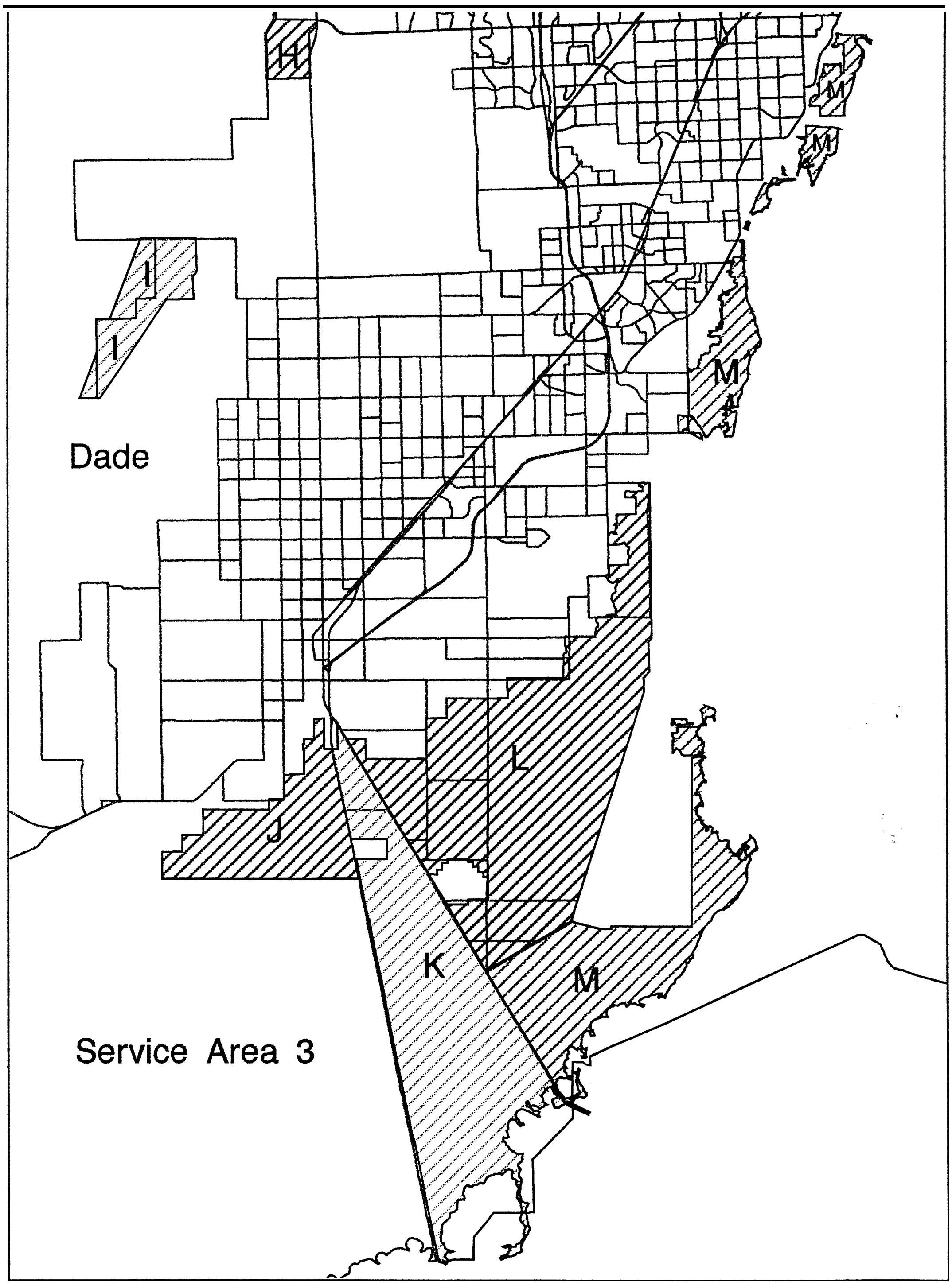
Water Preserve Areas
Site Maps
Service Area 1



Water Preserve Areas
Site Maps
Service Area 2



Water Preserve Areas
Site Maps
Service Area 3 (Miami-Dade County)



Water Preserve Areas

Site Maps

Service Area 3 (South Miami-Dade County)

Table 2: Output Measurement Units for Each Functional Category

FUNCTIONAL CATEGORY	DESIRED EFFECT (unit of measure)
Function A – Improve Quality of Lake Okeechobee Inflows	Reduced Phosphorous Loading (tons)
Function B – Manage Lake Okeechobee Water Levels	Reduced Regulatory Releases (acre-feet)
Function C – Provide Additional Water Storage Capability within Lake Okeechobee	Increased Net Inflows to Lake (acre-feet)
Function D – Increase Regional Water Supply in Lower East Coast Area	Reduced Demand on Existing System (acre-feet)
Function E – Increase Spatial Extent Of Wetlands	Restored or Preserved Wetlands (acres)
Function F – Increase Everglades Protection Area Inflows from Everglades Agricultural Area	Increased Storage Capacity in EAA (acre-feet)
Function G – Reduce Seepage	Increased Water Retained in EPA (acre-feet)

Two different levels of cost effectiveness information were derived for each functional area. The first level of information concerned the relative production efficiency of all individual scales of measures within each functional category. The second level of information concerned the relative production efficiency across all possible combinations of management measures within each category. The two types of information supported different types of decisions.

The information related to the production efficiency of individual measures was used in the preliminary screening to identify what measures were better investments than others at producing a given type of output. This information was used to support best professional judgement regarding what measures made it into subsequent iterations of comprehensive plan formulation.

A2.4 COST EFFECTIVENESS ANALYSIS DATA REQUIREMENTS

The cost effectiveness analyses required cost and benefit (or “output”) estimates for each management measure. Monetary cost estimates were developed for construction, real estate, and operation and maintenance costs and are displayed in ***Table 3*** in average annual equivalent terms. The nonmonetary output estimates for different functional areas were derived through a variety of models (described below) and are displayed in average annual terms.

Table 3 Preliminary Cost And Output for Components

	Management Function and Measures	IWR-Plan Designation	Unit of Measure (Average Annual)	Construction Cost ($)	Real Estate Cost ($)	Total Capital Cost ($)	Annual O&M ($1,000)	Annual Cost ($1,000)
A	**Improve quality of Lake Okeechobee inflows**		**Phosphorus (tons)**					
	KISSIMMEE RIVER AREA							
	Wetland Detention Areas							
	Maple River Marsh	A1	5.7	$1,408,000	$4,900,000	$6,308,000	$2	$481
	Yates Marsh	B1	5.1	$2,388,000	$5,600,000	$7,988,000	$2	$608
	Taylor Creek/Nubin Slough	C1	9.0	$2,409,375	$400,000	$2,809,375	$22	$236
	UPPER EAST COAST/ST. LUCIE AND MARTIN COUNTIES							
	Water Quality Treatment of existing flows from C-44 to Lake Okeechobee							
	50% Influent	D1	5.9	$38,519,000	$6,955,000	$45,474,000	$509	$3,961
	100% Influent	D2	11.1	$78,098,000	$14,603,000	$92,701,000	$1,012	$8,049
	CALOOSAHATCHEE							
	Water quality treatment of existing flows from C-43 to Lake Okeechobee							
	50% Influent	E1	2.8	$38,572,000	$4,003,000	$42,575,000	$507	$3,739
	100% Influent	E2	5.6	$42,169,000	$7,231,000	$49,400,000	$510	$4,260
	EVERGLADES AGRICULTURAL AREA							
	Water quality treatment facility to Lake Okeechobee (existing flows)							
	50% Influent	F1	1.9	$8,100,000	$2,753,000	$10,853,000	$85	$909
	100% Influent	F2	4.2	$14,789,000	$6,703,000	$21,492,000	$169	$1,800
B	**Improve management of Lake Okeechobee water levels**		**Acre-Feet**					
	KISSIMMEE RIVER AREA							
	Storage Reservoirs							
	10,000 Acres/4 feet	A1	6,619	$27,232,543	$29,599,000	$56,831,543	$160	$4,474
	10,000 Acres/8 feet	A2	12,773	$55,201,000	$29,599,000	$84,800,000	$310	$6,748
	10,000 Acres/12 feet	A3	18,927	$67,051,000	$29,599,000	$96,650,000	$880	$8,217
	20,000 Acres/4 feet	A4	12,773	$38,308,000	$64,300,000	$102,608,000	$318	$8,108
	20,000 Acres/8 feet	A5	25,080	$72,101,000	$64,300,000	$136,401,000	$598	$10,953
	20,000 Acres/12 feet	A6	37,388	$108,151,000	$64,300,000	$172,451,000	$888	$13,980
	30,000 Acres/4 feet	A7	18,927	$51,838,000	$96,032,000	$147,870,000	$465	$11,690
	30,000 Acres/8 feet	A8	37,388	$135,890,000	$96,032,000	$231,922,000	$895	$18,501
	30,000 Acres/12 feet	A9	53,536	$221,829,000	$96,032,000	$317,861,000	$1,325	$25,455
	LAKE OKEECHOBEE							
	New operating criteria							
	.5 feet Rise in Existing Schedule	B1	35,080	$0	$0	$0	$0	$0
	1 Foot Rise	B2	63,920	$32,344,000	$0	$32,344,000	$40	$2,495
	2 Feet Rise	B3	115,843	$247,877,000	$0	$247,877,000	$100	$18,917
	Lake Okeechobee regional ASR							
	25 wells	C1	7,615	$50,000,000	$1,077,000	$51,077,000	$1,250	$5,127
	50 wells	C2	14,764	$100,000,000	$27,010,000	$127,010,000	$2,500	$12,142
	75 wells	C3	21,914	$150,000,000	$36,800,000	$186,800,000	$3,750	$17,931
	100 wells	C4	29,063	$200,000,000	$59,610,000	$259,610,000	$5,000	$24,708
C	**Additional Lake Okeechobee water supply capability (water otherwise to tide)**		**Acre-Feet**					
	UPPER EAST COAST/ST. LUCIE AND MARTIN COUNTIES							
	Storage Reservoirs (C-44)							
	2,500 Acres/8 feet	A1	14,671	$15,763,000	$18,314,000	$34,077,000	$95	$2,682
	5,000 Acres/8 feet	A2	22,575	$24,486,000	$28,840,000	$53,326,000	$176	$4,224
	10,000 Acres/4 feet		19,056	$22,490,000	$57,680,000	$80,170,000	$170	$6,256
	10,000 Acres/8 feet	A3	27,974	$43,980,000	$57,680,000	$101,660,000	$350	$8,068
	10,000 Acres/12 feet	A4	30,684	$69,510,000	$57,680,000	$127,190,000	$460	$10,116
	20,000 Acres/4 feet		25,500	$38,825,000	$158,536,000	$197,361,000	$318	$15,301
	20,000 Acres/8 feet	A5	31,433	$77,729,000	$158,536,000	$236,265,000	$598	$18,534

Management Function and Measures		IWR-Plan Designation	Unit of Measure (Average Annual)	Construction Cost ($)	Real Estate Cost ($)	Total Capital Cost ($)	Annual O&M ($1,000)	Annual Cost ($1,000)
	20,000 Acres/12 feet	A6	31,926	$117,243,000	$158,536,000	$275,779,000	$888	$21,824
	30,000 Acres/4 feet		29,468	$51,163,000	$259,569,000	$310,732,000	$465	$24,054
	30,000 Acres/8 feet	A7	31,401	$104,820,000	$259,569,000	$364,389,000	$895	$28,557
	30,000 Acres/12 feet	A8	31,932	$170,103,000	$259,569,000	$429,672,000	$1,325	$33,943
	On-site Detention Facility (C-44)							
	30 Sites 64 acres each	B1	8,866	$46,260,000	$18,314,000	$64,574,000	$648	$5,550
	Backpump C-23, 24, 25 to Lake Okeechobee							
	10,000 Acre Facility	C1	108,100	$94,987,000	$126,615,000	$221,602,000	$445	$17,268
	Backpump C-44 to Lake Okeechobee (additional flows)							
	1,000 acre Site	D1	59,100	$19,506,000	$7,210,000	$26,716,000	$207	$2,235
	2,500 acre Site	D2	100,600	$53,125,000	$14,420,000	$67,545,000	$612	$5,739
	5,000 acre Site	D3	122,300	$84,850,000	$28,840,000	$113,690,000	$1,016	$9,647
	Regional ASR							
	4 Wells (2,500 acre Res)	E1	18,759	$20,363,000	$18,402,000	$38,765,000	$295	$3,238
	4 Wells (5,000 acre Res)	E2	24,590	$29,086,000	$28,928,000	$58,014,000	$376	$4,780
	8 Wells (2,500 acre Res)	E3	22,575	$24,963,000	$18,490,000	$43,453,000	$495	$3,794
	8 Wells (5,000 acre Res)	E4	27,581	$33,686,000	$29,016,000	$62,702,000	$576	$5,336
	16 Wells (2,500 acre Res)	E5	27,310	$34,163,000	$18,666,000	$52,829,000	$895	$4,905
	16 Wells (5,000 acre Res)	E6	30,758	$42,886,000	$29,192,000	$72,078,000	$976	$6,448
	33 Wells (2,500 acre Res)	E7	31,192	$53,713,000	$19,040,000	$72,753,000	$1,745	$7,268
	33 Wells (5,000 acre Res)	E8	31,102	$62,436,000	$29,566,000	$92,002,000	$1,826	$8,810
	CALOOSAHATCHEE							
	Storage Reservoirs							
	5,000 Acres/4 feet	F1	51,702	$14,088,000	$18,684,000	$32,772,000	$86	$2,573
	5,000 Acres/8 feet	F2	68,401	$26,004,000	$18,684,000	$44,688,000	$157	$3,550
	5,000 Acres/12 feet	F3	78,796	$41,075,000	$18,684,000	$59,759,000	$228	$4,765
	10,000Acres/4 feet	F4	68,401	$22,781,000	$51,361,000	$74,142,000	$165	$5,794
	10,000 Acres/8 feet	F5	87,891	$44,448,000	$51,361,000	$95,809,000	$306	$7,579
	10,000 Acres/12 feet	F6	97,577	$59,794,000	$51,361,000	$111,155,000	$449	$8,887
	20,000 Acres/4 feet	F7	87,891	$36,248,000	$104,865,000	$141,113,000	$314	$11,027
	20,000 Acres/8 feet	F8	102,114	$67,494,000	$104,865,000	$172,359,000	$600	$13,685
	20,000 Acres/12 feet	F9	104,238	$100,609,000	$104,865,000	$205,474,000	$886	$16,485
	On-site Detention							
	30 Sites @64 acres each	G1	31,636	$50,610,000	$8,006,000	$58,616,000	$648	$5,098
	Backpump C-43 to Lake Okeechobee (additional flow)							
	2,500 acre Site	H1	231,200	$37,854,000	$9,342,000	$47,196,000	$412	$3,995
	5,000 acre Site	H2	427,200	$106,997,000	$18,684,000	$125,681,000	$1,316	$10,857
	7,500 acre Site	H3	505,200	$168,009,000	$60,703,000	$228,712,000	$2,019	$19,381
	Regional ASR							
	4 Wells	I1	8,951	$8,600,000	$88,000	$8,688,000	$200	$860
	8 Wells	I2	15,468	$17,200,000	$176,000	$17,376,000	$400	$1,719
	w/5,000 Acres/4 feet	I3	62,824	$31,288,000	$18,860,000	$50,148,000	$486	$4,293
	16 Wells	I4	27,638	$34,400,000	$352,000	$34,752,000	$800	$3,438
	w/5,000 Acres/8 Feet	I5	84,946	$60,404,000	$19,036,000	$79,440,000	$957	$6,988
	w/10,000 Acres/8 feet	I6	97,211	$78,848,000	$51,713,000	$130,561,000	$1,263	$11,175
	33 Wells	I7	48,307	$70,950,000	$726,000	$71,676,000	$1,650	$7,091
	w/5,000 Acres/4 feet	I8	86,611	$85,038,000	$19,410,000	$104,448,000	$1,736	$9,665
	w/5,000 Acres/8 feet	I9	94,363	$96,954,000	$19,410,000	$116,364,000	$1,893	$10,726
	65 Wells	Z1	76,810	$139,750,000	$1,430,000	$141,180,000	$3,250	$13,967
	w/5,000 Acres/4	Z2	97,520	$153,838,000	$20,114,000	$173,952,000	$3,336	$16,541
	w/5,000 Acres/8 feet	Z3	101,814	$165,754,000	$20,114,000	$185,868,000	$3,493	$17,603
	Lake Hicpochee Reservoir	J1	51,702	$6,954,000	$5,099,000	$12,053,000	$57	$972
	Additional Storage in C-43 adjacent to Moore Haven	K1	582	$4,855,000	$0	$4,855,000	$0	$369
D	**Additional regional water source (Lower East Coast)**		**ACRE-FEET**					
	LOXAHATCHEE NWR (Water Conservation Area 1 - Service Area 1)							

	Management Function and Measures	IWR-Plan Designation	Unit of Measure (Average Annual)	Construction Cost ($)	Real Estate Cost ($)	Total Capital Cost ($)	Annual O&M ($1,000)	Annual Cost ($1,000)
	WPA - Water Supply Storage							
	SA1AC	B1	15,700	$6,972,000	$23,516,832	$30,488,832	$61	$2,375
	SA1CB	B2	19,957	$25,112,000	$21,519,000	$46,631,000	$229	$3,769
	SA1EB	B3	32,475	$20,834,000	$27,068,085	$47,902,085	$199	$3,836
	SA1CB+SA1EB	B4	35,932	$45,946,000	$48,587,085	$94,533,085	$429	$7,605
	SA1AC+SA1CB+SA1EB	B5	37,932	$52,918,000	$72,103,917	$125,021,917	$489	$9,980
	WATER CONSERVATION AREA 3A/3B (Service Area 2)							
	WPA - Water Supply Storage							
	SA2AB	C1	57,144	$24,804,000	$60,247,626	$85,051,626	$260	$6,716
	SA2DB.0	C2	40,000	$16,848,000	$75,645,115	$92,493,115	$180	$7,202
	SA2DB.1	C3	32,000	$12,217,000	$45,945,410	$58,162,410	$125	$4,540
	SA2EB	C4	28,526	$10,676,000	$30,400,930	$41,076,930	$100	$3,218
	SA2FC	C5	10,050	$6,346,000	$21,385,990	$27,731,990	$54	$2,159
	SA2GB	C6	35,109	$12,352,000	$42,791,776	$55,143,776	$122	$4,308
	SA2HB	C7	27,000	$11,018,000	$36,285,174	$47,303,174	$105	$3,696
	SA2IB.0	C8	31,000	$10,557,000	$42,826,880	$53,383,880	$107	$4,160
	SA2IB.1	X1	19,500	$6,195,000	$21,273,024	$27,468,024	$60	$2,145
	SA2AB+DB.1	X2	66,644	$37,021,000	$106,193,036	$143,214,036	$384	$11,256
	SA2AB+EB	X3	67,170	$35,480,000	$90,648,556	$126,128,556	$359	$9,934
	SA2AB+IB.1	X4	61,644	$30,999,000	$81,520,650	$112,519,650	$319	$8,861
	SA2DB.0+EB	X5	52,026	$27,524,000	$106,046,045	$133,570,045	$280	$10,420
	SA2DB.0+IB.0	X6	52,000	$27,405,000	$118,471,995	$145,876,995	$288	$11,362
	SA2AB+DB.0+IB.0	X7	74,644	$52,209,000	$178,719,621	$230,928,621	$548	$18,078
	SA2DB.0+EB+GB+HB+IB.0	X8	73,635	$61,451,000	$227,949,875	$289,400,875	$615	$22,584
	WATER CONSERVATION AREA 3B (Service Area 3 - Lake Belt Area)							
	WPA - Water Supply Storage							
	SA3AB.0	D1	50,106	$44,941,000	$43,481,880	$88,422,880	$560	$7,273
	SA3AB.1	D2	44,500	$30,384,000	$24,435,216	$54,819,216	$362	$4,523
	SA3BC.1	D3	31,717	$7,942,000	$7,851,018	$15,793,018	$162	$1,361
	SA3CB.0	D4	43,000	$54,744,000	$165,978,752	$220,722,752	$650	$17,406
	SA3CB.1	D5	44,500	$43,645,000	$124,371,184	$168,016,184	$512	$13,267
	SA3CB.2	D6	36,000	$15,003,000	$41,607,568	$56,610,568	$175	$4,472
	SA3CB.3	D7	43,000	$39,870,000	$85,833,952	$125,703,952	$442	$9,985
	SA3AB.1+BC.1	D8	55,435	$38,326,000	$32,286,234	$70,612,234	$524	$5,885
	SA3AB.1+CB.2	D9	44,000	$45,387,000	$66,042,784	$111,429,784	$536	$8,995
	SA3BC.1+CB.2	Y1	48,217	$22,945,000	$49,458,586	$72,403,586	$337	$5,833
	SA3BC.1+CB.3	Y2	50,217	$47,812,000	$93,684,970	$141,496,970	$604	$11,346
	EVERGLADES NATIONAL PARK							
	WPA - Water Supply Storage and Conveyance Improvements							
	SA3EB.0	E1	12,000	$20,060,000	$9,373,266	$29,433,266	$242	$2,476
	SA3EB.1	E2	12,200	$12,351,000	$4,675,230	$17,026,230	$142	$1,435
	SA3FB	E3	8,500	$10,017,000	$2,783,621	$12,800,621	$109	$1,080
	SA3FC	E4	12,000	$7,451,000	$4,291,552	$11,742,552	$143	$1,034
	SA3GC	E5	7,900	$4,399,000	$3,713,120	$8,112,120	$50	$666
	SA3HB	E6	9,500	$9,291,000	$7,248,428	$16,539,428	$106	$1,361
	SA3IC	E7	12,000	$13,482,000	$13,347,393	$26,829,393	$161	$2,198
	SA3EB.1+FB	E8	12,100	$22,368,000	$7,458,851	$29,826,851	$251	$2,515
	SA3EB.1+FC	E9	12,000	$19,802,000	$8,966,782	$28,768,782	$285	$2,469
	SA3FB+GC	Z1	12,100	$14,416,000	$6,496,741	$20,912,741	$159	$1,746
	SA3FC+GC	Z2	12,000	$11,850,000	$8,004,672	$19,854,672	$193	$1,700
	SA3GC+HB	Z3	12,100	$13,690,000	$10,961,548	$24,651,548	$156	$2,027
E	**Increase spatial extent of wetlands**		**ACRES**					
	KISSIMMEE RIVER AREA							
	Pool A Restoration	A1	2,590	$9,969,000	$5,219,000	$15,188,000	$0	$1,153
	Pool E Restoration	B1	2,718	$1,943,000	$37,000,000	$38,943,000	$6	$2,962
	Paradise Run	C1	3,600	$1,761,000	$8,511,000	$10,272,000	$0	$780
	UPPER EAST COAST/ST. LUCIE AND MARTIN COUNTIES							

	Management Function and Measures	IWR-Plan Designation	Unit of Measure (Average Annual)	Construction Cost ($)	Real Estate Cost ($)	Total Capital Cost ($)	Annual O&M ($1,000)	Annual Cost ($1,000)
	Wetland Restoration in western portion of Counties							
	2,000 Acre Site	D1	2,000	$4,630,000	$18,314,000	$22,944,000	$59	$1,801
	5,000 Acre Site	D2	5,000	$5,205,000	$49,660,000	$54,865,000	$64	$4,229
	10,000 Acre Site	D3	10,000	$5,840,000	$95,031,000	$100,871,000	$70	$7,728
	20,000 Acre Site	D4	20,000	$6,738,000	$217,315,000	$224,053,000	$78	$17,087
	LAKE OKEECHOBEE							
	Restoration of Kreamer, Torry and Ritta Islands	E1	3,813	$3,788,000	$29,918,000	$33,706,000	$0	$2,559
	South Miami-Dade County and Biscayne Bay							
	WPA - Model Lands and Biscayne Bay Coastal Wetland Preservation/ Restoration							
	SA3JA	G1	6,073	$13,071,000	$26,958,047	$40,029,047	$97	$3,136
	SA3KA.0	H1	16,357	$19,905,000	$29,884,239	$49,789,239	$239	$4,018
	SA3KA.1	H2	14,392	$23,128,000	$26,294,184	$49,422,184	$206	$3,957
	SA3LA.0	I1	22,103	$15,462,000	$41,708,361	$57,170,361	$214	$4,554
	SA3LA.1	I2	17,290	$20,838,000	$32,626,230	$53,464,230	$158	$4,217
	SA3MA	J1	13,538	$20,552,000	$11,656,218	$32,208,218	$212	$2,657
	LOXAHATCHEE NWR (Water Conservation Area 1 - Service Area 1)							
	WPA - Wetland Preservation/ Restoration							
	SA1BA	K1	4,438	$6,315,000	$147,470,302	$153,785,302	$94	$11,769
	SA1DA	L1	1,406	$10,825,000	$52,644,858	$63,469,858	$53	$4,871
	WATER CONSERVATION AREA 3A/3B (Service Area 2)							
	WPA - Wetland Preservation/ Restoration							
	SA2AA	M1	3,111	$6,569,000	$60,247,626	$66,816,626	$56	$5,128
	SA2BA	N1	1,871	$6,252,000	$65,720,746	$71,972,746	$53	$5,516
	SA2CA	O1	1,198	$3,562,000	$50,442,988	$54,004,988	$29	$4,129
	SA2DA.0	P1	2,249	$4,140,000	$75,645,115	$79,785,115	$34	$6,091
	SA2DA.1	P2	883	$2,341,000	$29,699,705	$32,040,705	$20	$2,452
	SA2EA	Q1	866	$3,737,000	$30,400,930	$34,137,930	$33	$2,625
	SA2FA	R1	305	$2,744,000	$21,385,990	$24,129,990	$24	$1,855
	SA2GA	S1	1,219	$4,112,000	$42,791,776	$46,903,776	$34	$3,595
	SA2HA	T1	969	$3,903,000	$36,285,174	$40,188,174	$32	$3,083
	SA2IA.1	U1	614	$2,233,000	$21,553,856	$23,786,856	$16	$1,822
	WATER CONSERVATION AREA 3B (Service Area 3 - Lake Belt Area)							
	WPA - Wetland Preservation/ Restoration							
	SA3AA.1	V1	352	$750,000	$2,086,656	$2,836,656	$18	$233
	SA3BA.0	W1	13,338	$6,664,000	$59,940,972	$66,604,972	$159	$5,216
	SA3BA.1	W2	11,591	$6,000,000	$52,089,954	$58,089,954	$143	$4,553
	BIG CYPRESS							
	Restoration of Southern Golden Gate Estates	X1	72,320	$11,653,000	$134,400,000	$146,053,000	$15	$11,102
	EVERGLADES NATIONAL PARK							
	WPA - Wetland Preservation/ Restoration							
	SA3EA	A1	2,877	$4,681,000	$9,373,266	$14,054,266	$48	$1,115
	SA3FA.1	B1	608	$1,123,000	$1,988,768	$3,111,768	$22	$258
	SA3FA.2	B2	274	$2,115,000	$896,254	$3,011,254	$11	$240
	SA3GA	C1	736	$2,522,000	$3,713,120	$6,235,120	$26	$499
F	Improve managment of Everglades Protection Area inflows							
	EVERGLADES AGRICULTURAL AREA							
	Storage Reservoirs				$6,883			
	20,000 Acres/6 feet	A1	118,234	$47,651,000	$137,650,000	$185,301,000	$278	$14,345
	20,000 Acres/10 feet	A2	178,419	$72,493,000	$137,650,000	$210,143,000	$436	$16,388
	40,000 Acres/6 feet	A3	179,686	$67,292,000	$275,300,000	$342,592,000	$512	$26,519
	40,000 Acres/10 feet	A4	236,652	$105,748,000	$275,300,000	$381,048,000	$819	$29,745
	60,000 Acres/6 feet	A5	212,568	$85,835,000	$412,950,000	$498,785,000	$736	$38,601
	60,000 Acres/10 feet	A6	265,332	$148,070,000	$412,950,000	$561,020,000	$1,187	$43,776
	Backpump/treat additional EAA water to Lake Okeechobee							
	2,500 Acre STA	B1	167,100	$41,898,000	$17,206,250	$59,104,250	$412	$4,899

	Management Function and Measures	IWR-Plan Designation	Unit of Measure (Average Annual)	Construction Cost ($)	Real Estate Cost ($)	Total Capital Cost ($)	Annual O&M ($1,000)	Annual Cost ($1,000)
	5,000 Acre STA	B2	285,000	$71,227,000	$34,412,500	$105,639,500	$616	$8,636
	7,500 Acre STA	B3	441,500	$156,407,000	$51,618,750	$208,025,750	$2,019	$17,811
G	Additional water retained in the regional system		Increase in water retained in the Everglades Protection Area (acre-feet)					
	LOXAHATCHEE NWR (Water Conservation Area 1 - Service Area 1)							
	Seepage Barrier	A1	73,370	$925,180,000	$0	$925,180,000	$0	$70,234
	Seepage Collection	A2	73,370	$17,606,000	$0	$17,606,000	$120	$1,457
	WATER CONSERVATION AREA 2A/2B (Service Area 2)							
	Seepage Barrier	B1	77,357	$457,516,000	$0	$457,516,000	$0	$34,732
	Seepage Collection	B2	77,357	$14,007,000	$0	$14,007,000	$96	$1,159
	Step-down levee system inside WCA 2B	B3	32,623	$8,869,000	$0	$8,869,000	$27	$700
	WATER CONSERVATION AREA 3A/3B (Service Area 2)							
	Seepage Barrier	C1	45,144	$155,114,000	$0	$155,114,000	$0	$11,775
	Seepage Collection	C2	45,144	$11,409,000	$0	$11,409,000	$90	$956
	WATER CONSERVATION AREA 3B (Service Area 3 - Lake Belt Area)							
	Seepage Barrier	D1	183,133	$112,842,000	$0	$112,842,000	$0	$8,566
	Seepage Collection	D2	183,133	$46,230,000	$0	$46,230,000	$440	$3,949
	EVERGLADES NATIONAL PARK							
	Seepage Barriers	E1	103,991	$43,147,000	$0	$43,147,000	$0	$3,275
	Seepage Collection	E2	103,991	$29,894,000	$0	$29,894,000	$312	$2,581

The no-action options for each measure show zero cost and zero output – this does not mean that there is no change in the future, but rather that by not implementing a measure, the future condition will not change. All cost and output estimates used in these analyses reflect the difference between the future condition with no action and the future condition with implementing the respective management measure - "with and without" analysis.

The output estimates for management measures designed to improve the quality of Lake Okeechobee inflows (*Function A*) were obtained by using the same design equations used for the Stormwater Treatment Areas for the Everglades Construction Project (Burns and McDonnell, 1994). The output estimates for measures designed to manage Lake Okeechobee water levels (*Function B*) and to provide additional water storage capability within Lake Okeechobee (*Function C*) were calculated from the South Florida Water Management Model (see Appendix B for a description of this model). The Everglades Screening Model (Appendix B) was used to estimate outputs for management measures designed to:

(1) provide additional regional water sources within the Lower East Coast (*Function D*),
(2) manage Everglades Protection Area inflows from the Everglades Agricultural Area (*Function F*), and
(3) retain additional water in the regional system (*Function G*).

Finally spatial extent of wetlands (*Function E*) was calculated by estimating the acreage of wetlands to be restored, protected, or enhanced.

A2.5 COST EFFECTIVENESS ANALYSIS APPROACH

The cost analyses were generally conducted in three stages and utilized the following tools: ECO-EASY: Cost Effectiveness and Incremental Cost Analyses Software, Beta Version 2.6; IWR-PLAN Decision Support Software, Alpha Version 1.5; and Microsoft Excel '97. Management measures for each functional category were entered into the ECO-EASY software with their cost and output estimates. ECO-EASY was used to derive all combinations and conduct the cost effectiveness and incremental cost analyses. Input data and results from each category were then imported into Microsoft Excel from the ECO-EASY output files. Excel was used to sort input data by average cost, and to format the tables and graphs included in this summary. When IWR-PLAN became available, it was used to verify the results of the analyses.

The first stage of the analyses calculated the average cost of all measures within each functional area and sorted them by increasing average cost. The result of this step was an ordered list of management measures, ordered by decreasing efficiency in producing that function's output. That is, the first measure in the list would be the most efficient, producing output at the lowest cost per unit of output, and the last measure in the list would be the least efficient, having the highest cost per unit.

The second stage of the analyses looked at all possible combinations of management measures within each functional category, comparing the different costs and output of each combination. Combinations were identified as "non-cost effective" if any other combination provided the same level of output for less cost, or if any other combination provided more output for the same or less cost. This analysis identified which combinations of measures "dominate" other combinations. The goal was not to delete non-cost effective solutions from further consideration, but rather to explicitly identify where combinations exist that appear to be better financial investments for providing output.

In the third stage of the analyses, an incremental cost analysis was performed on the cost effective set of combinations from each functional category to identify the most efficient combinations for producing output. The resultant subset of combinations, called the "best buys", comprise the most efficient production schedule for the output in each functional category based upon the management measures considered and their cost and output estimates. Just as cost-effective solutions were "better" investments than non-cost effective solutions; best buy combinations are the subset of the cost effective set that can be thought of as "superior" investments. The best buys provide the greatest increase in output for the least increase in cost – or in other words, "the biggest restoration bang for the buck".

A2.6 REPORT ORGANIZATION

The remainder of this Cost Effectiveness Screening Summary provides the results of the cost effectiveness analyses conducted for each of the functional categories. The results of each function's results include discussions of the *Cost Effectiveness Analysis Approach*, the *Management Measures and Data*, and the *Results of Analyses*.

The *Cost Effectiveness Analysis Approach* section describes the approach taken for conducting the analyses within that functional area. The *Management Measures and Data* section lists the management measures examined in each functional area with cost, output, and average cost; and describes which measures were combinable with others. The *Results of Analyses* section provides a discussion of the results of each stage of the analyses with tables showing: management measures sorted by average cost, cost effective combinations of management measures, and best buy combinations of management measures. Graphs accompany the tables for cost effective combinations of management measures, and best buy combinations of management measures. The information for decision making section describes how the results of the analyses were used in the Restudy.

A2.7 ANALYSIS RESULTS: FUNCTION A, IMPROVE QUALITY OF LAKE OKEECHOBEE INFLOWS

A2.7.1 Cost Effectiveness Analysis Approach.

For Function A, six management measures were examined through cost effectiveness and incremental cost analyses. Three of these management measures included multiple scales. The approach for Function A was to (1) calculate the average cost for each management measure and sort measures by increasing average cost, (2) formulate all possible combinations of these measures and identify the cost effective set, and (3) conduct an incremental cost analysis to identify the most efficient production schedule, or set of "best-buys".

A2.7.2 Management Measures and Data.

Function A's six management measures (with cost, output and average cost) are included in ***Table A1***. The management measures are grouped by geographic area. The entry in the "Code" column will be referenced when showing all possible combinations of Function A measures. Each measure has its own code letter. The no-action option, or "scale" for any measure gets a "0" following its code letter. Each scale of a measure has a different number following its code letter. For example, measure D has three scales: D0, D1, and D2. All Function A management measures

Table A1 – Function A Management Measures

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (tons phosphorous)	AVG. COST ($1,000/ton)
Kissimmee River Area				
A0	No Action – Maple River Wetland Detention Center	0	0.0	not applicable
A1	MAPLE RIVER WETLAND DETENTION CENTER	481	5.7	84.3860
B0	No Action – Yates Marsh Wetland Detention Center	0	0.0	not applicable
B1	YATES MARSH WETLAND DETENTION CENTER	608	5.1	119.2157
C0	No Action – Taylor Creek Treatment Center	0	0.0	not applicable
C1	TAYLOR CREEK TREATMENT CENTER	236	9.0	26.2222
Upper East Coast/Saint Lucie and Martin Counties				
D0	No Action – C-44 Backpump	0	0.0	not applicable
D1	C-44 BACKPUMP (50% INFLUENT)	3,961	5.9	671.3559
D2	C-44 BACKPUMP (100% INFLUENT)	8,049	11.1	725.1351
Caloosahatchee Basin				
E0	No Action – Backpump C-43 to Lake Okeechobee	0	0.0	not applicable
E1	BACKPUMP C-43 TO LAKE OKEECHOBEE	3,739	2.8	1,335.3571
E2	BACKPUMP C-43 TO LAKE OKEECHOBEE	4,260	5.6	760.7143
Everglades Agricultural Area				
F0	No Action – EAA Water Treatment Facility	0	0.0	not applicable
F1	EAA TREATMENT FACILITY (50% INFLUENT)	909	1.9	478.4211
F2	EAA TREATMENT FACILITY(100% INFLUENT)	1,800	4.2	428.5714

were combinable with one another; scales of the same measure were not combinable.

A2.7.3 Results of Analyses.

The first step in the analyses was to display the management measures sorted by increasing average cost. This display is included in ***Table A2***. This table shows the relative production efficiency of the management measures being considered in Function A. The measure with the lowest average cost is the most efficient measure (from a financial investment perspective) for reducing phosphorous loading into Lake Okeechobee. Each successive measure is less efficient at reducing tons of phosphorous from the Lake.

Table A2 – Function A Management Measures Sorted by Average Cost

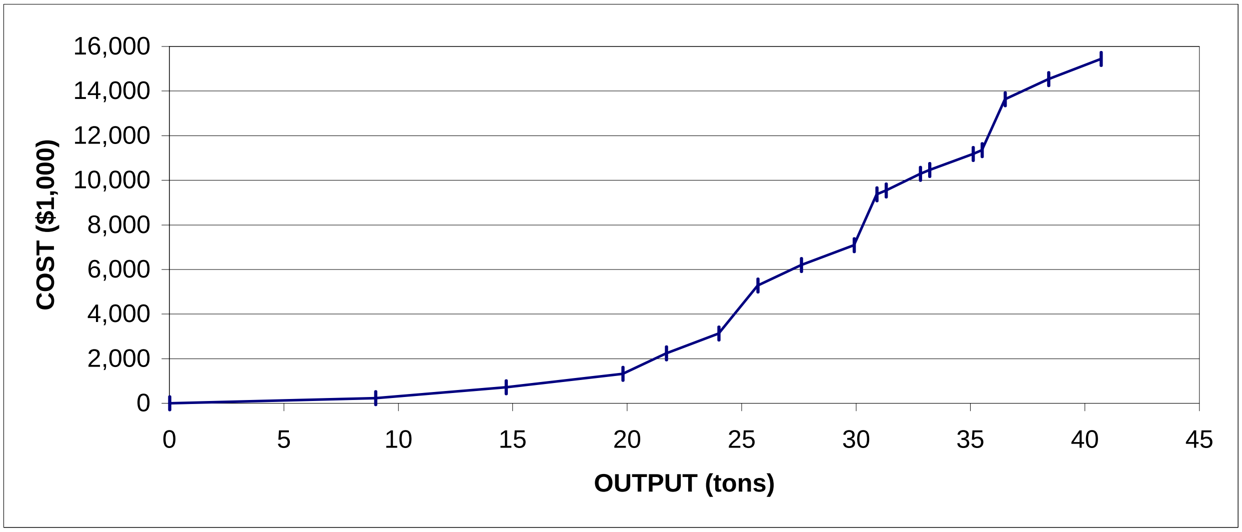
CODE	DESCRIPTION	COST ($1,000)	OUTPUT (tons phosphorous)	AVG. COST ($1,000/ton)
C1	TAYLOR CREEK TREATMENT CENTER	236	9.0	26.2222
A1	MAPLE RIVER WETLAND DETENTION CENTER	481	5.7	84.3860
B1	YATES MARSH WETLAND DETENTION CENTER	608	5.1	119.2157
F2	EAA TREATMENT FACILITY (100% INFLUENT)	1,800	4.2	428.5714
F1	EAA TREATMENT FACILITY(50% INFLUENT)	909	1.9	478.4211
D1	C-44 BACKPUMP (50% INFLUENT)	3,961	5.9	671.3559
D2	C-44 BACKPUMP (100% INFLUENT)	8,049	11.1	725.1351
E2	BACKPUMP C-43 TO LAKE OKEECHOBEE	4,260	5.6	760.7143
E1	BACKPUMP C-43 TO LAKE OKEECHOBEE	3,739	2.8	1,335.3571

The second step of the analyses was to formulate all possible combinations of the Function A management measures and identify the cost effective set. Of the full 216 combinations of Function A management measures, 18 were cost effective. The 18 cost effective combinations can be found in ***Table A3***. The value in the "Count" column simply counts the number of cost effective plans. The entries in the "Code" columns correspond to the Codes from Tables A1 and A2 and show what measures are included in each combination. A graph of cost vs. output for cost effective combinations of Function A measures is plotted in ***Figure A3***.

Table A3 – Cost Effective Combinations of Management Measures for Function A

COUNT	CODE						COST ($1,000)	OUTPUT (tons)	AVG. COST ($1,000/ton)
1	A0	B0	D0	E0	F0	C0	0	0.0	not applicable
2	A0	B0	D0	E0	F0	C1	236	9.0	26.2222
3	A1	B0	D0	E0	F0	C1	717	14.7	48.7755
4	A1	B1	D0	E0	F0	C1	1,325	19.8	66.9192
5	A1	B1	D0	E0	F1	C1	2,234	21.7	102.9493
6	A1	B1	D0	E0	F2	C1	3,125	24.0	130.2083
7	A1	B1	D1	E0	F0	C1	5,286	25.7	205.6809
8	A1	B1	D1	E0	F1	C1	6,195	27.6	224.4565
9	A1	B1	D1	E0	F2	C1	7,086	29.9	236.9900
10	A1	B1	D2	E0	F0	C1	9,374	30.9	303.3657
11	A1	B1	D1	E2	F0	C1	9,546	31.3	304.9840
12	A1	B1	D2	E0	F1	C1	10,283	32.8	313.5061
13	A1	B1	D1	E2	F1	C1	10,455	33.2	314.9096
14	A1	B1	D2	E0	F2	C1	11,174	35.1	318.3476
15	A1	B1	D1	E2	F2	C1	11,346	35.5	319.6056
16	A1	B1	D2	E2	F0	C1	13,634	36.5	373.5342
17	A1	B1	D2	E2	F1	C1	14,543	38.4	378.7240
18	A1	B1	D2	E2	F2	C1	15,434	40.7	379.2138

Figure A3 – Cost and Output of Cost Effective Combinations (Function A)



The third step of the cost analyses for Function A was to identify the subset of the cost-effective combinations that were most efficient at reducing phosphorous loading into Lake Okeechobee. The eight "best-buy" plans are listed in ***Table A4***.

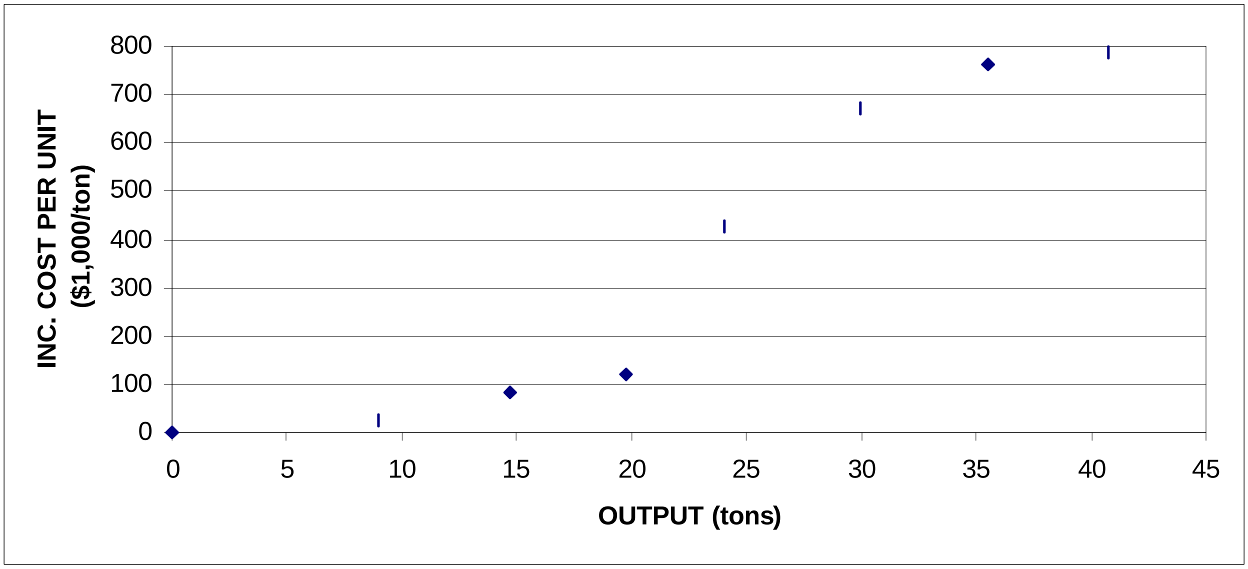
Table A4 – Best Buy Combinations of Management Measures for Function A

COUNT	CODE						COST ($1,000)	OUTPUT (tons)	AVG. COST ($1,000/ton)	INC. COST	INC. OUTPUT	INC. COST PER UNIT ($1,00/ton)
1	A0	B0	D0	E0	F0	C0	0	0.0	not applicable	not applicable	not applicable	not applicable
2	A0	B0	D0	E0	F0	C1	236	9.0	26.2222	236.00	9.0	26.2222
3	A1	B0	D0	E0	F0	C1	717	14.7	48.7755	481.00	5.7	84.3860
4	A1	B1	D0	E0	F0	C1	1,325	19.8	66.9192	608.00	5.1	119.2157
5	A1	B1	D0	E0	F2	C1	3,125	24.0	130.2083	1,800.00	4.2	428.5714
6	A1	B1	D1	E0	F2	C1	7,086	29.9	236.9900	3,961.00	5.9	671.3559
7	A1	B1	D1	E2	F2	C1	11,346	35.5	319.6056	4,260.00	5.6	760.7143
8	A1	B1	D2	E2	F2	C1	15,434	40.7	379.2138	4,088.00	5.2	786.1538

The values in the "Count" column simply count the number of best buys. The entries in the "Code" columns identify the management measures in each combination and correspond to the measure codes found in Tables A1 and A2. The values in the "Average Cost" column were calculated by dividing cost by output for each combination. The values in the "Incremental Cost" column show the change in cost from one combination to the next and were calculated by subtracting the cost of the next-smaller (in terms of output) combination from each combination. The values in the "Incremental Output" column show the change in output from one combination to the next and were calculated by subtracting the output of the next-smaller (in terms of output) combination from each combination. The last column

"Incremental Cost Per Unit" shows the cost per unit of the incremental output for each combination. A plot of output vs. incremental cost per unit for the Function A Best Buys is included in ***Figure A4***.

Figure A4 – Incremental Cost per Unit and Output of Best Buy Combinations (Function A)



A2.8 ANALYSIS RESULTS: FUNCTION B, MANAGE LAKE OKEECHOBEE WATER LEVELS

A2.8.1 Cost Effectiveness Analysis Approach.

For Function B, three management measures were examined through cost effectiveness analysis, all of which included multiple scales. The cost analysis approach for Function B was to: (1) calculate the average cost for each management measure and sort measures by increasing average cost; (2) formulate all possible combinations of these measures and identify the cost effective set; and (3) conduct an incremental cost analysis to identify the most efficient production schedule, or set of "best-buys".

A2.8.2 Management Measures and Data

Function B's three management measures (with cost, output and average cost) are included in ***Table B1***. The measures are grouped by geographic area. The entry in the "Code" column will be referenced when showing all possible combinations of Function B measures. Each measure has its own code letter. The no-action option, or "scale" for any measure gets a "0" following its code letter. Each scale of a measure has a different number following its code letter. For example, measure C has four scales: C0, C1, C2, C3, C4, and C5. In Function B, all measures were combinable with one another; scales of the same measure were not combinable.

Table B1 – Function B Management Measures

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
Kissimmee River Area (KRA)				
A0	No Action – Kissimmee Storage Reservoirs	0	0	not applicable
A1	KRA RESERVOIRS (10,000 ACRES/4 FEET)	4,474	6,619	0.6759
A2	KRA RESERVOIRS (10,000 ACRES/8 FEET)	6,748	12,773	0.5283
A3	KRA RESERVOIRS (10,000 ACRES/12 FEET)	8,217	18,927	0.4341
A4	KRA RESERVOIRS (20,000 ACRES/4 FEET)	8,108	12,733	0.6368
A5	KRA RESERVOIRS (20,000 ACRES/8 FEET)	10,953	25,080	0.4367
A6	KRA RESERVOIRS (20,000 ACRES/12 FEET)	13,980	37,388	0.3739
A7	KRA RESERVOIRS (30,000 ACRES/4 FEET)	11,690	18,927	0.6176
A8	KRA RESERVOIRS (30,000 ACRES/8 FEET)	18,501	37,388	0.4948
A9	KRA RESERVOIRS (30,000 ACRES/12 FEET)	25,455	53,536	0.4755
Lake Okeechobee				
B0	No Action –Lake Okeechobee Operating Criteria	0	0	not applicable
B1	.5 FOOT RISE IN EXISTING SCHEDULE	1	35,080	0.0000
B2	1 FOOT RISE IN EXISTING SCHEDULE	2,495	63,920	0.0390
B3	2 FEET RISE IN EXISTING SCHEDULE	18,917	115,843	0.1633
C0	No Action – Lake Okeechobee Regional ASR	0	0	not applicable
C1	LAKE OKEECHOBEE REGIONAL ASR (25 WELLS)	5,127	7,615	0.6733
C2	LAKE OKEECHOBEE REGIONAL ASR (50 WELLS)	12,142	14,764	0.8224
C3	LAKE OKEECHOBEE REGIONAL ASR (75 WELLS)	17,931	21,914	0.8182
C4	LAKE OKEECHOBEE REGIONAL ASR (100 WELLS)	24,708	29,063	0.8502

A2.8.3 Results of Analyses.

The first step in the analyses was to display the management measures sorted by increasing average cost. This display is included in ***Table B2***. This table shows the relative production efficiency of the management measures being considered in Function B. The measure with the lowest average cost is the most efficient measure for reducing regulatory releases from Lake Okeechobee. Each successive measure is less efficient at reducing releases from the Lake.

Table B2 – Function B Management Measures Sorted by Average Cost

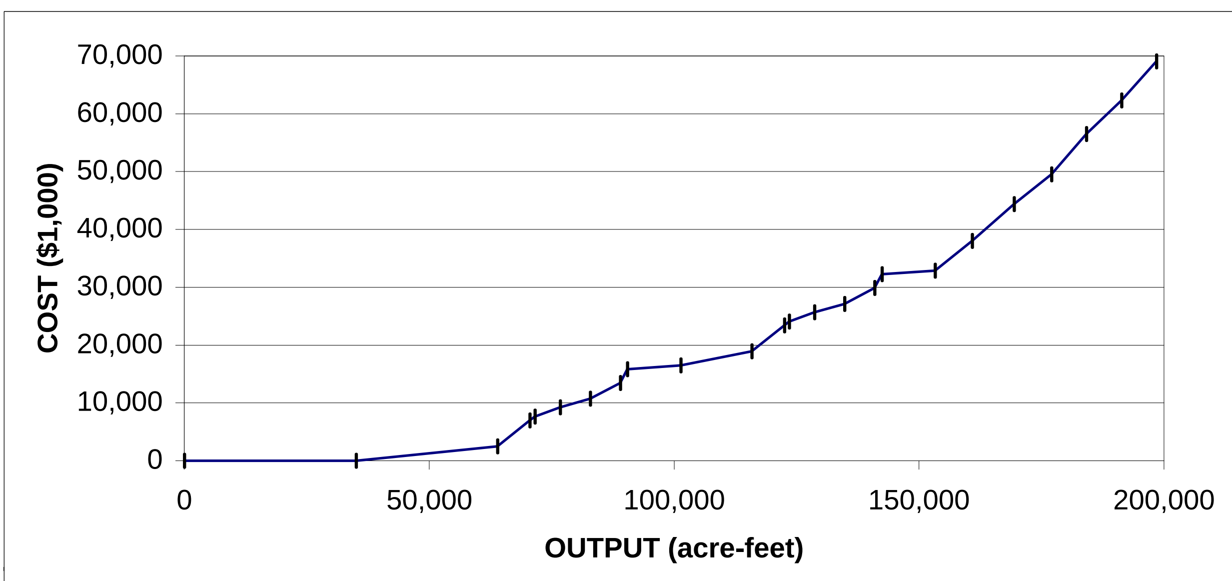
CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
B1	.5 FOOT RISE IN EXISTING SCHEDULE	0	35,080	0.0000
B2	1 FOOT RISE IN EXISTING SCHEDULE	2,495.00	63,920	0.0390
B3	2 FOOT RISE IN EXISTING SCHEDULE	18,917	115,843	0.1633
A6	KRA RESEVOIRS (20,000 ACRES/12 FEET)	13,980	37,388	0.3739
A3	KRA RESEVOIRS (10,000 ACRES/12 FEET)	8,217	18,927	0.4341
A5	KRA RESEVOIRS (20,000 ACRES/8 FEET)	10,953	25,080	0.4367
A9	KRA RESEVOIRS (30,000 ACRES/12 FEET)	25,455	53,536	0.4755
A8	KRA RESEVOIRS (30,000 ACRES/8 FEET)	18,501	37,388	0.4948
A2	KRA RESEVOIRS (10,000 ACRES/8 FEET)	6,748	12,773	0.5283
A7	KRA RESEVOIRS (30,000 ACRES/4 FEET)	11,690	18,927	0.6176
A4	KRA RESEVOIRS (20,000 ACRES/4 FEET)	8,108	12,733	0.6368
C1	LAKE OKEECHOBEE REGIONAL ASR (25 WELLS)	5,127	7,615	0.6733
A1	KRA RESEVOIRS (10,000 ACRES/4 FEET)	4,474	6,619	0.6759
C3	LAKE OKEECHOBEE REGIONAL ASR (75 WELLS)	17,931	21,914	0.8182
C2	LAKE OKEECHOBEE REGIONAL ASR (50 WELLS)	12,142	14,764	0.8224
C4	LAKE OKEECHOBEE REGIONAL ASR (100 WELLS)	24,708	29,063	0.8502

The second step of the analyses was to formulate all possible combinations of the Function B management measures and identify the cost effective set. Of the full 200 combinations of Function B management measures, 24 were cost effective. The 24 cost effective combinations can be found in ***Table B3***. The value in the "Count" column simply counts the number of cost effective plans. The entries in the "Code" columns correspond to the Codes from Tables B1 and B2 and show what measures are included in each combination. A graph of cost vs. output for the Function B cost effective plans is plotted in ***Figure B3***.

Table B3 – Cost Effective Combinations of Management Measures for Function B

COUNT	CODE			COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre/foot)
1	A0	B0	C0	0	0	not applicable
2	A0	B1	C0	0	35,080	0.0000
3	A0	B2	C0	2,495	63,920	0.0390
4	A1	B2	C0	6,969	70,539	0.0988
5	A0	B2	C1	7,622	71,535	0.1065
6	A2	B2	C0	9,243	76,693	0.1205
7	A3	B2	C0	10,712	82,847	0.1293
8	A5	B2	C0	13,448	89,000	0.1511
9	A3	B2	C1	15,839	90,462	0.1751
10	A6	B2	C0	16,475	101,308	0.1626
11	A0	B3	C0	18,917	115,843	0.1633
12	A1	B3	C0	23,391	122,462	0.1910
13	A0	B3	C1	24,044	123,458	0.1948
14	A2	B3	C0	25,665	128,616	0.1995
15	A3	B3	C0	27,134	134,770	0.2013
16	A5	B3	C0	29,870	140,923	0.2120
17	A3	B3	C1	32,261	142,385	0.2266
18	A6	B3	C0	32,897	153,231	0.2147
19	A6	B3	C1	38,024	160,846	0.2364
20	A9	B3	C0	44,372	169,379	0.2620
21	A9	B3	C1	49,499	176,994	0.2797
22	A9	B3	C2	56,514	184,143	0.3069
23	A9	B3	C3	62,303	191,293	0.3257
24	A9	B3	C4	69,080	198,442	0.3481

Figure B3 – Cost and Output of Cost Effective Combinations (Function B)

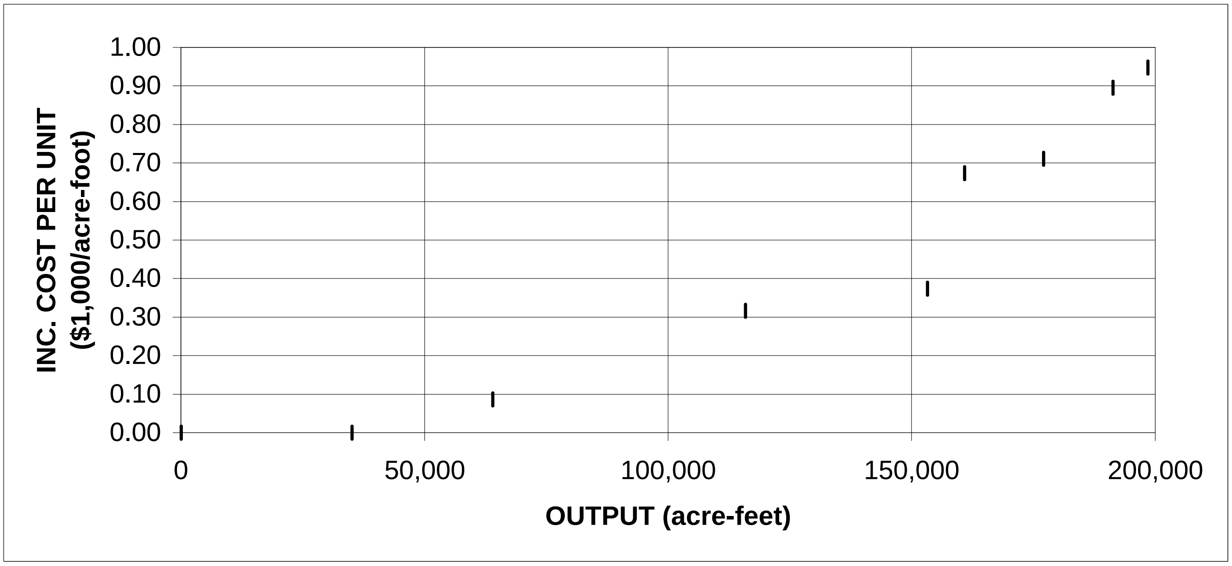


The third step of the cost analyses for Function B was to identify the subset of the cost-effective combinations that were most efficient at reducing regulatory releases from Lake Okeechobee. These nine "best-buy" plans are listed in ***Table B4***. The values in the "Count" column simply count the number of best buys. The entries in the "Code" columns identify the management measures in each combination and correspond to the measure codes found in Tables B1 and B2. The values in the "Average Cost" column were calculated by dividing cost by output for each combination. The values in the "Incremental Cost" column show the change in cost from one combination to the next and were calculated by subtracting the cost of the next-smaller (in terms of output) combination from each combination. The values in the "Incremental Output" column show the change in output from one combination to the next and were calculated by subtracting the output of the next-smaller (in terms of output) combination from each combination. The last column "Incremental Cost Per Unit" shows the cost per unit of the incremental output for each combination. A plot of output vs. incremental cost per unit for the Function B Best Buys is included in ***Figure B4***.

Table B4 – Best Buy Combinations of Management Measures for Function B

COUNT	*CODE*			COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)	INC. COST ($1,000)	INC. OUTPUT (acre-feet)	INC. COST PER UNIT ($1,000/acre-foot)
1	A0	B0	C0	0	0	0.0000	0	0	0.0000
2	A0	B1	C0	0	35080	0.0000	0	35080	0.0000
3	A0	B2	C0	2495	63920	0.0390	2494	28840	0.0865
4	A0	B3	C0	18917	115843	0.1633	16422	51923	0.3163
5	A6	B3	C0	32897	153231	0.2147	13980	37388	0.3739
6	A6	B3	C1	38024	160846	0.2364	5127	7615	0.6733
7	A9	B3	C1	49499	176994	0.2797	11475	16148	0.7106
8	A9	B3	C3	62303	191293	0.3257	12804	14299	0.8954
9	A9	B3	C4	69080	198442	0.3481	6777	7149	0.9480

Figure B4 – Incremental Cost per Unit and Output of Best Buy Combinations Function B



A2.9 ANALYSIS RESULTS: FUNCTION C, PROVIDE ADDITIONAL LAKE OKEECHOBEE WATER SUPPLY FROM EAST AND WEST BASINS

A2.9.1 Cost Effectiveness Analysis Approach.

For Function C, six management measures were examined through cost effectiveness analysis, three of which included multiple scales. The cost analysis approach for Function C was to: (1) calculate the average cost for each management measure and sort measures by increasing average cost; (2) formulate all possible combinations of these measures and identify the cost effective set; and (3) conduct an incremental cost analysis to identify the most efficient production schedule, or set of "best-buys".

A2.9.2 Management Measures and Data.

Function C's twelve management measures (with cost, output and average cost) are included in ***Table C1***. The measures are grouped by geographic area. The entry in the "Code" column will be referenced when showing combinations of Function C measures. Each measure has its own code letter. The no-action option for any measure gets a "0" following its code letter. Each scale of a measure has a different number following its code letter. For example, measure B has two scales:

B0 and B1. In Function C, measure A was not combinable with measures E and X; measure F was not combinable with measures I or J; and measure I was not combinable with measures F or Z. In all cases, scales of the same measure were not combinable.

Table C1 – Function C Management Measures

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
Upper East Coast/St Lucie and Martin Counties				
A0	No Action – C44 Storage Reservoirs	0	0	not applicable
A1	C44 RESERVOIRS (2,500 ACRES/8 FEET)	2,682	14,671	0.1828
A2	C44 RESERVOIRS (5,000 ACRES/8 FEET)	4,224	22,575	0.1871
A3	C44 RESERVOIRS (10,000 ACRES/8 FEET)	8,068	27,974	0.2884
A4	C44 RESERVOIRS (10,000 ACRES/12 FEET)	10,116	30,684	0.3297
A5	C44 RESERVOIRS (20,000 ACRES/8 FEET)	18,534	31,433	0.5896
A6	C44 RESERVOIRS (20,000 ACRES/12 FEET)	21,824	31,926	0.6836
A7	C44 RESERVOIRS (30,000 ACRES/8 FEET)	28,557	31,401	0.9094
A8	C44 RESERVOIRS (30,000 ACRES/12 FEET)	33,943	31,932	1.0630
X1	C44 RESERVOIIRS (10,000 ACRES/4 FEET)	6,256	19,056	0.3283
X2	C44 RESERVOIRS (20,000 ACRES/4 FEET)	15,301	25,500	0.6000
X3	C44 RESERVOIRS (30,000 ACRES/4 FEET)	24,054	29,468	0.8163
B0	No Action – C44 On-Site Detention Facility	0	0	not applicable
B1	C44 ON-SITE DETENTION FACILITY (30 SITES @ 64 ACRES EACH)	5,550	8,866	0.6260
C0	No Action – Backpump C-23,24,25 to Lake Okeechobee	0	0	not applicable
C1	BACKPUMP C-23,24,25 (10,000 ACRE FACILITY)	17,268	108,100	0.1597
D0	No Action – Backpump C44 to Lake Okeechobee	0	0	not applicable
D1	BACKPUMP C44 (1,000 ACRE SITE)	2,235	59,100	0.0378
D2	BACKPUMP C44 (2,500 ACRE SITE)	5,739	100,600	0.0570
D3	BACKPUMP C44 (5,000 ACRE SITE)	9,647	122,300	0.0789
E0	No Action – UEC Regional ASR	0	0	not applicable
E1	UEC REGIONAL ASR (4 WELLS - 2,500 ACRES)	3,238	18,759	0.1726
E2	UEC REGIONAL ASR (4 WELLS - 5,000 ACRES)	4,780	24,590	0.1944
E3	UEC REGIONAL ASR (8 WELLS - 2,500 ACRES)	3,794	22,575	0.1681
E4	UEC REGIONAL ASR (8 WELLS - 5,000 ACRES)	5,336	27,581	0.1935
E5	UEC REGIONAL ASR (16 WELLS-2,500 ACRES)	4,905	27,310	0.1796
E6	UEC REGIONAL ASR (16 WELLS-5,000 ACRES)	6,448	30,758	0.2096
E7	UEC REGIONAL ASR (33 WELLS-2,500 ACRES)	7,268	31,192	0.2330
E8	UEC REGIONAL ASR (33 WELLS-5,000 ACRES)	8,810	31,102	0.2833
Caloosahatchee Basin				
F0	No Action – Caloosahatchee Storage Reservoirs	0	0	not applicable
F1	CALOOSAHATCHEE STORAGE RESERVOIRS (5,000 ACRES/4 FEET)	2,573	51,702	0.0498
F2	CALOOSAHATCHEE STORAGE RESERVOIRS (5,000 ACRES/8 FEET)	3,550	68,401	0.0519
F3	CALOOSAHATCHEE STORAGE RESERVOIRS (5,000 ACRES/12 FEET)	4,765	78,796	0.0605

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
F4	CALOOSAHATCHEE STORAGE RESERVOIRS (10,000 ACRES/4 FEET)	5,794	68,401	0.0847
F5	CALOOSAHATCHEE STORAGE RESERVOIRS (10,000 ACRES/8 FEET)	7,579	87,891	0.0862
F6	CALOOSAHATCHEE STORAGE RESERVOIRS (10,000 ACRES/12 FEET)	8,887	97,577	0.0911
F7	CALOOSAHATCHEE STORAGE RESERVOIRS (20,000 ACRES/4 FEET)	11,027	87,891	0.1255
F8	CALOOSAHATCHEE STORAGE RESERVOIRS (20,000 ACRES/8 FEET)	13,685	102,114	0.1340
F9	CALOOSAHATCHEE STORAGE RESERVOIRS (20,000 ACRES/12 FEET)	16,485	104,238	0.1581
G0	No Action – Caloosahatchee On-Site Detention	0	0	not applicable
G1	CALOOSAHATCHEE ON-SITE DETENTION (30 SITES @ 64 ACRES EACH)	5,098	31,636	0.1611
H0	No Action – Backpump C43 to Lake Okeechobee	0	0	not applicable
H1	BACKPUMP C43 (2,500 ACRE SITE)	3,995	231,200	0.0173
H2	BACKPUMP C43 (5,000 ACRE SITE)	10,857	427,200	0.0254
H3	BACKPUMP C43 (7,500 ACRE SITE)	19,381	505,200	0.0384
I0	No Action – Caloosahatchee Regional ASR	0	0	not applicable
I1	CALOOSAHATCHEE REGIONAL ASR (4 WELLS)	860	8,951	0.0961
I2	CALOOSAHATCHEE REGIONAL ASR (8 WELLS)	1,719	15,468	0.1111
I3	CALOOSAHATCHEE REGIONAL ASR (8 WELLS W/5,000 ACRES/4 FEET)	4,293	62,824	0.0683
I4	CALOOSAHATCHEE REGIONAL ASR (16 WELLS)	3,438	27,638	0.1244
I5	CALOOSAHATCHEE REGIONAL ASR (16 WELLS W/5,000 ACRES/4 FEET)	6,988	84,946	0.0823
I6	CALOOSAHATCHEE REGIONAL ASR (16 WELLS W/5,000 ACRES/8 FEET)	11,175	97,211	0.1150
I7	CALOOSAHATCHEE REGIONAL ASR (33 WELLS)	7,091	48,307	0.1468
I8	CALOOSAHATCHEE REGIONAL ASR (33 WELLS W/5,000 ACRES/4 FEET)	9,665	86,611	0.1116
I9	CALOOSAHATCHEE REGIONAL ASR (33 WELLS W/5,000 ACRES/8 FEET)	10,726	94,363	0.1137
Z1	CALOOSAHATCHEE REGIONAL ASR (65 WELLS)	13,967	76,810	0.1818
Z2	CALOOSAHATCHEE REGIONAL ASR (65 WELLS W/5,000 ACRES/4 FEET)	16,541	97520	0.1696
Z3	CALOOSAHATCHEE REGIONAL ASR (65 WELLS W/5,000 ACRES/8 FEET)	17,603	101,814	0.1729
J0	No Action – Lake Hicpochee Reservoir	0	0	not applicable
J1	LAKE HICPOCHEE RESERVOIR	972	51,702	0.0188
K0	*No Action – C43 Storage at Moore Haven*	0	0	not applicable
K1	C-43 STORAGE AT MOORE HAVEN	369	582	0.6340

A2.9.3 Results of Analyses.

The first step in the analyses was to display the management measures sorted by increasing average cost. This display is included in ***Table C2***. This table shows the relative production efficiency of the management measures being considered in Function C. The measure with the lowest average cost is the most efficient measure for increasing net inflows into Lake Okeechobee. Each successive measure is less efficient at increasing net inflows.

Table C2 – Function C Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
H1	BACKPUMP C43 (2,500 ACRE SITE)	3,995	231,200	0.0173
J1	LAKE HICPOCHEE RESERVOIR	972	51,702	0.0188
H2	BACKPUMP C43 (5,000 ACRE SITE)	10,857	427,200	0.0254
D1	BACKPUMP C44 (1,000 ACRE SITE)	2,235	59,100	0.0378
H3	BACKPUMP C43 (7,500 ACRE SITE)	19,381	505,200	0.0384
F1	CALOOSAHATCHEE STORAGE RESERVOIRS (5,000 ACRES/4 FEET)	2,573	51,702	0.0498
F2	CALOOSAHATCHEE STORAGE RESERVOIRS (5,000 ACRES/8 FEET)	3,550	68,401	0.0519
D2	BACKPUMP C44 (2,500 ACRE SITE)	5,739	100,600	0.0570
F3	CALOOSAHATCHEE STORAGE RESERVOIRS (5,000 ACRES/12 FEET)	4,765	78,796	0.0605
I3	CALOOSAHATCHEE REGIONAL ASR (8 WELLS W/5,000 ACRES/4 FEET)	4,293	62,824	0.0683
D3	BACKPUMP C44 (5,000 ACRE SITE)	9,647	122,300	0.0789
I5	CALOOSAHATCHEE REGIONAL ASR (16 WELLS W/5,000 ACRES/4 FEET)	6,988	84,946	0.0823
F4	CALOOSAHATCHEE STORAGE RESERVOIRS (10,000 ACRES/4 FEET)	5,794	68,401	0.0847
F5	CALOOSAHATCHEE STORAGE RESERVOIRS (10,000 ACRES/8 FEET)	7,579	87,891	0.0862
F6	CALOOSAHATCHEE STORAGE RESERVOIRS (10,000 ACRES/12 FEET)	8,887	97,577	0.0911
I1	CALOOSAHATCHEE REGIONAL ASR (4 WELLS)	860	8,951	0.0961
I2	CALOOSAHATCHEE REGIONAL ASR (8 WELLS)	1,719	15,468	0.1111
I8	CALOOSAHATCHEE REGIONAL ASR (33 WELLS W/5,000 ACRES/4 FEET)	9,665	86,611	0.1116
I9	CALOOSAHATCHEE REGIONAL ASR (33 WELLS W/5,000 ACRES/8 FEET)	10,726	94,363	0.1137
I6	CALOOSAHATCHEE REGIONAL ASR (16 WELLS W/5,000 ACRES/8 FEET)	11,175	97,211	0.1150
I4	CALOOSAHATCHEE REGIONAL ASR (16 WELLS)	3,438	27,638	0.1244
F7	CALOOSAHATCHEE STORAGE RESERVOIRS (20,000 ACRES/4 FEET)	11,027	87,891	0.1255

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
F8	CALOOSAHATCHEE STORAGE RESERVOIRS (20,000 ACRES/8 FEET)	13,685	102,114	0.1340
I7	CALOOSAHATCHEE REGIONAL ASR (33 WELLS)	7,091	48,307	0.1468
F9	CALOOSAHATCHEE STORAGE RESERVOIRS (20,000 ACRES/12 FEET)	16,485	104,238	0.1581
C1	BACKPUMP C-23,24,25 (10,000 ACRE FACILITY)	17,268	108,100	0.1597
G1	CALOOSAHATCHEE ON-SITE DETENTION (30 SITES @ 64 ACRES EACH)	5,098	31636	0.1611
E3	UEC REGIONAL ASR (8 WELLS - 2,500 ACRES)	3,794	22,575	0.1681
Z2	CALOOSAHATCHEE REGIONAL ASR (65 WELLS W/5,000 ACRES/4 FEET)	16,541	97,520	0.1696
E1	UEC REGIONAL ASR (4 WELLS - 2,500 ACRES)	3,238	18,759	0.1726
Z3	CALOOSAHATCHEE REGIONAL ASR (65 WELLS W/5,000 ACRES/8 FEET)	17,603	101,814	0.1729
E5	UEC REGIONAL ASR (16 WELLS-2,500 ACRES)	4,905	27310	0.1796
Z1	CALOOSAHATCHEE REGIONAL ASR (65 WELLS)	13,967	76,810	0.1818
A1	C44 RESERVOIRS (2,500 ACRES/8 FEET)	2,682	14,671	0.1828
A2	C44 RESERVOIRS (5,000 ACRES/8 FEET)	4,224	22,575	0.1871
E4	UEC REGIONAL ASR (8 WELLS - 5,000 ACRES)	5,336	27,581	0.1935
E2	UEC REGIONAL ASR (4 WELLS - 5,000 ACRES)	4,780	24,590	0.1944
E6	UEC REGIONAL ASR (16 WELLS-5,000 ACRES)	6,448	30,758	0.2096
E7	UEC REGIONAL ASR (33 WELLS-2,500 ACRES)	7,268	31,192	0.2330
E8	UEC REGIONAL ASR (33 WELLS-5,000 ACRES)	8,810	31,102	0.2833
A3	C44 RESERVOIRS (10,000 ACRES/8 FEET)	8,068	27,974	0.2884
X1	C44 RESERVOIIRS (10,000 ACRES/4 FEET)	6,256	19,056	0.3283
A4	C44 RESERVOIRS (10,000 ACRES/12 FEET)	10,116	30,684	0.3297
A5	C44 RESERVOIRS (20,000 ACRES/8 FEET)	18,534	31,433	0.5896
X2	C44 RESERVOIRS (20,000 ACRES/4 FEET)	15301	25,500	0.6000
B1	C44 ON-SITE DETENTION FACILITY (30 SITES @ 64 ACRES EACH)	5,550	8,866	0.6260
K1	C-43 STORAGE AT MOORE HAVEN	369	582	0.6340
A6	C44 RESERVOIRS (20,000 ACRES/12 FEET)	21,824	31926	0.6836
X3	C44 RESERVOIRS (30,000 ACRES/4 FEET)	24054	29,468	0.8163
A7	C44 RESERVOIRS (30,000 ACRES/8 FEET)	28,557	31,401	0.9094
A8	C44 RESERVOIRS (30,000 ACRES/12 FEET)	33,943	31,932	1.0630

The second step of the analyses was to formulate all possible combinations of the Function C management measures and identify the cost effective set. Of the full 698,386 combinations of Function C management measures, 294 were cost effective. The 294 cost-effective combinations can be found in ***Table C3***. The value in the "Count" column simply counts the number of cost effective plans. The entries in the "Code" columns correspond to the Codes from Tables C1 and C2 and show what measures are included in each combination. A graph of cost vs. output for Function C's cost effective combinations of management measures is plotted in Figure C3.

Table C3 – Cost Effective Combinations of Management Measures for Function C

COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
1	A0	B0	D0	E0	F0	G0	H0	I0	J0	K0	Z0	C0	X0	0	0	0.0000
2	A0	B0	D0	E0	F0	G0	H0	I0	J0	K1	Z0	C0	X0	369	582	0.6340
3	A0	B0	D0	E0	F0	G0	H0	I1	J0	K0	Z0	C0	X0	860	8,951	0.0961
4	A0	B0	D0	E0	F0	G0	H0	I0	J1	K0	Z0	C0	X0	972	51,702	0.0188
5	A0	B0	D0	E0	F0	G0	H0	I0	J1	K1	Z0	C0	X0	1,341	52,284	0.0256
6	A0	B0	D0	E0	F0	G0	H0	I1	J1	K0	Z0	C0	X0	1,832	60,653	0.0302
7	A0	B0	D0	E0	F0	G0	H0	I1	J1	K1	Z0	C0	X0	2,201	61,235	0.0359
8	A0	B0	D0	E0	F0	G0	H0	I2	J1	K0	Z0	C0	X0	2,691	67,170	0.0401
9	A0	B0	D0	E0	F0	G0	H0	I2	J1	K1	Z0	C0	X0	3,060	67,752	0.0452
10	A0	B0	D1	E0	F0	G0	H0	I1	J0	K0	Z0	C0	X0	3,095	68,051	0.0455
11	A0	B0	D1	E0	F0	G0	H0	I0	J1	K0	Z0	C0	X0	3,207	110,802	0.0289
12	A0	B0	D1	E0	F0	G0	H0	I0	J1	K1	Z0	C0	X0	3,576	111,384	0.0321
13	A0	B0	D0	E0	F0	G0	H1	I0	J0	K0	Z0	C0	X0	3,995	231,200	0.0173
14	A0	B0	D0	E0	F0	G0	H1	I0	J0	K1	Z0	C0	X0	4,364	231,782	0.0188
15	A0	B0	D0	E0	F0	G0	H1	I1	J0	K0	Z0	C0	X0	4,855	240,151	0.0202
16	A0	B0	D0	E0	F0	G0	H1	I0	J1	K0	Z0	C0	X0	4,967	282,902	0.0176
17	A0	B0	D0	E0	F0	G0	H1	I0	J1	K1	Z0	C0	X0	5,336	283,484	0.0188
18	A0	B0	D0	E0	F0	G0	H1	I1	J1	K0	Z0	C0	X0	5,827	291,853	0.0200
19	A0	B0	D0	E0	F0	G0	H1	I1	J1	K1	Z0	C0	X0	6,196	292,435	0.0212
20	A0	B0	D0	E0	F0	G0	H1	I2	J1	K0	Z0	C0	X0	6,686	298,370	0.0224
21	A0	B0	D0	E0	F0	G0	H1	I2	J1	K1	Z0	C0	X0	7,055	298,952	0.0236
22	A0	B0	D1	E0	F0	G0	H1	I1	J0	K0	Z0	C0	X0	7,090	299,251	0.0237
23	A0	B0	D1	E0	F0	G0	H1	I0	J1	K0	Z0	C0	X0	7,202	342,002	0.0211
24	A0	B0	D1	E0	F0	G0	H1	I0	J1	K1	Z0	C0	X0	7,571	342,584	0.0221
25	A0	B0	D1	E0	F0	G0	H1	I1	J1	K0	Z0	C0	X0	8,062	350,953	0.0230
26	A0	B0	D1	E0	F0	G0	H1	I1	J1	K1	Z0	C0	X0	8,431	351,535	0.0240
27	A0	B0	D1	E0	F0	G0	H1	I2	J1	K0	Z0	C0	X0	8,921	357,470	0.0250
28	A0	B0	D1	E0	F0	G0	H1	I2	J1	K1	Z0	C0	X0	9,290	358,052	0.0259
29	A0	B0	D1	E0	F2	G0	H1	I0	J0	K0	Z0	C0	X0	9,780	358,701	0.0273
30	A0	B0	D1	E0	F2	G0	H1	I0	J0	K1	Z0	C0	X0	10,149	359,283	0.0282
31	A0	B0	D1	E1	F0	G0	H1	I0	J1	K0	Z0	C0	X0	10,440	360,761	0.0289
32	A0	B0	D1	E0	F0	G0	H1	I4	J1	K0	Z0	C0	X0	10,640	369,640	0.0288
33	A0	B0	D2	E0	F0	G0	H1	I0	J1	K0	Z0	C0	X0	10,706	383,502	0.0279
34	A0	B0	D0	E0	F0	G0	H2	I0	J0	K0	Z0	C0	X0	10,857	427,200	0.0254
35	A0	B0	D0	E0	F0	G0	H2	I0	J0	K1	Z0	C0	X0	11,226	427,782	0.0262
36	A0	B0	D0	E0	F0	G0	H2	I1	J0	K0	Z0	C0	X0	11,717	436,151	0.0269
37	A0	B0	D0	E0	F0	G0	H2	I0	J1	K0	Z0	C0	X0	11,829	478,902	0.0247
38	A0	B0	D0	E0	F0	G0	H2	I0	J1	K1	Z0	C0	X0	12,198	479,484	0.0254

COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
39	A0	B0	D0	E0	F0	G0	H2	I1	J1	K0	Z0	C0	X0	12,689	487,853	0.0260
40	A0	B0	D0	E0	F0	G0	H2	I1	J1	K1	Z0	C0	X0	13,058	488,435	0.0267
41	A0	B0	D0	E0	F0	G0	H2	I2	J1	K0	Z0	C0	X0	13,548	494,370	0.0274
42	A0	B0	D0	E0	F0	G0	H2	I2	J1	K1	Z0	C0	X0	13,917	494,952	0.0281
43	A0	B0	D1	E0	F0	G0	H2	I1	J0	K0	Z0	C0	X0	13,952	495,251	0.0282
44	A0	B0	D1	E0	F0	G0	H2	I0	J1	K0	Z0	C0	X0	14,064	538,002	0.0261
45	A0	B0	D1	E0	F0	G0	H2	I0	J1	K1	Z0	C0	X0	14,433	538,584	0.0268
46	A0	B0	D1	E0	F0	G0	H2	I1	J1	K0	Z0	C0	X0	14,924	546,953	0.0273
47	A0	B0	D1	E0	F0	G0	H2	I1	J1	K1	Z0	C0	X0	15,293	547,535	0.0279
48	A0	B0	D1	E0	F0	G0	H2	I2	J1	K0	Z0	C0	X0	15,783	553,470	0.0285
49	A0	B0	D1	E0	F0	G0	H2	I2	J1	K1	Z0	C0	X0	16,152	554,052	0.0292
50	A0	B0	D1	E0	F2	G0	H2	I0	J0	K0	Z0	C0	X0	16,642	554,701	0.0300
51	A0	B0	D1	E0	F2	G0	H2	I0	J0	K1	Z0	C0	X0	17,011	555,283	0.0306
52	A0	B0	D1	E1	F0	G0	H2	I0	J1	K0	Z0	C0	X0	17,302	556,761	0.0311
53	A0	B0	D1	E0	F0	G0	H2	I4	J1	K0	Z0	C0	X0	17,502	565,640	0.0309
54	A0	B0	D2	E0	F0	G0	H2	I0	J1	K0	Z0	C0	X0	17,568	579,502	0.0303
55	A0	B0	D2	E0	F0	G0	H2	I0	J1	K1	Z0	C0	X0	17,937	580,084	0.0309
56	A0	B0	D1	E0	F0	G0	H2	I3	J1	K0	Z0	C0	X0	18,357	600,826	0.0306
57	A0	B0	D1	E0	F0	G0	H2	I3	J1	K1	Z0	C0	X0	18,726	601,408	0.0311
58	A0	B0	D2	E0	F0	G0	H2	I4	J1	K0	Z0	C0	X0	21,006	607,140	0.0346
59	A1	B0	D1	E0	F0	G0	H2	I3	J1	K0	Z0	C0	X0	21,039	615,497	0.0342
60	A0	B0	D1	E0	F0	G0	H2	I5	J1	K0	Z0	C0	X0	21,052	622,948	0.0338
61	A0	B0	D1	E0	F0	G0	H2	I5	J1	K1	Z0	C0	X0	21,421	623,530	0.0344
62	A0	B0	D2	E0	F0	G0	H2	I3	J1	K0	Z0	C0	X0	21,861	642,326	0.0340
63	A0	B0	D2	E0	F0	G0	H2	I3	J1	K1	Z0	C0	X0	22,230	642,908	0.0346
64	A1	B0	D2	E0	F0	G0	H2	I3	J1	K0	Z0	C0	X0	24,543	656,997	0.0374
65	A0	B0	D2	E0	F0	G0	H2	I5	J1	K0	Z0	C0	X0	24,556	664,448	0.0370
66	A0	B0	D2	E0	F0	G0	H2	I5	J1	K1	Z0	C0	X0	24,925	665,030	0.0375
67	A0	B0	D2	E3	F0	G0	H2	I3	J1	K1	Z0	C0	X0	26,024	665,483	0.0391
68	A0	B0	D2	E2	F0	G0	H2	I3	J1	K0	Z0	C0	X0	26,641	666,916	0.0399
69	A0	B0	D2	E5	F0	G0	H2	I3	J1	K0	Z0	C0	X0	26,766	669,636	0.0400
70	A0	B0	D1	E0	F0	G0	H3	I3	J1	K0	Z0	C0	X0	26,881	678,826	0.0396
71	A1	B0	D2	E0	F0	G0	H2	I5	J1	K0	Z0	C0	X0	27,238	679,119	0.0401
72	A0	B0	D1	E0	F0	G0	H3	I3	J1	K1	Z0	C0	X0	27,250	679,408	0.0401
73	A1	B0	D2	E0	F0	G0	H2	I5	J1	K1	Z0	C0	X0	27,607	679,701	0.0406
74	A0	B0	D2	E1	F0	G0	H2	I5	J1	K0	Z0	C0	X0	27,794	683,207	0.0407
75	A0	B0	D2	E1	F0	G0	H2	I5	J1	K1	Z0	C0	X0	28,163	683,789	0.0412
76	A0	B0	D2	E3	F0	G0	H2	I5	J1	K0	Z0	C0	X0	28,350	687,023	0.0413
77	A0	B0	D2	E3	F0	G0	H2	I5	J1	K1	Z0	C0	X0	28,719	687,605	0.0418
78	A0	B0	D2	E2	F0	G0	H2	I5	J1	K0	Z0	C0	X0	29,336	689,038	0.0426
79	A0	B0	D2	E5	F0	G0	H2	I5	J1	K0	Z0	C0	X0	29,461	691,758	0.0426
80	A1	B0	D1	E0	F0	G0	H3	I3	J1	K0	Z0	C0	X0	29,563	693,497	0.0426
81	A0	B0	D1	E0	F0	G0	H3	I5	J1	K0	Z0	C0	X0	29,576	700,948	0.0422
82	A0	B0	D1	E0	F0	G0	H3	I5	J1	K1	Z0	C0	X0	29,945	701,530	0.0427
83	A0	B0	D2	E0	F0	G0	H3	I3	J1	K0	Z0	C0	X0	30,385	720,326	0.0422
84	A0	B0	D2	E0	F0	G0	H3	I3	J1	K1	Z0	C0	X0	30,754	720,908	0.0427
85	A1	B0	D2	E0	F0	G0	H3	I3	J1	K0	Z0	C0	X0	33,067	734,997	0.0450
86	A0	B0	D2	E0	F0	G0	H3	I5	J1	K0	Z0	C0	X0	33,080	742,448	0.0446

COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
87	A0	B0	D2	E0	F0	G0	H3	I5	J1	K1	Z0	C0	X0	33,449	743,030	0.0450
88	A0	B0	D2	E3	F0	G0	H3	I3	J1	K1	Z0	C0	X0	34,548	743,483	0.0465
89	A0	B0	D2	E2	F0	G0	H3	I3	J1	K0	Z0	C0	X0	35,165	744,916	0.0472
90	A0	B0	D2	E5	F0	G0	H3	I3	J1	K0	Z0	C0	X0	35,290	747,636	0.0472
91	A0	B0	D2	E0	F0	G1	H3	I3	J1	K0	Z0	C0	X0	35,483	751,962	0.0472
92	A1	B0	D2	E0	F0	G0	H3	I5	J1	K0	Z0	C0	X0	35,762	757,119	0.0472
93	A1	B0	D2	E0	F0	G0	H3	I5	J1	K1	Z0	C0	X0	36,131	757,701	0.0477
94	A0	B0	D2	E1	F0	G0	H3	I5	J1	K0	Z0	C0	X0	36,318	761,207	0.0477
95	A0	B0	D2	E1	F0	G0	H3	I5	J1	K1	Z0	C0	X0	36,687	761,789	0.0482
96	A0	B0	D2	E3	F0	G0	H3	I5	J1	K0	Z0	C0	X0	36,874	765,023	0.0482
97	A0	B0	D2	E3	F0	G0	H3	I5	J1	K1	Z0	C0	X0	37,243	765,605	0.0486
98	A0	B0	D2	E2	F0	G0	H3	I5	J1	K0	Z0	C0	X0	37,860	767,038	0.0494
99	A0	B0	D2	E5	F0	G0	H3	I5	J1	K0	Z0	C0	X0	37,985	769,758	0.0493
100	A0	B0	D2	E0	F0	G1	H3	I5	J1	K0	Z0	C0	X0	38,178	774,084	0.0493
101	A0	B0	D2	E0	F0	G1	H3	I5	J1	K1	Z0	C0	X0	38,547	774,666	0.0498
102	A0	B0	D2	E3	F0	G1	H3	I3	J1	K1	Z0	C0	X0	39,646	775,119	0.0511
103	A1	B0	D3	E0	F0	G0	H3	I5	J1	K0	Z0	C0	X0	39,670	778,819	0.0509
104	A1	B0	D3	E0	F0	G0	H3	I5	J1	K1	Z0	C0	X0	40,039	779,401	0.0514
105	A0	B0	D3	E1	F0	G0	H3	I5	J1	K0	Z0	C0	X0	40,226	782,907	0.0514
106	A0	B0	D3	E1	F0	G0	H3	I5	J1	K1	Z0	C0	X0	40,595	783,489	0.0518
107	A0	B0	D3	E3	F0	G0	H3	I5	J1	K0	Z0	C0	X0	40,782	786,723	0.0518
108	A1	B0	D2	E0	F0	G1	H3	I5	J1	K0	Z0	C0	X0	40,860	788,755	0.0518
109	A1	B0	D2	E0	F0	G1	H3	I5	J1	K1	Z0	C0	X0	41,229	789,337	0.0522
110	A0	B0	D2	E1	F0	G1	H3	I5	J1	K0	Z0	C0	X0	41,416	792,843	0.0522
111	A0	B0	D2	E1	F0	G1	H3	I5	J1	K1	Z0	C0	X0	41,785	793,425	0.0527
112	A0	B0	D2	E3	F0	G1	H3	I5	J1	K0	Z0	C0	X0	41,972	796,659	0.0527
113	A0	B0	D2	E3	F0	G1	H3	I5	J1	K1	Z0	C0	X0	42,341	797,241	0.0531
114	A0	B0	D2	E2	F0	G1	H3	I5	J1	K0	Z0	C0	X0	42,958	798,674	0.0538
115	A0	B0	D2	E5	F0	G1	H3	I5	J1	K0	Z0	C0	X0	43,083	801,394	0.0538
116	A0	B0	D2	E5	F0	G1	H3	I5	J1	K1	Z0	C0	X0	43,452	801,976	0.0542
117	A0	B0	D2	E4	F0	G1	H3	I5	J1	K1	Z0	C0	X0	43,883	802,247	0.0547
118	A0	B0	D2	E6	F0	G1	H3	I5	J1	K0	Z0	C0	X0	44,626	804,842	0.0554
119	A1	B0	D3	E0	F0	G1	H3	I5	J1	K0	Z0	C0	X0	44,768	810,455	0.0552
120	A1	B0	D3	E0	F0	G1	H3	I5	J1	K1	Z0	C0	X0	45,137	811,037	0.0557
121	A0	B0	D3	E1	F0	G1	H3	I5	J1	K0	Z0	C0	X0	45,324	814,543	0.0556
122	A0	B0	D3	E1	F0	G1	H3	I5	J1	K1	Z0	C0	X0	45,693	815,125	0.0561
123	A0	B0	D3	E3	F0	G1	H3	I5	J1	K0	Z0	C0	X0	45,880	818,359	0.0561
124	A0	B0	D3	E3	F0	G1	H3	I5	J1	K1	Z0	C0	X0	46,249	818,941	0.0565
125	A0	B0	D3	E2	F0	G1	H3	I5	J1	K0	Z0	C0	X0	46,866	820,374	0.0571
126	A0	B0	D3	E5	F0	G1	H3	I5	J1	K0	Z0	C0	X0	46,991	823,094	0.0571
127	A0	B0	D3	E5	F0	G1	H3	I5	J1	K1	Z0	C0	X0	47,360	823,676	0.0575
128	A0	B0	D2	E0	F0	G0	H3	I3	J1	K0	Z0	C1	X0	47,653	828,426	0.0575
129	A0	B0	D2	E0	F0	G0	H3	I3	J1	K1	Z0	C1	X0	48,022	829,008	0.0579
130	A0	B0	D3	E3	F0	G1	H3	I6	J1	K0	Z0	C0	X0	50,067	830,624	0.0603
131	A1	B0	D2	E0	F0	G0	H3	I3	J1	K0	Z0	C1	X0	50,335	843,097	0.0597
132	A0	B0	D2	E0	F0	G0	H3	I5	J1	K0	Z0	C1	X0	50,348	850,548	0.0592
133	A0	B0	D2	E0	F0	G0	H3	I5	J1	K1	Z0	C1	X0	50,717	851,130	0.0596
134	A0	B0	D2	E3	F0	G0	H3	I3	J1	K1	Z0	C1	X0	51,816	851,583	0.0608

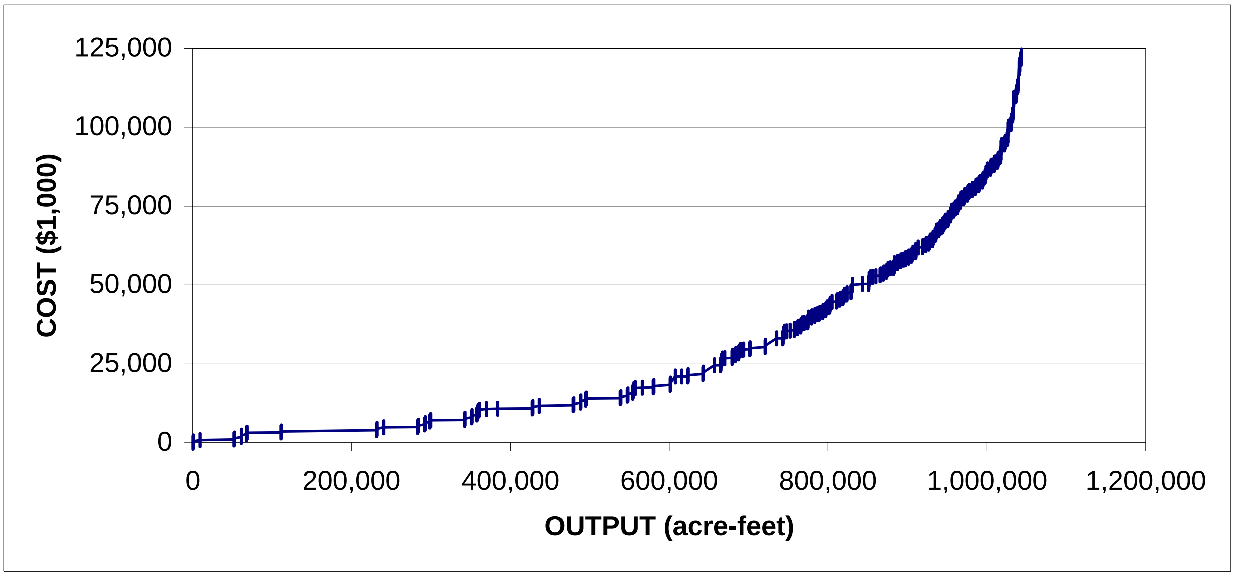
COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
135	A0	B0	D2	E2	F0	G0	H3	I3	J1	K0	Z0	C1	X0	52,433	853,016	0.0615
136	A0	B0	D2	E5	F0	G0	H3	I3	J1	K0	Z0	C1	X0	52,558	855,736	0.0614
137	A0	B0	D2	E0	F0	G1	H3	I3	J1	K0	Z0	C1	X0	52,751	860,062	0.0613
138	A1	B0	D2	E0	F0	G0	H3	I5	J1	K0	Z0	C1	X0	53,030	865,219	0.0613
139	A1	B0	D2	E0	F0	G0	H3	I5	J1	K1	Z0	C1	X0	53,399	865,801	0.0617
140	A0	B0	D2	E1	F0	G0	H3	I5	J1	K0	Z0	C1	X0	53,586	869,307	0.0616
141	A0	B0	D2	E1	F0	G0	H3	I5	J1	K1	Z0	C1	X0	53,955	869,889	0.0620
142	A0	B0	D2	E3	F0	G0	H3	I5	J1	K0	Z0	C1	X0	54,142	873,123	0.0620
143	A0	B0	D2	E3	F0	G0	H3	I5	J1	K1	Z0	C1	X0	54,511	873,705	0.0624
144	A0	B0	D2	E2	F0	G0	H3	I5	J1	K0	Z0	C1	X0	55,128	875,138	0.0630
145	A0	B0	D2	E5	F0	G0	H3	I5	J1	K0	Z0	C1	X0	55,253	877,858	0.0629
146	A0	B0	D2	E0	F0	G1	H3	I5	J1	K0	Z0	C1	X0	55,446	882,184	0.0629
147	A0	B0	D2	E0	F0	G1	H3	I5	J1	K1	Z0	C1	X0	55,815	882,766	0.0632
148	A0	B0	D2	E3	F0	G1	H3	I3	J1	K1	Z0	C1	X0	56,914	883,219	0.0644
149	A1	B0	D3	E0	F0	G0	H3	I5	J1	K0	Z0	C1	X0	56,938	886,919	0.0642
150	A1	B0	D3	E0	F0	G0	H3	I5	J1	K1	Z0	C1	X0	57,307	887,501	0.0646
151	A0	B0	D3	E1	F0	G0	H3	I5	J1	K0	Z0	C1	X0	57,494	891,007	0.0645
152	A0	B0	D3	E1	F0	G0	H3	I5	J1	K1	Z0	C1	X0	57,863	891,589	0.0649
153	A0	B0	D3	E3	F0	G0	H3	I5	J1	K0	Z0	C1	X0	58,050	894,823	0.0649
154	A1	B0	D2	E0	F0	G1	H3	I5	J1	K0	Z0	C1	X0	58,128	896,855	0.0648
155	A1	B0	D2	E0	F0	G1	H3	I5	J1	K1	Z0	C1	X0	58,497	897,437	0.0652
156	A0	B0	D2	E1	F0	G1	H3	I5	J1	K0	Z0	C1	X0	58,684	900,943	0.0651
157	A0	B0	D2	E1	F0	G1	H3	I5	J1	K1	Z0	C1	X0	59,053	901,525	0.0655
158	A0	B0	D2	E3	F0	G1	H3	I5	J1	K0	Z0	C1	X0	59,240	904,759	0.0655
159	A0	B0	D2	E3	F0	G1	H3	I5	J1	K1	Z0	C1	X0	59,609	905,341	0.0658
160	A0	B0	D2	E2	F0	G1	H3	I5	J1	K0	Z0	C1	X0	60,226	906,774	0.0664
161	A0	B0	D2	E5	F0	G1	H3	I5	J1	K0	Z0	C1	X0	60,351	909,494	0.0664
162	A0	B0	D2	E5	F0	G1	H3	I5	J1	K1	Z0	C1	X0	60,720	910,076	0.0667
163	A0	B0	D2	E4	F0	G1	H3	I5	J1	K1	Z0	C1	X0	61,151	910,347	0.0672
164	A0	B0	D2	E6	F0	G1	H3	I5	J1	K0	Z0	C1	X0	61,894	912,942	0.0678
165	A1	B0	D3	E0	F0	G1	H3	I5	J1	K0	Z0	C1	X0	62,036	918,555	0.0675
166	A1	B0	D3	E0	F0	G1	H3	I5	J1	K1	Z0	C1	X0	62,405	919,137	0.0679
167	A0	B0	D3	E1	F0	G1	H3	I5	J1	K0	Z0	C1	X0	62,592	922,643	0.0678
168	A0	B0	D3	E1	F0	G1	H3	I5	J1	K1	Z0	C1	X0	62,961	923,225	0.0682
169	A0	B0	D3	E3	F0	G1	H3	I5	J1	K0	Z0	C1	X0	63,148	926,459	0.0682
170	A0	B0	D3	E3	F0	G1	H3	I5	J1	K1	Z0	C1	X0	63,517	927,041	0.0685
171	A0	B0	D3	E2	F0	G1	H3	I5	J1	K0	Z0	C1	X0	64,134	928,474	0.0691
172	A0	B0	D3	E5	F0	G1	H3	I5	J1	K0	Z0	C1	X0	64,259	931,194	0.0690
173	A0	B0	D3	E5	F0	G1	H3	I5	J1	K1	Z0	C1	X0	64,628	931,776	0.0694
174	A0	B0	D3	E4	F0	G1	H3	I5	J1	K1	Z0	C1	X0	65,059	932,047	0.0698
175	A0	B0	D3	E6	F0	G1	H3	I5	J1	K0	Z0	C1	X0	65,802	934,642	0.0704
176	A0	B0	D3	E6	F0	G1	H3	I5	J1	K1	Z0	C1	X0	66,171	935,224	0.0708
177	A0	B0	D3	E3	F0	G1	H3	I9	J1	K0	Z0	C1	X0	66,886	935,876	0.0715
178	A0	B0	D3	E3	F0	G1	H3	I9	J1	K1	Z0	C1	X0	67,255	936,458	0.0718
179	A0	B0	D3	E3	F0	G1	H3	I6	J1	K0	Z0	C1	X0	67,335	938,724	0.0717
180	A0	B0	D3	E3	F0	G1	H3	I6	J1	K1	Z0	C1	X0	67,704	939,306	0.0721
181	A0	B0	D3	E5	F0	G1	H3	I9	J1	K0	Z0	C1	X0	67,997	940,611	0.0723
182	A0	B0	D3	E2	F0	G1	H3	I6	J1	K0	Z0	C1	X0	68,321	940,739	0.0726

COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
183	A0	B0	D3	E5	F0	G1	H3	I9	J1	K1	Z0	C1	X0	68,366	941,193	0.0726
184	A0	B0	D3	E5	F0	G1	H3	I6	J1	K0	Z0	C1	X0	68,446	943,459	0.0725
185	A0	B0	D3	E5	F0	G1	H3	I6	J1	K1	Z0	C1	X0	68,815	944,041	0.0729
186	A0	B0	D3	E4	F0	G1	H3	I6	J1	K1	Z0	C1	X0	69,246	944,312	0.0733
187	A0	B0	D3	E3	F0	G1	H3	I5	J1	K0	Z0	C1	X1	69,404	945,515	0.0734
188	A0	B0	D3	E3	F0	G1	H3	I5	J1	K1	Z0	C1	X1	69,773	946,097	0.0737
189	A0	B0	D3	E6	F0	G1	H3	I6	J1	K0	Z0	C1	X0	69,989	946,907	0.0739
190	A0	B0	D3	E6	F0	G1	H3	I6	J1	K1	Z0	C1	X0	70,358	947,489	0.0743
191	A0	B0	D3	E2	F0	G1	H3	I5	J1	K0	Z0	C1	X1	70,390	947,530	0.0743
192	A0	B0	D3	E5	F0	G1	H3	I5	J1	K0	Z0	C1	X1	70,515	950,250	0.0742
193	A0	B0	D3	E5	F0	G1	H3	I5	J1	K1	Z0	C1	X1	70,884	950,832	0.0745
194	A0	B0	D3	E4	F0	G1	H3	I5	J1	K1	Z0	C1	X1	71,315	951,103	0.0750
195	A0	B0	D3	E6	F0	G1	H3	I5	J1	K0	Z0	C1	X1	72,058	953,698	0.0756
196	A0	B0	D3	E6	F0	G1	H3	I5	J1	K1	Z0	C1	X1	72,427	954,280	0.0759
197	A0	B0	D3	E3	F0	G1	H3	I9	J1	K0	Z0	C1	X1	73,142	954,932	0.0766
198	A0	B0	D3	E3	F0	G1	H3	I9	J1	K1	Z0	C1	X1	73,511	955,514	0.0769
199	A0	B0	D3	E3	F0	G1	H3	I6	J1	K0	Z0	C1	X1	73,591	957,780	0.0768
200	A0	B0	D3	E3	F0	G1	H3	I6	J1	K1	Z0	C1	X1	73,960	958,362	0.0772
201	A0	B0	D3	E5	F0	G1	H3	I9	J1	K0	Z0	C1	X1	74,253	959,667	0.0774
202	A0	B0	D3	E2	F0	G1	H3	I6	J1	K0	Z0	C1	X1	74,577	959,795	0.0777
203	A0	B0	D3	E5	F0	G1	H3	I9	J1	K1	Z0	C1	X1	74,622	960,249	0.0777
204	A0	B0	D3	E5	F0	G1	H3	I6	J1	K0	Z0	C1	X1	74,702	962,515	0.0776
205	A0	B0	D3	E5	F0	G1	H3	I6	J1	K1	Z0	C1	X1	75,071	963,097	0.0779
206	A0	B0	D3	E4	F0	G1	H3	I6	J1	K1	Z0	C1	X1	75,502	963,368	0.0784
207	A0	B0	D3	E6	F0	G1	H3	I9	J1	K1	Z0	C1	X1	76,165	963,697	0.0790
208	A0	B0	D3	E6	F0	G1	H3	I6	J1	K0	Z0	C1	X1	76,245	965,963	0.0789
209	A0	B0	D3	E3	F3	G1	H3	I0	J0	K0	Z2	C1	X0	76,494	966,127	0.0792
210	A0	B0	D3	E6	F0	G1	H3	I6	J1	K1	Z0	C1	X1	76,614	966,545	0.0793
211	A0	B0	D3	E3	F3	G1	H3	I0	J0	K1	Z2	C1	X0	76,863	966,709	0.0795
212	A0	B0	D3	E1	F3	G1	H3	I0	J0	K1	Z3	C1	X0	77,369	967,187	0.0800
213	A0	B0	D3	E2	F3	G1	H3	I0	J0	K0	Z2	C1	X0	77,480	968,142	0.0800
214	A0	B0	D3	E3	F3	G1	H3	I0	J0	K0	Z3	C1	X0	77,556	970,421	0.0799
215	A0	B0	D3	E5	F3	G1	H3	I0	J0	K0	Z2	C1	X0	77,605	970,862	0.0799
216	A0	B0	D3	E3	F3	G1	H3	I0	J0	K1	Z3	C1	X0	77,925	971,003	0.0803
217	A0	B0	D3	E5	F3	G1	H3	I0	J0	K1	Z2	C1	X0	77,974	971,444	0.0803
218	A0	B0	D3	E4	F3	G1	H3	I0	J0	K1	Z2	C1	X0	78,405	971,715	0.0807
219	A0	B0	D3	E2	F3	G1	H3	I0	J0	K0	Z3	C1	X0	78,542	972,436	0.0808
220	A0	B0	D3	E5	F3	G1	H3	I0	J0	K0	Z3	C1	X0	78,667	975,156	0.0807
221	A0	B0	D3	E5	F3	G1	H3	I0	J0	K1	Z3	C1	X0	79,036	975,738	0.0810
222	A0	B0	D3	E4	F3	G1	H3	I0	J0	K1	Z3	C1	X0	79,467	976,009	0.0814
223	A1	B0	D3	E0	F6	G1	H3	I0	J0	K0	Z2	C1	X0	79,504	977,004	0.0814
224	A1	B0	D3	E0	F6	G1	H3	I0	J0	K1	Z2	C1	X0	79,873	977,586	0.0817
225	A0	B0	D3	E1	F6	G1	H3	I0	J0	K0	Z2	C1	X0	80,060	981,092	0.0816
226	A0	B0	D3	E1	F6	G1	H3	I0	J0	K1	Z2	C1	X0	80,429	981,674	0.0819
227	A0	B0	D3	E3	F6	G1	H3	I0	J0	K0	Z2	C1	X0	80,616	984,908	0.0819
228	A0	B0	D3	E3	F6	G1	H3	I0	J0	K1	Z2	C1	X0	80,985	985,490	0.0822
229	A0	B0	D3	E1	F6	G1	H3	I0	J0	K1	Z3	C1	X0	81,491	985,968	0.0827
230	A0	B0	D3	E2	F6	G1	H3	I0	J0	K0	Z2	C1	X0	81,602	986,923	0.0827

COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
231	A0	B0	D3	E3	F6	G1	H3	I0	J0	K0	Z3	C1	X0	81,678	989,202	0.0826
232	A0	B0	D3	E5	F6	G1	H3	I0	J0	K0	Z2	C1	X0	81,727	989,643	0.0826
233	A0	B0	D3	E3	F6	G1	H3	I0	J0	K1	Z3	C1	X0	82,047	989,784	0.0829
234	A0	B0	D3	E5	F6	G1	H3	I0	J0	K1	Z2	C1	X0	82,096	990,225	0.0829
235	A0	B0	D3	E4	F6	G1	H3	I0	J0	K1	Z2	C1	X0	82,527	990,496	0.0833
236	A0	B0	D3	E2	F6	G1	H3	I0	J0	K0	Z3	C1	X0	82,664	991,217	0.0834
237	A0	B0	D3	E5	F6	G1	H3	I0	J0	K0	Z3	C1	X0	82,789	993,937	0.0833
238	A0	B0	D3	E5	F6	G1	H3	I0	J0	K1	Z3	C1	X0	83,158	994,519	0.0836
239	A0	B0	D3	E4	F6	G1	H3	I0	J0	K1	Z3	C1	X0	83,589	994,790	0.0840
240	A0	B0	D3	E6	F6	G1	H3	I0	J0	K0	Z3	C1	X0	84,332	997,385	0.0846
241	A0	B0	D3	E6	F6	G1	H3	I0	J0	K1	Z3	C1	X0	84,701	997,967	0.0849
242	A0	B0	D3	E7	F6	G1	H3	I0	J0	K1	Z3	C1	X0	85,521	998,401	0.0857
243	A0	B0	D3	E1	F6	G1	H3	I0	J0	K0	Z2	C1	X1	86,316	1,000,148	0.0863
244	A0	B0	D3	E1	F6	G1	H3	I0	J0	K1	Z2	C1	X1	86,685	1,000,730	0.0866
245	A0	B0	D3	E3	F6	G1	H3	I0	J0	K0	Z2	C1	X1	86,872	1,003,964	0.0865
246	A0	B0	D3	E3	F6	G1	H3	I0	J0	K1	Z2	C1	X1	87,241	1,004,546	0.0868
247	A0	B0	D3	E1	F6	G1	H3	I0	J0	K1	Z3	C1	X1	87,747	1,005,024	0.0873
248	A0	B0	D3	E2	F6	G1	H3	I0	J0	K0	Z2	C1	X1	87,858	1,005,979	0.0873
249	A0	B0	D3	E3	F6	G1	H3	I0	J0	K0	Z3	C1	X1	87,934	1,008,258	0.0872
250	A0	B0	D3	E5	F6	G1	H3	I0	J0	K0	Z2	C1	X1	87,983	1,008,699	0.0872
251	A0	B0	D3	E3	F6	G1	H3	I0	J0	K1	Z3	C1	X1	88,303	1,008,840	0.0875
252	A0	B0	D3	E5	F6	G1	H3	I0	J0	K1	Z2	C1	X1	88,352	1,009,281	0.0875
253	A0	B0	D3	E4	F6	G1	H3	I0	J0	K1	Z2	C1	X1	88,783	1,009,552	0.0879
254	A0	B0	D3	E2	F6	G1	H3	I0	J0	K0	Z3	C1	X1	88,920	1,010,273	0.0880
255	A0	B0	D3	E5	F6	G1	H3	I0	J0	K0	Z3	C1	X1	89,045	1,012,993	0.0879
256	A0	B0	D3	E5	F6	G1	H3	I0	J0	K1	Z3	C1	X1	89,414	1,013,575	0.0882
257	A0	B0	D3	E4	F6	G1	H3	I0	J0	K1	Z3	C1	X1	89,845	1,013,846	0.0886
258	A0	B0	D3	E6	F6	G1	H3	I0	J0	K0	Z3	C1	X1	90,588	1,016,441	0.0891
259	A0	B0	D3	E6	F6	G1	H3	I0	J0	K1	Z3	C1	X1	90,957	1,017,023	0.0894
260	A0	B0	D3	E7	F6	G1	H3	I0	J0	K1	Z3	C1	X1	91,777	1,017,457	0.0902
261	A0	B1	D3	E5	F6	G1	H3	I0	J0	K0	Z2	C1	X1	93,533	1,017,565	0.0919
262	A0	B1	D3	E3	F6	G1	H3	I0	J0	K1	Z3	C1	X1	93,853	1,017,706	0.0922
263	A0	B1	D3	E5	F6	G1	H3	I0	J0	K1	Z2	C1	X1	93,902	1,018,147	0.0922
264	A0	B1	D3	E4	F6	G1	H3	I0	J0	K1	Z2	C1	X1	94,333	1,018,418	0.0926
265	A0	B1	D3	E2	F6	G1	H3	I0	J0	K0	Z3	C1	X1	94,470	1,019,139	0.0927
266	A0	B1	D3	E5	F6	G1	H3	I0	J0	K0	Z3	C1	X1	94,595	1,021,859	0.0926
267	A0	B1	D3	E5	F6	G1	H3	I0	J0	K1	Z3	C1	X1	94,964	1,022,441	0.0929
268	A0	B1	D3	E4	F6	G1	H3	I0	J0	K1	Z3	C1	X1	95,395	1,022,712	0.0933
269	A0	B1	D3	E6	F6	G1	H3	I0	J0	K0	Z3	C1	X1	96,138	1,025,307	0.0938
270	A0	B1	D3	E6	F6	G1	H3	I0	J0	K1	Z3	C1	X1	96,507	1,025,889	0.0941
271	A0	B1	D3	E7	F6	G1	H3	I0	J0	K1	Z3	C1	X1	97,327	1,026,323	0.0948
272	A0	B1	D3	E5	F8	G1	H3	I0	J0	K0	Z3	C1	X1	99,393	1,026,396	0.0968
273	A0	B1	D3	E5	F8	G1	H3	I0	J0	K1	Z3	C1	X1	99,762	1,026,978	0.0971
274	A0	B1	D3	E4	F8	G1	H3	I0	J0	K1	Z3	C1	X1	100,193	1,027,249	0.0975
275	A0	B1	D3	E6	F8	G1	H3	I0	J0	K0	Z3	C1	X1	100,936	1,029,844	0.0980
276	A0	B1	D3	E6	F8	G1	H3	I0	J0	K1	Z3	C1	X1	101,305	1,030,426	0.0983
277	A0	B1	D3	E7	F8	G1	H3	I0	J0	K1	Z3	C1	X1	102,125	1,030,860	0.0991
278	A0	B1	D3	E6	F9	G1	H3	I0	J0	K0	Z3	C1	X1	103,736	1,031,968	0.1005

COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
279	A0	B1	D3	E6	F9	G1	H3	I0	J0	K1	Z3	C1	X1	104,105	1,032,550	0.1008
280	A0	B1	D3	E7	F9	G1	H3	I0	J0	K1	Z3	C1	X1	104,925	1,032,984	0.1016
281	A0	B1	D3	E5	F8	G1	H3	I0	J0	K1	Z3	C1	X2	108,807	1,033,422	0.1053
282	A0	B1	D3	E4	F8	G1	H3	I0	J0	K1	Z3	C1	X2	109,238	1,033,693	0.1057
283	A0	B1	D3	E6	F8	G1	H3	I0	J0	K0	Z3	C1	X2	109,981	1,036,288	0.1061
284	A0	B1	D3	E6	F8	G1	H3	I0	J0	K1	Z3	C1	X2	110,350	1,036,870	0.1064
285	A0	B1	D3	E7	F8	G1	H3	I0	J0	K1	Z3	C1	X2	111,170	1,037,304	0.1072
286	A0	B1	D3	E6	F9	G1	H3	I0	J0	K0	Z3	C1	X2	112,781	1,038,412	0.1086
287	A0	B1	D3	E6	F9	G1	H3	I0	J0	K1	Z3	C1	X2	113,150	1,038,994	0.1089
288	A0	B1	D3	E7	F9	G1	H3	I0	J0	K1	Z3	C1	X2	113,970	1,039,428	0.1096
289	A0	B1	D3	E6	F8	G1	H3	I0	J0	K0	Z3	C1	X3	118,734	1,040,256	0.1141
290	A0	B1	D3	E6	F8	G1	H3	I0	J0	K1	Z3	C1	X3	119,103	1,040,838	0.1144
291	A0	B1	D3	E7	F8	G1	H3	I0	J0	K1	Z3	C1	X3	119,923	1,041,272	0.1152
292	A0	B1	D3	E6	F9	G1	H3	I0	J0	K0	Z3	C1	X3	121,534	1,042,380	0.1166
293	A0	B1	D3	E6	F9	G1	H3	I0	J0	K1	Z3	C1	X3	121,903	1,042,962	0.1169
294	A0	B1	D3	E7	F9	G1	H3	I0	J0	K1	Z3	C1	X3	122,723	1,043,396	0.1176

Figure C3 – Cost and Output of Cost Effective Combinations (Function C)



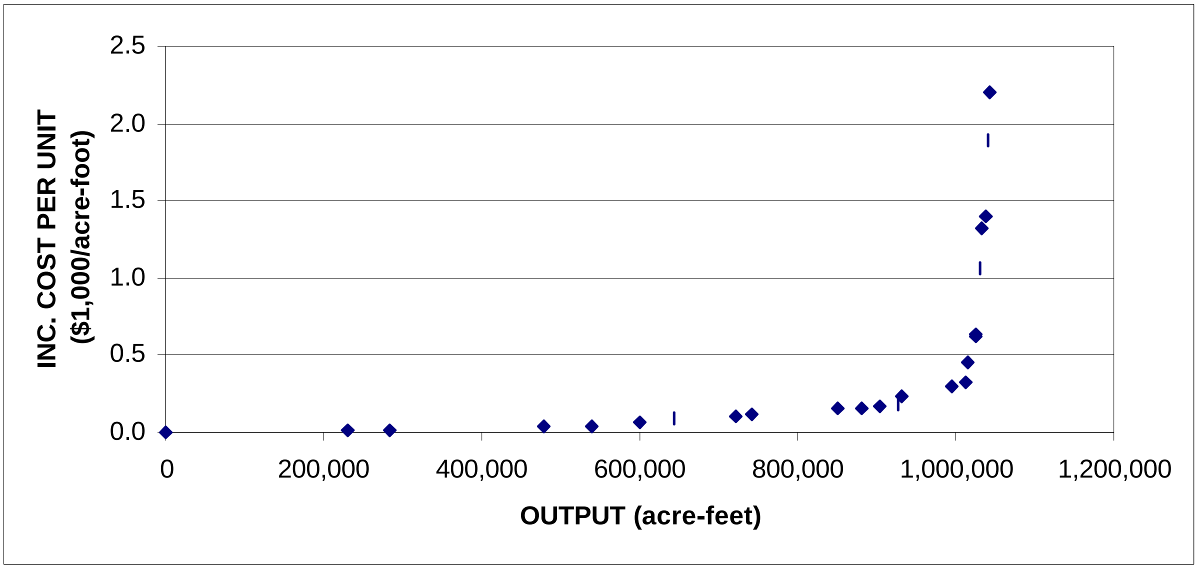
The third step of the cost analyses for Function C was to identify the subset of the cost effective combinations that were most efficient at providing additional water supply to Lake Okeechobee from the east and west basins. The 24 "best-buy" combinations are listed in ***Table C4***.

The values in the "Count" column simply count the number of best buys. The entries in the "Code" columns identify the management measures in each combination and correspond to the measure codes found in Tables C1 and C2. The values in the "Average Cost" column were calculated by dividing cost by output for each combination. The values in the "Incremental Cost" column show the change in cost from one combination to the next and were calculated by subtracting the cost of the next-smaller (in terms of output) combination from each combination. The values in the "Incremental Output" column show the change in output from one combination to the next and were calculated by subtracting the output of the next-smaller (in terms of output) combination from each combination. The last column "Incremental Cost Per Unit" shows the cost per unit of the incremental output for each combination. A plot of output vs. incremental cost per unit for the Function C best buys is included in ***Figure C4***.

Table A4 – Best Buy Combinations of Management Measures for Function C

COUNT	CODE													COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)	INC. COST ($1,000)	INC. OUTPUT (acre-feet)	INC. COST PER UNIT ($1,000/acre-foot)
1	A0	B0	D0	E0	F0	G0	H0	I0	J0	K0	Z0	C0	X0	0	0	0.0000	0	0	0.0000
2	A0	B0	D0	E0	F0	G0	H1	I0	J0	K0	Z0	C0	X0	3,995	231,200	0.0173	3,995	231,200	0.0173
3	A0	B0	D0	E0	F0	G0	H1	I0	J1	K0	Z0	C0	X0	4,967	282,902	0.0176	972	51,702	0.0188
4	A0	B0	D0	E0	F0	G0	H2	I0	J1	K0	Z0	C0	X0	11,829	478,902	0.0247	6,862	196,000	0.0350
5	A0	B0	D1	E0	F0	G0	H2	I0	J1	K0	Z0	C0	X0	14,064	538,002	0.0261	2,235	59,100	0.0378
6	A0	B0	D1	E0	F0	G0	H2	I3	J1	K0	Z0	C0	X0	18,357	600,826	0.0306	4,293	62,824	0.0683
7	A0	B0	D2	E0	F0	G0	H2	I3	J1	K0	Z0	C0	X0	21,861	642,326	0.0340	3,504	41,500	0.0844
8	A0	B0	D2	E0	F0	G0	H3	I3	J1	K0	Z0	C0	X0	30,385	720,326	0.0422	8,524	78,000	0.1093
9	A0	B0	D2	E0	F0	G0	H3	I5	J1	K0	Z0	C0	X0	33,080	742,448	0.0446	2,695	22,122	0.1218
10	A0	B0	D2	E0	F0	G0	H3	I5	J1	K0	Z0	C1	X0	50,348	850,548	0.0592	17,268	108,100	0.1597
11	A0	B0	D2	E0	F0	G1	H3	I5	J1	K0	Z0	C1	X0	55,446	882,184	0.0629	5,098	31,636	0.1611
12	A0	B0	D2	E3	F0	G1	H3	I5	J1	K0	Z0	C1	X0	59,240	904,759	0.0655	3,794	22,575	0.1681
13	A0	B0	D3	E3	F0	G1	H3	I5	J1	K0	Z0	C1	X0	63,148	926,459	0.0682	3,908	21,700	0.1801
14	A0	B0	D3	E5	F0	G1	H3	I5	J1	K0	Z0	C1	X0	64,259	931,194	0.0690	1,111	4,735	0.2346
15	A0	B0	D3	E5	F6	G1	H3	I0	J0	K0	Z3	C1	X0	82,789	993,937	0.0833	18,530	62,743	0.2953
16	A0	B0	D3	E5	F6	G1	H3	I0	J0	K0	Z3	C1	X1	89,045	1,012,993	0.0879	6,256	19,056	0.3283
17	A0	B0	D3	E6	F6	G1	H3	I0	J0	K0	Z3	C1	X1	90,588	1,016,441	0.0891	1,543	3,448	0.4475
18	A0	B1	D3	E6	F6	G1	H3	I0	J0	K0	Z3	C1	X1	96,138	1,025,307	0.0938	5,550	8,866	0.6260
19	A0	B1	D3	E6	F6	G1	H3	I0	J0	K1	Z3	C1	X1	96,507	1,025,889	0.0941	369	582	0.6340
20	A0	B1	D3	E6	F8	G1	H3	I0	J0	K1	Z3	C1	X1	101,305	1,030,426	0.0983	4,798	4,537	1.0575
21	A0	B1	D3	E6	F9	G1	H3	I0	J0	K1	Z3	C1	X1	104,105	1,032,550	0.1008	2,800	2,124	1.3183
22	A0	B1	D3	E6	F9	G1	H3	I0	J0	K1	Z3	C1	X2	113,150	1,038,994	0.1089	9,045	6,444	1.4036
23	A0	B1	D3	E7	F9	G1	H3	I0	J0	K1	Z3	C1	X2	113,970	1,039,428	0.1096	820	434	1.8894
24	A0	B1	D3	E7	F9	G1	H3	I0	J0	K1	Z3	C1	X3	122,723	1,043,396	0.1176	8,753	3,968	2.2059

Figure C4 – Incremental Cost per Unit and Output of Best Buy Combinations (Function C)



A2.10 ANALYSIS RESULTS: FUNCTION D, INCREASE REGIONAL WATER SUPPLY IN LOWER EAST COAST AREA

A2.10.1 Cost Effectiveness Analysis Approach.

For Function D, eight management measures were examined through cost effectiveness analysis, all of which included multiple scales. The cost analysis approach for Function D was to (1) calculate the average cost for each management measure and sort measures by increasing average cost, (2) formulate all possible combinations of these measures and identify the cost effective set, and (3) conduct an incremental cost analysis to identify the most efficient production schedule, or set of "best-buys".

A2.10.2 Management Measures and Data.

Function D's eight management measures (with cost, output and average cost) are included in ***Table D1***. The measures are grouped by geographic area. The entry in the "Code" column will be referenced when showing all possible combinations of Function D measures. Each measure has its own code letter. The no-action option for any measure gets a "0" following its code letter. Each scale of a measure has a different number following its code letter. In Function D, measure C was not combinable with measure X, measure D was not combinable with measure Y, and measure E was not combinable with measure Z.

Table D1 – Function D Management Measures

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre -foot)
Loxahatchee National Wildlife Refuge (Water Conservation Area 1, Service Area 1)				
B0	*No Action - LNWR Storage*	0	0	0.0000
B1	LNWR STORAGE (SA1AC)	2,375	15,700	0.1513
B2	LNWR STORAGE (SA1CB)	3,769	19,957	0.1889
B3	LNWR STORAGE (SA1EB)	3,836	32,475	0.1181
B4	LNWR STORAGE (SA1CB+SA1EB)	7,605	35,932	0.2116
B5	LNWR STORAGE (SA1AC+SA1CB+SA1EB)	9,980	37,932	0.2631
Water Conservation Area 3A/3B (Service Area 2)				
C0	*No Action – WCA3A/3B Storage*	0	0	0.0000
C1	WCA3A/3B STORAGE (SA2AB)	6,716	57,144	0.1175
C2	WCA3A/3B STORAGE (SA2DB.0)	7,202	40,000	0.1801
C3	WCA3A/3B STORAGE (SA2DB.1)	4,540	32,000	0.1419
C4	WCA3A/3B STORAGE (SA2EB)	3,218	28,526	0.1128
C5	WCA3A/3B STORAGE (SA2FC)	2,159	10,050	0.2148
C6	WCA3A/3B STORAGE (SA2GB)	4,308	35,109	0.1227
C7	WCA3A/3B STORAGE (SA2HB)	3,696	27,000	0.1369
C8	WCA3A/3B STORAGE (SA2IB.0)	4,160	31,000	0.1342
X0	*No Action – WCA3A/3B Storage*	0	0	0.0000
X1	WCA3A/3B STORAGE (SA2IB.1)	2,145	19,500	0.1100
X2	WCA3A/3B STORAGE (SA2AB+SA2DB.1)	11,256	66,644	0.1689
X3	WCA3A/3B STORAGE (SA2AB+SA2EB)	9,934	67,170	0.1479
X4	WCA3A/3B STORAGE (SA2AB+SA2IB.1)	8,861	61,644	0.1437
X5	WCA3A/3B STORAGE (SA2DB.0+SA2EB)	10,420	52,026	0.2003
X6	WCA3A/3B STORAGE (SA2DB.0+SA2IB.0)	11,362	52,000	0.2185
X7	WCA3A/3B STORAGE (SA2AB+SA2DB.0+SA2IB.0)	18,078	74,644	0.2422
X8	WCA3A/3B STORAGE (SA2DB.0+SA2EB+SA2GB+SA2HB+SA2IB.0)	22,584	73,635	0.3067
Water Conservation Area 3B (Service Area 3B, Lake Belt Area)				
D0	*No Action – WCA3B Storage*	0	0	0.0000
D1	WCA3B STORAGE (SA3AB.0)	7,273	50,106	0.1452
D2	WCA3B STORAGE (SA3AB.1)	4,523	44,500	0.1016
D3	WCA3B STORAGE (SA3BC.1)	1,361	31,717	0.0429
D4	WCA3B STORAGE (SA3CB.0)	17,406	43,000	0.4048
D5	WCA3B STORAGE (SA3CB.1)	13,267	44,500	0.2981
D6	WCA3B STORAGE (SA3CB.2)	4,472	36,000	0.1242
D7	WCA3B STORAGE (SA3CB.3)	9,985	43,000	0.2322
D8	WCA3B STORAGE (SA3AB.1+SA3BC.1)	5,885	55,435	0.1062
D9	WCA3B STORAGE (SA3AB.1+SA3CB.2)	8,995	44,000	0.2044
Y0	*No Action - WCA3B Storage*	0	0	0.0000
Y1	WCA3B STORAGE (SA3BC.1+SA3CB.2)	5,833	48,217	0.1210
Y2	WCA3B STORAGE (SA3BC.1+SA3CB.3)	11,346	50,217	0.2259
Everglades National Park				
E0	*No Action – ENP Storage and Conveyance*	0	0	0.0000

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre -foot)
E1	ENP STORAGE AND CONVEYANCE (SA3EB.0)	2,476	12,000	0.2063
E2	ENP STORAGE AND CONVEYANCE (SA3EB.1)	1,435	12,200	0.1176
E3	ENP STORAGE AND CONVEYANCE (SA3FB)	1,080	8,500	0.1271
E4	ENP STORAGE AND CONVEYANCE (SA3FC)	1,034	12,000	0.0862
E5	ENP STORAGE AND CONVEYANCE (SA3GC)	666	7,900	0.0843
E6	ENP STORAGE AND CONVEYANCE (SA3HB)	1,361	9,500	0.1433
E7	ENP STORAGE AND CONVEYANCE (SA3IC)	2,198	12,000	0.1832
E8	ENP STORAGE AND CONVEYANCE (SA3EB.1+SA3FB)	2,515	12,100	0.2079
E9	ENP STORAGE AND CONVEYANCE (SA3EB.1+SA3FC)	2,469	12,000	0.2058
Z0	*No Action - ENP Storage and Conveyance*	0	0	0.0000
Z1	ENP STORAGE AND CONVEYANCE (SA3FB+SA3GC)	1,746	12,100	0.1443
Z2	ENP STORAGE AND CONVEYANCE (SA3FC+SA3GC)	1,700	12,000	0.1417
Z3	ENP STORAGE AND CONVEYANCE (SA3GC+SA3HB)	2,027	12,100	0.1675

A2.10.3 Results of Analyses.

The first step in the analyses was to display the management measures sorted by increasing average cost. This display is included in ***Table D2***. This table shows the relative production efficiency of the management measures being considered in Function D. The measure with the lowest average cost is the most efficient measure for reducing demands on the existing system. Each successive measure is less efficient at reducing demands.

Table D2 – Function D Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre -foot)
D3	WCA3B STORAGE (SA3BC.1)	1,361	31,717	0.0429
E5	ENP STORAGE AND CONVEYANCE (SA3GC)	666	7,900	0.0843
E4	ENP STORAGE AND CONVEYANCE (SA3FC)	1,034	12,000	0.0862
D2	WCA3B STORAGE (SA3AB.1)	4,523	44,500	0.1016
D8	WCA3B STORAGE (SA3AB.1+SA3BC.1)	5,885	55,435	0.1062
X1	WCA3A/3B STORAGE (SA2IB.1)	2,145	19,500	0.1100
C4	WCA3A/3B STORAGE (SA2EB)	3,218	28,526	0.1128
C1	WCA3A/3B STORAGE (SA2AB)	6,716	57,144	0.1175
E2	ENP STORAGE AND CONVEYANCE (SA3EB.1)	1,435	12,200	0.1176
B3	LNWR STORAGE (SA1EB)	3,836	32,475	0.1181
Y1	WCA3B STORAGE (SA3BC.1+SA3CB.2)	5,833	48,217	0.1210
C6	WCA3A/3B STORAGE (SA2GB)	4,308	35,109	0.1227
D6	WCA3B STORAGE (SA3CB.2)	4,472	36,000	0.1242
E3	ENP STORAGE AND CONVEYANCE (SA3FB)	1,080	8,500	0.1271
C8	WCA3A/3B STORAGE (SA2IB.0)	4,160	31,000	0.1342
C7	WCA3A/3B STORAGE (SA2HB)	3,696	27,000	0.1369
Z2	ENP STORAGE AND CONVEYANCE (SA3FC+SA3GC)	1,700	12,000	0.1417

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre -foot)
C3	WCA3A/3B STORAGE (SA2DB.1)	4,540	32,000	0.1419
E6	ENP STORAGE AND CONVEYANCE (SA3HB)	1,361	9,500	0.1433
X4	WCA3A/3B STORAGE (SA2AB+SA2IB.1)	8,861	61,644	0.1437
Z1	ENP STORAGE AND CONVEYANCE (SA3FB+SA3GC)	1,746	12,100	0.1443
D1	WCA3B STORAGE (SA3AB.0)	7,273	50,106	0.1452
X3	WCA3A/3B STORAGE (SA2AB+SA2EB)	9,934	67,170	0.1479
B1	LNWR STORAGE (SA1AC)	2,375	15,700	0.1513
Z3	ENP STORAGE AND CONVEYANCE (SA3GC+SA3HB)	2,027	12,100	0.1675
X2	WCA3A/3B STORAGE (SA2AB+SA2DB.1)	11,256	66,644	0.1689
C2	WCA3A/3B STORAGE (SA2DB.0)	7,202	40,000	0.1801
E7	ENP STORAGE AND CONVEYANCE (SA3IC)	2,198	12,000	0.1832
B2	LNWR STORAGE (SA1CB)	3,769	19,957	0.1889
X5	WCA3A/3B STORAGE (SA2DB.0+SA2EB)	10,420	52,026	0.2003
D9	WCA3B STORAGE (SA3AB.1+SA3CB.2)	8,995	44,000	0.2044
E9	ENP STORAGE AND CONVEYANCE (SA3EB.1+SA3FC)	2,469	12,000	0.2058
E1	ENP STORAGE AND CONVEYANCE (SA3EB.0)	2,476	12,000	0.2063
E8	ENP STORAGE AND CONVEYANCE (SA3EB.1+SA3FB)	2,515	12,100	0.2079
B4	LNWR STORAGE (SA1CB+SA1EB)	7,605	35,932	0.2116
C5	WCA3A/3B STORAGE (SA2FC)	2,159	10,050	0.2148
X6	WCA3A/3B STORAGE (SA2DB.0+SA2IB.0)	11,362	52,000	0.2185
Y2	WCA3B STORAGE (SA3BC.1+SA3CB.3)	11,346	50,217	0.2259
D7	WCA3B STORAGE (SA3CB.3)	9,985	43,000	0.2322
X7	WCA3A/3B STORAGE (SA2AB+SA2DB.0+SA2IB.0)	18,078	74,644	0.2422
B5	LNWR STORAGE (SA1AC+SA1CB+SA1EB)	9,980	37,932	0.2631
D5	WCA3B STORAGE (SA3CB.1)	13,267	44,500	0.2981
X8	WCA3A/3B STORAGE (SA2DB.0+SA2EB+SA2GB+SA2HB+SA2IB.0)	22,584	73,635	0.3067
D4	WCA3B STORAGE (SA3CB.0)	17,406	43,000	0.4048

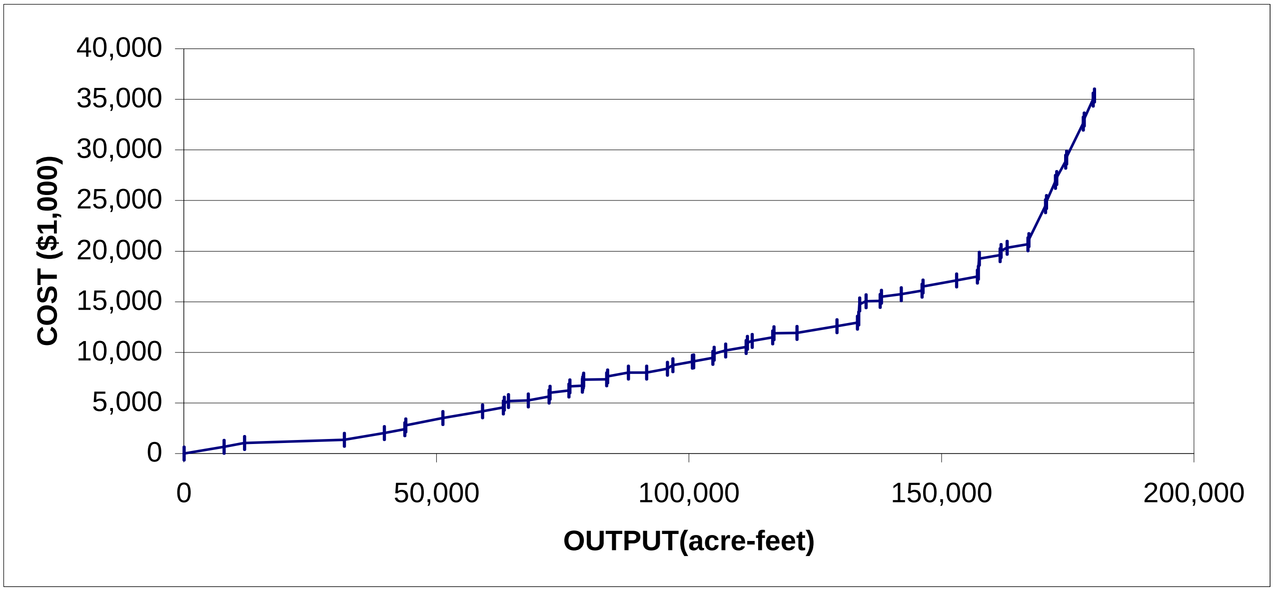
The second step of the analyses was to formulate all possible combinations of the Function D management measures and identify the cost effective set. Of the full 15,915 combinations of Function D management measures, 67 were cost effective. The 67 cost effective combinations can be found in ***Table D3***. The value in the “Count” column simply counts the number of cost effective plans. The entries in the “Code” columns correspond to the Codes from Tables D1 and D2 and show what measures are included in each combination. A graph of cost vs. output for Function D’s cost effective combinations is plotted in ***Figure D3***.

Table D3 – Cost Effective Combinations of Management Measures for Function D

COUNT	CODE							COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
1	B0	C0	X0	D0	Y0	E0	Z0	0	0	0.0000
2	B0	C0	X0	D0	Y0	E5	Z0	666	7,900	0.0843
3	B0	C0	X0	D0	Y0	E4	Z0	1,034	12,000	0.0862
4	B0	C0	X0	D3	Y0	E0	Z0	1,361	31,717	0.0429
5	B0	C0	X0	D3	Y0	E5	Z0	2,027	39,617	0.0512
6	B0	C0	X0	D3	Y0	E4	Z0	2,395	43,717	0.0548
7	B0	C0	X0	D3	Y0	E2	Z0	2,796	43,917	0.0637
8	B0	C0	X1	D3	Y0	E0	Z0	3,506	51,217	0.0685
9	B0	C0	X1	D3	Y0	E5	Z0	4,172	59,117	0.0706
10	B0	C0	X1	D3	Y0	E4	Z0	4,540	63,217	0.0718
11	B0	C0	X1	D3	Y0	E2	Z0	4,941	63,417	0.0779
12	B3	C0	X0	D3	Y0	E0	Z0	5,197	64,192	0.0810
13	B0	C4	X0	D3	Y0	E5	Z0	5,245	68,143	0.0770
14	B0	C4	X0	D3	Y0	E4	Z0	5,613	72,243	0.0777
15	B0	C4	X0	D3	Y0	E2	Z0	6,014	72,443	0.0830
16	B3	C0	X0	D3	Y0	E4	Z0	6,231	76,192	0.0818
17	B3	C0	X0	D3	Y0	E2	Z0	6,632	76,392	0.0868
18	B0	C6	X0	D3	Y0	E4	Z0	6,703	78,826	0.0850
19	B1	C0	X1	D3	Y0	E4	Z0	6,915	78,917	0.0876
20	B0	C6	X0	D3	Y0	E2	Z0	7,104	79,026	0.0899
21	B1	C0	X1	D3	Y0	E2	Z0	7,316	79,117	0.0925
22	B3	C0	X1	D3	Y0	E0	Z0	7,342	83,692	0.0877
23	B1	C4	X0	D3	Y0	E5	Z0	7,620	83,843	0.0909
24	B1	C4	X0	D3	Y0	E4	Z0	7,988	87,943	0.0908
25	B3	C0	X1	D3	Y0	E5	Z0	8,008	91,592	0.0874
26	B3	C0	X1	D3	Y0	E4	Z0	8,376	95,692	0.0875
27	B0	C1	X0	D3	Y0	E5	Z0	8,743	96,761	0.0904
28	B3	C4	X0	D3	Y0	E5	Z0	9,081	100,618	0.0903
29	B0	C1	X0	D3	Y0	E4	Z0	9,111	100,861	0.0903
30	B3	C4	X0	D3	Y0	E4	Z0	9,449	104,718	0.0902
31	B3	C4	X0	D3	Y0	E2	Z0	9,850	104,918	0.0939
32	B3	C6	X0	D3	Y0	E5	Z0	10,171	107,201	0.0949
33	B3	C6	X0	D3	Y0	E4	Z0	10,539	111,301	0.0947
34	B3	C6	X0	D3	Y0	E2	Z0	10,940	111,501	0.0981
35	B1	C1	X0	D3	Y0	E5	Z0	11,118	112,461	0.0989
36	B1	C1	X0	D3	Y0	E4	Z0	11,486	116,561	0.0985
37	B1	C1	X0	D3	Y0	E2	Z0	11,887	116,761	0.1018
38	B3	C1	X0	D3	Y0	E0	Z0	11,913	121,336	0.0982
39	B3	C1	X0	D3	Y0	E5	Z0	12,579	129,236	0.0973
40	B3	C1	X0	D3	Y0	E4	Z0	12,947	133,336	0.0971

COUNT	CODE							COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
41	B3	C1	X0	D3	Y0	E2	Z0	13,348	133,536	0.1000
42	B3	C0	X4	D3	Y0	E5	Z0	14,724	133,736	0.1101
43	B3	C6	X0	D8	Y0	E4	Z0	15,063	135,019	0.1116
44	B3	C0	X4	D3	Y0	E4	Z0	15,092	137,836	0.1095
45	B3	C0	X4	D3	Y0	E2	Z0	15,493	138,036	0.1122
46	B3	C1	X0	D2	Y0	E5	Z0	15,741	142,019	0.1108
47	B3	C1	X0	D2	Y0	E4	Z0	16,109	146,119	0.1102
48	B3	C1	X0	D2	Y0	E2	Z0	16,510	146,319	0.1128
49	B3	C1	X0	D8	Y0	E5	Z0	17,103	152,954	0.1118
50	B3	C1	X0	D8	Y0	E4	Z0	17,471	157,054	0.1112
51	B3	C1	X0	D8	Y0	E2	Z0	17,872	157,254	0.1137
52	B3	C0	X4	D8	Y0	E5	Z0	19,248	157,454	0.1222
53	B3	C0	X4	D8	Y0	E4	Z0	19,616	161,554	0.1214
54	B3	C0	X4	D8	Y0	E2	Z0	20,017	161,754	0.1237
55	B3	C0	X3	D8	Y0	E5	Z0	20,321	162,980	0.1247
56	B3	C0	X3	D8	Y0	E4	Z0	20,689	167,080	0.1238
57	B3	C0	X3	D8	Y0	E2	Z0	21,090	167,280	0.1261
58	B4	C0	X3	D8	Y0	E4	Z0	24,458	170,537	0.1434
59	B4	C0	X3	D8	Y0	E2	Z0	24,859	170,737	0.1456
60	B5	C0	X3	D8	Y0	E4	Z0	26,833	172,537	0.1555
61	B5	C0	X3	D8	Y0	E2	Z0	27,234	172,737	0.1577
62	B3	C0	X7	D8	Y0	E4	Z0	28,833	174,554	0.1652
63	B3	C0	X7	D8	Y0	E2	Z0	29,234	174,754	0.1673
64	B4	C0	X7	D8	Y0	E4	Z0	32,602	178,011	0.1831
65	B4	C0	X7	D8	Y0	E2	Z0	33,003	178,211	0.1852
66	B5	C0	X7	D8	Y0	E4	Z0	34,977	180,011	0.1943
67	B5	C0	X7	D8	Y0	E2	Z0	35,378	180,211	0.1963

Figure D3 – Cost and Output of Cost Effective Combinations (Function D)



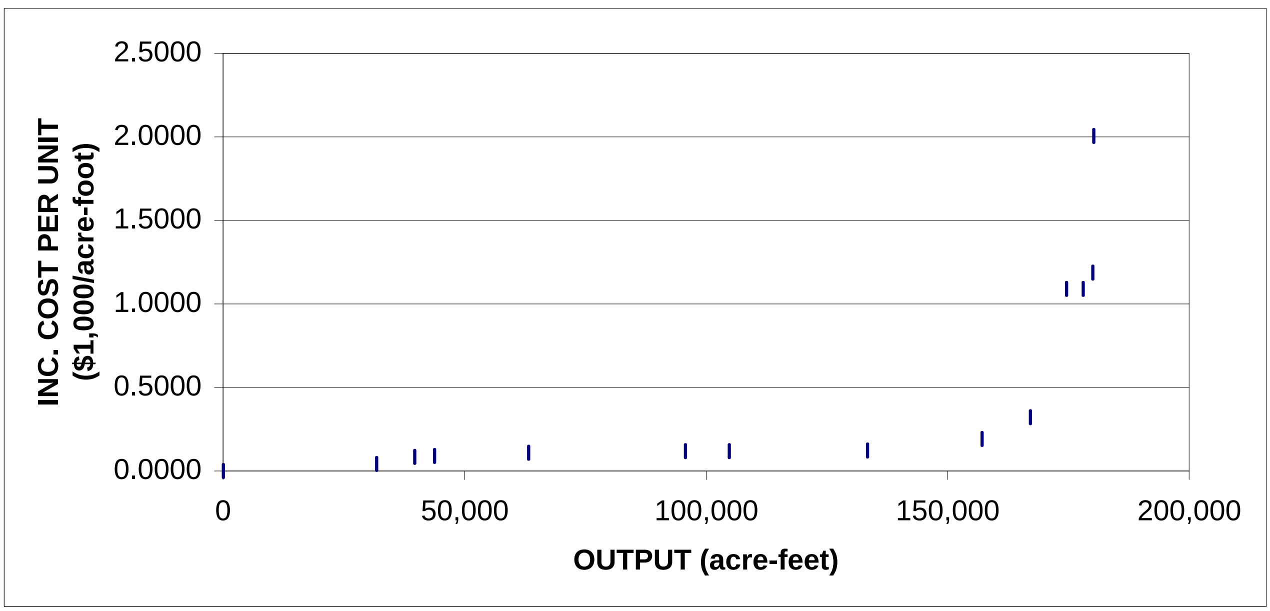
The third step of the cost analyses for Function D was to identify the subset of the cost-effective combinations that were most efficient at reducing demand on the existing system. These 14 "best-buy" plans are listed in ***Table D4***.

The values in the "Count" column simply count the number of best buys. The entries in the "Code" columns identify the management measures in each combination and correspond to the measure codes found in Tables D1 and D2. The values in the "Average Cost" column were calculated by dividing cost by output for each combination. The values in the "Incremental Cost" column show the change in cost from one combination to the next and were calculated by subtracting the cost of the next-smaller (in terms of output) combination from each combination. The values in the "Incremental Output" column show the change in output from one combination to the next and were calculated by subtracting the output of the next-smaller (in terms of output) combination from each combination. The last column "Incremental Cost Per Unit" shows the cost per unit of the incremental output for each combination. A plot of output vs. incremental cost per unit for the Function D best buys is included in ***Figure D4***.

Table D4 – Best Buy Combinations of Management Measures for Function D

COUNT	CODE							COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)	INC. COST ($1,000)	INC. OUTPUT (acre-feet)	INC. COST PER UNIT ($1,000/acre-foot)
1	B0	C0	X0	D0	Y0	E0	Z0	0	0	0.0000	0	0	0.0000
2	B0	C0	X0	D3	Y0	E0	Z0	1,361	31,717	0.0429	1,361	31,717	0.0429
3	B0	C0	X0	D3	Y0	E5	Z0	2,027	39,617	0.0512	666	7,900	0.0843
4	B0	C0	X0	D3	Y0	E4	Z0	2,395	43,717	0.0548	368	4,100	0.0898
5	B0	C0	X1	D3	Y0	E4	Z0	4,540	63,217	0.0718	2,145	19,500	0.1100
6	B3	C0	X1	D3	Y0	E4	Z0	8,376	95,692	0.0875	3,836	32,475	0.1181
7	B3	C4	X0	D3	Y0	E4	Z0	9,449	104,718	0.0902	1,073	9,026	0.1189
8	B3	C1	X0	D3	Y0	E4	Z0	12,947	133,336	0.0971	3,498	28,618	0.1222
9	B3	C1	X0	D8	Y0	E4	Z0	17,471	157,054	0.1112	4,524	23,718	0.1907
10	B3	C0	X3	D8	Y0	E4	Z0	20,689	167,080	0.1238	3,218	10,026	0.3210
11	B3	C0	X7	D8	Y0	E4	Z0	28,833	174,554	0.1652	8,144	7,474	1.0896
12	B4	C0	X7	D8	Y0	E4	Z0	32,602	178,011	0.1831	3,769	3,457	1.0903
13	B5	C0	X7	D8	Y0	E4	Z0	34,977	180,011	0.1943	2,375	2,000	1.1875
14	B5	C0	X7	D8	Y0	E2	Z0	35,378	180,211	0.1963	401	200	2.0050

Figure D4 – Incremental Cost per Unit and Output of Best Buy Combinations (Function D)



A2.11 ANALYSIS RESULTS: FUNCTION E, INCREASE SPATIAL EXTENT OF WETLANDS

A2.11.1 Cost Effectiveness Analysis Approach.

The cost analysis for Function E involved a different approach than was carried out for other functional areas. In Function E, cost effectiveness analyses were conducted individually for each of nine geographic areas: Kissimmee River Area, Upper East Coast/ St. Lucie and Martin Counties, Lake Okeechobee, South Miami-Dade County/Biscayne Bay, Loxahatchee National Wildlife Refuge, Water Conservation Area 3A/3B (Service Area 2), Water Conservation Area 3B (Service Area 3 – Lake Belt Area), Big Cypress, and Everglades National Park.

It was chosen not to look at all combinations of Function E measures after determining that there were 1,274,019,840 possible combinations. Instead, the best-buy combinations, identified through each of the individual (geographic) cost effectiveness and incremental cost analyses runs were combined. To examine the relative cost effectiveness of all Function E management measures (across all geographic areas within Function E) measures were sorted by increasing average cost.

A2.11.2 All Function E Management Measures and Data.

Function E included 26 management measures, many of which had multiple scales. The Function E measures (with cost, output and average cost) are included in ***Table E1***. Measures are grouped by geographic area. Each measure has its own code letter. The no-action option for any measure gets a "0" following its code letter. Each scale of a measure has a different number following its code letter. For example, measure A has two scales: A0 and A1. In Function E, all measures were combinable with one another; scales of the same measure were not combinable.

Table E1 – All Function E Management Measures

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres of wetlands)	AVG. COST ($1,000/acre)
Kissimmee River Area				
A0	No Action - Pool A	0	0	not applicable
A1	POOL A RESTORATION	1,153	2,590	0.4452
B0	No Action - Pool E	0	0	not applicable
B1	POOL E RESTORATION	2,962	2,718	1.0898
C0	No Action - Paradise Run	0	0	not applicable
C1	PARADISE RUN RESTORATION	780	3,600	0.2167
Upper East Coast/St. Lucie and Martin Counties				
D0	No Action - UEC Wetlands Restoration	0	0	not applicable
D1	UEC WETLAND RESTORATION (2,000 acres)	1,801	2,000	0.9005

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres of wetlands)	AVG. COST ($1,000/acre)
D2	UEC WETLAND RESTORATION (5,000 acres)	4,229	5,000	0.8458
D3	UEC WETLAND RESTORATION (10,000 acres)	7,728	10,000	0.7728
D4	UEC WETLAND RESTORATION (20,000 acres)	17,087	20,000	0.8544
Lake Okeechobee				
E0	No Action - Restore Kreamer,Torry, & Rita Islands	0	0	not applicable
E1	RESTORE KREAMER,TORRY, & RITA ISLANDS	2,559	3,813	0.6711
South Miami-Dade County and Biscayne Bay				
G0	No Action - Coastal Wetlands Restoration (SA3JA)	0	0	not applicable
G1	COASTAL WETLANDS RESTORATION (SA3JA)	3,136	6,073	0.5164
H0	No Action - Coastal Wetlands Restoration (SA3KA)	0	0	not applicable
H1	COASTAL WETLANDS RESTORATION (SA3KA.0)	4,018	16,357	0.2456
H2	COASTAL WETLANDS RESTORATION (SA3KA.1)	3,957	14,392	0.2749
I0	No Action - Coastal Wetlands Restoration (SA3LA)	0	0	not applicable
I1	COASTAL WETLANDS RESTORATION (SA3LA.0)	4,554	22,103	0.2060
I2	COASTAL WETLANDS RESTORATION (SA3LA.1)	4,217	17,290	0.2439
J0	No Action - Coastal Wetlands Restoration (SA3MA)	0	0	not applicable
J1	COASTAL WETLANDS RESTORATION (SA3MA)	2,657	13,538	0.1963
Loxahatchee National Wildlife Refuge (Water Conservation Area 1 - Service Area 1)				
K0	No Action - LNWR Wetlands Restoration (SA1BA)	0	0	not applicable
K1	LNWR WETLANDS RESTORATION (SA1BA)	11,769	4,438	2.6519
L0	No Action - LNWR Wetlands Restoration (SA1DA)	0	0	not applicable
L1	LNWR WETLANDS RESTORATION (SA1DA)	4,871	1,406	3.4644
Water Conservation Area 3A/3B (Service Area 2)				
M0	No Action - Wetlands Restoration (SA2AA)	0	0	not applicable
M1	WETLANDS RESTORATION (SA2AA)	5,128	3,111	1.6483
N0	No Action - Wetlands Restoration (SA2BA)	0	0	not applicable
N1	WETLANDS RESTORATION (SA2BA)	5,516	1,871	2.9482
O0	No Action - Wetlands Restoration (SA2CA)	0	0	not applicable
O1	WETLANDS RESTORATION (SA2CA)	4,129	1,198	3.4466
P0	No Action - Wetlands Restoration (SA2DA)	0	0	not applicable
P1	WETLANDS RESTORATION (SA2DA.0)	6,091	2,249	2.7083
P2	WETLANDS RESTORATION (SA2DA.1)	2,452	883	2.7769
Q0	No Action - Wetlands Restoration (SA2EA)	0	0	not applicable
Q1	WETLANDS RESTORATION (SA2EA)	2,625	866	3.0312
R0	No Action - Wetlands Restoration (SA2FA)	0	0	not applicable
R1	WETLANDS RESTORATION (SA2FA)	1,855	305	6.0820
S0	No Action - Wetlands Restoration (SA2GA)	0	0	not applicable
S1	WETLANDS RESTORATION (SA2GA)	3,595	1,219	2.9491
T0	No Action - Wetlands Restoration (SA2HA)	0	0	not applicable
T1	WETLANDS RESTORATION (SA2HA)	3,083	969	3.1816
U0	No Action - Wetlands Restoration (SA2IA)	0	0	not applicable
U1	WETLANDS RESTORATION (SA2IA)	1,822	614	2.9674
Water Conservation Area 3B (Service Area 3 - Lake Belt Area)				
V0	No Action - Wetlands Restoration (SA3AA.1)	0	0	not applicable
V1	WETLANDS RESTORATION (SA3AA.1)	233	352	0.6619
W0	No Action - Wetlands Restoration (SA3BA)	0	0	not applicable
W1	WETLANDS RESTORATION (SA3BA.0)	5,216	13,338	0.3911

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres of wetlands)	AVG. COST ($1,000/acre)
W2	WETLANDS RESTORATION (SA3BA.1)	4,553	11,591	0.3928
Big Cypress				
X0	No Action - Restore Golden Gate Estates	0	0	not applicable
X1	WETLANDS RESTORATION (Golden Gate Estates)	11,102	72,320	0.1535
Everglades National Park				
F0	No Action - Wetlands Restoration (SA3EA)	0	0	not applicable
F1	WETLANDS RESTORATION (SA3EA)	1,115	2,877	0.3876
Y0	No Action - Wetlands Restoration (SA3FA)	0	0	not applicable
Y1	WETLANDS RESTORATION (SA3FA.1)	258	608	0.4243
Y2	WETLANDS RESTORATION (SA3FA.2)	240	274	0.8759
Z0	No Action - Wetlands Restoration (SA3GA)	0	0	not applicable
Z1	WETLANDS RESTORATION (SA3GA)	499	736	0.6780

A2.11.3 Results of Analyses.

The first step in the analyses was to display all the Function E management measures sorted by increasing average cost. This display is included in ***Table E2***. This table shows the relative production efficiency of the management measures being considered in Function E. The measure with the lowest average cost is the most efficient measure for increasing spatial extent of wetlands. Each successive measure is less efficient at preserving or restoring wetlands.

Table E2 – All Function E Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres of wetlands)	AVG. COST ($1,000/acre)
X1	WETLANDS RESTORATION (Golden Gate Estates)	11,102	72,320	0.1535
J1	COASTAL WETLANDS RESTORATION (SA3MA)	2,657	13,538	0.1963
I1	COASTAL WETLANDS RESTORATION (SA3LA.0)	4,554	22,103	0.2060
C1	PARADISE RUN RESTORATION	780	3,600	0.2167
I2	COASTAL WETLANDS RESTORATION (SA3LA.1)	4,217	17,290	0.2439
H1	COASTAL WETLANDS RESTORATION (SA3KA.0)	4,018	16,357	0.2456
H2	COASTAL WETLANDS RESTORATION (SA3KA.1)	3,957	14,392	0.2749
F1	WETLANDS RESTORATION (SA3EA)	1,115	2,877	0.3876
W1	WETLANDS RESTORATION (SA3BA.0)	5,216	13,338	0.3911
W2	WETLANDS RESTORATION (SA3BA.1)	4,553	11,591	0.3928
Y1	WETLANDS RESTORATION (SA3FA.1)	258	608	0.4243
A1	POOL A RESTORATION	1,153	2,590	0.4452
G1	COASTAL WETLANDS RESTORATION (SA3JA)	3,136	6,073	0.5164
V1	WETLANDS RESTORATION (SA3AA.1)	233	352	0.6619
E1	RESTORE KREAMER,TORRY, & RITA ISLANDS	2,559	3,813	0.6711
Z1	WETLANDS RESTORATION (SA3GA)	499	736	0.6780
D3	UEC WETLAND RESTORATION (10,000 acres)	7,728	10,000	0.7728
D2	UEC WETLAND RESTORATION (5,000 acres)	4,229	5,000	0.8458

D4	UEC WETLAND RESTORATION (20,000 acres)	17,087	20,000	0.8544
Y2	WETLANDS RESTORATION (SA3FA.2)	240	274	0.8759
D1	UEC WETLAND RESTORATION (2,000 acres)	1,801	2,000	0.9005
B1	POOL E RESTORATION	2,962	2,718	1.0898
M1	WETLANDS RESTORATION (SA2AA)	5,128	3,111	1.6483
K1	LNWR WETLANDS RESTORATION (SA1BA)	11,769	4,438	2.6519
P1	WETLANDS RESTORATION (SA2DA.0)	6,091	2,249	2.7083
P2	WETLANDS RESTORATION (SA2DA.1)	2,452	883	2.7769
N1	WETLANDS RESTORATION (SA2BA)	5,516	1,871	2.9482
S1	WETLANDS RESTORATION (SA2GA)	3,595	1,219	2.9491
U1	WETLANDS RESTORATION (SA2IA)	1,822	614	2.9674
Q1	WETLANDS RESTORATION (SA2EA)	2,625	866	3.0312
T1	WETLANDS RESTORATION (SA2HA)	3,083	969	3.1816
O1	WETLANDS RESTORATION (SA2CA)	4,129	1,198	3.4466
L1	LNWR WETLANDS RESTORATION (SA1DA)	4,871	1,406	3.4644
R1	WETLANDS RESTORATION (SA2FA)	1,855	305	6.0820

The second phase of the analyses for Function E involved conducting an individual cost effectiveness and incremental cost analysis for each geographic area within the Function E category. For each geographic area, the approach was to: (1) calculate the average cost for each management measure and sort measures by increasing average cost: (2) formulate all possible combinations of these measures and identify the cost effective set: and (3) conduct an incremental cost analysis to identify the most efficient production schedule, or set of "best-buys". The results of the analyses for each geographic area are summarized sequentially below.

A2.11.4 Analysis Results: Function EA, Kissimmee River Area (KRA)

Table E_A1 – Function E_A - KRA Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre)
C1	PARADISE RUN RESTORATION	780	3,600	0.2167
A1	POOL A RESTORATION	1,153	2,590	0.4452
B1	POOL E RESTORATION	2,962	2,718	1.0898

Table E_A 2 – Function $E_{\underline{A}}$ - KRA Cost Effective Combinations of Management Measures

COUNT	CODE			COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
1	A0	B0	C0	0	0	0.0000
2	A0	B0	C1	780	3,600	0.2167
3	A1	B0	C1	1,933	6,190	0.3123
4	A0	B1	C1	3,742	6,318	0.5923
5	A1	B1	C1	4,895	8,908	0.5495

Table E_A 3 – Function E_A - KRA Best Buy Combinations of Management Measures

COUNT	CODE			COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/acre)
1	A0	B0	C0	0	0	0.0000	0	0	0.0000
2	A0	B0	C1	780	3,600	0.2167	780	3,600	0.2167
3	A1	B0	C1	1,933	6,190	0.3123	1,153	2,590	0.4452
4	A1	B1	C1	4,895	8,908	0.5495	2,962	2,718	1.0898

A2.11.5 Analysis Results: **Function E_B, Upper East Coast/St. Lucie and Martin Counties (UEC)**

Table E_B 1 – Function E_B - UEC Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
F1	UEC WETLAND RESTORATION (10,000 ACRES)	7,728	10,000	0.7728
E1	UEC WETLAND RESTORATION (5,000 ACRES)	4,229	5,000	0.8458
G1	UEC WETLAND RESTORATION (20,000 ACRES)	17,087	20,000	0.8544
D1	UEC WETLAND RESTORATION (2,000 ACRES)	1,801	2,000	0.9005

Table E_B 2 – Function E_B: UEC Cost Effective Combinations of Management Measures

COUNT	CODE				COST ($1,000)	OUTPUT (acres)	AVG. C0ST ($1,000/acre)
1	D0	E0	F0	G0	0	0	0.0000
2	D1	E0	F0	G0	1,801	2,000	0.9005
3	D0	E1	F0	G0	4,229	5,000	0.8458
4	D0	E0	F1	G0	7,728	10,000	0.7728
5	D0	E0	F0	G1	17,087	20,000	0.8544

Table E_B 3 – Function E_B: UEC Best Buy Combinations of Management Measures

COUNT	CODE				COST ($1,000)	OUTPUT (acres)	AVG. C0ST ($1,000/acre-foot)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/acre)
1	D0	E0	F0	G0	0	0	0.00	0	0	0.00
2	D0	E0	F1	G0	7,728	10,000	0.77	7,728	10,000	0.77
3	D0	E0	F0	G1	17,087	20,000	0.85	9,359	10,000	0.94

A2.11.6 Analysis Results: **Function E_C, Lake Okeechobee (LO)**

Table E_C 1 – Function E_C: LO Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
E1	RESTORE KREAMER, TORRY, & RITA ISLANDS	2,559	3,813	0.6711

Table E_C 2 – Function E_C: LO Cost Effective Combinations of Management Measures

COUNT	CODE	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
1	E0	0.00	0.00	not applicable
2	E1	2559.00	3813.00	0.6711

Table E_C 3 – Function E_C: LO Best Buy Combinations of Management Measures

COUNT	CODE	COST ($1,000)	OUTPUT (acres)	AVG. C0ST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acre)	INC. COST PER UNIT ($1,000/acre)
1	E0	0	0	not applicable	not applicable	not applicable	not applicable
2	E1	2,559	3,813	0.6711	2,559	3,813	0.6711

A2.11.7 Analysis Results: **Function E_E, South Miami-Dade County and Biscayne Bay (SDC/BB)**

Table E_E 1 – Function E_E: SDC/BB Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
J1	SA3MA	2,657	13,538	0.1963
I1	SA3LA.0	4,554	22,103	0.2060
I2	SA3LA.1	4,217	17,290	0.2439
H1	SA3KA.0	4,018	16,357	0.2456
H2	SA3KA.1	3,957	14,392	0.2749
G1	SA3JA	3,136	6,073	0.5164

Table E_E 2 – Function E_E: SDC/BB Cost Effective Combinations of Management Measures

COUNT	CODE				COST ($1,000)	OUTPUT (acres)	AVG. COST $1,000/acre)
1	G0	H0	I0	J0	0	0	0.0000
2	G0	H0	I0	J1	2,657	13,538	0.1963
3	G0	H2	I0	J0	3,957	14,392	0.2749
4	G0	H1	I0	J0	4,018	16,357	0.2456
5	G0	H0	I2	J0	4,217	17,290	0.2439
6	G0	H0	I1	J0	4,554	22,103	0.2060
7	G0	H2	I0	J1	6,614	27,930	0.2368
8	G0	H1	I0	J1	6,675	29,895	0.2233
9	G0	H0	I2	J1	6,874	30,828	0.2230
10	G0	H0	I1	J1	7,211	35,641	0.2023
11	G0	H2	I1	J0	8,511	36,495	0.2332
12	G0	H1	I1	J0	8,572	38,460	0.2229
13	G1	H0	I1	J1	10,347	41,714	0.2480
14	G0	H2	I2	J1	10,831	45,220	0.2395
15	G0	H1	I2	J1	10,892	47,185	0.2308
16	G0	H2	I1	J1	11,168	50,033	0.2232
17	G0	H1	I1	J1	11,229	51,998	0.2160
18	G1	H1	I2	J1	14,028	53,258	0.2634
19	G1	H2	I1	J1	14,304	56,106	0.2549
20	G1	H1	I1	J1	14,365	58,071	0.2474

Table E_E 3 – Function E_E: SDC/BB Best Buy Combinations of Management Measures

COUNT	CODE				COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/acre)
1	G0	H0	I0	J0	0	0	0.0000	0	0	0.0000
2	G0	H0	I0	J1	2,657	13,538	0.1963	2,657	13,538	0.1963
3	G0	H0	I1	J1	7,211	35,641	0.2023	4,554	22,103	0.2060
4	G0	H1	I1	J1	11,229	51,998	0.2160	4,018	16,357	0.2456
5	G1	H1	I1	J1	14,365	58,071	0.2474	3,136	6,073	0.5164

A2.11.8 Analysis Results: Function E_F, Loxahatchee National Wildlife Refuge (LNWR)

Table E_F 1 – Function E_F: LNWR Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
K1	SA1BA	11,769	4,438	2.6519
L1	SA1DA	4,871	1,406	3.4644

Table E_F 2 – Function E_F: LNWR Cost Effective Combinations of Management Measures

COUNT	CODE		COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
1	K0	L0	0	0	0.0000
2	K0	L1	4,871	1,406	3.4644
3	K1	L0	11,769	4,438	2.6519
4	K1	L1	16,640	5,844	2.8474

Table E_F 3 – Function E_F: LNWR Best Buy Combinations of Management Measures

COUNT	CODE		COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/acre)
1	K0	L0	0	0	0.0000	0	0	0.0000
2	K1	L0	11,769	4,438	2.6519	11,769	4,438	2.6519
3	K1	L1	16,640	5,844	2.8474	4,871	1,406	3.4644

A2.11.9 Analysis Results: Function E_G, Water Conservation Area 3A/3B – Service Area 2 (WCA3A/3B)

Table E_G 1 – Function E_G: WCA3A/3B Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
M1	SA2AA	5,128	3,111	1.6483
P1	SA2DA.0	6,091	2,249	2.7083
P2	SA2DA.1	2,452	883	2.7769
N1	SA2BA	5,516	1,871	2.9482
S1	SA2GA	3,595	1,219	2.9491
U1	SA2IA	1,822	614	2.9674
Q1	SA2EA	2,625	866	3.0312
T1	SA2HA	3,083	969	3.1816
O1	SA2CA	4,129	1,198	3.4466
R1	SA2FA	1,855	305	6.0820

Table E_G 2 – Function E_G: WCA3A/3B Cost Effective Combinations of Management Measures

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
1	M0	N0	O0	P0	Q0	R0	S0	T0	U0	0	0	0.0000
2	M0	N0	O0	P0	Q0	R0	S0	T0	U1	1,822	614	2.9674
3	M0	N0	O0	P2	Q0	R0	S0	T0	U0	2,452	883	2.7769
4	M0	N0	O0	P0	Q0	R0	S0	T1	U0	3,083	969	3.1816
5	M0	N0	O0	P0	Q0	R0	S1	T0	U0	3,595	1,219	2.9491
6	M0	N0	O0	P2	Q0	R0	S0	T0	U1	4,274	1,497	2.8550
7	M0	N0	O0	P0	Q0	R0	S0	T1	U1	4,905	1,583	3.0985
8	M0	N0	O0	P2	Q1	R0	S0	T0	U0	5,077	1,749	2.9028
9	M1	N0	O0	P0	Q0	R0	S0	T0	U0	5,128	3,111	1.6483
10	M1	N0	O0	P0	Q0	R0	S0	T0	U1	6,950	3,725	1.8658
11	M1	N0	O0	P2	Q0	R0	S0	T0	U0	7,580	3,994	1.8978
12	M1	N0	O0	P0	Q0	R0	S0	T1	U0	8,211	4,080	2.0125
13	M1	N0	O0	P0	Q0	R0	S1	T0	U0	8,723	4,330	2.0145
14	M1	N0	O0	P2	Q0	R0	S0	T0	U1	9,402	4,608	2.0404
15	M1	N0	O0	P0	Q0	R0	S0	T1	U1	10,033	4,694	2.1374
16	M1	N0	O0	P2	Q1	R0	S0	T0	U0	10,205	4,860	2.0998
17	M1	N0	O0	P0	Q0	R0	S1	T0	U1	10,545	4,944	2.1329
18	M1	N1	O0	P0	Q0	R0	S0	T0	U0	10,644	4,982	2.1365
19	M1	N0	O0	P2	Q0	R0	S1	T0	U0	11,175	5,213	2.1437
20	M1	N0	O0	P1	Q0	R0	S0	T0	U0	11,219	5,360	2.0931
21	M1	N0	O0	P2	Q1	R0	S0	T0	U1	12,027	5,474	2.1971
22	M1	N1	O0	P0	Q0	R0	S0	T0	U1	12,466	5,596	2.2277
23	M1	N0	O0	P2	Q0	R0	S1	T0	U1	12,997	5,827	2.2305
24	M1	N0	O0	P1	Q0	R0	S0	T0	U1	13,041	5,974	2.1830
25	M1	N0	O0	P2	Q1	R0	S1	T0	U0	13,800	6,079	2.2701
26	M1	N0	O0	P1	Q1	R0	S0	T0	U0	13,844	6,226	2.2236
27	M1	N0	O0	P1	Q0	R0	S0	T1	U0	14,302	6,329	2.2598
28	M1	N0	O0	P1	Q0	R0	S1	T0	U0	14,814	6,579	2.2517
29	M1	N0	O0	P2	Q1	R0	S1	T0	U1	15,622	6,693	2.3341
30	M1	N0	O0	P1	Q1	R0	S0	T0	U1	15,666	6,840	2.2904
31	M1	N0	O0	P1	Q0	R0	S0	T1	U1	16,124	6,943	2.3223
32	M1	N0	O0	P1	Q0	R0	S1	T0	U1	16,636	7,193	2.3128
33	M1	N1	O0	P1	Q0	R0	S0	T0	U0	16,735	7,231	2.3143
34	M1	N0	O0	P1	Q1	R0	S1	T0	U0	17,439	7,445	2.3424
35	M1	N0	O0	P1	Q0	R0	S1	T1	U0	17,897	7,548	2.3711
36	M1	N1	O0	P2	Q0	R0	S1	T0	U1	18,513	7,698	2.4049
37	M1	N1	O0	P1	Q0	R0	S0	T0	U1	18,557	7,845	2.3655
38	M1	N0	O0	P1	Q1	R0	S1	T0	U1	19,261	8,059	2.3900
39	M1	N1	O0	P1	Q1	R0	S0	T0	U0	19,360	8,097	2.3910
40	M1	N0	O0	P1	Q0	R0	S1	T1	U1	19,719	8,162	2.4160
41	M1	N1	O0	P1	Q0	R0	S0	T1	U0	19,818	8,200	2.4168
42	M1	N1	O0	P1	Q0	R0	S1	T0	U0	20,330	8,450	2.4059
43	M1	N1	O0	P2	Q1	R0	S1	T0	U1	21,138	8,564	2.4682

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
44	M1	N1	O0	P1	Q1	R0	S0	T0	U1	21,182	8,711	2.4316
45	M1	N1	O0	P1	Q0	R0	S0	T1	U1	21,640	8,814	2.4552
46	M1	N1	O0	P1	Q0	R0	S1	T0	U1	22,152	9,064	2.4440
47	M1	N1	O0	P1	Q1	R0	S0	T1	U0	22,443	9,066	2.4755
48	M1	N1	O0	P1	Q1	R0	S1	T0	U0	22,955	9,316	2.4640
49	M1	N1	O0	P1	Q0	R0	S1	T1	U0	23,413	9,419	2.4857
50	M1	N1	O0	P2	Q1	R0	S1	T1	U1	24,221	9,533	2.5408
51	M1	N1	O0	P1	Q1	R0	S0	T1	U1	24,265	9,680	2.5067
52	M1	N1	O0	P1	Q1	R0	S1	T0	U1	24,777	9,930	2.4952
53	M1	N1	O0	P1	Q0	R0	S1	T1	U1	25,235	10,033	2.5152
54	M1	N1	O0	P1	Q1	R0	S1	T1	U0	26,038	10,285	2.5316
55	M1	N1	O1	P1	Q1	R0	S1	T0	U0	27,084	10,514	2.5760
56	M1	N1	O1	P1	Q0	R0	S1	T1	U0	27,542	10,617	2.5941
57	M1	N1	O0	P1	Q1	R0	S1	T1	U1	27,860	10,899	2.5562
58	M1	N1	O1	P1	Q1	R0	S1	T0	U1	28,906	11,128	2.5976
59	M1	N1	O1	P1	Q0	R0	S1	T1	U1	29,364	11,231	2.6145
60	M1	N1	O1	P1	Q1	R0	S1	T1	U0	30,167	11,483	2.6271
61	M1	N1	O1	P1	Q0	R1	S1	T1	U1	31,219	11,536	2.7062
62	M1	N1	O1	P1	Q1	R0	S1	T1	U1	31,989	12,097	2.6444
63	M1	N1	O1	P1	Q1	R1	S1	T1	U1	33,844	12,402	2.7289

Table E_G 3 – Function E_G: WCA3A/3B Best Buy Combinations of Management Measures

COUNT	C.11.9..1		CODE							COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/ acre)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/ acre)
1	M0	N0	O0	P0	Q0	R0	S0	T0	U0	0	0	0.0000	0	0	0.0000
2	M1	N0	O0	P0	Q0	R0	S0	T0	U0	5,128	3,111	1.6483	5,128	3,111	1.6483
3	M1	N0	O0	P1	Q0	R0	S0	T0	U0	11,219	5,360	2.0931	6,091	2,249	2.7083
4	M1	N1	O0	P1	Q0	R0	S0	T0	U0	16,735	7,231	2.3143	5,516	1,871	2.9482
5	M1	N1	O0	P1	Q0	R0	S1	T0	U0	20,330	8,450	2.4059	3,595	1,219	2.9491
6	M1	N1	O0	P1	Q0	R0	S1	T0	U1	22,152	9,064	2.4440	1,822	614	2.9674
7	M1	N1	O0	P1	Q1	R0	S1	T0	U1	24,777	9,930	2.4952	2,625	866	3.0312
8	M1	N1	O0	P1	Q1	R0	S1	T1	U1	27,860	10,899	2.5562	3,083	969	3.1816
9	M1	N1	O1	P1	Q1	R0	S1	T1	U1	31,989	12,097	2.6444	4,129	1,198	3.4466
10	M1	N1	O1	P1	Q1	R1	S1	T1	U1	33,844	12,402	2.7289	1,855	305	6.0820

A2.11.10 Analysis Results: **Function E_H, Water Conservation Area 3B – Service Area 3, Lake Belt Area (WCA3B)**

Table E_H 1 – Function E_H: WCA33B Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
W1	SA3BA.0	5,216	13,338	0.3911
W2	SA3BA.1	4,553	11,591	0.3928
V1	SA3AA.1	233	352	0.6619

Table E_H 2 – Function E_H: WCA3B Cost Effective Combinations of Management Measures

COUNT	CODE		COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
1	V0	W0	0	0	0.0000
2	V1	W0	233	352	0.6619
3	V0	W2	4,553	11,591	0.3928
4	V1	W2	4,786	11,943	0.4007
5	V0	W1	5,216	13,338	0.3911
6	V1	W1	5,449	13,690	0.3980

Table E_H 3 – Function E_H: WCA3B Best Buy Combinations of Management Measures

COUNT	CODE		COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/acre)
1	V0	W0	0	0	0.0000	0	0	0.0000
2	V0	W2	4,553	11,591	0.3928	4,553	11,591	0.3928
3	V0	W1	5,216	13,338	0.3911	663	1,747	0.3795
4	V1	W1	5,449	13,690	0.3980	233	352	0.6619

A2.11.11 Analysis Results: Function E_I, Big Cypress (BC)

Table E_I 1 – Function E_I: BC Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
X1	RESTORE GOLDEN GATE ESTATES	11,102	72,320	0.1535

Table E_I 2 – Function E_I: BC Cost Effective Combinations of Management Measures

COUNT	CODE	COST ($1,000)	OUTPUT (acres)	AVG. C0ST ($1,000/acre)
1	X0	0.00	0.00	not applicable
2	X1	11102.00	72320.00	0.1535

Table E_I 3 – Function E_I: BC Best Buy Combinations of Management Measures

COUNT	CODE	COST ($1,000)	OUTPUT (acres)	AVG. C0ST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acre)	INC. COST PER UNIT ($1,000/acre)
1	X0	0	0	not applicable	not applicable	not applicable	not applicable
2	X1	11,102	72,320	0.1535	11,102	72,320	0.1535

A2.11.12 Analysis Results: Function E_J, Everglades National Park (ENP)

Table E_J 1 – Function E_B: ENP Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
A0	No Action	0	0	0.0000
B0	No Action	0	0	0.0000
C0	No Action	0	0	0.0000
A1	SA3EA	1,115	2,877	0.3876
B1	SA3FA.1	258	608	0.4243
C1	SA3GA	499	736	0.6780
B2	SA3FA.2	240	274	0.8759

Table E_J 2 – Function E_B: ENP Cost Effective Combinations of Management Measures

COUNT	C.11.12..1	CODE		COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
1	A0	B0	C0	0	0	0.0000
2	A0	B2	C0	240	274	0.8759
3	A0	B1	C0	258	608	0.4243
4	A0	B0	C1	499	736	0.6780
5	A0	B2	C1	739	1,010	0.7317
6	A0	B1	C1	757	1,344	0.5632
7	A1	B0	C0	1,115	2,877	0.3876
8	A1	B2	C0	1,355	3,151	0.4300
9	A1	B1	C0	1,373	3,485	0.3940
10	A1	B0	C1	1,614	3,613	0.4467
11	A1	B2	C1	1,854	3,887	0.4770
12	A1	B1	C1	1,872	4,221	0.4435

Table E_J 3 – Function E_B: ENP Best Buy Combinations of Management Measures

COUNT	CODE			COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/acre)
1	A0	B0	C0	0	0	0.0000	0	0	0.0000
2	A1	B0	C0	1,115	2,877	0.3876	1,115	2,877	0.3876
3	A1	B1	C0	1,373	3,485	0.3940	258	608	0.4243
4	A1	B1	C1	1,872	4,221	0.4435	499	736	0.6780

A2.11.13 Combinations of Best Buys from all Geographical Areas.

After the cost effective and best buy plans were identified for each geographic area within Function E, the best buys from each were combined to identify the best set of investments looking at the entire Function E category. To enter the best buys into the cost effectiveness analysis software, a new code letter had to be assigned to each. Each geographic area was treated as a "management measure" with each best buy combination from that area treated as a "scale" of that measure. Table E3 lists these new management measure codes – and for each, the code description from the previous cost analysis run (runs E_A-E_J) and the description from Table E1 that describes what measures make up each best buy combination. ***Table E4*** lists the same measures as ***Table E3*** with cost, output, and average cost. The entries in the "New Code" column will correspond to the codes for the cost effective and best buy combinations in ***Tables E5*** and ***E6***, respectively.

Table E3 – Best Buys from Each Geographic Category with Description

NEW CODE	CODE FROM COST ANALYSIS RUNS E_A-E_J	DESCRIPTION FROM TABLE E1
Best Buys from Function E_A – Kissimmee River Area		
A0	*No Action – Function E_A*	
A1	C1	Paradise Run Restoration
A2	C1 A1	Paradise Run Restoration + Pool A Restoration
A3	C1 A1 B1	Paradise Run Restoration + Pool A Restoration + Pool E Restoration
Best Buys from Function E_B – Upper East Coast/St. Lucie and Martin Islands		
B0	*No Action – Function E_B*	
B1	D3	UEC WETLAND RESTORATION (10,000 ACRES)
B2	D4	UEC WETLAND RESTORATION (20,000 ACRES)
Best Buys from Function E_C – Lake Okeechobee		
C0	*No Action – Function E_C*	
C1	E1	RESTORE KREAMER, TORRY AND RITA ISLANDS
Best Buys from Function E_E – South Miami-Dade County and Biscayne Bay		
E0	*No Action – Function E_E*	
E1	J1	SA3MA
E2	J1I1	SA3MA + SA3LA.0
E3	J1I1H1	SA3MA + SA3LA.0 + SA3KA.0
E4	J1I1H1G1	SA3MA + SA3LA.0 + SA3KA.0 + SA3JA

Best Buys from Function E_F – Loxahatchee National Wildlife Refuge (Water Conservation Area 1 -Service Area 1)		
F0	*No Action – Function E_F*	
F1	K1	SA1BA
F2	K1L1	SA1BA + SA1DA
Best Buys from Function E_G – Water Conservation Area 3A/3B (Service Area 2)		
G0	*No Action – Function E_G*	
G1	M1	SA2AA
G2	M1P1	SA2AA + SA2DA.0
G3	M1P1N1	SA2AA + SA2DA.0 + SA2BA
G4	M1P1N1S1	SA2AA + SA2DA.0 + SA2BA + SA2GA
G5	M1P1N1S1U1	SA2AA + SA2DA.0 + SA2BA + SA2GA + SA2IA.1
G6	M1P1N1S1U1Q1	SA2AA + SA2DA.0 + SA2BA + SA2GA + SA2IA.1 + SA2EA
G7	M1P1N1S1U1Q1T1	SA2AA + SA2DA.0 + SA2BA + SA2GA + SA2IA.1 + SA2EA + SA2HA
G8	M1P1N1S1U1Q1T1O1	SA2AA + SA2DA.0 + SA2BA + SA2GA + SA2IA.1 + SA2EA + SA2HA + SA2CA
G9	M1P1N1S1U1Q1T1O1R1	SA2AA+SA2DA.0+SA2BA+SA2GA+SA2IA.1+SA2EA+SA2HA+SA2CA+SA2FA
Best Buys from Function E_H – Water Conservation Area 3B (Service Area 3 – Lake Belt Area)		
H0	*No Action – Function E_H*	
H1	W2	SA3BA.1
H2	W1	SA3BA.0
H3	W1V1	SA3BA.0 + SA3AA.1
Best Buys from Function E_I – Big Cypress		
I0	*No Action – Function E_I*	
I1	X1	RESTORE GOLDEN GATE ESTATES
Best Buys from Function E_J – Everglades National Park		
J0	*No Action – Function E_J*	
J1	F1	SA3EA
J2	F1Y1	SA3EA + SA3FA.1
J3	F1Y1Z1	SA3EA + SA3FA.1 + SA3GA

Table E4– Best Buys from Each Geographic Category with Cost, Output, & Average Cost

NEW CODE	CODE FROM COST ANALYSIS RUNS E_A-E_J (maps back to Table E1)	COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
Best Buys from Function E_A – Kissimmee River Area				
A0	*No Action – Function E_A*	0	0	0.0000
A1	C1	780	3,600	0.2167
A2	C1 A1	1,933	6,190	0.3123
A3	C1 A1 B1	4,895	8,908	0.5495
Best Buys from Function E_B – Upper East Coast/St. Lucie and Martin Islands				
B0	*No Action – Function E_B*	0	0	0.0000
B1	D3	7,728	10,000	0.7728
B2	D4	17,087	20,000	0.8544
Best Buys from Function E_C – Lake Okeechobee				
C0	*No Action – Function E_C*	0	0	0.0000
C1	E1	2,559	3,813	0.6711
Best Buys from Function E_E – South Miami-Dade County and Biscayne Bay				
E0	*No Action – Function E_E*	0	0	0.0000

E1	J1	2,657	13,538	0.1963
E2	J1 I1	7,211	35,641	0.2023
E3	J1 I1 H1	11,229	51,998	0.2160
E4	J1 I1 H1 G1	14,365	58,071	0.2474
Best Buys from Function E_F – Loxahatchee National Wildlife Refuge (Water Conservation Area 1 -Service Area 1)				
F0	*No Action – Function E_F*	0	0	0.0000
F1	K1	11,769	4,438	2.6519
F2	K1 L1	16,640	5,844	2.8474
Best Buys from Function E_G – Water Conservation Area 3A/3B (Service Area 2)				
G0	*No Action – Function E_G*	0	0	0.0000
G1	M1	5,128	3,111	1.6483
G2	M1P1	11,219	5,360	2.0931
G3	M1P1N1	16,735	7,231	2.3143
G4	M1P1N1S1	20,330	8,450	2.4059
G5	M1P1N1S1U1	22,152	9,064	2.4440
G6	M1P1N1S1U1Q1	24,777	9,930	2.4952
G7	M1P1N1S1U1Q1T1	27,860	10,899	2.5562
G8	M1P1N1S1U1Q1T1O1	31,989	12,097	2.6444
G9	M1P1N1S1U1Q1T1O1R1	33,844	12,402	2.7289
Best Buys from Function E_H – Water Conservation Area 3B (Service Area 3 – Lake Belt Area)				
H0	*No Action – Function E_H*	0	0	0.0000
H1	W2	4,553	11,591	0.3928
H2	W1	5,216	13,338	0.3911
H3	V1W1	5,449	13,690	0.3980
Best Buys from Function E_I – Big Cypress				
I0	*No Action – Function E_I*	0	0	0.0000
I1	X1	11,102	72,320	0.1535
Best Buys from Function E_J – Everglades National Park				
J0	*No Action – Function E_J*	0	0	0.0000
J1	F1	1,115	2,877	0.3876
J2	F1Y1	1,373	3,485	0.3940
J3	F1Y1Z1	1,872	4,221	0.4435

All possible combinations of Function E management measures were derived to identify the cost effective set. Of the full 115,200 possible combinations, 233 were cost effective. The 233 cost effective combinations can be found in Table E3. The value in the "Count" column simply counts the number of cost effective plans. The entries in the "Code" columns correspond to the Codes from Tables E3 and E4 and show what best buys are included in each combination. A graph of cost vs. output for Function E's cost effective combinations of best buys from each geographic area is plotted in ***Figure E5***.

Table E5 – Cost Effective Combinations of Best Buys from all Function E Geographic Categories

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
1	A0	B0	C0	E0	F0	G0	H0	J0	I0	0	0	0.0000
2	A1	B0	C0	E0	F0	G0	H0	J0	I0	780	3,600	0.2167
3	A0	B0	C0	E0	F0	G0	H0	J3	I0	1,872	4,221	0.4435
4	A1	B0	C0	E0	F0	G0	H0	J1	I0	1,895	6,477	0.2926
5	A1	B0	C0	E0	F0	G0	H0	J2	I0	2,153	7,085	0.3039
6	A1	B0	C0	E0	F0	G0	H0	J3	I0	2,652	7,821	0.3391
7	A0	B0	C0	E1	F0	G0	H0	J0	I0	2,657	13,538	0.1963
8	A1	B0	C0	E1	F0	G0	H0	J0	I0	3,437	17,138	0.2005
9	A0	B0	C0	E1	F0	G0	H0	J3	I0	4,529	17,759	0.2550
10	A1	B0	C0	E1	F0	G0	H0	J1	I0	4,552	20,015	0.2274
11	A1	B0	C0	E1	F0	G0	H0	J2	I0	4,810	20,623	0.2332
12	A1	B0	C0	E1	F0	G0	H0	J3	I0	5,309	21,359	0.2486
13	A2	B0	C0	E1	F0	G0	H0	J1	I0	5,705	22,605	0.2524
14	A2	B0	C0	E1	F0	G0	H0	J2	I0	5,963	23,213	0.2569
15	A2	B0	C0	E1	F0	G0	H0	J3	I0	6,462	23,949	0.2698
16	A0	B0	C0	E1	F0	G0	H1	J0	I0	7,210	25,129	0.2869
17	A0	B0	C0	E2	F0	G0	H0	J0	I0	7,211	35,641	0.2023
18	A1	B0	C0	E2	F0	G0	H0	J0	I0	7,991	39,241	0.2036
19	A0	B0	C0	E2	F0	G0	H0	J3	I0	9,083	39,862	0.2279
20	A1	B0	C0	E2	F0	G0	H0	J1	I0	9,106	42,118	0.2162
21	A1	B0	C0	E2	F0	G0	H0	J2	I0	9,364	42,726	0.2192
22	A1	B0	C0	E2	F0	G0	H0	J3	I0	9,863	43,462	0.2269
23	A2	B0	C0	E2	F0	G0	H0	J1	I0	10,259	44,708	0.2295
24	A2	B0	C0	E2	F0	G0	H0	J2	I0	10,517	45,316	0.2321
25	A2	B0	C0	E2	F0	G0	H0	J3	I0	11,016	46,052	0.2392
26	A0	B0	C0	E0	F0	G0	H0	J0	I1	11,102	72,320	0.1535
27	A1	B0	C0	E0	F0	G0	H0	J0	I1	11,882	75,920	0.1565
28	A0	B0	C0	E0	F0	G0	H0	J3	I1	12,974	76,541	0.1695
29	A1	B0	C0	E0	F0	G0	H0	J1	I1	12,997	78,797	0.1649
30	A1	B0	C0	E0	F0	G0	H0	J2	I1	13,255	79,405	0.1669
31	A1	B0	C0	E0	F0	G0	H0	J3	I1	13,754	80,141	0.1716
32	A0	B0	C0	E1	F0	G0	H0	J0	I1	13,759	85,858	0.1603
33	A1	B0	C0	E1	F0	G0	H0	J0	I1	14,539	89,458	0.1625
34	A0	B0	C0	E1	F0	G0	H0	J3	I1	15,631	90,079	0.1735
35	A1	B0	C0	E1	F0	G0	H0	J1	I1	15,654	92,335	0.1695
36	A1	B0	C0	E1	F0	G0	H0	J2	I1	15,912	92,943	0.1712
37	A1	B0	C0	E1	F0	G0	H0	J3	I1	16,411	93,679	0.1752
38	A2	B0	C0	E1	F0	G0	H0	J1	I1	16,807	94,925	0.1771

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
39	A2	B0	C0	E1	F0	G0	H0	J2	I1	17,065	95,533	0.1786
40	A2	B0	C0	E1	F0	G0	H0	J3	I1	17,564	96,269	0.1824
41	A0	B0	C0	E1	F0	G0	H1	J0	I1	18,312	97,449	0.1879
42	A0	B0	C0	E2	F0	G0	H0	J0	I1	18,313	107,961	0.1696
43	A1	B0	C0	E2	F0	G0	H0	J0	I1	19,093	111,561	0.1711
44	A0	B0	C0	E2	F0	G0	H0	J3	I1	20,185	112,182	0.1799
45	A1	B0	C0	E2	F0	G0	H0	J1	I1	20,208	114,438	0.1766
46	A1	B0	C0	E2	F0	G0	H0	J2	I1	20,466	115,046	0.1779
47	A1	B0	C0	E2	F0	G0	H0	J3	I1	20,965	115,782	0.1811
48	A2	B0	C0	E2	F0	G0	H0	J1	I1	21,361	117,028	0.1825
49	A2	B0	C0	E2	F0	G0	H0	J2	I1	21,619	117,636	0.1838
50	A2	B0	C0	E2	F0	G0	H0	J3	I1	22,118	118,372	0.1869
51	A0	B0	C0	E3	F0	G0	H0	J0	I1	22,331	124,318	0.1796
52	A1	B0	C0	E3	F0	G0	H0	J0	I1	23,111	127,918	0.1807
53	A0	B0	C0	E3	F0	G0	H0	J3	I1	24,203	128,539	0.1883
54	A1	B0	C0	E3	F0	G0	H0	J1	I1	24,226	130,795	0.1852
55	A1	B0	C0	E3	F0	G0	H0	J2	I1	24,484	131,403	0.1863
56	A1	B0	C0	E3	F0	G0	H0	J3	I1	24,983	132,139	0.1891
57	A2	B0	C0	E3	F0	G0	H0	J1	I1	25,379	133,385	0.1903
58	A2	B0	C0	E3	F0	G0	H0	J2	I1	25,637	133,993	0.1913
59	A2	B0	C0	E3	F0	G0	H0	J3	I1	26,136	134,729	0.1940
60	A0	B0	C0	E3	F0	G0	H1	J0	I1	26,884	135,909	0.1978
61	A1	B0	C0	E4	F0	G0	H0	J1	I1	27,362	136,868	0.1999
62	A0	B0	C0	E3	F0	G0	H2	J0	I1	27,547	137,656	0.2001
63	A1	B0	C0	E3	F0	G0	H1	J0	I1	27,664	139,509	0.1983
64	A1	B0	C0	E3	F0	G0	H2	J0	I1	28,327	141,256	0.2005
65	A1	B0	C0	E3	F0	G0	H3	J0	I1	28,560	141,608	0.2017
66	A1	B0	C0	E3	F0	G0	H1	J1	I1	28,779	142,386	0.2021
67	A1	B0	C0	E3	F0	G0	H1	J2	I1	29,037	142,994	0.2031
68	A1	B0	C0	E3	F0	G0	H2	J1	I1	29,442	144,133	0.2043
69	A1	B0	C0	E3	F0	G0	H3	J1	I1	29,675	144,485	0.2054
70	A1	B0	C0	E3	F0	G0	H2	J2	I1	29,700	144,741	0.2052
71	A2	B0	C0	E3	F0	G0	H1	J1	I1	29,932	144,976	0.2065
72	A1	B0	C0	E3	F0	G0	H3	J2	I1	29,933	145,093	0.2063
73	A2	B0	C0	E3	F0	G0	H1	J2	I1	30,190	145,584	0.2074
74	A1	B0	C0	E3	F0	G0	H3	J3	I1	30,432	145,829	0.2087
75	A2	B0	C0	E3	F0	G0	H2	J1	I1	30,595	146,723	0.2085
76	A2	B0	C0	E3	F0	G0	H3	J1	I1	30,828	147,075	0.2096
77	A2	B0	C0	E3	F0	G0	H2	J2	I1	30,853	147,331	0.2094
78	A2	B0	C0	E3	F0	G0	H3	J2	I1	31,086	147,683	0.2105
79	A2	B0	C0	E3	F0	G0	H2	J3	I1	31,352	148,067	0.2117
80	A2	B0	C0	E3	F0	G0	H3	J3	I1	31,585	148,419	0.2128
81	A1	B0	C0	E4	F0	G0	H1	J1	I1	31,915	148,459	0.2150

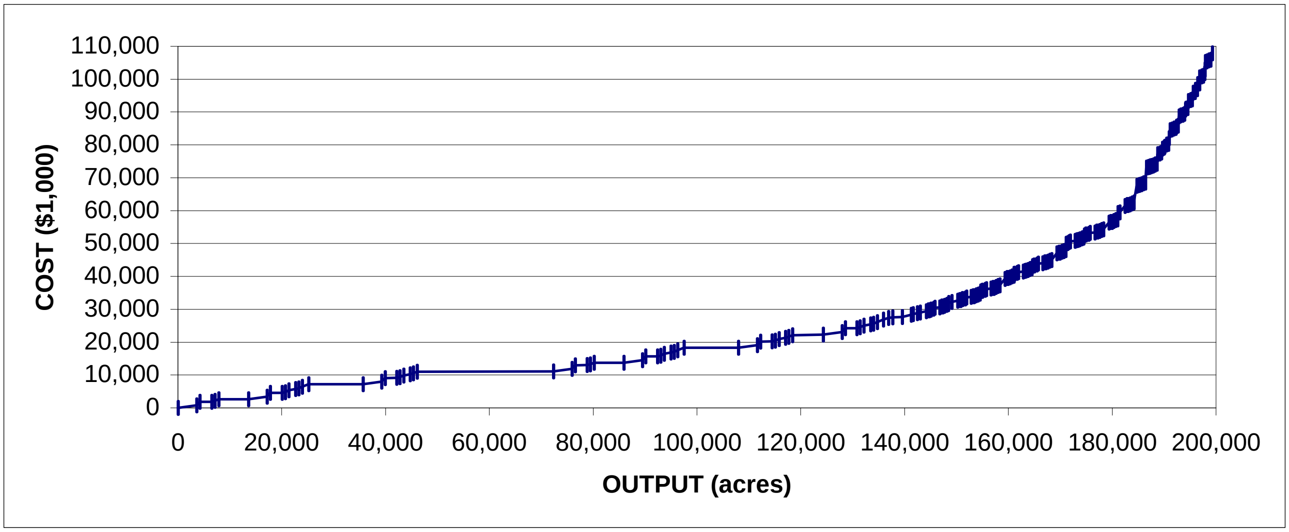
COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
82	A1	B0	C0	E4	F0	G0	H1	J2	I1	32,173	149,067	0.2158
83	A1	B0	C0	E4	F0	G0	H2	J1	I1	32,578	150,206	0.2169
84	A1	B0	C0	E4	F0	G0	H3	J1	I1	32,811	150,558	0.2179
85	A1	B0	C0	E4	F0	G0	H2	J2	I1	32,836	150,814	0.2177
86	A2	B0	C0	E4	F0	G0	H1	J1	I1	33,068	151,049	0.2189
87	A1	B0	C0	E4	F0	G0	H3	J2	I1	33,069	151,166	0.2188
88	A2	B0	C0	E4	F0	G0	H1	J2	I1	33,326	151,657	0.2197
89	A1	B0	C0	E4	F0	G0	H3	J3	I1	33,568	151,902	0.2210
90	A2	B0	C0	E4	F0	G0	H2	J1	I1	33,731	152,796	0.2208
91	A2	B0	C0	E4	F0	G0	H3	J1	I1	33,964	153,148	0.2218
92	A2	B0	C0	E4	F0	G0	H2	J2	I1	33,989	153,404	0.2216
93	A2	B0	C0	E4	F0	G0	H3	J2	I1	34,222	153,756	0.2226
94	A2	B0	C0	E4	F0	G0	H2	J3	I1	34,488	154,140	0.2237
95	A2	B0	C0	E4	F0	G0	H3	J3	I1	34,721	154,492	0.2247
96	A1	B0	C1	E4	F0	G0	H2	J2	I1	35,395	154,627	0.2289
97	A2	B0	C1	E4	F0	G0	H1	J1	I1	35,627	154,862	0.2301
98	A1	B0	C1	E4	F0	G0	H3	J2	I1	35,628	154,979	0.2299
99	A2	B0	C1	E4	F0	G0	H1	J2	I1	35,885	155,470	0.2308
100	A1	B0	C1	E4	F0	G0	H3	J3	I1	36,127	155,715	0.2320
101	A2	B0	C1	E4	F0	G0	H2	J1	I1	36,290	156,609	0.2317
102	A2	B0	C1	E4	F0	G0	H3	J1	I1	36,523	156,961	0.2327
103	A2	B0	C1	E4	F0	G0	H2	J2	I1	36,548	157,217	0.2325
104	A2	B0	C1	E4	F0	G0	H3	J2	I1	36,781	157,569	0.2334
105	A2	B0	C1	E4	F0	G0	H2	J3	I1	37,047	157,953	0.2345
106	A2	B0	C1	E4	F0	G0	H3	J3	I1	37,280	158,305	0.2355
107	A3	B0	C1	E4	F0	G0	H2	J1	I1	39,252	159,327	0.2464
108	A3	B0	C1	E4	F0	G0	H3	J1	I1	39,485	159,679	0.2473
109	A3	B0	C1	E4	F0	G0	H2	J2	I1	39,510	159,935	0.2470
110	A3	B0	C1	E4	F0	G0	H3	J2	I1	39,743	160,287	0.2479
111	A3	B0	C1	E4	F0	G0	H2	J3	I1	40,009	160,671	0.2490
112	A3	B0	C1	E4	F0	G0	H3	J3	I1	40,242	161,023	0.2499
113	A2	B1	C0	E4	F0	G0	H1	J1	I1	40,796	161,049	0.2533
114	A1	B1	C0	E4	F0	G0	H3	J2	I1	40,797	161,166	0.2531
115	A2	B1	C0	E4	F0	G0	H1	J2	I1	41,054	161,657	0.2540
116	A1	B1	C0	E4	F0	G0	H3	J3	I1	41,296	161,902	0.2551
117	A2	B1	C0	E4	F0	G0	H2	J1	I1	41,459	162,796	0.2547
118	A2	B1	C0	E4	F0	G0	H3	J1	I1	41,692	163,148	0.2555
119	A2	B1	C0	E4	F0	G0	H2	J2	I1	41,717	163,404	0.2553
120	A2	B1	C0	E4	F0	G0	H3	J2	I1	41,950	163,756	0.2562
121	A2	B1	C0	E4	F0	G0	H2	J3	I1	42,216	164,140	0.2572
122	A2	B1	C0	E4	F0	G0	H3	J3	I1	42,449	164,492	0.2581
123	A1	B1	C1	E4	F0	G0	H2	J2	I1	43,123	164,627	0.2619
124	A2	B1	C1	E4	F0	G0	H1	J1	I1	43,355	164,862	0.2630

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
125	A1	B1	C1	E4	F0	G0	H3	J2	I1	43,356	164,979	0.2628
126	A2	B1	C1	E4	F0	G0	H1	J2	I1	43,613	165,470	0.2636
127	A1	B1	C1	E4	F0	G0	H3	J3	I1	43,855	165,715	0.2646
128	A2	B1	C1	E4	F0	G0	H2	J1	I1	44,018	166,609	0.2642
129	A2	B1	C1	E4	F0	G0	H3	J1	I1	44,251	166,961	0.2650
130	A2	B1	C1	E4	F0	G0	H2	J2	I1	44,276	167,217	0.2648
131	A2	B1	C1	E4	F0	G0	H3	J2	I1	44,509	167,569	0.2656
132	A2	B1	C1	E4	F0	G0	H2	J3	I1	44,775	167,953	0.2666
133	A2	B1	C1	E4	F0	G0	H3	J3	I1	45,008	168,305	0.2674
134	A3	B1	C1	E4	F0	G0	H2	J1	I1	46,980	169,327	0.2775
135	A3	B1	C1	E4	F0	G0	H3	J1	I1	47,213	169,679	0.2782
136	A3	B1	C1	E4	F0	G0	H2	J2	I1	47,238	169,935	0.2780
137	A3	B1	C1	E4	F0	G0	H3	J2	I1	47,471	170,287	0.2788
138	A3	B1	C1	E4	F0	G0	H2	J3	I1	47,737	170,671	0.2797
139	A3	B1	C1	E4	F0	G0	H3	J3	I1	47,970	171,023	0.2805
140	A2	B1	C1	E4	F0	G1	H2	J3	I1	49,903	171,064	0.2917
141	A2	B1	C1	E4	F0	G1	H3	J3	I1	50,136	171,416	0.2925
142	A2	B2	C0	E4	F0	G0	H1	J2	I1	50,413	171,657	0.2937
143	A1	B2	C0	E4	F0	G0	H3	J3	I1	50,655	171,902	0.2947
144	A2	B2	C0	E4	F0	G0	H2	J1	I1	50,818	172,796	0.2941
145	A2	B2	C0	E4	F0	G0	H3	J1	I1	51,051	173,148	0.2948
146	A2	B2	C0	E4	F0	G0	H2	J2	I1	51,076	173,404	0.2945
147	A2	B2	C0	E4	F0	G0	H3	J2	I1	51,309	173,756	0.2953
148	A2	B2	C0	E4	F0	G0	H2	J3	I1	51,575	174,140	0.2962
149	A2	B2	C0	E4	F0	G0	H3	J3	I1	51,808	174,492	0.2969
150	A1	B2	C1	E4	F0	G0	H2	J2	I1	52,482	174,627	0.3005
151	A2	B2	C1	E4	F0	G0	H1	J1	I1	52,714	174,862	0.3015
152	A1	B2	C1	E4	F0	G0	H3	J2	I1	52,715	174,979	0.3013
153	A2	B2	C1	E4	F0	G0	H1	J2	I1	52,972	175,470	0.3019
154	A1	B2	C1	E4	F0	G0	H3	J3	I1	53,214	175,715	0.3028
155	A2	B2	C1	E4	F0	G0	H2	J1	I1	53,377	176,609	0.3022
156	A2	B2	C1	E4	F0	G0	H3	J1	I1	53,610	176,961	0.3029
157	A2	B2	C1	E4	F0	G0	H2	J2	I1	53,635	177,217	0.3027
158	A2	B2	C1	E4	F0	G0	H3	J2	I1	53,868	177,569	0.3034
159	A2	B2	C1	E4	F0	G0	H2	J3	I1	54,134	177,953	0.3042
160	A2	B2	C1	E4	F0	G0	H3	J3	I1	54,367	178,305	0.3049
161	A3	B2	C1	E4	F0	G0	H2	J1	I1	56,339	179,327	0.3142
162	A3	B2	C1	E4	F0	G0	H3	J1	I1	56,572	179,679	0.3149
163	A3	B2	C1	E4	F0	G0	H2	J2	I1	56,597	179,935	0.3145
164	A3	B2	C1	E4	F0	G0	H3	J2	I1	56,830	180,287	0.3152
165	A3	B2	C1	E4	F0	G0	H2	J3	I1	57,096	180,671	0.3160
166	A3	B2	C1	E4	F0	G0	H3	J3	I1	57,329	181,023	0.3167
167	A2	B2	C1	E4	F0	G1	H2	J3	I1	59,262	181,064	0.3273

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
168	A2	B2	C1	E4	F0	G1	H3	J3	I1	59,495	181,416	0.3279
169	A3	B2	C1	E4	F0	G1	H2	J1	I1	61,467	182,438	0.3369
170	A3	B2	C1	E4	F0	G1	H3	J1	I1	61,700	182,790	0.3375
171	A3	B2	C1	E4	F0	G1	H2	J2	I1	61,725	183,046	0.3372
172	A3	B2	C1	E4	F0	G1	H3	J2	I1	61,958	183,398	0.3378
173	A3	B2	C1	E4	F0	G1	H2	J3	I1	62,224	183,782	0.3386
174	A3	B2	C1	E4	F0	G1	H3	J3	I1	62,457	184,134	0.3392
175	A3	B2	C1	E4	F0	G2	H2	J1	I1	67,558	184,687	0.3658
176	A3	B2	C1	E4	F0	G2	H3	J1	I1	67,791	185,039	0.3664
177	A3	B2	C1	E4	F0	G2	H2	J2	I1	67,816	185,295	0.3660
178	A3	B2	C1	E4	F0	G2	H3	J2	I1	68,049	185,647	0.3666
179	A3	B2	C1	E4	F0	G2	H2	J3	I1	68,315	186,031	0.3672
180	A3	B2	C1	E4	F0	G2	H3	J3	I1	68,548	186,383	0.3678
181	A3	B2	C1	E4	F0	G3	H2	J1	I1	73,074	186,558	0.3917
182	A3	B2	C1	E4	F1	G1	H2	J1	I1	73,236	186,876	0.3919
183	A3	B2	C1	E4	F0	G3	H3	J1	I1	73,307	186,910	0.3922
184	A3	B2	C1	E4	F0	G3	H2	J2	I1	73,332	187,166	0.3918
185	A3	B2	C1	E4	F1	G1	H3	J1	I1	73,469	187,228	0.3924
186	A3	B2	C1	E4	F1	G1	H2	J2	I1	73,494	187,484	0.3920
187	A3	B2	C1	E4	F0	G3	H3	J2	I1	73,565	187,518	0.3923
188	A3	B2	C1	E4	F1	G1	H3	J2	I1	73,727	187,836	0.3925
189	A3	B2	C1	E4	F0	G3	H2	J3	I1	73,831	187,902	0.3929
190	A3	B2	C1	E4	F1	G1	H2	J3	I1	73,993	188,220	0.3931
191	A3	B2	C1	E4	F0	G3	H3	J3	I1	74,064	188,254	0.3934
192	A3	B2	C1	E4	F1	G1	H3	J3	I1	74,226	188,572	0.3936
193	A3	B2	C1	E4	F0	G4	H3	J2	I1	77,160	188,737	0.4088
194	A3	B2	C1	E4	F0	G4	H2	J3	I1	77,426	189,121	0.4094
195	A3	B2	C1	E4	F0	G4	H3	J3	I1	77,659	189,473	0.4099
196	A3	B2	C1	E4	F2	G1	H2	J3	I1	78,864	189,626	0.4159
197	A3	B2	C1	E4	F2	G1	H3	J3	I1	79,097	189,978	0.4163
198	A3	B2	C1	E4	F0	G5	H3	J3	I1	79,481	190,087	0.4181
199	A3	B2	C1	E4	F1	G2	H2	J3	I1	80,084	190,469	0.4205
200	A3	B2	C1	E4	F1	G2	H3	J3	I1	80,317	190,821	0.4209
201	A3	B2	C1	E4	F0	G6	H3	J3	I1	82,106	190,953	0.4300
202	A3	B2	C1	E4	F2	G2	H2	J2	I1	84,456	191,139	0.4419
203	A3	B2	C1	E4	F2	G2	H3	J2	I1	84,689	191,491	0.4423
204	A3	B2	C1	E4	F2	G2	H2	J3	I1	84,955	191,875	0.4428
205	A3	B2	C1	E4	F2	G2	H3	J3	I1	85,188	192,227	0.4432
206	A3	B2	C1	E4	F1	G3	H2	J3	I1	85,600	192,340	0.4450
207	A3	B2	C1	E4	F1	G3	H3	J3	I1	85,833	192,692	0.4454
208	A3	B2	C1	E4	F1	G4	H2	J2	I1	88,696	192,823	0.4600
209	A3	B2	C1	E4	F1	G4	H3	J2	I1	88,929	193,175	0.4604
210	A3	B2	C1	E4	F1	G4	H2	J3	I1	89,195	193,559	0.4608

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)
211	A3	B2	C1	E4	F1	G4	H3	J3	I1	89,428	193,911	0.4612
212	A3	B2	C1	E4	F2	G3	H3	J3	I1	90,704	194,098	0.4673
213	A3	B2	C1	E4	F1	G5	H2	J3	I1	91,017	194,173	0.4687
214	A3	B2	C1	E4	F1	G5	H3	J3	I1	91,250	194,525	0.4691
215	A3	B2	C1	E4	F1	G6	H3	J2	I1	93,376	194,655	0.4797
216	A3	B2	C1	E4	F1	G6	H2	J3	I1	93,642	195,039	0.4801
217	A3	B2	C1	E4	F1	G6	H3	J3	I1	93,875	195,391	0.4804
218	A3	B2	C1	E4	F2	G5	H2	J3	I1	95,888	195,579	0.4903
219	A3	B2	C1	E4	F2	G5	H3	J3	I1	96,121	195,931	0.4906
220	A3	B2	C1	E4	F1	G7	H2	J3	I1	96,725	196,008	0.4935
221	A3	B2	C1	E4	F1	G7	H3	J3	I1	96,958	196,360	0.4938
222	A3	B2	C1	E4	F2	G6	H2	J3	I1	98,513	196,445	0.5015
223	A3	B2	C1	E4	F2	G6	H3	J3	I1	98,746	196,797	0.5018
224	A3	B2	C1	E4	F1	G8	H3	J2	I1	100,588	196,822	0.5111
225	A3	B2	C1	E4	F1	G8	H2	J3	I1	100,854	197,206	0.5114
226	A3	B2	C1	E4	F1	G8	H3	J3	I1	101,087	197,558	0.5117
227	A3	B2	C1	E4	F2	G7	H3	J3	I1	101,829	197,766	0.5149
228	A3	B2	C1	E4	F1	G9	H3	J3	I1	102,942	197,863	0.5203
229	A3	B2	C1	E4	F2	G8	H2	J2	I1	105,226	197,876	0.5318
230	A3	B2	C1	E4	F2	G8	H3	J2	I1	105,459	198,228	0.5320
231	A3	B2	C1	E4	F2	G8	H2	J3	I1	105,725	198,612	0.5323
232	A3	B2	C1	E4	F2	G8	H3	J3	I1	105,958	198,964	0.5325
233	A3	B2	C1	E4	F2	G9	H3	J3	I1	107,813	199,269	0.5410

Figure E5 – Cost and Output of Cost Effective Combinations of Function E Best Buys from all Geographic Areas



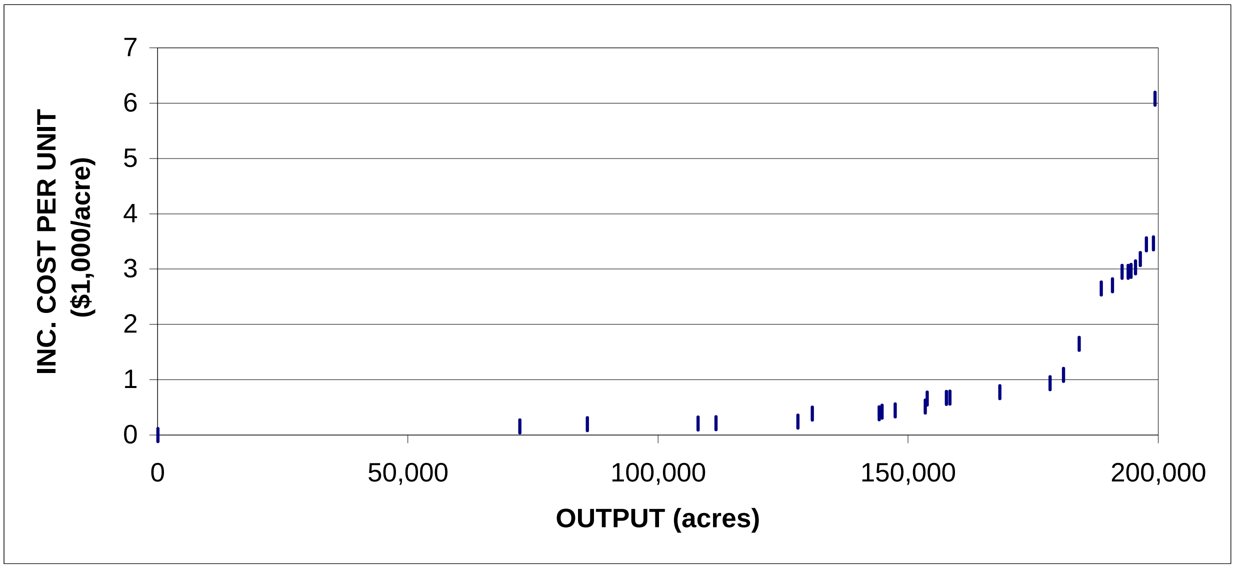
The third step of the cost analyses for Function E was to identify the subset of the cost effective combinations that were most efficient at protecting or restoring wetlands. These 28 best-buy plans are listed in ***Table E6***.

The values in the "Count" column simply count the number of best buys. The entries in the "Code" columns identify the management measures in each combination and correspond to the measure codes found in Tables E3 and E4. The values in the "Average Cost" column were calculated by dividing cost by output for each combination. The values in the "Incremental Cost" column show the change in cost from one combination to the next and were calculated by subtracting the cost of the next-smaller (in terms of output) combination from each combination. The values in the "Incremental Output" column show the change in output from one combination to the next and were calculated by subtracting the output of the next-smaller (in terms of output) combination from each combination. The last column "Incremental Cost Per Unit" shows the cost per unit of the incremental output for each combination. A plot of output vs. incremental cost per unit for the Function E best buys is included in ***Figure A6***.

Table E6 – Best Buy Combinations of Best Buys from all Function E Geographic Categories

COUNT	CODE									COST ($1,000)	OUTPUT (acres)	AVG. COST ($1,000/acre)	INC. COST ($1,000)	INC. OUTPUT (acres)	INC. COST PER UNIT ($1,000/acre)
1	A0	B0	C0	E0	F0	G0	H0	J0	I0	0	0	0.0000	0	0	0.0000
2	A0	B0	C0	E0	F0	G0	H0	J0	I1	11,102	72,320	0.1535	11,102	72,320	0.1535
3	A0	B0	C0	E1	F0	G0	H0	J0	I1	13,759	85,858	0.1603	2,657	13,538	0.1963
4	A0	B0	C0	E2	F0	G0	H0	J0	I1	18,313	107,961	0.1696	4,554	22,103	0.2060
5	A1	B0	C0	E2	F0	G0	H0	J0	I1	19,093	111,561	0.1711	780	3,600	0.2167
6	A1	B0	C0	E3	F0	G0	H0	J0	I1	23,111	127,918	0.1807	4,018	16,357	0.2456
7	A1	B0	C0	E3	F0	G0	H0	J1	I1	24,226	130,795	0.1852	1,115	2,877	0.3876
8	A1	B0	C0	E3	F0	G0	H2	J1	I1	29,442	144,133	0.2043	5,216	13,338	0.3911
9	A1	B0	C0	E3	F0	G0	H2	J2	I1	29,700	144,741	0.2052	258	608	0.4243
10	A2	B0	C0	E3	F0	G0	H2	J2	I1	30,853	147,331	0.2094	1,153	2,590	0.4452
11	A2	B0	C0	E4	F0	G0	H2	J2	I1	33,989	153,404	0.2216	3,136	6,073	0.5164
12	A2	B0	C0	E4	F0	G0	H3	J2	I1	34,222	153,756	0.2226	233	352	0.6619
13	A2	B0	C1	E4	F0	G0	H3	J2	I1	36,781	157,569	0.2334	2,559	3,813	0.6711
14	A2	B0	C1	E4	F0	G0	H3	J3	I1	37,280	158,305	0.2355	499	736	0.6780
15	A2	B1	C1	E4	F0	G0	H3	J3	I1	45,008	168,305	0.2674	7,728	10,000	0.7728
16	A2	B2	C1	E4	F0	G0	H3	J3	I1	54,367	178,305	0.3049	9,359	10,000	0.9359
17	A3	B2	C1	E4	F0	G0	H3	J3	I1	57,329	181,023	0.3167	2,962	2,718	1.0898
18	A3	B2	C1	E4	F0	G1	H3	J3	I1	62,457	184,134	0.3392	5,128	3,111	1.6483
19	A3	B2	C1	E4	F1	G1	H3	J3	I1	74,226	188,572	0.3936	11,769	4,438	2.6519
20	A3	B2	C1	E4	F1	G2	H3	J3	I1	80,317	190,821	0.4209	6,091	2,249	2.7083
21	A3	B2	C1	E4	F1	G3	H3	J3	I1	85,833	192,692	0.4454	5,516	1,871	2.9482
22	A3	B2	C1	E4	F1	G4	H3	J3	I1	89,428	193,911	0.4612	3,595	1,219	2.9491
23	A3	B2	C1	E4	F1	G5	H3	J3	I1	91,250	194,525	0.4691	1,822	614	2.9674
24	A3	B2	C1	E4	F1	G6	H3	J3	I1	93,875	195,391	0.4804	2,625	866	3.0312
25	A3	B2	C1	E4	F1	G7	H3	J3	I1	96,958	196,360	0.4938	3,083	969	3.1816
26	A3	B2	C1	E4	F1	G8	H3	J3	I1	101,087	197,558	0.5117	4,129	1,198	3.4466
27	A3	B2	C1	E4	F2	G8	H3	J3	I1	105,958	198,964	0.5325	4,871	1,406	3.4644
28	A3	B2	C1	E4	F2	G9	H3	J3	I1	107,813	199,269	0.5410	1,855	305	6.0820

Figure E6 – Incremental Cost per Unit and Output of Best Buy Combinations of Best Buys from Each Function E Geographical Area



A2.12 ANALYSIS RESULTS: FUNCTION F, MANAGE EVERGLADES PROTECTION AREA INFLOWS

A2.12.1 Cost Effectiveness Analysis Approach.

For Function F, two management measures were examined through cost effectiveness analysis, both of which included multiple scales. The cost analysis approach for Function F was to: (1) calculate the average cost for each management measure and sort measures by increasing average cost; (2) formulate all possible combinations of these measures and identify the cost effective set; and (3) conduct an incremental cost analysis to identify the most efficient production schedule, or set of "best-buys".

A2.12.2 Management Measures and Data.

Function F's two management measures (with cost, output and average cost) are included in ***Table F1***. The measures are grouped by geographical area. The entry in the "Code" column will be referenced when showing all possible combinations of Function F measures. Each measure has its own code letter. The no-action option for any measure gets a "0" following its code letter. Each scale of a measure has a different number following its code letter. For example, measure B has three scales: B0, B1, and B2. In Function F, both measures were combinable; scales of the same measure were not combinable.

Table F1 – Function F Management Measures

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
Everglades Agricultural Area				
A0	*No Action - EAA Storage Reservoirs*	0	0	0.0000
A1	EAA STORAGE RESEVOIRS (20,000 ACRES/6 FEET)	14,345	118,234	0.1213
A2	EAA STORAGE RESEVOIRS (20,000 ACRES/10 FEET)	16,388	178,419	0.0919
A3	EAA STORAGE RESEVOIRS (40,000 ACRES/6 FEET)	26,519	179,686	0.1476
A4	EAA STORAGE RESEVOIRS (40,000 ACRES/10 FEET)	29,745	236,652	0.1257
A5	EAA STORAGE RESEVOIRS (60,000 ACRES/6 FEET)	38,601	212,568	0.1816
A6	EAA STORAGE RESEVOIRS (60,000 ACRES/10 FEET)	43,776	265,332	0.1650
B0	*No Action - Treat/Backpump EAA Water to Lake Okeechobee*	0	0	0.0000
B1	TREAT BACKPUMP EAA WATER TO LAKE OKEECHOBEE (2,500 ACRE STATION)	4,899	167,100	0.0293
B2	TREAT BACKPUMP EAA WATER TO LAKE OKEECHOBEE (5,000 ACRE STATION)	8,636	285,000	0.0303
B3	TREAT BACKPUMP EAA WATER TO LAKE OKEECHOBEE (7,500 ACRE STATION)	17,811	441,500	0.0403

A2.12.3 Results of Analyses.

The first step in the analyses was to display the management measures sorted by increasing average cost. This display is included in ***Table F2***. This table shows the relative production efficiency of the management measures being considered in Function F. The measure with the lowest average cost is the most efficient measure for providing increased storage capacity in the Everglades Agricultural Area to manage inflows into the Everglades Protection Area. Each successive measure is less efficient at holding this water for the EPA.

Table F2 – Function A Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
B1	BACKPUMP EAA WATER TO LAKE OKEECHOBEE (2,500 ACRE STATION)	4,899	167,100	0.0293
B2	BACKPUMP EAA WATER TO LAKE OKEECHOBEE (5,000 ACRE STATION)	8,636	285,000	0.0303
B3	BACKPUMP EAA WATER TO LAKE OKEECHOBEE (7,500 ACRE STATION)	17,811	441,500	0.0403
A2	EAA STORAGE RESEVOIRS (20,000 ACRES/10 FEET)	16,388	178,419	0.0919
A1	EAA STORAGE RESEVOIRS (20,000 ACRES/6 FEET)	14,345	118,234	0.1213
A4	EAA STORAGE RESEVOIRS (40,000 ACRES/10 FEET)	29,745	236,652	0.1257

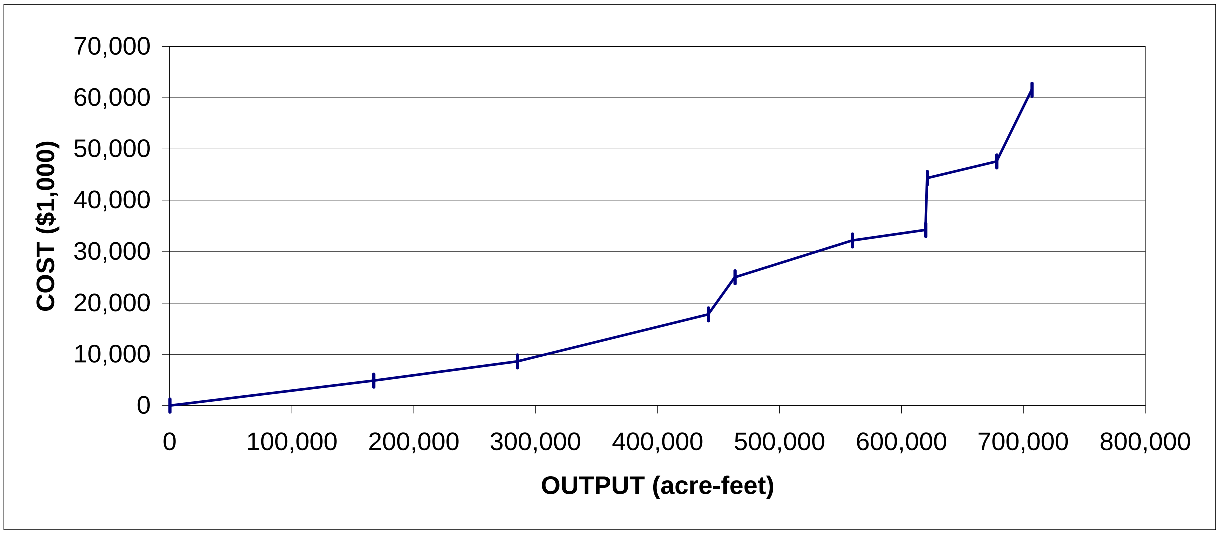
CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
A3	EAA STORAGE RESEVOIRS (40,000 ACRES/6 FEET)	26,519	179,686	0.1476
A6	EAA STORAGE RESEVOIRS (60,000 ACRES/10 FEET)	43,776	265,332	0.1650
A5	EAA STORAGE RESEVOIRS (60,000 ACRES/6 FEET)	38,601	212,568	0.1816

The second step of the analyses was to formulate all possible combinations of the Function F management measures and identify the cost effective set. Of the 28 possible combinations of Function F measures, 10 were cost effective. The cost-effective combinations can be found in ***Table F3***. The value in the "Count" column simply counts the number of cost effective plans. The entries in the "Code" columns correspond to the Codes from Tables F1 and F2 and show what measures are included in each combination. A graph of cost vs. output for cost effective combinations of Function F's management measures is plotted in Figure F3.

Table F3 – Cost Effective Combinations of Management Measures for Function F

COUNT	CODE		COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
1	A0	B0	0	0	0.0000
2	A0	B1	4,899	167,100	0.0293
3	A0	B2	8,636	285,000	0.0303
4	A0	B3	17,811	441,500	0.0403
5	A2	B2	25,024	463,419	0.0540
6	A1	B3	32,156	559,734	0.0574
7	A2	B3	34,199	619,919	0.0552
8	A3	B3	44,330	621,186	0.0714
9	A4	B3	47,556	678,152	0.0701
10	A6	B3	61,587	706,832	0.0871

Figure F3 – Cost and Output of Cost Effective Combinations (Function F)



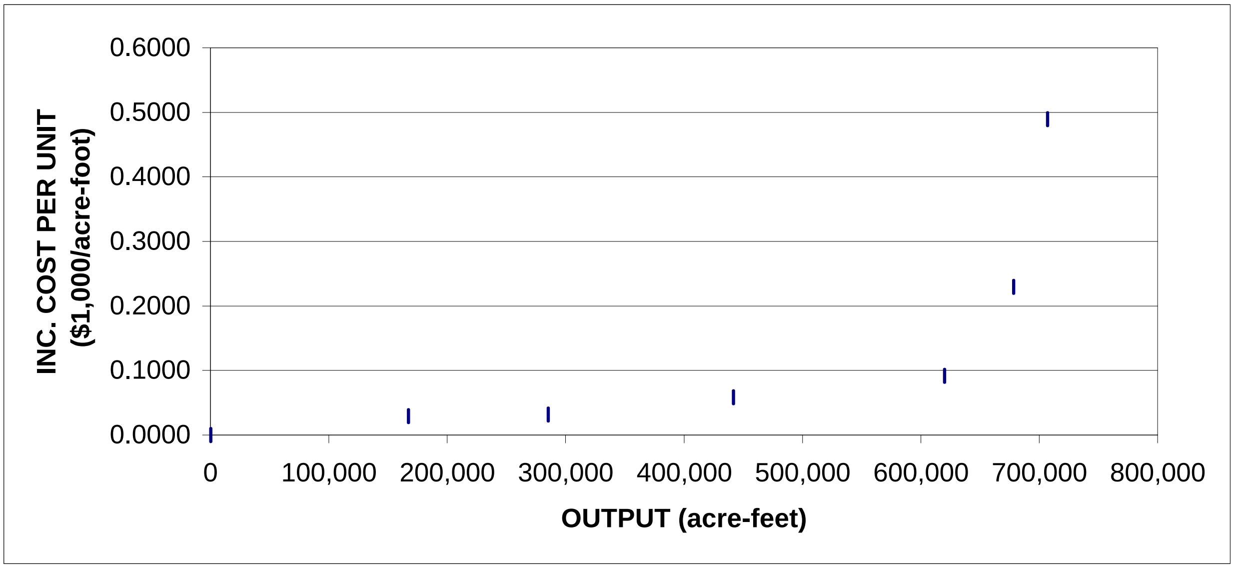
The third step of the cost analyses for Function F was to identify the subset of the cost-effective combinations that were most efficient at storing water for the EPA. These seven best-buy plans are listed in ***Table F4***.

The values in the "Count" column simply count the number of best buys. The entries in the "Code" columns identify the management measures in each combination and correspond to the measure codes found in Tables F1 and F2. The values in the "Average Cost" column were calculated by dividing cost by output for each combination. The values in the "Incremental Cost" column show the change in cost from one combination to the next and were calculated by subtracting the cost of the next-smaller (in terms of output) combination from each combination. The values in the "Incremental Output" column show the change in output from one combination to the next and were calculated by subtracting the output of the next-smaller (in terms of output) combination from each combination. The last column "Incremental Cost Per Unit" shows the cost per unit of the incremental output for each combination. A plot of output vs. incremental cost per unit for the Function F best buys is included in ***Figure F4***.

Table F4 – Best Buy Combinations of Management Measures for Function F

COUNT	CODE		COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)	INC. COST ($1,000)	INC. OUTPUT (acre-feet)	INC. COST PER UNIT ($1,000 per acre-foot)
1	A0	B0	0	0	0.0000	0	0	0.0000
2	A0	B1	4,899	167,100	0.0293	4,899	167,100	0.0293
3	A0	B2	8,636	285,000	0.0303	3,737	117,900	0.0317
4	A0	B3	17,811	441,500	0.0403	9,175	156,500	0.0586
5	A2	B3	34,199	619,919	0.0552	16,388	178,419	0.0919
6	A4	B3	47,556	678,152	0.0701	13,357	58,233	0.2294
7	A6	B3	61,587	706,832	0.0871	14,031	28,680	0.4892

Figure F4 – Incremental Cost per Unit and Output of Best Buy Combinations (Function F)



A2.13 ANALYSIS RESULTS: FUNCTION G, REDUCE SEEPAGE FOR EVERGLADE PROTECTION AREA

A2.13.1 Cost Effectiveness Analysis Approach.

For Function G, five management measures were examined through cost effectiveness analysis, all of which included multiple scales. The cost analysis approach for Function G was to (1) calculate the average cost for each management measure and sort measures by increasing average cost, (2) formulate all possible combinations of these measures and identify the cost effective set, and (3) conduct an incremental cost analysis to identify the most efficient production schedule, or set of "best-buys".

A2.13.2 Management Measures and Data.

Function G's five management measures (with cost, output and average cost) are included in ***Table G1***. The measures are grouped by geographical area. The entry in the "Code" column will be referenced when showing all possible combinations of Function G measures. Each measure has its own code letter. The no-action option for any measure gets a "0" following its code letter. Each scale of a measure has a different number following its code letter. For example, measure A has three scales: A0, A1, and A2. In Function G, all measures were combinable with one another; scales of the same measure were not combinable.

Table G1 – Function G Management Measures

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre -foot)
Loxahatchee National Wildlife Refuge - Water Conservation Area 1, Service Area1				
A0	*No Action - LNWR Seepage Reduction*	0	0	0.0000
A1	LNWR (SEEPAGE BARRIER)	70,234	73,370	0.9573
A2	LNWR (SEEPAGE RECYCLE)	1,457	73,370	0.0199
Water Conservation Area 2A/2B - Service Area 2				
B0	*No Action - WCA2A/2B Seepage Reduction*	0	0	0.0000
B1	WCA2A/2B (SEEPAGE BARRIER)	34,732	77,357	0.4490
B2	WCA 2A/2B (SEEPAGE RECYCLE)	1,159	77,357	0.0150
B3	WCA 2A/2B (WPA – STEP-DOWN LEVVEE IN WCA2B)	700	32,623	0.0215
Water Conservation Area 3A/3B - Service Area 2				
C0	*No Action - WCA3A/3B Seepage Reduction*	0	0	0.0000
C1	WCA 3A/3B (SEEPAGE BARRIER)	11,775	45,144	0.2608
C2	WCA 3A/3B (SEEPAGE RECYCLE)	956	45,144	0.0212
Water Conservation Area 3B – Service Area 3, Lake Belt Area				
D0	*No Action - WCA 3B Seepage Reduction*	0	0	0.0000
D1	WCA3B (SEEPAGE BARRIER)	8,566	183,133	0.0468
D2	WCA 3B (SEEPAGE RECYCLE)	3,949	183,133	0.0216
Everglades National Park				
E0	*No Action - ENP Seepage Reduction*	0	0	0.0000
E1	ENP (SEEPAGE BARRIER)	3,275	103,991	0.0315
E2	ENP (SEEPAGE RECYCLE)	2,581	103,991	0.0248

A2.13.3 Results of Analyses.

The first step in the analyses was to display the management measures sorted by increasing average cost. This display is included in ***Table G2***. This table shows the relative production efficiency of the management measures being considered in Function G. The measure with the lowest average cost is the most efficient measure for reducing seepage of water from the EPA. Each successive measure is less efficient at reducing seepage.

Table G2 – Function G Management Measures Sorted by Average Cost

CODE	DESCRIPTION	COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre -foot)
B2	WCA 2A/2B (SEEPAGE RECYCLE)	1,159	77,357	0.0150
A2	LNWR (SEEPAGE RECYCLE)	1,457	73,370	0.0199
C2	WCA 3A/3B (SEEPAGE RECYCLE)	956	45,144	0.0212
B3	WCA 2A/2B (SEEPAGE RECYCLE)	700	32,623	0.0215
D2	WCA 3B (SEEPAGE RECYCLE)	3,949	183,133	0.0216

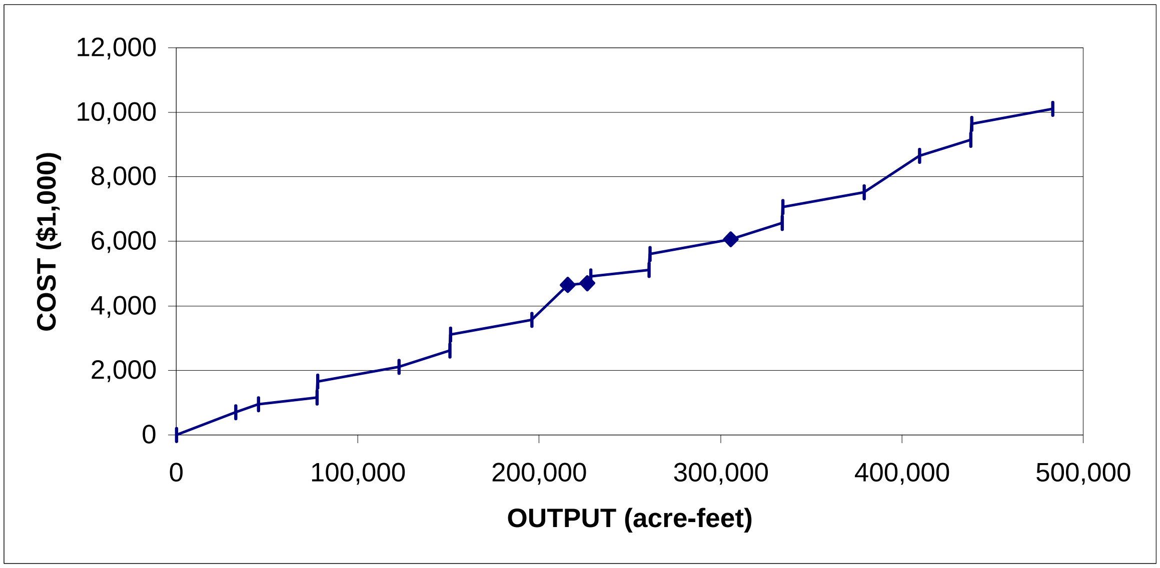
E2	ENP (SEEPAGE RECYCLE)	2,581	103,991	0.0248
E1	ENP (SEEPAGE BARRIER)	3,275	103,991	0.0315
D1	WCA3B (SEEPAGE BARRIER)	8,566	183,133	0.0468
C1	WCA 3A/3B (SEEPAGE BARRIER)	11,775	45,144	0.2608
B1	WCA2A/2B (SEEPAGE BARRIER)	34,732	77,357	0.4490
A1	LNWR (SEEPAGE BARRIER)	70,234	73,370	0.9573

The second step of the analyses was to formulate all possible combinations of the Function G management measures and identify the cost effective set. Of the full 324 combinations of Function G management measures, 22 were cost effective. The 22 cost effective combinations can be found in ***Table G3***. The value in the "Count" column simply counts the number of cost effective plans. The entries in the "Code" columns correspond to the Codes from Tables G1 and G2 and show what measures are included in each combination. A graph of this data is plotted in ***Figure G3.***

Table G3 – Cost Effective Combinations of Management Measures for Function G

COUNT	CODE					COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)
1	A0	B0	C0	D0	E0	0	0	0.0000
2	A0	B3	C0	D0	E0	700	32,623	0.0215
3	A0	B0	C2	D0	E0	956	45,144	0.0212
4	A0	B2	C0	D0	E0	1,159	77,357	0.0150
5	A0	B3	C2	D0	E0	1,656	77,767	0.0213
6	A0	B2	C2	D0	E0	2,115	122,501	0.0173
7	A2	B2	C0	D0	E0	2,616	150,727	0.0174
8	A2	B3	C2	D0	E0	3,113	151,137	0.0206
9	A2	B2	C2	D0	E0	3,572	195,871	0.0182
10	A0	B3	C0	D2	E0	4,649	215,756	0.0215
11	A0	B2	C2	D0	E2	4,696	226,492	0.0207
12	A0	B0	C2	D2	E0	4,905	228,277	0.0215
13	A0	B2	C0	D2	E0	5,108	260,490	0.0196
14	A0	B3	C2	D2	E0	5,605	260,900	0.0215
15	A0	B2	C2	D2	E0	6,064	305,634	0.0198
16	A2	B2	C0	D2	E0	6,565	333,860	0.0197
17	A2	B3	C2	D2	E0	7,062	334,270	0.0211
18	A2	B2	C2	D2	E0	7,521	379,004	0.0198
19	A0	B2	C2	D2	E2	8,645	409,625	0.0211
20	A2	B2	C0	D2	E2	9,146	437,851	0.0209
21	A2	B3	C2	D2	E2	9,643	438,261	0.0220
22	A2	B2	C2	D2	E2	10,102	482,995	0.0209

Figure G3 – Cost and Output of Cost Effective Combinations (Function G)



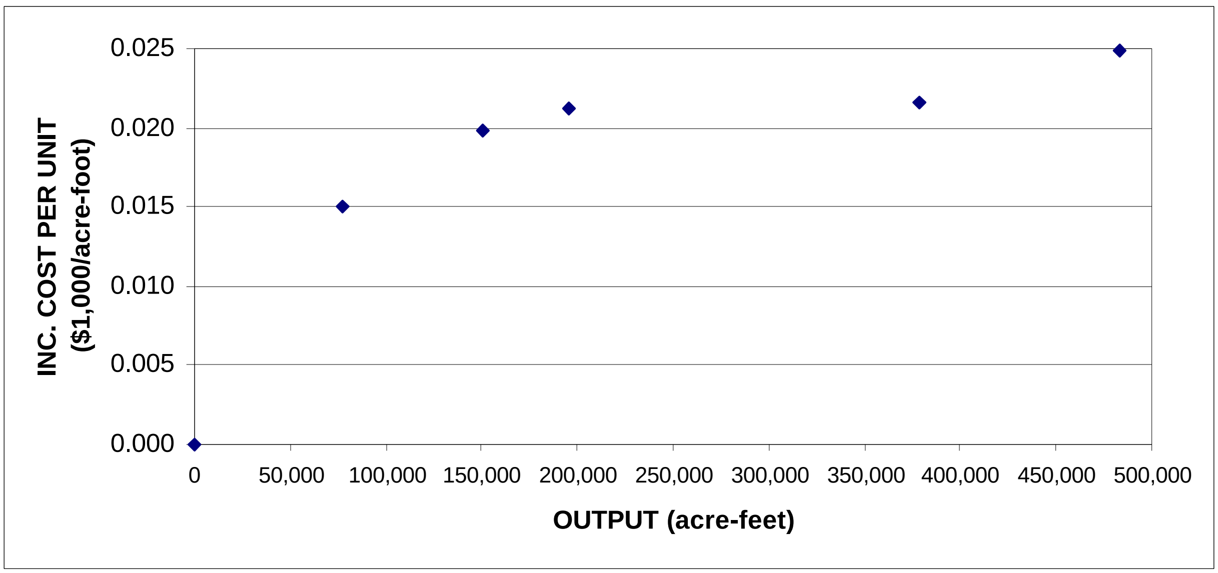
The third step of the cost analyses for Function G was to identify the subset of the cost-effective combinations that were most efficient at reducing seepage form the EPA. The six best-buy plans are listed in ***Table G4***.

The values in the "Count" column simply count the number of best buys. The entries in the "Code" columns identify the management measures in each combination and correspond to the measure codes found in Tables G1 and G2. The values in the "Average Cost" column were calculated by dividing cost by output for each combination. The values in the "Incremental Cost" column show the change in cost from one combination to the next and were calculated by subtracting the cost of the next-smaller (in terms of output) combination from each combination. The values in the "Incremental Output" column show the change in output from one combination to the next and were calculated by subtracting the output of the next-smaller (in terms of output) combination from each combination. The last column "Incremental Cost Per Unit" shows the cost per unit of the incremental output for each combination. A plot of output vs. incremental cost per unit for the Function G best buys is included in ***Figure G4***.

Table G4 – Best Buy Combinations of Management Measures for Function G

COUNT	CODE					COST ($1,000)	OUTPUT (acre-feet)	AVG. COST ($1,000/acre-foot)	INC. COST ($1,000)	INC. OUTPUT (acre-feet)	INC. COST PER UNIT ($1,000 per acre-foot)
1	A0	B0	C0	D0	E0	0	0	0.0000	0	0	0.0000
2	A0	B2	C0	D0	E0	1,159	77,357	0.0150	1,159	77,357	0.0150
3	A2	B2	C0	D0	E0	2,616	150,727	0.0174	1,457	73,370	0.0199
4	A2	B2	C2	D0	E0	3,572	195,871	0.0182	956	45,144	0.0212
5	A2	B2	C2	D2	E0	7,521	379,004	0.0198	3,949	183,133	0.0216
6	A2	B2	C2	D2	E2	10,102	482,995	0.0209	2,581	103,991	0.0248

Figure G4 – Incremental Cost per Unit and Output of Best Buy Combinations (Function G)



APPENDIX A3

SUMMARY DESCRIPTIONS OF ALTERNATIVES A-D

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APPENDIX A3
SUMMARY DESCRIPTIONS OF ALTERNATIVES A - D

A3.1 ALTERNATIVE A

Alternative A is the first of four alternatives (Alternatives A – D) which was evaluated and compared by the Alternative Evaluation Team in the selection of the technically preferred alternative. The components contained in Alternative A were derived from components which were developed in earlier Alternatives. Some components have been modified from their original design to allow the comparison of the four alternatives on an equal basis.

A3.1.1 Summary of Alternative A by Geographic Regions

The following is a summary of the components, which have been included in Alternative A, grouped by region.

A3.1.1.3 Lake Okeechobee

- Storage reservoirs have been proposed north, east and west of the Lake to provide flood flow attenuation to the St. Lucie River and Caloosahatchee River estuaries and lands adjacent to the Lake. The storage reservoirs will also provide water supply benefits, water quality benefits and benefits to the Lake littoral zone.

- Aquifer Storage and Recovery has been proposed around the Lake and in conjunction with reservoirs to provide additional storage for use during dry times to meet regional water supply demands and enhance flood protection.

- The desired estuary target discharges at S-79 and S-80 for the Caloosahatchee (C-43) and St. Lucie (C-44) basins were revised to support the desired estuary environmental values and also to reduce the volume of discharges required from the basin storage reservoirs and Lake Okeechobee.

- Operational changes to the Lake Okeechobee regulation schedule are proposed to eliminate all but emergency discharges to the estuaries.

A3.1.1.4 Everglades Agricultural Area

- Storage reservoirs have been proposed in the Everglades Agricultural Area to provide flood flow attenuation, water supply benefits and water quality benefits to the Everglades Agricultural Area and to increase regional water resources.

- Conveyance in the Miami and North New River Canals from Lake Okeechobee and the Everglades Agricultural Area storage area was increased to convey additional Lake Okeechobee regulatory releases which would have been discharged to the estuaries.

A3.1.1.5 Water Conservation Areas And Everglades National Park

- The timing and location of water depths in the Holey Land and Rotenberger Wildlife Management Areas and Loxahatchee National Wildlife Refuge were improved.

- The timing and location of water depths in the Water Conservation Areas and Everglades National Park were improved by modifying the rain-driven operations.

- Conveyance was improved between Water Conservation Area 3B and Everglades National Park.

- Levee seepage for Water Conservation Area 2B along L-35A and a portion of L-36 was managed only during the wet season.

- Levee seepage was reduced for Water Conservation Areas 3A and 3B by allowing higher water levels and longer inundation in the marsh areas located east of the Water Conservation Areas and west of US Highway 27 while maintaining flood protection. Wet season levee seepage was further reduced by L-31N Levee improvements along Everglades National Park.

- Operational changes to the S-343 A & B Structures were proposed to reduce potential adverse impacts on the nesting season of the Cape Sable Seaside Sparrow.

- The S-345 structures, allowing flow through the L-67 Levee were relocated south to relieve high water conditions in northern Water Conservation Area 3B.

- Deliveries were improved to Northeast Shark River Slough in Everglades National Park and seepage was reduced to Lower East Coast Service Area 3.

- Hydropattern restoration and water availability was increased in northwest corner of Water Conservation Area 3A.

A3.1.1.6 Lower East Coast

- The L-8 Project was modified to capture additional excess water from the southern L-8, C-51 and C-17 basins and route this water to the West Palm

Beach water Catchment Area in order to increase regional water supplies, improve hydropatterns in the Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River.

- In the lower east coast urban areas, wellfield pumpages were shifted inland to reduce the impact of saltwater intrusion for Riviera Beach, Dania, Miramar, Broward County 3A, Lake Worth, Lantana, Manalapan, Boca Raton, Hollywood (including water supply to Broward 3B and 3C), Hallandale and Florida City.

- The Broward County Secondary Canal System was enhanced by the increase of pump capacities and construction of canal improvements and pump facilities to provide recharge to the groundwater and wellfields and stabilize the saltwater interface in southeastern and southern coastal Broward County.

- The Dade-Broward Levee was improved to reduce seepage to the east from the Pennsuco wetlands and southern Water Conservation Area 3B, enhance hydroperiods in the Pennsuco, and enhance recharge to the Miami-Dade County's NW wellfield.

- An additional control structure was added in the C-4 Canal to increase recharge to coastal wellfields and reduce demand on Lake Okeechobee and the Water Conservation Areas.

A3.1.1.7 Water Preserve Areas

- Water Preserve Area components for Site 1, C-9 and C-11 Stormwater Treatment Area/Impoundments, Central Lake Belt In-ground Storage Area and the Bird Drive Recharge Area were included to provide storage for flood flow attenuation, water quality treatment, groundwater and wellfield recharge, seepage control, dry season flows to meet environmental and urban water supply demands and to reduce the impact of saltwater intrusion.

- Regional groundwater Aquifer Storage and Recovery facilities were used to capture and store excess water which would have been lost to tide in the C-51 and Hillsboro Canal basins.

- The Water Preserve Area components for backpumping from the C-51 and C-17 Canals were modified to enhance the performance of the stormwater treatment areas.

A3.1.2 List of Components in Alternative A

The following is a list of each component included in Alternative A along with a brief summary.

Component A6. A Storage Reservoir (20,000 acres at 10 ft. maximum depth) north of Lake Okeechobee. Purpose: incorporate climate-based inflow forecasting to increase the utilization of the reservoir to provide additional flood protection, water supply and environmental enhancement. Operation revised from Alternative 5.

Component B2. A Storage Reservoir (10,000 acres at 4 ft. maximum depth) in the St. Lucie basin. Purpose: capture local runoff from C-44 for flood attenuation, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.

Component C6. Environmental Water Supply Deliveries to the St. Lucie Estuary. Purpose: provide freshwater flow to the St. Lucie Estuary to protect and restore more natural estuarine conditions. The time series of estuary target flows was revised from Alternative 5.

Component D5. A Storage Reservoir (20,000 acres at 8 ft. maximum depth) with Aquifer Storage and Recovery (44, 5-MGD wells) in the Caloosahatchee basin. Purpose: capture basin runoff and regulatory releases from Lake Okeechobee to provide water supply benefits, some flood attenuation and environmental water supply deliveries to the Caloosahatchee estuary. Operated in conjunction with DDD5.

Component E5. Environmental Water Supply Deliveries to the Caloosahatchee Estuary (operational change only). Purpose: provide freshwater deliveries to the Caloosahatchee Estuary to establish desirable salinity at locations of key estuarine biota. Operational target flow at S-79 revised in Alternative 5.

Component F3. Current Lake Okeechobee Regulation Schedule (elimination of all except Zone A [emergency] regulatory releases to the St. Lucie and Caloosahatchee Estuaries). Purpose: implement operating criteria for Lake Okeechobee that includes flood control, water supply (including releases to the Water Conservation Areas to meet estimated natural system needs) as well as Lake littoral zone and estuary protection.

Component G3. A Storage Reservoir (one 20,000 acre compartment at 6 ft. maximum depth for supplying EAA irrigation demands and one 40,000 acre compartment at 6 ft. maximum depth for supplying environmental demands) in the Everglades Agricultural Area with increased conveyance from Lake Okeechobee to the reservoir. Purpose: improve timing of environmental deliveries to the Water Conservation Areas including reducing damaging flood releases from the EAA to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands and increase flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami and North New River Canals between Lake Okeechobee and the Storage Reservoirs are increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries.

Component H3. Everglades Rain-Driven Operations. Purpose: improve the timing and location of water depths in the Water Conservation Areas and Everglades National Park.

Component I3. Improved Conveyance between Water Conservation Area 3B and Everglades National Park. Purpose: improve water deliveries to Everglades National Park from Water Conservation Area 3B by increasing conveyance capacity through L-29 and US Highway 41 (Tamiami Trail).

Component J. Plug L-67A borrow canal (between S-151 and Modified Water Delivery Structures S-345s). Not included in this Alternative.

Component K2. Water Preserve Areas / L-8 Project Phase II in northern Palm Beach County – modified from Alternative 1 to capture additional water and improve stages in the West Palm Beach Water Catchment Area. Purpose: reduce water supply restrictions in the Northern Palm Beach County Service Area by capturing more of the annual discharges from portions of the southern L-8, C-51 and C-17 basins and route this water to the West Palm Beach Water Catchment Area. Intent is to increase water supply availability and provide pass through flow to enhance hydroperiods in Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River.

Component L3. Change Coastal Wellfields Operations in the Lower East Coast Service Area. Purpose: shift demands from eastern wellfields inland to western facilities away from the saltwater interface to reduce impact of salt water intrusion.

Component M4. Water Preserve Areas / Site 1 Impoundment (1660 acres at 6 ft. maximum depth) with Aquifer Storage and Recovery wells increased to 15, 5-MGD wells in Palm Beach County. Purpose: increase regional water resources and supplement water deliveries to the Hillsboro Canal during the dry-season.

Component N2. Water Conservation Area 2B Levee Seepage Management in Broward County to manage only wet season seepage. Purpose: implement seasonal seepage management along the eastern edge of Water Conservation Area 2B to reduce losses due to levee seepage to the Lower East Coast.

Component O1. Water Conservation Area 3A and 3B Levee Seepage Management in Broward County. Purpose: reduce seepage from Water Conservation Areas 3A and 3B, to improve hydropatterns within the Conservation Areas by utilizing the marsh areas that are located east of the Water Conservation Areas and west of U.S. Highway 27 and to allow higher water levels and longer inundation durations within those marshes. Seepage from the marshes will be collected and returned to the Water Conservation Areas to maintain flood protection. Serves to separate Water Conservation Area 3A seepage water from urban runoff originating in the C-11 Basin.

Component P2. Water Preserve Areas / North New River Diversion Canal and Treatment Facility (1600 acres at 4 ft. maximum depth north of C-11) in Broward County with increased pump and structure capacities and seasonal S-141 operations. Purpose: capture excess North New River and Water Conservation Area 2B water, store and treat it in western C-11 and backpump it to Water Conservation Area 3A. This will (1) restore a portion of water deliveries to Water Conservation Area 3A that are eliminated by segregating the C-11 runoff from levee seepage, (2) reduce stages above NSM in Water Conservation 2B and (3) divert water through Water Conservation Area Nos. 3A and 3B to North East Shark River Slough. Untreated, western C-11 runoff that is presently backpumped through the S-9 pump station into Water Conservation Area 3A will be redirected into the new canal and diverted to the Central Lake Belt Storage Area (refer to Component Q1).

Component Q1. Water Preserve Areas / Western C-11 Diversion Canal (to Central Lake Belt Storage) in Broward County. Purpose: divert untreated runoff from western C-11 (presently discharged into Water Conservation Area 3A) and excess flows from the North New River and C-9 Canals to the Central Lake Belt Reservoir.

Component R3. Water Preserve Areas / C-9 Stormwater Treatment Area/Impoundment (2500 acres at 4 ft. maximum depth) in Broward County. Purpose: capture runoff from western C-9 basin by backpumping into the impoundment area to provide flood peak attenuation within the basin, groundwater recharge and seepage control.

Component S3. Central Lake Belt In-ground Storage Area (4000 acres) in Miami-Dade County. Purpose: capture a portion of runoff from western North New River, C-11, C-9, C-6 and C-7 basins in an in-ground reservoir which will allow storage of untreated runoff without concerns of ground water contamination. The stored water will be used to maintain stages during the dry season in the C-9, C-6, Northwest wellfield protection canal, C-4, C-2 and the South Dade Conveyance System Canals.

Component T6. C-4 Structures (2) in Miami-Dade County. Purpose: maintain higher water levels in the C-4 Canal to reduce seepage losses from the Pennsuco Wetlands and areas west of the Dade-Broward Levee and reduce deliveries from Lake Okeechobee and the Water Conservation Areas by diverting dry season stormwater flows into the C-2 Canal to increase recharge to several nearby coastal wellfields.

Component U3. Water Preserve Areas / Bird Drive Recharge Area (2877 acres at 4 ft. maximum depth) in Miami-Dade County with operational rules for the C-4 downstream diversion structure. Purpose: capture runoff from western C-4 basin and induce seepage collection/treatment of Bird Drive water by pumping seepage collection canal to L-31N. The facility will provide C-4 flood peak attenuation within the basin, provide water to L-31N available to be pumped west through the proposed S-356 A and B pumps (see Component FF3) and enhance groundwater recharge.

Component V2. L-31N Levee Improvements for Seepage Management in Miami-Dade County with additional reduction of seepage in the wet season. Purpose: manage levee seepage along the eastern edge (L-31N) of Everglades National Park to eliminate losses to the East Coast. An additional feature has been added to reduce all wet-season seepage/ground water flows to the east to help restore hydropatterns in Everglades National Park.

Component W2. Taylor Creek / Nubbin Slough Storage and Treatment Area (5000-acre storage area at 10 ft. maximum depth and 5000-acre stormwater treatment area at 4 ft. maximum depth) in Okeechobee and St. Lucie Counties. Purpose: provide flood protection, water quality treatment, estuary protection and water supply benefits.

Component X6. Water Preserve Areas / C-17 Backpumping in North Palm Beach Service Area (550-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-17 basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in the Loxahatchee Slough. Delivery route to the stormwater treatment area revised and operational changes made from Alternative 5.

Component Y6. Water Preserve Areas / C-51 Backpumping to Water Catchment Area in Palm Beach County (600-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-51 West basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in Loxahatchee Slough. Operational changes made to the stormwater treatment area as compared to Alternative 5.

Component AA3. Additional S-345 Structures in L-67A in Water Conservation Area 3B. Purpose: improve conveyance to Water Conservation Area (WCA) 3B through the L-67 levee system to help in re-establishing NSM-like hydroperiods and hydropatterns in WCA 3B and Northeast Shark River Slough.

Component BB4. Dade-Broward Levee / Pennsuco Wetlands in Miami-Dade County. Purpose: reduce seepage to the east from the Pennsuco wetlands and southern Water Conservation Area 3B, enhance hydroperiods in the Pennsuco and enhance recharge to Miami-Dade County's NW wellfield.

Component CC6. Broward County Secondary Canal System. Purpose: increase pump capacity of existing facilities (from the 2050 Base Case) and construct additional canal improvements and pump facilities for the Broward County Secondary Canal System to provide additional recharge to wellfields located in central and southern coastal Broward County, stabilize the salt water interface and reduce discharges to tide. The groundwater table and recharge to the aquifer were improved from Alternative 5 by modifying secondary canals in the C-10 and C-12 basins.

Component DD5. Revised Holey Land Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Holey Land Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component EE5. Modified Rotenberger Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Rotenberger Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component FF3. Construction of S-356 A & B Structures (L-31N along east side of Northeast Shark River Slough) in Miami-Dade County. Purpose: improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3.

Component GG4. Lake Okeechobee Aquifer Storage and Recovery (200, 5-MGD wells) along the lake peripheral levee. Purpose: utilize climate based operational rules for the aquifer storage and recovery wells to provide additional regional storage while reducing both evapotranspiration losses and the amount of land removed from current land use (e.g. agriculture) that would normally be associated with construction and operation of above-ground storage facilities (reservoirs); increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades; manage a portion of regulatory releases from the Lake primarily to improve Everglades hydropatterns, meet environmental targets within the Water Conservation Areas (WCAs), and meet supplemental water supply demands of the Lower East Coast; reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee estuaries; and maintain existing level of flood protection.

Component HH3. Operation Change of S-343 A and B (closed during the January to June time period) in Miami-Dade County. Purpose: reduce the potential adverse effects on the nesting season of the Cape Sable Seaside Sparrow due to high water levels, the S-343 A and B structures will be closed during the January to June time period.

Component II3. Pump Station G-404 Modification in Palm Beach County. Purpose: increase the capacity of proposed Everglades Construction Project pump station G-404 from 1000 cfs to 2000 cfs to improve the hydropattern restoration in the northwest corner of Water Conservation Area (WCA) 3A and increase the amount of water available in the west-central region of WCA 3A to reduce dry out periods.

Component JJ. Loxahatchee National Wildlife Refuge Rainfall-Driven Operations in Palm Beach County. Not included in this Alternative.

Component KK4. Loxahatchee National Wildlife Refuge Internal Canal Structures. Purpose: improve timing and location of water depths in the Refuge by keeping the borrow canal structures closed except to pass Stormwater Treatment Areas 1 East and 1 West outflow and water supply deliveries.

Component LL3. C-51 Regional Groundwater Aquifer Storage and Recovery (34 well clusters) in Palm Beach County. Purpose: capture and store excess water during wet periods, then recover the water for utilization during dry periods to increase regional water resources.

Component MM4. Hillsboro Canal Basin Regional Groundwater Aquifer Storage and Recovery (22 well clusters, total injection and recovery capacity is 110 MGD) in Broward and Palm Beach Counties. Purpose: increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods.

Component NN. North New River Regional Groundwater Aquifer Storage and Recovery. Not included in this Alternative.

Component OO4. Modification to South Dade Conveyance System in Southern Portion of L-31N and C-111. Purpose: modify C-111 Canal operations to improve deliveries to Everglades National Park and decrease potential flood risk in the lower east coast service area.

Component PP3. Backpumping of the C-7 Basin to the Central Lake Belt In-ground Storage Reservoir via the C-6 Canal in Miami-Dade County. Purpose: backpump a portion of excess runoff from the C-7 basin, previously lost to tide, to the Central

Lake Belt Storage Reservoir to be used for water supply and decrease flooding problems in the C-7 basin.

Component QQ. Decompartmentalization of Water Conservation Area 3. Not included in this Alternative.

Component RR. Flow to Central Water Conservation Area 3A. Not included in this Alternative.

Component SS. Reroute Miami-Dade County Water Supply Deliveries. Not included in this Alternative.

Component TT. Decompartmentalization of Water Conservation Area 2. Not included in this Alternative.

Component UU6. Storage Reservoirs (20,200 acres at 8 ft. maximum depth and 15,000 acres at 2 ft. maximum depth) in Martin and St. Lucie Counties. Purpose: capture local runoff from the C-23, 24, and Northfork and Southfork Basins of the St. Lucie River Estuary for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The reservoirs were increased in size and reconfigured from the design presented in Alternative 5.

Component VV. Palm Beach County Agricultural Reserve Reservoir. Not included in this Alternative.

Component WW. C-111N Spreader Canal in Miami-Dade County. Not included in this Alternative.

Component XX. North Lake Belt Storage Area in Miami-Dade County. Not included in this Alternative.

Component YY. Divert Water Conservation Area 2 flows to Central Lake Belt Storage in Broward County. Not included in this Alternative.

Component ZZ. Divert Water Conservation Area 3A and 3B flows to Central Lake Belt Storage Area. Not included in this Alternative.

Component AAA. Lower East Coast Utility Water Conservation. Not included in this Alternative.

Component BBB. South Miami-Dade County Reuse (South District Reclaimed Water Treatment Plant). Not included in this Alternative.

Component CCC. Big Cypress/ L-28 Interceptor Modifications. Not included in this Alternative.

Component DDD5. Caloosahatchee Backpumping with Stormwater Treatment Area. Purpose: increase the regional water resources by capturing excess C-43 basin runoff and diverting it into Lake Okeechobee after treatment through a stormwater treatment area when storage is available in the Lake.

Component EEE. Flows to Eastern Water Conservation Area 3B from Central Lake Belt Storage Area. Not included in this Alternative.

Component FFF. Biscayne Bay Coastal Canals. Not included in this Alternative.

Component GGG. C-51 and Southern L-8 Reservoir. Not included in this Alternative.

Component HHH. West Miami-Dade Reuse. Not included in this Alternative.

A3.2 ALTERNATIVE B

Alternative B is second of four alternatives (Alternatives A – D) which were evaluated and compared by the Alternative Evaluation Team in the selection of the technically preferred alternative. Alternative B enhances the performance of Alternative A by modifying or adding features that are considered to have the potential to solve system-wide problems identified by the Alternative Evaluation Team. Many of the components developed for Alternative A have not been modified and are included as part of Alternative B.

A3.2.1 Summary of Alternative B by Geographic Regions

The following is a summary of the components which have either changed from Alternative A or been added in Alternative B, grouped by region.

A3.2.1.3 Lake Okeechobee

(No changes in this area as compared to Alternative A.)

A3.2.1.4 Everglades Agricultural Area

(No changes in this area as compared to Alternative A.)

A3.2.1.5 Water Conservation Areas And Everglades National Park

- The timing and location of water depths in the Water Conservation Areas and Everglades National Park were further improved by modifying the rain-driven operations and relocating pumps and increasing capacities.

- Levee seepage from the eastern boundaries of Water Conservation Areas 2 and 3 was modified to send all seepage south to Northeast Shark River Slough or the Central Lake Belt In-ground Storage Area enhance hydroperiods within the Water Conservation Areas and Pennsuco Wetlands and keep it separate from runoff from the eastern basins.

- Water supply deliveries to Northeast Shark River Slough were improved and seepage losses from L-31N were reduced by relocating and increasing the capacities of the S-356 pumps and relocating the L-31N levee east of buffer area.

- Water Conservation Area 3 was decompartmentalized to re-establish historic sheetflow and the ecologic and hydrologic connections between the Water Conservation Area and Northeast Shark River Slough (removal of the L-28 and L-28 Tieback levees, the L-29, L-67A, L-67-C and L-68A levees and backfilling of the Miami Canal).

- The S-140 pump station capacity was increased and relocated to increase water depths and extend hydroperiods in central Water Conservation Area 3A.

- The Miami Canal water supply deliveries to Miami-Dade County were re-routed through the North New River Canal as a result of the decompartmentalization of Water Conservation Area 3.

- The additional S-345 structures in L-67A were eliminated and the S-343 A and B structure operations were returned to normal as a result of decompartmentalization of Water Conservation Area 3.

A3.2.1.6 Lower East Coast

- The L-8 Project was modified to include the addition of 25 MGD Aquifer Storage and Recovery (ASR) well clusters at Lake Mangonia.

- The capacity of the ASR system along the C-51 Canal was increased by 100 MGD.

- The backpumping of the C-7 basin to the Central Lake Belt Storage Area was eliminated.

- Water supply deliveries to the Model Lands and Southern Glades were improved by pumping water from C-111 to C-111E through a Stormwater Treatment Area to C-111N.

A3.2.1.7 Water Preserve Areas

- The Water Preserve Area components for the C-9 and C-11 Stormwater Treatment Area/Impoundments, the Central Lake Belt In-ground Storage Area and the Bird Drive Recharge Area were modified to further increase the regional water resources, improve wellfield and groundwater recharge, provide seepage control, flood peak attenuation and reduce discharge of fresh water to tide.

- The Water Preserve Area components for the North Lake Belt Storage Area and the Palm Beach County Agricultural Reserve Reservoir were added to increase the regional water resources.

A3.2.2 List of Components in Alternative B

The following is a list of each component included in Alternative B along with a brief summary.

Component A6. A Storage Reservoir (20,000 acres at 10 ft. maximum depth) north of Lake Okeechobee. Purpose: incorporate climate-based inflow forecasting to increase the utilization of the reservoir to provide additional flood protection, water supply and environmental enhancement. Operation revised from Alternative 5.

Component B2. A Storage Reservoir (10,000 acres at 4 ft. maximum depth) in the St. Lucie basin. Purpose: capture local runoff from C-44 for flood attenuation, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.

Component C6. Environmental Water Supply Deliveries to the St. Lucie Estuary. Purpose: provide freshwater flow to the St. Lucie Estuary to protect and restore more natural estuarine conditions. The time series of estuary target flows was revised from Alternative 5.

Component D5. A Storage Reservoir (20,000 acres at 8 ft. maximum depth) with Aquifer Storage and Recovery (44, 5-MGD wells) in the Caloosahatchee basin. Purpose: capture basin runoff and regulatory releases from Lake Okeechobee to provide water supply benefits, some flood attenuation and environmental water supply deliveries to the Caloosahatchee estuary. Operated in conjunction with DDD5.

Component E5. Environmental Water Supply Deliveries to the Caloosahatchee Estuary (operational change only). Purpose: provide freshwater deliveries to the Caloosahatchee Estuary to establish desirable salinity at locations of key estuarine biota. Operational target flow at S-79 revised in Alternative 5.

Component F3. Current Lake Okeechobee Regulation Schedule (elimination of all except Zone A [emergency] regulatory releases to the St. Lucie and Caloosahatchee Estuaries). Purpose: implement operating criteria for Lake Okeechobee that includes flood control, water supply (including releases to the Water Conservation Areas to meet estimated natural system needs) as well as Lake littoral zone and estuary protection.

Component G3. A Storage Reservoir (one 20,000 acre compartment at 6 ft. maximum depth for supplying EAA irrigation demands and one 40,000 acre compartment at 6 ft. maximum depth for supplying environmental demands) in the Everglades Agricultural Area with increased conveyance from Lake Okeechobee to the reservoir. Purpose: improve timing of environmental deliveries to the Water Conservation Areas including reducing damaging flood releases from the EAA to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands and increase flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami and North New River Canals between Lake Okeechobee and the Storage Reservoirs are increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries.

Component H4. Everglades Rain-Driven Operations. Purpose: improve the timing and location of water depths in the Water Conservation Areas and Everglades National Park. Operational change from Alternative A.

Component I. Improved Conveyance between Water conservation Area 3B and Everglades National Park. Not included in this Alternative.

Component J. Plug L-67A borrow canal (between S-151 and Modified Water Delivery Structures S-345s). Not included in this Alternative.

Component K4. Water Preserve Areas / L-8 Project. Purpose: further reduce water supply restrictions in the Northern Palm Beach County Service Area by capturing more of the annual discharges from portions of the southern L-8, C-51 and C-17 basins in local Aquifer Storage and Recovery facilities (25 MGD well clusters at Lake Mangonia) and route this water to the West Palm Beach Water Catchment Area. Intent is to increase regional water supply availability, provide pass through flow to enhance hydroperiods in Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River.

Component L3. Change Coastal Wellfields Operations in the Lower East Coast Service Area. Purpose: shift demands from eastern wellfields inland to western facilities away from the saltwater interface to reduce impact of salt water intrusion.

Component M4. Water Preserve Areas / Site 1 Impoundment (1660 acres at 6 ft. maximum depth) with Aquifer Storage and Recovery wells increased to 15, 5-MGD wells in Palm Beach County. Purpose: increase regional water resources and supplement water deliveries to the Hillsboro Canal during the dry-season.

Component N. Water Conservation Area 2B Levee Seepage Management in Broward County to manage only wet season seepage. Not included in this Alternative.

Component O4. Water Conservation Area (WCA) 3A and 3B Levee Seepage Management. Purpose: reduce seepage from WCAs 3A and 3B and to improve hydropatterns within the Conservation Areas by allowing higher water levels in the borrow canals and longer inundation durations within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes will be collected and directed south into the Central Lake Belt Storage Area. This will maintain flood protection and the separation of seepage water from urban runoff originating in the C-11 Basin and separation of Lake Okeechobee water supply deliveries.

Component P2. Water Preserve Areas / North New River Diversion Canal and Treatment Facility. Not included in this Alternative.

Component Q4. Water Preserve Areas / Western C-11 Diversion Impoundment and Canal (1600 acres of stormwater treatment area / impoundment and 2500 cfs diversion canal) in Broward County. Purpose: divert untreated runoff from western C-11 that is presently discharged into Water Conservation Area 3A through the C-11 Stormwater Treatment Area / Impoundment and then into the North Lake Belt Storage Area.

Component R4. Water Preserve Areas / C-9 Stormwater Treatment Area / Impoundment (2500 acres at 4 ft. maximum depth) in Broward County. Purpose: provide treatment of water supply deliveries from the North Lake Belt Storage Area prior to deliveries to the C-9, C-6/C-7 and C-2/C-4 Canals, groundwater recharge within the basin and seepage control of Water Conservation Area 3 and buffer areas to the west.

Component S5. Central Lake Belt Storage Area (5200 acres with subterranean seepage barrier around the perimeter) in Miami-Dade County. Purpose: receive and store excess water from Water Conservation Area (WCA) 2B, 3A and 3B without groundwater seepage losses in this highly transmissive region. The stored water will be provided based on priority to 1) Northeast Shark River Slough, 2) Water Conservation Area 3B, 3) to supply flows to Biscayne Bay and 4) when available to meet Snapper Creek demands and to maintain Dade-Broward levee borrow canal at elevation 5.0 feet NGVD.

Component T6. C-4 Structures (2) in Miami-Dade County. Purpose: maintain higher water levels in the C-4 Canal to reduce seepage losses from the Pennsuco Wetlands and areas west of the Dade-Broward Levee and reduce deliveries from Lake Okeechobee and the Water Conservation Areas by diverting dry season stormwater flows into the C-2 Canal to increase recharge to several nearby coastal wellfields.

Component U4. Water Preserve Areas / Bird Drive Recharge Area (2877 acres at 4 ft. maximum depth) in Miami-Dade County. Purpose: provide flood peak attenuation by capturing runoff from western C-4 basin and pumping it to the Bird Drive Recharge Area, reduce seepage from the Everglades National Park buffer areas by increasing water table elevations east of Krome Ave. and enhance groundwater recharge.

Component V4. L-31N Levee Improvements for Seepage Management in Miami-Dade County with additional reduction of seepage in the wet season. Purpose: manage levee seepage along the eastern edge (L-31N) of Everglades National Park to eliminate losses to the East Coast. In Alternative 4, an additional feature was added to reduce all wet-season seepage/ground water flows to the east to help restore hydropatterns in Everglades National Park. (refer to Component FF4)

Component W2. Taylor Creek / Nubbin Slough Storage and Treatment Area (5000-acre storage area at 10 ft. maximum depth and 5000-acre stormwater treatment area at 4 ft. maximum depth) in Okeechobee and St. Lucie Counties. Purpose: provide flood protection, water quality treatment, estuary protection and water supply benefits.

Component X6. Water Preserve Areas / C-17 Backpumping in North Palm Beach Service Area (550-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-17 basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in the Loxahatchee Slough. Delivery route to the stormwater treatment area revised and operational changes made from Alternative 5.

Component Y6. Water Preserve Areas / C-51 Backpumping to Water Catchment Area in Palm Beach County (600-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-51 West basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in Loxahatchee Slough. Operational changes made to the stormwater treatment area as compared to Alternative 5.

Component AA3. Additional S-345 Structures in L-67A in Water Conservation Area 3B. Not included in this Alternative.

Component BB4. Dade-Broward Levee / Pennsuco Wetlands in Miami-Dade County. Purpose: to reduce seepage to the east from the Pennsuco wetlands and southern Water Conservation Area 3B, enhance hydroperiods in the Pennsuco and enhance recharge to Miami-Dade County's NW wellfield.

Component CC6. Broward County Secondary Canal System. Purpose: increase pump capacity of existing facilities (from the 2050 Base Case) and construct additional canal improvements and pump facilities for the Broward County Secondary Canal System to provide additional recharge to wellfields located in central and southern coastal Broward County, stabilize the salt water interface and reduce discharges to tide. The groundwater table and recharge to the aquifer were improved from Alternative 5 by modifying secondary canals in the C-10 and C-12 basins.

Component DD5. Revised Holey Land Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Holey Land Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component EE5. Modified Rotenberger Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Rotenberger Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component FF4. Construction of S-356 A & B Structures and relocation of a portion of L-31N in Miami-Dade County. Purpose: improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3.

Component GG4. Lake Okeechobee Aquifer Storage and Recovery (200, 5-MGD wells) along the lake peripheral levee. Purpose: utilize climate based operational rules for the aquifer storage and recovery wells to provide additional regional storage while reducing both evapotranspiration losses and the amount of land removed from current land use (e.g. agriculture) that would normally be associated with construction and operation of above-ground storage facilities (reservoirs);

increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades; manage a portion of regulatory releases from the Lake primarily to improve Everglades hydropatterns, meet environmental targets within the Water Conservation Areas (WCAs), and meet supplemental water supply demands of the Lower East Coast; reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee estuaries; and maintain existing level of flood protection.

<u>Component HH3</u>. Operation Change of S-343 A and B. Not included in this Alternative.

<u>Component II3</u>. Pump Station G-404 Modification in Palm Beach County. Purpose: increase the capacity of proposed Everglades Construction Project pump station G-404 from 1000 cfs to 2000 cfs to improve the hydropattern restoration in the northwest corner of Water Conservation Area (WCA) 3A and increase the amount of water available in the west-central region of WCA 3A to reduce dry out periods.

<u>Component JJ</u>. Loxahatchee National Wildlife Refuge Rainfall-Driven Operations. Not included in this Alternative.

<u>Component KK4</u>. Loxahatchee National Wildlife Refuge Internal Canal Structures. Purpose: improve timing and location of water depths in the Refuge by keeping the borrow canal structures closed except to pass Stormwater Treatment Areas 1 East and 1 West outflow and water supply deliveries.

<u>Component LL4</u>. C-51 Regional Groundwater Aquifer Storage and Recovery (54 well clusters, total injection and recovery capacity is 170 MGD) in Palm Beach County. Purpose: increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods.

<u>Component MM4</u>. Hillsboro Canal Basin Regional Groundwater Aquifer Storage and Recovery (22 well clusters, total injection and recovery capacity is 110 MGD) in Broward and Palm Beach Counties. Purpose: increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods.

<u>Component NN</u>. North New River Regional Groundwater Aquifer Storage and Recovery. Not included in this Alternative.

<u>Component OO4</u>. Modification to South Dade Conveyance System in Southern Portion of L-31N and C-111. Purpose: modify C-111 Canal operations to improve deliveries to Everglades National Park and decrease potential flood risk in the lower east coast service area.

Component PP. Backpumping of the C-7 Basin to the Central Lake Belt Storage System via the C-6 Canal. Not included in this Alternative.

Component QQ4. Decompartmentalization of Water Conservation Area 3. Purpose: remove flow obstructions to achieve uncontrolled flow between Water Conservation Areas 3A and 3B and Northeast Shark River Slough and re-establish the ecologic and hydrologic connection between these areas.

Component RR4. Flow to Central Water Conservation Area 3A. Purpose: increase depths and extend hydroperiods in central Water Conservation Area 3A by relocating the S-140 pump station approximately 8 miles south and increasing the capacity to 2000 cfs.

Component SS4. Reroute Miami-Dade County Water Supply Deliveries. Purpose: reroute water supply deliveries made to Miami-Dade County from the Miami and Tamiami Canals and Water Conservation Area 3 (WCA 3) to the North New River Canal due to the backfilling of the Miami Canal as part of the decompartmentalization of WCA 3.

Component TT. Decompartmentalization of Water Conservation Area 2. Not included in this Alternative.

Component UU6. Storage Reservoirs (20,200 acres at 8 ft. maximum depth and 15,000 acres at 2 ft. maximum depth) in Martin and St. Lucie Counties. Purpose: capture local runoff from the C-23, 24, and Northfork and Southfork Basins of the St. Lucie River Estuary for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The reservoirs were increased in size and reconfigured from the design presented in Alternative 5.

Component VV4. Palm Beach County Agricultural Reserve Reservoir (1660 acres at 6 ft. maximum depth). Purpose: increase regional water resources in central and southern Palm Beach County by capturing and storing water currently discharged to tide to be used to maintain canal stages during the dry season.

Component WW4. C-111N Spreader Canal in Miami-Dade County. Purpose: reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Miami-Dade area.

Component XX4. North Lake Belt Storage Area (3500 acres with subterranean seepage barrier around the perimeter) in Miami-Dade County. Purpose: increase regional water resources by capturing a portion of runoff from western C-6, western C-11 and C-9 basins without seepage losses in this very transmissive groundwater region and without concerns of ground water contamination from untreated runoff. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals.

Component YY4. Divert Water Conservation Area 2 flows to Northeast Shark River Slough or Central Lake Belt Storage in Broward County. Purpose: capture excess water in Water Conservation Area 2B (WCA 2B) to reduce stages above targets and to divert water through improved L-37 and L-33 borrow canals to meet the following prioritized demands 1) Northeast Shark River Slough (NESRS), or 2) Central Lake Belt Area for future delivery to NESRS, 3) to Snapper Creek and 4) to maintain Dade-Broward levee borrow canal at elevation 5.0 feet NGVD.

Component ZZ. Divert Water Conservation Area 3A and 3B flows to Central Lake Belt Storage Area. Not included in this Alternative.

Component AAA. Lower East Coast Utility Water Conservation. Not included in this Alternative.

Component BBB. South Miami-Dade County Reuse (South District Reclaimed Water Treatment Plant). Not included in this Alternative.

Component CCC. Big Cypress/ L-28 Interceptor Modifications. Not included in this Alternative.

Component DDD5. Caloosahatchee Backpumping with Stormwater Treatment Area. Purpose: increase the regional water resources by capturing excess C-43 basin runoff and diverting it into Lake Okeechobee after treatment through a stormwater treatment area when storage is available in the Lake.

Component EEE. Flows to Eastern Water Conservation Area 3B from Central Lake Belt Storage Area. Not included in this Alternative.

Component FFF. Biscayne Bay Coastal Canals. Not included in this Alternative.

Component GGG. C-51 and Southern L-8 Reservoir. Not included in this Alternative.

Component HHH. West Miami-Dade Reuse. Not included in this Alternative.

A3.3 ALTERNATIVE C

Alternative C is the third of four alternatives (Alternatives A – D) that was evaluated and compared by the Alternative Evaluation Team for the technically preferred alternative. Alternative C enhances the performance of Alternative B by modifying or adding features that are considered to have the potential to solve system-wide problems which have been identified by the Alternative Evaluation Team. Many of the components developed for Alternatives A or B have not been modified and are included as part of Alternative C.

A3.3.1 Summary of Alternative C by Geographic Regions

The following is a summary of the components which have either changed from Alternative B or been added in Alternative C, grouped by region.

A3.3.1.3 Lake Okeechobee

(No changes in this area as compared to Alternative B.)

A3.3.1.4 Everglades Agricultural Area

- The Everglades Agricultural Area reservoir includes two compartments, compartment 1 – 20,000 acres and compartment 2 – 40,000 acres. Compartment 1 remains unchanged. Compartment 2 ("the surge tank") was modified to operate as a dry storage area with withdrawals being made down to 18" below ground level. It has also been subdivided into two 20,000-acre compartments to allow for more efficient use of the reservoir and for alternative uses of the compartments during dry times (eg. agriculture).

A3.3.1.5 Water Conservation Areas And Everglades National Park

- Further refinements were made to the Everglades Rain-Driven Operations to improve timing and location of water depths in the Water Conservation Areas and Everglades National Park.

- Decompartmentalization of Water Conservation Area 3 was modified from Alternative B by maintaining the L-28 and L-29 Levees while degrading L-29 south of WCA 3B. The function of the L-67 A and C levees has been replaced by a passive weir structure to facilitate high flow sheetflow from Water Conservation Area 3A to 3B.

- The S-345 structures, allowing flow through the L-67 Levee, were replaced (same as in Alternative A) in the passive weir structure as part of the decompartmentalization of Water Conservation Area 3 to relieve high water conditions in northern Water Conservation Area 3B.

- The operational changes to the S-343 A and B structures were re-implemented from Alternative A to reduce potential adverse impacts on the nesting season of the Cape Sable Seaside Sparrow as a result of the modification to the decompartmentalization of Water Conservation Area 3.

- Excess Water Conservation Area 3A & B flows were diverted to the Central Lake Belt In-ground Storage Area, and deliveries made to eastern WCA 3B from Central Lake Belt Storage Area when needed during dryouts.

A3.3.1.6 Other Natural Systems

- The West Feeder Canal and structure S-190 of the L-28 Interceptor Canal (north) were modified to allow for compliance with the Seminole Tribe's Conceptual Water Conservation System master plan,

A3.3.1.7 Lower East Coast

- The operation of the Western C-11 Canal was modified to improve groundwater elevations in the Eastern C-11 basin.

- The Dade-Broward Levee component was modified in Alternative C to use the regional system as a source of recharge.

- The C-111N Spreader Canal component was modified to extend the C-111N east of Card Sound Road.

- Utility Water Conservation was modified to reduce the public water supply demands through the full implementation of the SFWMD's current mandatory water conservation program. This results in a reduction of public water supply demands of approximately 5 percent.

- The South Biscayne Bay and Coastal Wetlands Enhancement component was introduced to maintain higher canal stages during the dry season in the C-100, C-102 and C-103 Canals with water provided from local basin runoff and from a wastewater treatment facility (South District Reclaimed Water Treatment Plant).

A3.3.1.8 Water Preserve Areas

- The Palm Beach County Agricultural Reserve Reservoir was modified to include Aquifer Storage and Recovery, increasing the regional water resources,

- The North Lake Belt Storage Area was modified to capture additional runoff from the C-6, C-11 and C-9 basins.

A3.3.2 List of Components in Alternative C

The following is a list of each component included in Alternative C along with a brief summary.

Component A6. A Storage Reservoir (20,000 acres at 10 ft. maximum depth) north of Lake Okeechobee. Purpose: incorporate climate-based inflow forecasting to increase the utilization of the reservoir to provide additional flood protection, water supply and environmental enhancement. Operation revised from Alternative 5.

Component B2. A Storage Reservoir (10,000 acres at 4 ft. maximum depth) in the St. Lucie basin. Purpose: capture local runoff from C-44 for flood attenuation, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.

Component C6. Environmental Water Supply Deliveries to the St. Lucie Estuary. Purpose: provide freshwater flow to the St. Lucie Estuary to protect and restore more natural estuarine conditions. The time series of estuary target flows was revised from Alternative 5.

Component D5. A Storage Reservoir (20,000 acres at 8 ft. maximum depth) with Aquifer Storage and Recovery (44, 5-MGD wells) in the Caloosahatchee basin. Purpose: capture basin runoff and regulatory releases from Lake Okeechobee to provide water supply benefits, some flood attenuation and environmental water supply deliveries to the Caloosahatchee estuary. Operated in conjunction with DDD5.

Component E5. Environmental Water Supply Deliveries to the Caloosahatchee Estuary (operational change only). Purpose: provide freshwater deliveries to the Caloosahatchee Estuary to establish desirable salinity at locations of key estuarine biota. Operational target flow at S-79 revised in Alternative 5.

Component F3. Current Lake Okeechobee Regulation Schedule (elimination of all except Zone A [emergency] regulatory releases to the St. Lucie and Caloosahatchee Estuaries). Purpose: implement operating criteria for Lake Okeechobee that includes flood control, water supply (including releases to the Water Conservation Areas to meet estimated natural system needs) as well as Lake littoral zone and estuary protection.

Component G5. A Storage Reservoir (one 20,000 acre compartment at 6 ft. maximum depth for supplying EAA irrigation demands and one 40,000 acre compartment at 6 ft. maximum depth for supplying environmental demands) in the

Everglades Agricultural Area with increased conveyance from Lake Okeechobee to the reservoir. Purpose: improve timing of environmental deliveries to the Water Conservation Areas including reducing damaging flood releases from the EAA to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands and increase flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami and North New River Canals between Lake Okeechobee and the Storage Reservoirs are increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries. In Alternative 5, the reservoir was modified to operate compartment 2 as a dry storage area with withdrawals being made down to 18" below ground level. It was also been subdivided into two 20,000-acre compartments to allow for more efficient use of the reservoir and for alternative uses of the compartments during dry times (ie. agriculture).

<u>Component H6</u>. Everglades Rain-Driven Operations. Purpose: improve timing and location of water depths in the Water Conservation Areas and Everglades National Park. Operational change from Alternative 5.

<u>Component I</u>. Improved Conveyance between Water conservation Area 3B and Everglades National Park. Not included in this Alternative.

<u>Component J</u>. Plug L-67A borrow canal (between S-151 and Modified Water Delivery Structures S-345s). Not included in this Alternative.

<u>Component K4</u>. Water Preserve Areas / L-8 Project. Purpose: further reduce water supply restrictions in the Northern Palm Beach County Service Area by capturing more of the annual discharges from portions of the southern L-8, C-51 and C-17 basins in local Aquifer Storage and Recovery facilities (25 MGD well clusters at Lake Mangonia) and route this water to the West Palm Beach Water Catchment Area. Intent is to increase regional water supply availability, provide pass through flow to enhance hydroperiods in Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River.

<u>Component L3</u>. Change Coastal Wellfields Operations in the Lower East Coast Service Area. Purpose: shift demands from eastern wellfields inland to western facilities away from the saltwater interface to reduce impact of salt water intrusion.

<u>Component M4</u>. Water Preserve Areas / Site 1 Impoundment (1660 acres at 6 ft. maximum depth) with Aquifer Storage and Recovery wells increased to 15, 5-MGD wells in Palm Beach County. Purpose: increase regional water resources and supplement water deliveries to the Hillsboro Canal during the dry-season.

Component N. Water Conservation Area 2B Levee Seepage Management in Broward County to manage only wet season seepage. Not included in this Alternative.

Component O4. Water Conservation Area (WCA) 3A and 3B Levee Seepage Management. Purpose: reduce seepage from WCAs 3A and 3B and to improve hydropatterns within the Conservation Areas by allowing higher water levels in the borrow canals and longer inundation durations within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes will be collected and directed south into the Central Lake Belt Storage Area. This will maintain flood protection and the separation of seepage water from urban runoff originating in the C-11 Basin and separation of Lake Okeechobee water supply deliveries.

Component P2. Water Preserve Areas / North New River Diversion Canal and Treatment Facility. Not included in this Alternative.

Component Q5. Water Preserve Areas / Western C-11 Diversion Impoundment and Canal (1600 acres of stormwater treatment area / impoundment and 2500 cfs diversion canal) in Broward County. Purpose: divert untreated runoff from western C-11 that is presently discharged into Water Conservation Area 3A through the C-11 Stormwater Treatment Area / Impoundment and then into the North Lake Belt Storage Area. Alternative 5 maintains the western C-11 Canal at elevation 3.0 feet NGVD in order to improve groundwater conditions in the eastern C-11 basin.

Component R4. Water Preserve Areas / C-9 Stormwater Treatment Area / Impoundment (2500 acres at 4 ft. maximum depth) in Broward County. Purpose: provide treatment of water supply deliveries from the North Lake Belt Storage Area prior to deliveries to the C-9, C-6/C-7 and C-2/C-4 Canals, groundwater recharge within the basin and seepage control of Water Conservation Area 3 and buffer areas to the west.

Component S5. Central Lake Belt Storage Area (5200 acres with subterranean seepage barrier around the perimeter) in Miami-Dade County. Purpose: receive and store excess water from Water Conservation Area (WCA) 2B, 3A and 3B without groundwater seepage losses in this highly transmissive region. The stored water will be provided based on priority to 1) Northeast Shark River Slough, 2) Water Conservation Area 3B, 3) to supply flows to Biscayne Bay and 4) when available to meet Snapper Creek demands and to maintain Dade-Broward levee borrow canal at elevation 5.0 feet NGVD.

Component T6. C-4 Structures (2) in Miami-Dade County. Purpose: maintain higher water levels in the C-4 Canal to reduce seepage losses from the Pennsuco

Wetlands and areas west of the Dade-Broward Levee and reduce deliveries from Lake Okeechobee and the Water Conservation Areas by diverting dry season stormwater flows into the C-2 Canal to increase recharge to several nearby coastal wellfields.

Component U4. Water Preserve Areas / Bird Drive Recharge Area (2877 acres at 4 ft. maximum depth) in Miami-Dade County. Purpose: provide flood peak attenuation by capturing runoff from western C-4 basin and pumping it to the Bird Drive Recharge Area, reduce seepage from the Everglades National Park buffer areas by increasing water table elevations east of Krome Ave. and enhance groundwater recharge.

Component V4. L-31N Levee Improvements for Seepage Management in Miami-Dade County with additional reduction of seepage in the wet season. Purpose: manage levee seepage along the eastern edge (L-31N) of Everglades National Park to eliminate losses to the East Coast. In Alternative 4, an additional feature was added to reduce all wet-season seepage/ground water flows to the east to help restore hydropatterns in Everglades National Park. (refer to Component FF4)

Component W2. Taylor Creek / Nubbin Slough Storage and Treatment Area (5000-acre storage area at 10 ft. maximum depth and 5000-acre stormwater treatment area at 4 ft. maximum depth) in Okeechobee and St. Lucie Counties. Purpose: provide flood protection, water quality treatment, estuary protection and water supply benefits.

Component X6. Water Preserve Areas / C-17 Backpumping in North Palm Beach Service Area (550-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-17 basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in the Loxahatchee Slough. Delivery route to the stormwater treatment area revised and operational changes made from Alternative 5.

Component Y6. Water Preserve Areas / C-51 Backpumping to Water Catchment Area in Palm Beach County (600-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-51 West basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in Loxahatchee Slough. Operational changes made to the stormwater treatment area as compared to Alternative 5.

Component AA3. Additional S-345 Structures in L-67A in Water Conservation Area 3B. Purpose: improve conveyance to Water Conservation Area (WCA) 3B through the L-67 levee system to help in re-establishing NSM-like hydroperiods and hydropatterns in WCA 3B and Northeast Shark River Slough.

Component BB5. Dade-Broward Levee / Pennsuco Wetlands in Miami-Dade County. Purpose: reduce seepage to the east from the Pennsuco wetlands and southern Water Conservation Area 3B, enhance hydroperiods in the Pennsuco and enhance recharge to Miami-Dade County's NW wellfield. Alternative 5 recharged the Dade-Broward Levee canal with deliveries from Lake Okeechobee and the Water Conservation Areas.

Component CC6. Broward County Secondary Canal System. Purpose: increase pump capacity of existing facilities (from the 2050 Base Case) and construct additional canal improvements and pump facilities for the Broward County Secondary Canal System to provide additional recharge to wellfields located in central and southern coastal Broward County, stabilize the salt water interface and reduce discharges to tide. The groundwater table and recharge to the aquifer were improved from Alternative 5 by modifying secondary canals in the C-10 and C-12 basins.

Component DD5. Revised Holey Land Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Holey Land Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component EE5. Modified Rotenberger Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Rotenberger Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component FF4. Construction of S-356 A & B Structures and relocation of a portion of L-31N in Miami-Dade County. Purpose: improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3.

Component GG4. Lake Okeechobee Aquifer Storage and Recovery (200, 5-MGD wells) along the lake peripheral levee. Purpose: utilize climate based operational rules for the aquifer storage and recovery wells to provide additional regional storage while reducing both evapotranspiration losses and the amount of land removed from current land use (e.g. agriculture) that would normally be associated with construction and operation of above-ground storage facilities (reservoirs); increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades; manage a portion of regulatory releases from the Lake primarily to improve

Everglades hydropatterns, meet environmental targets within the Water Conservation Areas (WCAs), and meet supplemental water supply demands of the Lower East Coast; reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee estuaries; and maintain existing level of flood protection.

Component HH3. Operation Change of S-343 A and B (closed during the January to June time period) in Miami-Dade County. Purpose: reduce the potential adverse effects on the nesting season of the Cape Sable Seaside Sparrow due to high water levels, the S-343 A and B structures will be closed during the January to June time period.

Component II3. Pump Station G-404 Modification in Palm Beach County. Purpose: increase the capacity of proposed Everglades Construction Project pump station G-404 from 1000 cfs to 2000 cfs to improve the hydropattern restoration in the northwest corner of Water Conservation Area (WCA) 3A and increase the amount of water available in the west-central region of WCA 3A to reduce dry out periods.

Component JJ. Loxahatchee National Wildlife Refuge Rainfall-Driven Operations. Not included in this Alternative.

Component KK4. Loxahatchee National Wildlife Refuge Internal Canal Structures. Purpose: improve timing and location of water depths in the Refuge by keeping the borrow canal structures closed except to pass Stormwater Treatment Areas 1 East and 1 West outflow and water supply deliveries.

Component LL4. C-51 Regional Groundwater Aquifer Storage and Recovery (54 well clusters, total injection and recovery capacity is 170 MGD) in Palm Beach County. Purpose: increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods.

Component MM4. Hillsboro Canal Basin Regional Groundwater Aquifer Storage and Recovery (22 well clusters, total injection and recovery capacity is 110 MGD) in Broward and Palm Beach Counties. Purpose: increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods.

Component NN. North New River Regional Groundwater Aquifer Storage and Recovery. Not included in this Alternative.

Component OO4. Modification to South Dade Conveyance System in Southern Portion of L-31N and C-111. Purpose: modify C-111 Canal operations to improve deliveries to Everglades National Park and decrease potential flood risk in the lower east coast service area.

Component PP. Backpumping of the C-7 Basin to the Central Lake Belt Storage System via the C-6 Canal. Not included in this Alternative.

Component QQ5. Decompartmentalization of Water Conservation Area 3. Purpose: remove most flow obstructions to achieve unconstrained or passive flow between Water Conservation Areas 3A and 3B and Northeast Shark River Slough and re-establish the ecologic and hydrologic connection between these areas.

Component RR4. Flow to Central Water Conservation Area 3A. Purpose: increase depths and extend hydroperiods in central Water Conservation Area 3A by relocating the S-140 pump station approximately 8 miles south and increasing the capacity to 2000 cfs.

Component SS4. Reroute Miami-Dade County Water Supply Deliveries. Purpose: reroute water supply deliveries made to Miami-Dade County from the Miami and Tamiami Canals and Water Conservation Area 3 (WCA 3) to the North New River Canal due to the backfilling of the Miami Canal as part of the decompartmentalization of WCA 3.

Component TT. Decompartmentalization of Water Conservation Area 2. Not included in this Alternative.

Component UU6. Storage Reservoirs (20,200 acres at 8 ft. maximum depth and 15,000 acres at 2 ft. maximum depth) in Martin and St. Lucie Counties. Purpose: capture local runoff from the C-23, 24, and Northfork and Southfork Basins of the St. Lucie River Estuary for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The reservoirs were increased in size and reconfigured from the design presented in Alternative 5.

Component VV5. Palm Beach County Agricultural Reserve Reservoir (1660 acres at 6 ft. maximum depth) with Aquifer Storage and Recovery wells, 15, 5-MGD wells. Purpose: increase regional water resources in central and southern Palm Beach County by capturing and storing water currently discharged to tide to be used to maintain canal stages during the dry season.

Component WW5. C-111N Spreader Canal in Miami-Dade County. Purpose: reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Miami-Dade area. C-111N was extended east of Card Sound Road.

Component XX5. C-111N Spreader Canal in Miami-Dade County. Purpose: reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Miami-Dade area. C-111N was extended east of Card Sound Road.

Component YY4. Divert Water Conservation Area 2 flows to Northeast Shark River Slough or Central Lake Belt Storage in Broward County. Purpose: capture excess water in Water Conservation Area 2B (WCA 2B) to reduce stages above targets and to divert water through improved L-37 and L-33 borrow canals to meet the following prioritized demands 1) Northeast Shark River Slough (NESRS), or 2) Central Lake Belt Area for future delivery to NESRS, 3) to Snapper Creek and 4) to maintain Dade-Broward levee borrow canal at elevation 5.0 feet NGVD.

Component ZZ5. Divert Water Conservation Area 3A and 3B flows to Central Lake Belt Storage Area. Purpose: capture excess water above target stages in Water Conservation Area 3A and 3B and divert it through modified structures at S-9 and S-31 to the Central Lake Belt Storage Area via the L-33 borrow canal.

Component AAA6. Lower East Coast Utility Water Conservation. Purpose: reduce the public water supply demands through the full implementation of the SFWMD's current mandatory water conservation program.

Component BBB6. South Miami-Dade County Reuse (South District Reclaimed Water Treatment Plant). Purpose: augment water supply to the South Biscayne Bay and Coastal Wetlands Enhancement Project to restore overland flow in the coastal area, recharge groundwater to enhance groundwater discharge to Biscayne Bay and provide saltwater intrusion benefits to the southern part of Miami-Dade County through the use of superiorly treated reclaimed water from the South District Wastewater Treatment Plant. Modified from Alternative 5 to send flows northward in L-31E and L-31E extension towards C-100.

Component CCC6. Big Cypress/ L-28 Interceptor Modifications. Purpose: alleviate over-drainage in Northeast Big Cypress, Kissimmee Billy and Mullet Slough area, ensure applicable water quality treatment and restore sheetflow to wetland areas in northeast Big Cypress Addition. Modified from Alternative 5 to allow for compliance with the Seminole Tribe's Conceptual Water Conservation System master plan.

Component DDD5. Caloosahatchee Backpumping with Stormwater Treatment Area. Purpose: increase the regional water resources by capturing excess C-43 basin runoff and diverting it into Lake Okeechobee after treatment through a stormwater treatment area when storage is available in the Lake.

Component EEE5. Flows to Eastern Water Conservation Area 3B from Central Lake Belt Storage Area. Purpose: capture excess surface water and seepage from

Water Conservation Areas (WCA) 2B, 3A and 3B, store them in the Central Lake Belt Storage Area and deliver them to eastern WCA 3B during dryouts.

Component FFF5. Biscayne Bay Coastal Canals. Purpose: maintain higher stages in the C-102 and C-103 Canals for urban and environmental water supply. A proposed borrow canal will interconnect the downstream reaches of the C-102 and C-103 Canals.

Component GGG. C-51 and Southern L-8 Reservoir. Not included in this Alternative.

Component HHH. West Miami-Dade Reuse. Not included in this Alternative.

A3.4 ALTERNATIVE D

Alternative D is the fourth of four alternatives (Alternatives A – D) that were evaluated and compared by the Alternative Evaluation Team for the technically preferred alternative. Alternative D enhances the performance of Alternative C by modifying or adding features that are considered to have the potential to solve system-wide problems identified by the Alternative Evaluation Team. Many of the components developed for Alternatives A, B or C have not been modified and are included as part of Alternative D.

A3.4.1 Summary of Alternative A by Geographic Regions

The following is a summary of the components which have either changed from Alternative C or been added in Alternative D, grouped by region.

A3.4.1.3 Lake Okeechobee

(No changes in this area as compared to Alternative C.)

A3.4.1.4 Everglades Agricultural Area

(No changes in this area as compared to Alternative C.)

A3.4.1.5 Water Conservation Areas And Everglades National Park

- Decompartmentalization of Water Conservation Area 3 was increased over Alternative C with the removal of the L-28 Tieback Levee.

A3.4.1.6 Other Natural Systems

(No changes in this area as compared to Alternative C.)

A3.4.1.7 Lower East Coast

- The C-51 Regional Groundwater Aquifer Storage and Recovery capacity was reduced from Alternative C and the Hillsboro Canal Basin Regional Aquifer Storage and Recovery capacity was relocated to the Site 1 Impoundment.

- The L-8 Project was modified to include a storage reservoir and increase the ASR capacity to improve hydropatterns in the Loxahatchee Slough, increase base flows to the Northwest Fork of the Loxahatchee River, provide flood peak attenuation to the C-51 and southern L-8 basins and increase regional water supplies.

A3.4.1.8 Water Preserve Areas

- The Site 1 Impoundment was increased in size and additional ASR capacity was added to store additional fresh water which would have been lost to tide; thereby increasing regional water resources.

- The Bird Drive Recharge Area was modified to include the introduction of the West Dade Reuse water and the outflows were re-prioritized.

- The North Lake Belt Storage Area outflows were re-prioritized.

- The Central Lake Belt Storage Area and the Palm Beach County Agricultural Reserve Reservoir were modified to store additional excess water which would have been lost to tide thereby increasing the regional water resources.

- Storage in the southern L-8 basin was increased by 1,200 acres to provide estuarine benefits to the Lake Worth Lagoon, water supply benefits and to attenuate peak flood flows.

A3.4.2 List of Components in Alternative D

The following is a list of each component included in Alternative D along with a brief summary.

Component A6. A Storage Reservoir (20,000 acres at 10 ft. maximum depth) north of Lake Okeechobee. Purpose: incorporate climate-based inflow forecasting to increase the utilization of the reservoir to provide additional flood protection, water supply and environmental enhancement. Operation revised from Alternative 5.

Component B2. A Storage Reservoir (10,000 acres at 4 ft. maximum depth) in the St. Lucie basin. Purpose: capture local runoff from C-44 for flood attenuation, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.

Component C6. Environmental Water Supply Deliveries to the St. Lucie Estuary. Purpose: provide freshwater flow to the St. Lucie Estuary to protect and restore more natural estuarine conditions. The time series of estuary target flows was revised from Alternative 5.

Component D5. A Storage Reservoir (20,000 acres at 8 ft. maximum depth) with Aquifer Storage and Recovery (44, 5-MGD wells) in the Caloosahatchee basin. Purpose: capture basin runoff and regulatory releases from Lake Okeechobee to provide water supply benefits, some flood attenuation and environmental water supply deliveries to the Caloosahatchee estuary. Operated in conjunction with DDD5.

Component E5. Environmental Water Supply Deliveries to the Caloosahatchee Estuary (operational change only). Purpose: provide freshwater deliveries to the Caloosahatchee Estuary to establish desirable salinity at locations of key estuarine biota. Operational target flow at S-79 revised in Alternative 5.

Component F3. Current Lake Okeechobee Regulation Schedule (elimination of all except Zone A [emergency] regulatory releases to the St. Lucie and Caloosahatchee Estuaries). Purpose: implement operating criteria for Lake Okeechobee that includes flood control, water supply (including releases to the Water Conservation Areas to meet estimated natural system needs) as well as Lake littoral zone and estuary protection.

Component G5. A Storage Reservoir (one 20,000 acre compartment at 6 ft. maximum depth for supplying EAA irrigation demands and two 20,000 acre compartments at 6 ft. maximum depth for supplying environmental demands) in the Everglades Agricultural Area with increased conveyance from Lake Okeechobee to the reservoir. Purpose: improve timing of environmental deliveries to the Water Conservation Areas including reducing damaging flood releases from the EAA to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands and increase flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami and North New River Canals between Lake Okeechobee and the Storage Reservoirs are increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries. In Alternative 5, the two compartments were modified to operate as a dry storage areas with withdrawals being made down to 18” below ground level. It was also been subdivided into two 20,000-acre compartments to allow for more efficient use of the reservoir and for alternative uses of the compartments during dry times (ie. agriculture).

Component H6. Everglades Rain-Driven Operations. Purpose: improve timing and location of water depths in the Water Conservation Areas and Everglades National Park. Operational change from Alternative 5.

Component I. Improved Conveyance between Water Conservation Area 3B and Everglades National Park. Not included in this Alternative since L-29 is removed.

Component J. Plug L-67A borrow canal (between S-151 and Modified Water Delivery Structures S-345s). Not included in this Alternative.

Component K6. Water Preserve Areas / L-8 Project. Purpose: further reduce water supply restrictions in the Northern Palm Beach County Service Area by capturing more of the discharges from portions of the southern L-8, C-51 and C-17 basins in a western reservoir located north of the C-51 Canal, west of the L-8 borrow canal, and in increased local Aquifer Storage and Recovery facilities (50 MGD capacity). This water will be routed to the West Palm Beach Water Catchment Area. Intent is to increase regional water supply availability, provide pass through flow to enhance hydroperiods in Loxahatchee Slough, increase base flows to the Northwest Fork of the Loxahatchee River and provide some peak flood flow attenuation. Operated in conjunction with GGG6.

Component L3. Change Coastal Wellfields Operations in the Lower East Coast Service Area. Purpose: shift demands from eastern wellfields inland to western facilities away from the saltwater interface to reduce impact of salt water intrusion.

Component M6. Water Preserve Areas / Site 1 Impoundment (increased to 2460 acres at 6 ft. maximum depth) with Aquifer Storage and Recovery wells (increased to 30, 5-MGD wells) in Palm Beach County. Purpose: increase regional water resources and supplement water deliveries to the Hillsboro Canal during the dry-season.

Component N. Water Conservation Area 2B Levee Seepage Management. Not included in this Alternative.

Component O4. Water Conservation Area (WCA) 3A and 3B Levee Seepage Management. Purpose: reduce seepage from WCAs 3A and 3B and to improve hydropatterns within the Conservation Areas by allowing higher water levels in the borrow canals and longer inundation durations within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes will be collected and directed south into the Central Lake Belt Storage Area. This will maintain flood protection and the separation of seepage water from urban runoff originating in the C-11 Basin and separation of Lake Okeechobee water supply deliveries.

Component P. North New River Diversion Canal and Treatment Facility. Not included in this Alternative.

Component Q5. Water Preserve Areas / Western C-11 Diversion Impoundment and Canal (1600 acres of stormwater treatment area / impoundment and 2500 cfs diversion canal) in Broward County. Purpose: divert untreated runoff from western C-11 that is presently discharged into Water Conservation Area 3A through the C-11 Stormwater Treatment Area / Impoundment and then into the North Lake Belt Storage Area. Alternative 5 maintains the western C-11 Canal at elevation 3.0 ft. NGVD in order to improve groundwater conditions in the eastern C-11 basin.

Component R4. Water Preserve Areas / C-9 Stormwater Treatment Area / Impoundment (2500 acres at 4 ft. maximum depth) in Broward County. Purpose: provide treatment of water supply deliveries from the North Lake Belt Storage Area prior to deliveries to the C-9, C-6/C-7 and C-2/C-4 Canals, groundwater recharge within the basin and seepage control of Water Conservation Area 3 and buffer areas to the west.

Component S6. Central Lake Belt Storage Area (5200 acres with subterranean seepage barrier around the perimeter) in Miami-Dade County. Purpose: receive and store excess water from Water Conservation Area (WCA) 2B, 3A and 3B without groundwater seepage losses in this highly transmissive region. The stored water will be provided based on priority to 1) Northeast Shark River Slough, 2) Water Conservation Area 3B and 3) to supply flows to Biscayne Bay when available. Changes from Alternative 5 include increasing the above ground storage height to 16 ft. and reprioritizing outflows.

Component T6. C-4 Structures (2) in Miami-Dade County. Purpose: maintain higher water levels in the C-4 Canal to reduce seepage losses from the Pennsuco Wetlands and areas west of the Dade-Broward Levee and reduce deliveries from Lake Okeechobee and the Water Conservation Areas by diverting dry season stormwater flows into the C-2 Canal to increase recharge to several nearby coastal wellfields.

Component U6. Water Preserve Areas / Bird Drive Recharge Area (2877 acres at 4 ft. maximum depth) in Miami-Dade County. Purpose: provide flood peak attenuation by capturing runoff from western C-4 basin and pumping it to the Bird Drive Recharge Area, enhance groundwater recharge and reduce seepage from the Everglades National Park buffer areas by increasing water table elevations east of Krome Ave. with the introduction of inflows from the West Miami-Dade Wastewater

Treatment Plant (new from Alternative 5). The facility will also provide water supply deliveries to the South Dade Conveyance System and potentially to Northeast Shark River Slough.

Component V4. L-31N Levee Improvements for Seepage Management in Miami-Dade County with additional reduction of seepage in the wet season. Purpose: manage levee seepage along the eastern edge (L-31N) of Everglades National Park to eliminate losses to the East Coast. In Alternative 4, an additional feature was added to reduce all wet-season seepage/ground water flows to the east to help restore hydropatterns in Everglades National Park. (refer to Component FF4)

Component W2. Taylor Creek / Nubbin Slough Storage and Treatment Area (5000-acre storage area at 10 ft. maximum depth and 5000 acre stormwater treatment area at 4 ft. maximum depth) in Okeechobee and St. Lucie Counties. Purpose: provide flood protection, water quality treatment, estuary protection and water supply benefits.

Component X6. Water Preserve Areas / C-17 Backpumping in North Palm Beach Service Area (550-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-17 basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in the Loxahatchee Slough. Delivery route to the stormwater treatment area revised and operational changes made from Alternative 5.

Component Y6. Water Preserve Areas / C-51 Backpumping to Water Catchment Area in Palm Beach County (600-acre stormwater treatment area at 4 ft. maximum depth). Purpose: increase regional water resources to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-51 West basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area and enhance hydroperiods in Loxahatchee Slough. Operational changes made to the stormwater treatment area as compared to Alternative 5.

Component AA3. Additional S-345 Structures in L-67A in Water Conservation Area 3B. Purpose: improve conveyance to Water Conservation Area (WCA) 3B through the L-67 levee system to help in re-establishing NSM-like hydroperiods and hydropatterns in WCA 3B and Northeast Shark River Slough.

Component BB5. Dade-Broward Levee / Pennsuco Wetlands in Miami-Dade County. Purpose: reduce seepage to the east from the Pennsuco wetlands and southern Water Conservation Area 3B, enhance hydroperiods in the Pennsuco and enhance recharge to Miami-Dade County's NW wellfield. Alternative 5 recharged the Dade-Broward Levee canal with deliveries from Lake Okeechobee and the Water Conservation Areas.

Component CC6. Broward County Secondary Canal System. Purpose: increase pump capacity of existing facilities (from the 2050 Base Case) and construct additional canal improvements and pump facilities for the Broward County Secondary Canal System to provide additional recharge to wellfields located in central and southern coastal Broward County, stabilize the salt water interface and reduce discharges to tide. The groundwater table and recharge to the aquifer were improved from Alternative 5 by modifying secondary canals in the C-10 and C-12 basins.

Component DD5. Revised Holey Land Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Holey Land Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component EE5. Modified Rotenberger Operation Plan (based on rain-driven operations) in Palm Beach County. Purpose: improve timing and location of water depths within the Rotenberger Wildlife Management Area based on rain-driven operations. Operational change only for Alternative 5.

Component FF4. Construction of S-356 A & B Structures and relocation of a portion of L-31N in Miami-Dade County. Purpose: improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3.

Component GG4. Lake Okeechobee Aquifer Storage and Recovery (200,5-MGD wells) along the lake peripheral levee. Purpose: utilize climate-based operational rules for the aquifer storage and recovery wells to provide additional regional storage while reducing both evapotranspiration losses and the amount of land removed from current land use (e.g. agriculture) that would normally be associated with construction and operation of above-ground storage facilities (reservoirs); increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades; manage a portion of regulatory releases from the Lake primarily to improve Everglades hydropatterns, meet environmental targets within the Water Conservation Areas (WCAs), and meet supplemental water supply demands of the Lower East Coast; reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee estuaries; and maintain existing level of flood protection.

Component HH3. Operation Change of S-343 A and B (closed during the January to June time period) in Miami-Dade County. Purpose: reduce the potential adverse effects on the nesting season of the Cape Sable Seaside Sparrow due to high water levels, the S-343 A and B structures will be closed during the January to June time period.

Component II3. Pump Station G-404 Modification in Palm Beach County. Purpose: increase the capacity of proposed Everglades Construction Project pump station G-404 from 1000 cfs to 2000 cfs to improve the hydropattern restoration in the northwest corner of Water Conservation Area (WCA) 3A and increase the amount of water available in the west-central region of WCA 3A to reduce dry out periods.

Component JJ. Loxahatchee National Wildlife Refuge Rainfall-driven Operations. Not included in this Alternative.

Component KK4. Loxahatchee National Wildlife Refuge Internal Canal Structures. Purpose: improve timing and location of water depths in the Refuge by keeping the borrow canal structures closed except to pass Stormwater Treatment Areas 1 East and 1 West outflow and water supply deliveries.

Component LL6. C-51 Regional Groundwater Aquifer Storage and Recovery (34 well clusters, total injection and recovery capacity is 170 MGD) in Palm Beach County. Purpose: increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods. ASR capacity reduced from 54 well clusters in Alternative 5 to 34 well clusters.

Component MM. Hillsboro Canal Basin Regional Groundwater Aquifer Storage and Recovery. Not included in this Alternative.

Component NN. North New River Regional Groundwater Aquifer Storage and Recovery. Not included in this Alternative.

Component OO4. Modification to South Dade Conveyance System in Southern Portion of L-31N and C-111. Purpose: modify C-111 Canal operations to improve deliveries to Everglades National Park and decrease potential flood risk in the lower east coast service area.

Component PP. Backpumping of the C-7 Basin to the Central Lake Belt Storage System via the C-6 Canal. Not included in this Alternative.

Component QQ6. Decompartmentalization of Water Conservation Area 3. Purpose: remove most flow obstructions to achieve unconstrained or passive flow between Water Conservation Areas 3A and 3B and Northeast Shark River Slough and reestablish the ecologic and hydrologic connection between these areas. Alternative D adds the removal of the L-28 Tieback Levee.

Component RR4. Flow to Central Water Conservation Area 3A. Purpose: increase depths and extend hydroperiods in central Water Conservation Area 3A by relocating the S-140 pump discharge approximately 8 miles south and increasing the capacity to 2000 cfs.

Component SS4. Reroute Miami-Dade County Water Supply Deliveries. Purpose: reroute water supply deliveries made to Miami-Dade County from the Miami and Tamiami Canals and Water Conservation Area 3 (WCA 3) to the North New River Canal due to the backfilling of the Miami Canal as part of the decompartmentalization of WCA 3.

Component TT. Decompartmentalization of Water Conservation Area 2. Not included in this Alternative.

Component UU6. Storage Reservoirs (20,200 acres at 8 ft. maximum depth and 15,000 acres at 2 ft. maximum depth) in Martin and St. Lucie Counties. Purpose: capture local runoff from the C-23, 24, and Northfork and Southfork Basins of the St. Lucie River Estuary for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The reservoirs were increased in size and reconfigured from the design presented in Alternative 5.

Component VV6. Palm Beach County Agricultural Reserve Reservoir (1660 acres at 12 ft. maximum depth) with Aquifer Storage and Recovery wells, 15, 5-MGD wells. Purpose: increase regional water resources in central and southern Palm Beach County by capturing and storing water currently discharged to tide to be used to maintain canal stages during the dry season. The reservoir depth was increased to 12 ft. in Alternative D.

Component WW5. C-111N Spreader Canal in Miami-Dade County. Purpose: reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Miami-Dade area. C-111N was extended east of Card Sound Road.

Component XX6. North Lake Belt Storage Area (4500 acres with subterranean seepage barrier around the perimeter) in Miami-Dade County. Purpose: increase regional water resources by capturing a greater portion of runoff from western C-6, western C-11 and C-9 basins in the in-ground storage area without groundwater seepage losses in this highly transmissive region and without concerns of ground water contamination from untreated runoff. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals. Alternative D revises the priority of water deliveries to include Biscayne Bay.

Component YY4. Divert Water Conservation Area 2 flows to Northeast Shark River Slough or Central Lake Belt Storage in Broward County. Purpose: capture excess water in Water Conservation Area 2B (WCA 2B) to reduce stages above desired target levels and to divert water through improved L-37 and L-33 borrow canals to the following prioritized locations1) North East Shark River Slough to meet targets, or 2) Central Lake Belt Storage Area.

Component ZZ5. Divert Water Conservation Area 3A and 3B flows to Central Lake Belt Storage Area. Purpose: capture excess water above target stages in Water Conservation Area 3A and 3B and divert it through a new gravity structure at S-9 and a modified structure at S-31 to the Central Lake Belt Storage Area via the L-33 borrow canal.

Component AAA6. Lower East Coast Utility Water Conservation. Purpose: reduce the public water supply demands through the full implementation of the SFWMD's current mandatory water conservation program.

Component BBB6. South Miami-Dade County Reuse (South District Reclaimed Water Treatment Plant). Purpose: augment water supply to the South Biscayne Bay and Coastal Wetlands Enhancement Project to restore overland flow in the coastal area, recharge groundwater to enhance groundwater discharge to Biscayne Bay and provide saltwater intrusion benefits to the southern part of Miami-Dade County through the use of superiorly treated reclaimed water from the South District Wastewater Treatment Plant. Alternative D sends flows northward in L-31E and L-31E extension towards C-100.

Component CCC6. Big Cypress/ L-28 Interceptor Modifications. Purpose: alleviate over-drainage in Northeast Big Cypress, Kissimmee Billy and Mullet Slough area, ensure applicable water quality treatment and restore sheetflow to wetland areas in northeast Big Cypress Addition. Alternative D allows for compliance with the Seminole Tribe's Conceptual Water Conservation System master plan.

Component DDD5. Caloosahatchee Backpumping with Stormwater Treatment Area. Purpose: increase the regional water resources by capturing excess C-43 basin runoff and diverting it into Lake Okeechobee after treatment through a stormwater treatment area when storage capacity is available in the Lake.

Component EEE5. Flows to Eastern Water Conservation Area 3B from Central Lake Belt Storage Area. Purpose: capture excess surface water and seepage from Water Conservation Areas (WCA) 2B, 3A and 3B, store them in the Central Lake Belt Storage Area and deliver them to eastern WCA 3B, as needed, during dryouts.

Component FFF5. Biscayne Bay Coastal Canals. Purpose: better maintain dry season stages in the C-102 and C-103 Canals for urban and environmental water supply. A proposed borrow canal will interconnect the downstream reaches of the C-102 and C-103 Canals.

Component GGG6. C-51 and Southern L-8 Reservoir (1200 acres with 40 ft. of working storage depth) in Palm Beach County. Purpose: reduce the number, magnitude and volume of discharges to the Lake Worth Lagoon, provide water supply deliveries to the Northwest Fork of the Loxahatchee River, Lake Worth Drainage District and the West Palm Beach Water Catchment Area, and provide flood peak attenuation to the C-51 and southern L-8 basins.

Component HHH6. West Miami-Dade Reuse. Purpose: enhance groundwater recharge to the Bird Drive Recharge Area, and to provide water supplies to the South Dade Conveyance System and potentially to Northeast Shark River Slough.

APPENDIX A4

DESCRIPTION OF ALTERNATIVE D-13R

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APPENDIX A4
DESCRIPTION OF ALTERNATIVE D-13R

Alternative D13-R is the plan selected by the Restudy Team as the Initial Draft Plan. This plan is comprised of forty-nine operational and structural features that the are referred to as components. Together, these forty-nine components make the Initial Draft Plan; it is a Comprehensive Plan that addresses many of the water resources problems of south Florida. This Section of the Plan Formulation Appendix includes a description of each of the components that make up the Initial Draft Plan. At the end of this Section is a series of figures and maps to aid the reader in understanding the conceptual features of the Initial Draft Plan. However, not all components have been mapped due to uncertainty in site location.

Component A6 - D13R - North of Lake Okeechobee Storage Reservoir

Study Region: Kissimmee River

Map: This component is not mapped due to uncertainty in site location

Purpose: To increase the capacity of the hydrologic system to better meet the water management objectives associated with flood protection, water supply and environmental enhancement. The additional water storage capacity in the reservoir and stormwater treatment area allows for greater detention of water during wet periods for subsequent use during dry periods. It is also anticipated that this increased storage capacity will shorten the duration and frequency of both high water levels in Lake Okeechobee that are stressful to the Lake littoral ecosystems, and large discharges from the Lake that are disruptive to the downstream estuary ecosystems.

Operation: Water from Lake Okeechobee is to be pumped into the north storage reservoir when the climate-based inflow forecast projects that the Lake water level will rise significantly above those levels that are desirable for the Lake littoral zone (14.35 feet - 14.75 feet NGVD; Figure 1). During the dry season, flows will be allowed back to the Lake from the reservoir through the stormwater treatment area when the Lake level is projected to fall to within three-quarters of a foot of the supply-side management line in the same dry season, or below 11.75 feet NGVD in the upcoming wet season. During the wet season, flow is allowed from the reservoir through the stormwater treatment area to the Lake when climate-based inflow forecast projects less than 1.5 million acre-feet of inflow during the next 6 months and the Lake water level is either currently below 11.75 feet NGVD or projected to be in supply-side management during the upcoming dry season. The reservoir is also filled with runoff from the Kissimmee River or the S-65E drainage basin when water is available.

Design:
Reservoir:
17,500 acres at 11.5 feet maximum depth
Inflow pump capacity = 4800 cfs
Outflow structure = 4800 cfs
Stormwater Treatment Area:
2,500 acres at 4.0 feet maximum depth
gravity flow outlet

Location: To be determined – Specific site not necessary for Water Management Model simulation. Counties could include Glades, Highlands, or Okeechobee.

Assumption and Related Considerations: Uncertainty in land availability.

Component B2 - Component Title: St. Lucie/C-44 Basin Storage Reservoir

Study Region: Upper East Coast

Map: This component is not mapped due to uncertainty in site location

Purpose: Storage reservoir to capture local runoff from C-44 Basin. The reservoir will be designed for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.

Operation:
Inflows from C-44 basin runoff (and only when Lake stage is > 14.5 feet NGVD)

Design:
10,000 acres at 4 feet maximum depth
Inflow pump capacity = 1,000 cfs
Outflow structure capacity = 800 cfs

Location: To be determined – Specific site not necessary for Water Management Model simulation. Counties include Martin.

Assumption and Related Considerations:
1) Uncertainty in land availability.
2) Potential water quality benefits by reducing nutrient loading to the estuary

Component C6 - Environmental Water Supply Deliveries to St. Lucie Estuary

Study Region: St. Lucie/C-44 Basin

Map: This component is not mapped.

Purpose: To provide freshwater deliveries to the St. Lucie Estuary to protect and restore more natural estuarine conditions. The time series of estuary target flows were developed to respond to desirable estuarine conditions.

Operation: Deliver desired estuary target discharge through S-80 from the reservoir when water is available or from Lake Okeechobee when the Lake stage exceeds 11.5 feet NGVD.

Design: Operational change only

Location: C-44 and St. Lucie Estuary. Counties include: Martin and St. Lucie.

Assumption and Related Considerations: Estuary deliveries are based on maintaining salinity conditions in the estuary to support a range of aquatic vegetation seagrass, invertebrates, and fish communities.

Component D5 - Caloosahatchee Basin Storage Reservoir(s) with Aquifer Storage and Recovery

Study Region: Caloosahatchee River

Map: This component is not mapped due to uncertainty in site location

Purpose: Storage reservoir(s) with Aquifer Storage and Recovery (ASR) to capture basin runoff and releases from Lake Okeechobee. These facilities will be designed for water supply benefits, some flood attenuation, and to provide environmental water supply deliveries to the Caloosahatchee estuary.

Operation: Excess runoff from the C-43 Basin and Lake Okeechobee flood control discharges will be captured by the proposed C-43 reservoir(s). Water from the reservoir(s) will be used to provide environmental deliveries to the Caloosahatchee Estuary, to meet demands in the Caloosahatchee Basin and to inject water into the ASR wellfield for long-term (multi-season) storage. The source of water to be injected into the ASR facility is surficial ground water adjacent to the reservoir. Water from the ASR facilities will be used to meet environmental demand of the estuary and meet basin demands. Any estuarine demands not met by basin runoff, the reservoir and the ASR system will be met by Lake Okeechobee, as long as Lake

Stage is above 11.5 feet NGVD. Lake water is also used to meet the remaining basin demands subject to supply-side management.

The C-43 reservoir is operated in conjunction with Component DDD5, the Caloosahatchee Backpumping Facility, which includes an STA for water quality treatment. If the levels of water in the reservoir exceed 6.5 feet and Lake Okeechobee is below the pulse release zone (see Figure 1), then water is released and sent to the backpumping/treatment facility at 2000 cfs.

Design:
Reservoir(s) total of 20,000 acres at 8 feet maximum depth.
ASR wellfields total of 44, 5-MGD wells
Reservoir(s) Inflow pump capacity = 3,800 cfs
ASR inflow capacity = limited to 220 MGD
Reservoir(s) outflow structure capacity = 3,000 cfs
ASR outflow capacity = limited to 220 MGD

Location: To be determined -- Specific site not necessary for Water Management Model simulations. Counties include Hendry, Glades, or Lee.

Assumption and Related Considerations:
1) Uncertainty in land availability.
2) Potential water quality benefits by reducing nutrient loadings.
3) Raw water ASR injection permittable.
4) 70 percent recovery for injected ASR water.
5) Size of injection bubble not limited.
6) ASR facility sized to slightly exceed minimum flows to estuary.

Component E5 - Environmental Water Supply Deliveries to Caloosahatchee Estuary

Study Region: Caloosahatchee/C-43 Basin

Map: This component is not mapped.

Purpose: To provide freshwater deliveries to the Caloosahatchee Estuary to establish desirable salinity regimes at locations of key estuarine biota.

Operation: Deliver desired estuary target flow through S-79 in priority order, from basin runoff, from the C-43 storage reservoir, from the C-43 Basin ASR system and from Lake Okeechobee when the Lake stage exceeds 15 feet NGVD.

Design: Operational changes to assure that desirable salinity patterns will be achieved and at the same time makes some water available for capture and utilization in the regional system. The capture of the excess runoff is accomplished in by the Caloosahatchee Basin Reservoir and ASR system (Component D) and by Caloosahatchee Backpumping with Stormwater Treatment Area (Component DDD).

Location: C-43 and Caloosahatchee Estuary.

Assumption and Related Considerations: Estuary deliveries are made to maintain salinity conditions in the estuary that support a range of aquatic vegetation, seagrass, invertebrates and fish communities.

Component F3 - Lake Okeechobee Regulation Schedule

Study Region: Lake Okeechobee

Map: Refer to Figure 1

Purpose: Operating criteria for Lake Okeechobee that includes flood control, water supply (including releases to the Water Conservation Areas to meet estimated natural system needs), and Lake littoral zone and estuary protection.

Operation: Use current regulation schedule with the design modifications made in components A and GG and with the exception of eliminating all St. Lucie and Caloosahatchee regulatory discharges (except emergency releases - zone A, from Run 25).

Design: Operational changes only. Modify the regulation schedule by eliminating all but emergency discharges to both the St. Lucie and Caloosahatchee Estuaries.

Location: Within existing boundary of Lake Okeechobee
Counties: Glades, Hendry, Martin, Okeechobee and Palm Beach

Assumption and Related Considerations: It is assumed that the implementation of other project components will reduce the frequency of high Lake stage events therefore reducing the need for regulatory releases to the St. Lucie and Caloosahatchee Estuaries.

Component G6 - Everglades Agricultural Area Storage Reservoir

Study Region: Everglades Agricultural Area (EAA)

Map: This component is not mapped due to uncertainty in site location

Purpose: Storage reservoir improves timing of environmental deliveries to the Water Conservation Areas (WCA) including reducing damaging flood releases from the EAA to the Water Conservation Areas; reduces Lake Okeechobee regulatory releases to estuaries; meets supplemental agricultural irrigation demands; and increases flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami and North New River Canals between Lake Okeechobee and the storage reservoir(s) is increased to convey additional Lake Okeechobee flood control releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries. Conveyance capacity of the Bolles and Cross Canals between the Miami and Hillsboro Canals is increased to facilitate interbasin transfers for storage and flood protection.

Operation: Inflows are from Lake Okeechobee regulatory discharges and runoff from Miami and North New River and adjacent basins. The reservoir will be divided into three compartments.

Compartment 1: 20,000 acres, meets EAA irrigation demands only. The source of water is excess EAA runoff. Inlet capacities for excess runoff are 2700 and 2300 cfs, for the Miami Canal and the North New River Canal Basins, respectively. Outlet capacities for EAA demands are 3000 and 4400 cfs, for the Miami Canal and the North New River Canal Basins. Overflow to compartment 2 occurs when the depth of water approaches 6 feet maximum and Lake Okeechobee regulatory discharges are not occurring or impending. Excess EAA runoff is diverted to compartment 3 only if WCA-3A is too deep.

Compartment 2: 20,000 acres, meets environmental demands as a priority, but can supply a portion of EAA irrigation demands if environmental demands equal zero. The sources of water are overflow from compartment 1 and Lake Okeechobee regulatory releases including the weather forecasting to initiate storage usage. Compartment 2A will be operated as a dry storage reservoir and discharges made down to 18 inches below ground level.

Compartment 3: 20,000 acres, meets environmental demands as a priority. The sources of water are overflow from compartment 1 and 2A and Lake Okeechobee regulatory releases only during the extreme wet events. Compartment 3 will be operated as a dry storage reservoir and discharges made down to 18 inches below ground level.

The conveyance of the northern reaches of the Miami and North New River Canals in the EAA are tripled (200% increase) for Lake Okeechobee regulatory releases as in Alternative 3. Structures with a capacity of 4500 cfs for diversion of regulatory releases through the Miami Canal and 3000 cfs for diversion of regulatory releases through the North New River Canal are added to compartments 2 and 3. When the reservoir depth falls below 1.5 feet, Lake Okeechobee is used for meeting supplemental irrigation and environmental demands. The flows will be delivered to the Water Conservation Areas through Stormwater Treatment Area 3/4.

Design:
Compartment 1: 1-20,000 acre reservoir at 6 feet maximum depth
Inflow structure capacity: inflow pumps of 2700 cfs Miami Canal Basin and 2300 cfs North New River Canal Basin for diversion of EAA runoff

Outflow structure capacity:
To Everglades Agricultural Area: 1-3000 cfs structure to Miami Canal Basin and 1-4400 cfs structure to North New River and Hillsboro Basins (initially assumed to not constrain performance).

Compartment 2: 1-20,000-acre reservoir at 6 feet maximum depth
Inflow structure capacity: inflow pumps of 4500 cfs and 3000 cfs for diversion of Lake Okeechobee regulatory releases from the Miami Canal and the North New River Canal, respectively

Outflow structure capacity:
To Stormwater Treatment Area 3/4: 3600 cfs @ 6 feet head.
Increase in Miami, North New River and Bolles and Cross Canal capacities is 200%.
To Miami Canal: 4500 cfs
To North New River Canal: 3000 cfs

Compartment 3: 1-20,000-acre reservoir at 6 feet maximum depth
Inflow structure capacity: inflow pumps of 4500 cfs and 3000 cfs for diversion of Lake Okeechobee regulatory releases from the Miami Canal and the North New River Canal, respectively

Location: To be determined - conceptually located in Palm Beach County between Miami and North New River Canals for Water Management Model simulation purposes only.

Assumption and Related Considerations:

1) Land Availability.
2) Modifications to Stormwater Treatment Areas if needed for Everglades water deliveries to meet the appropriate water quality.

Component H6 - D13R - Everglades Rain-Driven Operations

Study Region: Water Conservation Areas and Everglades National Park

Map: This component is not mapped.

Purpose: Improve timing and location of water depths in the Water Conservation Areas (WCAs) and Everglades National Park (ENP).

The rain-driven operational concept is a basic shift from the current operational practice, which uses calendar-based regulation schedules for the WCAs. Regulation schedules, also referred to as flood-control schedules, typically specify the release rules for a WCA based on the water level at one or more key water level gages. Regulation schedules do not typically contain rules for importing water from an upstream source. The schedules also repeat every year and make no allowance for inter-annual variability. The rain-driven operational concept includes rules for importing and exporting water from the WCAs in order to mimic a desired target stage hydrograph at key locations within the Everglades system. The target stage hydrographs mimic an estimate of the more natural (pre-drainage Everglades) water level response to rainfall.

Operation: Note that for the description below, the term "trigger level" means the water level used to trigger action at an upstream or downstream structure. Trigger levels are related to the target stage hydrographs by simple offsets which typically range less than +/-1.0ft. There is usually one trigger level for the import rules; and two trigger levels associated with the exportation of water. The two export trigger levels define two release zones. The lower zone is a conditional release zone; so releases are made only if the downstream area has a "need". The upper zone is an unconditional release, or flood control, release zone; so releases are made in this zone even if the downstream area doesn't "need" the water.

WCA-1: No rain-driven operations (use 1995 interim regulation schedule)

WCA-2 Import Rules: Import water from Lake Okeechobee via STA-2 if water levels fall below trigger levels in northern WCA-2A (South Florida Water Management Model grid cell R45C28).

WCA-2 Export Rules:

a. Export water from WCA-2A to WCA-2B via S-144, S-145 & S-146, if levels at gage 2A-17 exceed trigger levels.

b. Export water from WCA-2A via the S-11's if levels at gage 2A-17 exceed triggers.

c. Export water from WCA-2B to ENP via new structures at south end of WCA-2B if levels at central WCA-2B (grid cell R36C30) exceed trigger levels.

WCA-3 Import Rules:

a. Import water from Everglades Agricultural Area (EAA) storage and/or Lake Okeechobee via STA-3/4 to:

(1) Northeast WCA-3A if levels fall below trigger levels at gage 3A-NE.

(2) Northwest WCA-3A (via L-5/L-4, S8, G404, and spreader along L-4) if levels fall below trigger levels at gage 3A-NW.

(3) Central WCA-3A, via an improved S-140 & a spreader along the southernmost ~8miles of L-28{north reach}, if levels fall below trigger levels at gage 3A-4.

b. Import water from WCA-2A via S-11's if levels fall below trigger levels at gage 3A-3 (and WCA-2 has excess water {levels at gage 2A-17 significantly exceed targets}).

WCA-3 Export Rules:

a. Export water from WCA-3A to WCA-3B via proposed L-67 weir structures if water levels upstream of weirs exceed their respective crest elevations (passive structures).

b. Export water from WCA-3A to WCA-3B via proposed S-345 and S-349 structures if water levels at grid cell R33C26 exceed trigger levels.

c. Export water from WCA-3A to Central Lakebelt storage area, via proposed gravity structure near S-9, if water levels at grid cell R26C33 exceed trigger levels.

d. Export water from WCA-3B to Central Lakebelt storage area, via S-31, if water levels at grid cell R30C27 exceed trigger levels.

ENP Import Rules:

a. Import water from WCA-3A via proposed S-345 and S-349 structures if the average of water levels at Northeast Shark River Slough (NESRS) gages, NESRS-1 and NESRS-2, falls below trigger levels.

b. Import water from Central Lakebelt storage via proposed S-356A&B structures if levels at G-1502 fall below trigger levels.

c. Import excess water from WCA-2B, via improved L-37 & L-33 canals and S-356A&B.

Design: Deliveries from upstream sources (EAA runoff, EAA storage area, and/or Lake Okeechobee) through the Stormwater Treatment Areas (STAs) prior to release into the WCAs. Distribution of STA outflow designed to improve hydropatterns. Flows to ENP from WCAs 3A and 3B are uncontrolled in this alternative since the S-355 and S-12 structures, L-29, and the L-29 borrow canal are removed to allow overland flow from WCAs 3A and 3B to ENP.

Location: Within the existing boundaries of the WCAs and ENP. Counties include: Broward, Dade, Monroe, and Palm Beach

Assumption and Related Considerations:

1) Consideration given to tree islands and minimum floor levels consistent with South Florida Water Management District's proposed minimum flows and levels for these areas.

2) Potential increases in hydropatterns in relatively overdrained areas (e.g., northern WCA-3A) and decreases in hydropatterns in deep water areas (e.g., southern WCA-3A).

Component I - (not included in this Alternative)

Component J - (not included in this Alternative)

Component K6 - L-8 Project

Study Region: Lower East Coast

Map: Refer to Component Map 1

Purpose: Reduce water supply restrictions in the Northern Palm Beach County Service Area by capturing more of the annual discharges from portions of the southern L-8, C-51 and C-17 Basins and route this water to the West Palm Beach Water Catchment Area. Intent is to increase water supply availability and provide pass through flow to enhance hydroperiods in Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River.

Operation: Capture excess L-8, C-51 and C-17 Basin water to meet urban water supply demands in the Northern Palm Beach County Service Area and enhance hydroperiods in the Loxahatchee Slough. Water would be diverted through the M-Canal to the Water Catchment Area. Stormwater treatment areas will be provided to meet all water quality standards required if necessary.

Design:
48,000 acre-feet reservoir as described in component GGG6. The reservoir covers an area of approximately 1200 acres and is located immediately west of the L-8 Canal and north of the C-51 Canal.

50 MGD Aquifer Storage and Recovery (ASR) to provide water during regionally triggered droughts and as a means of reducing withdrawals from the West Palm Beach Water Catchment Area when the water levels are substantially below the target hydrograph. The majority or all of the 50 MGD ASR well clusters will be located in the vicinity of the City of West Palm Beach Water Treatment Plant (Clear Lake). However for modeling purposes, the ASR wells were located in the West Palm Beach Water Catchment Area. During periods when the West Palm Beach Water Catchment Area is above 18.0 feet NGVD, an additional (above the flow rate required to supply the water treatment plant) 50 MGD (78 cfs) will be sent to Lake Mangonia for subsequent storage through the ASR clusters (surficial well discharging into a Floridan well). The ASR wells will provide water directly to Lake Mangonia when water levels in the West Palm Beach Water Catchment Area are within 0.2 feet of the level that triggers regional supply to the West Palm Beach Water Catchment Area.

Increase the pumping capacity from the L-8 Tieback into the M-canal to 300 cfs to increase the volume of water captured from the southern L-8 Canal and deliver it to the Water Catchment Area. This pump has dual purposes, 1) to capture L-8 Basin runoff when available and 2) to deliver regional deliveries when needed.

Assume that the Indian Trail Improvement District will adopt an operation plan which promotes water conservation by prioritizing discharge. In this operation excess storm water is first offered to the West Palm Beach Water Catchment Area through installation of 2 pumps (300 cfs and 200 cfs) and secondarily discharged through off peak releases to the C-51 Canal via the M-1 Canal. For this alternative pumping from Indian Trail Improvement District into the M-Canal for subsequent discharge into the West Palm Beach Water Catchment Area will be assumed to occur under the following conditions:

1) When the City of West Palm Beach Water Catchment Area has sufficient need for imported water as defined by being below 18.2 feet NGVD.
2) When water levels in the lower M-1 Basin exceed 14.0 feet NGVD during the wet season (June 1 through October 31) or 16.0 feet NGVD during the dry season (November 1 through May 31) the lower M-1 Basin may discharge up to 200 cfs for subsequent storage.
3) When water levels in the upper M-1 Basin exceed 15.0 feet NGVD during the wet season or 16.0 feet NGVD during the dry season) the upper M-1 Basin may discharge up to 300 cfs for subsequent storage.

Increase conveyance of the M-Canal between the pump and the West Palm Beach Water Catchment Area to accommodate the increased inflow from the L-8 Canal and the Indian Trail Improvement District.

Install a new structure in the south leg of C-18 just south of the west leg to facilitate better management of water levels and discharges from the Loxahatchee Slough. The new gravity structure would consist of a variable discharge up to 400 cfs and emergency overflow weirs.

50 cfs pump for water supply deliveries to utilities. A recharge canal may be improved to convey deliveries to utilities.

New culverts under Bee-Line Highway for up to 100 cfs deliveries to Loxahatchee Slough.

Eliminate ASR component described in the Future Without Project Condition.

Location: Southern L-8 Basin including the Indian Trail Improvement District, West Palm Beach Water Catchment Area, and the Loxahatchee Slough. Counties include Palm Beach.

Assumption and Related Considerations:
1) Should help maintain stages in the Loxahatchee Slough and reduce high discharges to the southwest fork of the Loxahatchee River.
2) Stormwater Treatment Area upstream of the Water Catchment Area may be needed to accommodate future degradation of water quality.
3) Secondary structures (recharge canals) may be needed downstream of the Water Catchment Area to provide water to achieve the desired result.

Component L3 - Change Coastal Wellfield Operations

Study Region: Lower East Coast

Map: This component is not mapped.

Purpose: Shift demands from eastern wellfields to western facilities away from the saltwater interface to reduce impact of salt water intrusion.

Operation: For coastal utilities in the Lower East Coast Service Area which are experiencing an increased threat of saltwater intrusion, demands will be shifted from the eastern facilities to the western facilities away from the saltwater interface. The volume shifted is dependent upon the degree of saltwater intrusion but is generally proportional to the increase in demands between the 1995 existing conditions and the 2050 future without project conditions unless otherwise noted.

Design: For this alternative the following utilities have a portion of their demands shifted inland and include Riviera Beach, Lake Worth, Lantana, Manalapan, Boca Raton, Hollywood (including Broward County 3B and 3C), Dania, Miramar, Broward County 3A, Hallandale and Florida City. Redistribution of demands for Lake Worth, Lantana, Manalapan, Boca Raton and Florida City are generally consistent with the Lower East Coast Water Supply Plan. For the City of Riviera Beach, demands will be shifted from the eastern facilities to the western facilities, with the western facilities absorbing the increased demand between the 1995 and 2050 conditions. For this alternative, the City of Miramar's eastern wellfield will be placed on standby and all demands will be met from the western wellfield. For the City of Hollywood, Hallandale, Dania, Broward County 3A, and Broward County 3B/3C all these wellfields will be placed on standby and the entire demand (with the exception of 4 MGD from the Floridan aquifer for Hollywood) will be met from the South Broward County Regional wellfield. Recharge to the Regional wellfield will be met through the existing canal system supplied from locally captured runoff from the C-9 Basin (Components R and S).

Location: Lower East Coast Service Area. Counties include: Broward, Miami-Dade and Palm Beach.

Assumption and Related Considerations: It is assumed that the western facilities of the individual utilities have sufficient capacity to meet the increased demands.

Component M6 - Site 1 Impoundment with Aquifer Storage and Recovery

Study Region: Lower East Coast

Map: Refer to Component Map 2

Purpose: Water supply storage reservoir to supplement water deliveries to the Hillsboro Canal during the dry-season.

Operation: The enlarged reservoir will be filled during the wet-season from excess water backpumped from the Hillsboro Canal. Water will be released back to the Hillsboro Canal to help maintain canal stages during the dry-season. If water is not available in the reservoir, existing rules for water delivery to this region will be applied. Aquifer Storage and Recovery (ASR) capacity is being increased to improve water supply during dry seasons and droughts. Fifteen (15) 5 MGD capacity ASR wells will be added for a total of thirty (30) ASR clusters for this alternative (total injection and recovery capacity is 150 MGD or about 230 cfs). Water will be injected into the ASR wells when stages in the impoundment are greater than 12.0 feet NGVD (0.5 feet of depth) The source of water to be injected is surficial ground water wells located adjacent to the reservoir. Water will be recovered from the ASR wells when stages in the Hillsboro Canal are less than 7.0 feet NGVD.

Design:
2460 acres with a maximum depth of 6 feet located north and south of the Hillsboro Canal. The portion of the canal that is located within the proposed reservoir will be incorporated into the reservoir.
Inflow pump capacity = 700 cfs and is relocated to the eastern end of the Hillsboro Canal.
Outflow structure capacity = 200 cfs @ 4 feet of head.
Emergency outflow structure = 700 cfs.
Thirty (30) – 5 MGD ASR wells (total capacity 150 MGD or about 230 cfs).

Location: The Water Preserve Area Land Suitability Analysis previously identified 2460-acre site. Counties include: Palm Beach

Assumption and Related Considerations:

1) Excess storage could be discharged to Water Conservation Area 2A if a treatment facility could be added to meet Everglades' water quality standards.

2) Based on results of the pilot project, ASR facilities maybe located along Hillsboro Canal
3) Recovery rate of 70 percent for water stored by ASR.

Component N - (not included in this Alternative)

Component O4 - Water Conservation Area 3A and 3B Levee Seepage Management

Study Region: Lower East Coast

Map: Refer to Component Map 4 and 5

Purpose: Reduce seepage from WCAs 3A and 3B to improve hydropatterns within the Conservation Areas by allowing higher water levels in the borrow canals and longer inundation durations within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes will be collected and directed south into the Central Lake Belt Storage Area. This will maintain flood protection and the separation of seepage water from urban runoff originating in the C-11 Basin and Lake Okeechobee water supply deliveries.

Operation: The L-37 and L-33 borrow canals will be held at higher stages as part of the WCA 3 seepage collection and conveyance system (Component YY). Seepage collected in the L-37 and L-33 borrow canals and from the marsh areas will be directed into the WCA 3 seepage collection and conveyance system and directed south into the Central Lake Belt Storage Area or directly to Northeast Shark River Slough.

Design: New levees will be constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal to separate seepage water from the urban runoff in the C-11 diversion canal (Component Q). The L-37 and L-33 borrow canals will be controlled at higher stages as will the marshes located east of the WCAs. A divide structure will be added to the C-11 Canal west of US Highway 27 to maintain the separation of seepage water from urban runoff. Water from C-11 west will be diverted to the North Lake Belt Storage Area.

Location: Seepage collected in borrow canals along the existing eastern protective levees adjacent to WCA 3. Divide structure located in C-11 Canal east of US Highway 27 in Broward County.

Assumption and Related Considerations: It is assumed that the seepage from the Water Conservation Areas meets the water quality standards necessary to achieve ecosystem restoration.

Component P - (not included in this Alternative)

Component Q5 - Western C-11 Diversion Impoundment and Diversion Canal

Study Region: Lower East Coast

Map: Refer to Component Map 4

Purpose: Divert untreated runoff from western C-11 that is presently discharged into Water Conservation Area 3A through the C-11 Stormwater Treatment Area / Impoundment to the North Lake Belt Storage Area.

Operation: Runoff in the western C-11 Canal that was previously backpumped into Water Conservation Area 3A will be diverted to the C-11 STA/Impoundment and then to North Lake Belt Storage Area (NLBSA). If storage capacity is not available in the impoundment or NLBSA, then the S-9 pump will be used for flood protection for the Western C-11 Basin, which pumps to WCA-3A. To improve groundwater elevations in the Eastern C-11 Basin, the S-9 seepage divide structure will be operated to maintain the Western C-11 Canal stage at elevation 3.0 feet NGVD.

Design:
2500 cfs diversion canal west of U.S. 27 between C-11 and C-9 and a 2500 cfs conveyance capacity improvements to the C-9 Canal between S-30 and the NLBSA.
Intermediate 2500 cfs pump station in the C-11 Canal to direct runoff to the C11 STA/impoundment.
1600 acre STA/Impoundment with a maximum depth of 4 feet.
Seepage collection canal and pump for C-11 STA/impoundment.
2200 cfs structure to discharge from the impoundment to C-11 west of US 27 to diversion canal.

Location: The diversion canal is located west of US-27 between C-11 and C-9 Canals. The C-11 STA/impoundment is located northeast of the intersection of US27 and C-11 Canal.
Counties: Broward, Miami-Dade

Assumption and Related Considerations:
1) Flood protection component for Florida Power and Light substation and mobile home park may be needed.
2) Telemetry systems will be required for all operable structures and pump stations.

Component R4 - C-9 Stormwater Treatment Area/Impoundment

Study Region: Lower East Coast

Map: Refer to Component Map 5

Purpose: Treatment of water supply deliveries from North Lake Belt Storage Area (NLBSA) to C-9, C-6/C-7 and C-2/C-4 Canals. NLBSA is used to capture runoff from western C-9 Basin and C-11 west by backpumping into the curtain walled reservoir area. The C-9 impoundment will provide treatment of runoff stored in North Lake Belt Storage Area, groundwater recharge within the basin and seepage control of WCA3 and buffer areas to the west.

Operation: Water supply deliveries from North Lake Belt Storage Area to C-9, C-6/C-7 and C-2/C-4 Canals will be pumped into the C-9 STA/impoundment for treatment of the stormwater runoff stored in the NLBSA. Seepage from C-9 impoundment will be collected and returned to the impoundment.

Design:
2500 acres with a maximum depth of 4 feet.
Inflow structure: 1000 cfs pump (see component XX North Lake Belt Storage Area).

Outflow structure: Gravity structure with 1000 cfs capacity at 4 foot head.
Discharge C-9 impoundment to C-9, C-6/C-7 and C-2/C-4 Canals for water supply deliveries.

Seepage Collection: 200 cfs recycled into the impoundment area.

Location: Site identified by Water Preserve Area Land Suitability Analysis
Counties: Broward

Assumption and Related Considerations:

1) Additional treatment facility needed if stored water is backpumped into Water Conservation Area 3A.
2) Telemetry systems will be required for all operable structures and pump stations

Component S6 - Central Lake Belt Storage Area

Study Region: Lower East Coast

Map: Refer to Component Map 6 and 6A

Purpose: In-ground reservoir to receive excess water from Water Conservation Areas (WCA) 2B, 3A and 3B. The Central Lake Belt Storage Area (CLBSA) is an in-ground reservoir with perimeter seepage barrier will allow storage of large quantities of water without groundwater seepage losses in this highly transmissive region. The water stored in CLBSA will be provided to:

1) Northeast Shark River Slough (NESRS),
2) Water Conservation Area 3B, and
3) to supply flows to Biscayne Bay when available.

Operation: Inflows from L-33 (see Component ZZ) is through a 1500 cfs pump. Inflow ceases when stages reach ~21.0 feet NGVD (16 feet above adjacent land elevation). Inflows from L-33 diverted to CLBSA.

Outflows for water deliveries are pumped through a polishing marsh cell prior delivery to NESRS via L-30 and a reconfigured L-31 N (see component U). Deliveries of water to NESRS to maintain inundation will occur when NESRS drys below trigger levels and target hydroperiods simulations call for NESRS to be inundated. CLBSA delivers water to WCA 3B through a polishing marsh cells via L-30 to inundate the eastern area of WCA 3B to a 6 inch depth when triggers call for deliveries. This delivery occurs when WCA 3B drys below 6 inches above ground and target hydroperiods simulations indicate inundation in WCA 3B. When available, outflows will be directed to Biscayne Bay through discharges to Snapper Creek at the Turnpike.

Supply from the reservoir can be withdrawn for stages down to –15 feet NGVD (up to 36 feet of working storage & maximum head on seepage barrier).

Design:
Reservoir: 5200 acres with subterranean seepage barrier around the perimeter to enable drawdown during dry periods and to prevent seepage losses.
STA: 640 acre Stormwater Treatment Area to serve as a polishing prior to discharging to the Everglades (if required)

Inflow Structures:

1500 cfs pump from the L-33 borrow canal.
500 cfs structure at S-9 pump station to gravity discharge from WCA 3A to L-33.
700 cfs structure (Existing S-31) for WCA 3B to CLBSA via C-6 Canal.

Outflow Structures:

800 cfs pump to polishing cell to make deliveries to NESRS and WCA 3B.
500 cfs pump off L-30 to deliver to WCA 3B.
300 cfs pump to make deliveries for Snapper Creek Canal

1100 cfs structure @ 0.5 feet head to provide regional system deliveries to Snapper Creek Canal via C-6 if CLBS is out of water.

Location: Reservoir would be located within the area proposed for rock mining by the Lake Belt Issue Team. It would be sited south of Miami Canal (C-6) and north of the Northwest Wellfield Delivery Canal to minimize impacts to the Northwest Wellfield. The feature is located in Miami-Dade County.

Assumption and Related Considerations:
1) No adverse effect of a subterranean wall on Miami-Dade County's Northwest Wellfield.
2) Treatment facility maybe needed.
3) All water quality considerations will be addressed regarding releases from the reservoir to the water supply wellfields.
4) Impacts on the cone of influence of the Northwest Wellfield and its effect on wetland mitigation around the wellfield.
5) Limestone Filter Treatment system within the Reservoir may be developed through use of compartmentalization of rockmining excavation pattern.
6) Telemetry systems will be required for all operable structures and pump stations.

Component T6 - C-4 Structures

Study Region: Lower East Coast

Map: This component is not mapped.

Purpose: Proposed structures (East and West) would provide two separate benefits. The West structure would control water levels in the C-4 Canal at higher elevation to reduce seepage losses from the Pennsuco Wetlands and areas to the west of the structure. The East structure would reduce regional system deliveries by diverting dry season stormwater flows to the C-2 Canal to increase recharge nearby in several coastal wellfields.

Operation: The West structure would maintain water levels at 6.5 feet NGVD for seepage control purposes and be capable of passing flood flows with a minimum of head loss and supplying water to the C-4 Basin to meet demands. The East structure would divert dry season stormwater flows from the western C-4 Basin to the C-2 Canal to recharge the wellfields in the eastern C-2 Basin.

Design:
East Structure- Operable lift-gate with 6.5 feet NGVD overflow and approximately 400 cfs capacity (final design specifications will be determined in detailed design and hydrologic and hydraulic modeling in the future).

Location: Just downstream of the Dade-Broward Levee in C-4 Canal in Miami-Dade County.

West Structure- Operable lift-gate with 4.5 feet NGVD overflow and approximately 600 cfs capacity (final design specifications will be determined in detailed design and hydrologic and hydraulic modeling in the future).

Location: In C-4, just downstream of the confluence of the C-2 and C-4 Canals in Miami Dade County.

Assumption and Related Considerations:
1) Benefits to WCA-3B associated with improved C-4 seepage control are directly related to the proposed G-356 pumpage (Modified Water Deliveries).
2) Head losses across the proposed structures will not inhibit passing flood releases when necessary.
3) A pump may be associated with the West structure if back pumping the C-4 basin runoff to the Bird Drive Recharge Area becomes a component of the final alternative.

Component U6 - Bird Drive Recharge Area

Study Region: Lower East Coast

Map: Refer to Component Map 7

Purpose: Captures runoff from the western C-4 Basin and accepts inflows from the West Miami-Dade Wastewater Treatment Plant (WDWTP) (see component HHH) to recharge groundwater and reduce seepage from the Everglades National Park (ENP) buffer areas by increasing water table elevations east of Krome Ave. The facility will also provide C-4 flood peak attenuation and water supply deliveries to the South Dade Conveyance System (SDCS) and Northeast Shark River Slough.

Operation: Inflows from western C-4 Basin and the WDWTP will be pumped into the proposed Recharge Area. C-4 runoff in excess of 200 cfs will be discharged eastward. Inflows from the WDWTP will be continuous when the Recharge Area depth is equal to or less than 3' above ground. WDWTP discharges will be to deep injection wells if the depth is greater than 3 feet. A seepage management system will be operated around the east and southern perimeters of the Recharge Area. Recharge Area outflows will be prioritized to meet 1) groundwater recharge demands, 2) South Dade Conveyance System demands and 3) Northeast Shark River Slough demands, when supply is available. Regional system deliveries will also be routed through the seepage collection canal system of the Bird Drive

Recharge Area to the South Dade Conveyance System, which should reduce seepage from areas west of Krome Avenue.

Design:
2877 acres with a maximum depth of 4 feet.
Inflow structure: 200 cfs pump (to be resized as needed) from C-4.

Outflow structure:
Water supply: Gravity structure with 200 cfs capacity at 2 feet of head.
Seepage Collection System: up to 500 cfs pump to control seepage collection canal at 5.0 feet NGVD. Seepage is returned to Bird Drive Recharge Area.

Delivery System: 800 cfs pump to provide regional system deliveries to SDCS.
800 cfs canal capacity, in addition to the canal required for the Bird Drive seepage collection system, to pass the regional system deliveries to the South Dade Conveyance System.
5 miles of canal with 800 cfs capacity between Bird Drive seepage collection system to C-1W just east of Krome Ave.
Relocate S-338 east of Krome Ave. and delivery canal.

Location: Northwestern 4 sections in Bird Drive Basin. This site was identified during the Water Preserve Area Land Suitability Analysis.
Counties: Miami-Dade

Assumption and Related Considerations:
1) Treatment facility needed if seepage collected does not meet Everglades standards (component HHH).
2) Telemetry systems will be required for all operable structures and pump stations.
3) Flood protection in the basin will not be removed by the introduction of the West Miami-Dade Wastewater Treatment Plant inflows.
4) Regional-scale simulation using SFWMM 2mi X 2mi resolution is rather coarse for this local-scale feature. Specific land elevations in the Bird Drive Recharge Area are not precisely mimicked due to location and scale considerations in the SFWMM.

Component V4 - L-31N Improvements for Seepage Management

Study Region: Lower East Coast

Map: See Component Map 7

Purpose: Levee seepage management along the eastern edge (L-31N) of Everglades National Park to eliminate losses due to levee seepage to the East Coast. An additional feature has been added to reduce all wet-season seepage/ground water flows to the east. Feature will help restore hydropatterns in Everglades National Park.

Operation: 100% reduction in levee seepage flow from Everglades National Park year-round (to be achieved via Component FF4). Further 100% reduction in all groundwater flows during the wet-season. Bird Drive Recharge Area and North Lake Belt Storage Area will be used to recharge aquifers to the east.

Design:
Levee Seepage: Refer to Component FF4.

Wet-Season Ground Water Seepage: Distributed ground water wells adjacent to L-31N and return flows to Everglades National Park.
If needed, aquifer recharge will occur from deliveries from Bird Drive Recharge Area and North Lake Belt Storage Area.

Location: Along the existing eastern protective levee (L-31N) adjacent to Everglades National Park.
Counties: Miami-Dade

Component W2 - Taylor Creek/Nubbin Slough Storage and Treatment Area

Study Region: Kissimmee River

Map: This component is not mapped due to uncertainty of site location.

Purpose: Storage reservoir to provide flood protection, water quality treatment, estuary protection and water supply benefits.

Operation: Local runoff from the Taylor Creek/Nubbin Slough Basin to be pumped into a 5000-acre reservoir and then into a 5000-acre stormwater treatment area. The stormwater treatment area will reduce phosphorus concentrations in the runoff from approximately 0.58 mg/l to 0.117 mg/l. Treated water will then be pumped into Lake Okeechobee when the lake stage is falling and is at least 0.5 feet below the bottom pulse release zone.

Design:

Storage Reservoir:
5000-acres at 10 feet maximum depth
Inflow pump capacity 2500 cfs
Outflow pump capacity 1000 cfs

Stormwater Treatment Area:

5000-acres at 4 feet maximum depth
Inflow pump capacity 1000 cfs (same structure as reservoir outflow)
Outflow pump capacity 1000 cfs

Location: North of Lake Okeechobee
Counties: Okeechobee, St. Lucie, Martin

Assumption and Related Considerations:
1) Uncertainty in land availability.
2) Potential increase in stage duration of Lake Okeechobee.
3) Potential decrease in maximum stages of Lake Okeechobee.
Phosphorus inflow concentrations (flow-weighted) for the Taylor Creek/Nubbin Slough (S-191) Basin obtained from 5-year rolling averages (1991-1995).
4) Average annual discharge rates determined from the period of record 1965-1990.

Component X6 - C-17 Backpumping

Study Region: Lower East Coast

Map: Refer to Component Map 8

Purpose: Reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-17 Basin to the West Palm Beach Water Catchment Area and enhance hydroperiods in the Loxahatchee Slough.

Operation: Capture excess C-17 Canal water to meet urban water supply demands in North Palm Beach Service Area. Water would be diverted through existing canals to a stormwater treatment area and ultimately to the West Palm Beach Water Catchment Area.

Design: 200 cfs pump in the existing Northern Palm Beach County Improvement District Canal at its intersection with the Turnpike Canal to pull flows west and direct them south into the east Turnpike Canal.
Culvert under 45th Street (N/S) to connect the east Turnpike Canal.
150 cfs capacity culvert and pump from the Turnpike Canal to direct flows into the proposed stormwater treatment area.
550 acre stormwater treatment area at 4 feet maximum depth.
200 cfs Culvert to connect stormwater treatment area under Florida's Turnpike to allow nonrestrictive flows.
100 cfs gravity discharge structure into West Palm Beach Water Catchment Area..

Location: 550 acres located east of the West Palm Beach Water Catchment Area in Palm Beach County.

Assumption and Related Considerations:
(1) Water quality of C-17 water similar to C-51 water quality.
(2) Location of stormwater treatment area south of existing landfill.
(3) Improve conveyance in the Northern Palm Beach County Improvement District and Turnpike canals as necessary to pass flows.

Component Y6 - C-51 Backpumping to West Palm Beach Water Catchment Area

Study Region: Lower East Coast

Map Refer to Component Map 9

Purpose: Reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-51 West Basin to the West Palm Beach Water Catchment Area and enhance hydroperiods in Loxahatchee Slough.

Operation: Capture excess C-51 Canal water to meet urban water supply demands in the North Palm Beach County Service Area. Water would be diverted from C-51 to a water treatment area and then into the Water Catchment Area.

Design: 600 acres at 4 feet maximum depth to be used for stormwater treatment.
Relocate the S-155A structure east of the intersection of Lake Worth Drainage District's E-1 Canal and the C-51 Canal and increase the capacity of S-155A as necessary to pass the additional inflows.
Improve conveyance between C-51 and the stormwater treatment area as necessary.
450 cfs inflow pump to stormwater treatment area.
100 cfs gravity discharge structure into West Palm Beach Water Catchment Area.

Location: 600 acres located southwest of West Palm Beach Water Catchment Area in Palm Beach County.

Assumption and Related Considerations:
(1) Uncertainty in land availability.
(2) Connection of L-8 and C-51 Basins.

Component Z - (not included in this Alternative)

Component AA6_D13R - Additional S-345 structures

Study Region: Water Conservation Areas

Map: Component Map

Purpose: The compartmentalization of the Water Conservation Areas (WCAs) has contributed to the loss of historic overland flows of the central Everglades slough system. This alteration of flows has resulted in temporal changes in hydropatterns and hydroperiods in the historic deepwater, central axis of the Shark River Slough system. This component adds conveyance to WCA 3B to help in re-establishing NSM-like hydroperiods and hydropatterns in WCA 3B and Northeast Shark River Slough.

Operation: The addition of a Northeast Shark River Slough rainfall trigger well and modification of western Shark River Slough Basin rainfall triggers deliver additional flows to the basin. Modification of L-67A decreases downstream conveyance to the S-12’s required to promote surface water flows to Water Conservation Area 3B and to Northeast Shark River Slough.

Design: Triple the total discharge capacity of S-345’s to 4500 cfs and the addition of associated plugs (S-349’s).

Location: The additional structures and plugs are to be spaced evenly along the southern half of L-67A.

Assumptions and related Considerations: The emphasis is in re-establishing the historic persistent, deep-water slough that existed in Water Conservation Area 3B and Northeast Shark River Slough.

Component BB5 - Dade Broward Levee / Pennsuco Wetlands

Study Region: Lower East Coast

Map: Refer to Component Map 6

Purpose: Reduce seepage to the east from the Pennsuco Wetlands and southern Water Conservation Area (WCA) 3B and enhance hydroperiods in the Pennsuco Wetlands. Also an improved Dade Broward Levee will enhance recharge to Miami-Dade County's Northwest Wellfield.

Operation: Improvements to the Dade-Broward Levee and associated conveyance system will reduce seepage losses to the east and provide recharge to Miami-Dade County's Northwest Wellfield. Seepage reduction will enhance hydroperiods in Pennsuco Wetlands and hold stage higher along southeastern WCA 3B. Recharging the conveyance features of the Dade-Broward Levee from the regional system deliveries provides recharge to Miami-Dade County's Northwest Wellfield. Treatment areas will be provided to meet all water quality standards required, if necessary.

Design:
Improve the Dade-Broward Levee:
Construct or improve existing levee to five-foot height with 2-foot top width while creating or improving existing conveyance to a capacity of up to 300 cfs.
150 cfs bypass structure and canal from C-6 Canal to Dade-Broward Levee to provide recharge from the regional system via the improved US Highway #27 borrow canal.
150 cfs gravity structure in the Dade-Broward Levee Borrow Channels due west of the southern end of the Northwest Wellfield.
Provide recharge for the Dade-Broward Levee from the regional system when the Conveyance Channel is below 5.0 feet NGVD at the C-4 structure located at the southern end of the Dade-Broward Levee.

Location: Dade-Broward Levee, Pennsuco Wetlands, WCA-3B, the Central Lake Belt Storage Area and Miami-Dade County's Northwest Wellfield.

Assumption and Related Considerations:
1) Wellfield protection must be maintain through recharge of acceptable water quality.
2) Secondary structures within the recharge canals may be needed to provide seepage reduction and wellfield recharge desired.

Component CC6 - Broward County Secondary Canal System

Study Region: Lower East Coast

Map: Refer to Component Map 10

Purpose: Increase pump capacity of existing facilities (from the 2050 Base Case) and construct additional canal and pump facilities for the Broward Secondary Canal System to provide recharge to wellfields located in central and southern coastal Broward County, stabilize the salt water interface and reduce storm water discharges to tide.

Operation: When excess water is available in the basin, water is pumped into the coastal canal systems to maintain canal stages. When local water is not sufficient to maintain canal stages, canals are maintained first from local sources and then from Lake Okeechobee and the Water Conservation Areas. Local sources include the Site 1 Impoundment (Component M) and the North Lake Belt Storage Area (Component XX).

Secondary canals maintained are 1) Broward County's C-2 from the Hillsboro Canal, 2) north secondary canal from C-13, 3) south secondary canal from C-13, 4)

Turnpike canal south from C-12 and 5) canal north from C-9 (added in Alternative 5) at levels discussed below.

Design:
Canal Conveyance: Improve canal conveyance of secondary canal located east of the Florida Turnpike from the C-12 Canal south to the Fort Lauderdale Golf and Country Club. Alternative 5 includes routing of water eastward to recharge the aquifer and help stabilize the saltwater interface at Ft. Lauderdale. Canal conveyance improvements may also be necessary for the Old Plantation Water Control District's eastern canal and in southeastern Broward County.

Pump capacities and maintenance levels:
100 cfs pump from Hillsboro to Broward County Secondary Canal (pump #1).
100 cfs pump from C-13 north to Broward County Secondary Canal.
100 cfs pump from C-13 south to Broward County Secondary Canal (pumps #2 and #3 described in the 2050 Base Case increased from 33 cfs to 100 cfs.
100 cfs pump on the east Turnpike canal withdrawing water from the C-12 Canal.
150 cfs pump on the C-9 Canal for maintaining water in southeastern Broward County.

Canal improvements and control elevations:
Improve east and west Turnpike canals and golf course lake system between C-12 and the North New River to achieve an average top width of 200 feet.
The Turnpike canals shall be maintained at a minimum elevation of 4.0 feet NGVD.
Improve canal/ lake systems in southeastern Broward County and the Orangebrook Golf Course to have an average canal top width of 30 feet.
The southeastern Broward Canal system shall be maintained at a minimum elevation of 2.5 feet NGVD.

Location: Broward County

Assumption and Related Considerations:
1) Canal levels are maintained from local basin runoff and sources. When water in not available from local sources, water is supplied to the canal systems from the regional system.
2) Canal operations do not impact existing flood control levels.

Component DD5 - Modified Holey Land Wildlife Management Area Water Management Operations

Study Region: Water Conservation Areas

Map: This component is not mapped.

Purpose: Improve timing and location of water depths within the Holey Land Wildlife Management Area based on rain-driven operations.

Operation: Rainfall-driven modified operational rules with NSM-like hydrologic conditions triggering deliveries. Rainfall-driven inflows are driven by target water depths in cell R45C18. Outflows are based on target water depths in cell R42C20. Alternative 5 truncates the peaks 1.5' above ground level and the troughs 1.0' below ground level.

Design: Operational changes only.

Location: Southern portion of the Everglades Agricultural Area, north of Water Conservation Area 3A in Palm Beach County.

Assumption and Related Considerations: Water deliveries are made to the Holey Land through G-200A or from Stormwater Treatment Areas 3 & 4 if Rotenberger Wildlife Management Area flows are insufficient. The deliveries are assumed to be of acceptable water quality from either Rotenberger Wildlife Management Area or Lake Okeechobee through Stormwater Treatment Areas 3 & 4.

Component EE5 - Modified Rotenberger Wildlife Management Area Water Management Operations

Study Region: Water Conservation Areas

Map: This component is not mapped.

Purpose: Improve timing and location of water depths within the Rotenberger Wildlife Management Area based on rain-driven operations.

Operation: Rainfall-driven operational rules with Natural System Model-like hydrologic conditions triggering deliveries. Rainfall-driven inflows and outflows are driven by the average of target water depths in South Florida Water Management Model grid cells R46C15 and R43C16. Alternative 5 truncates the peaks 1.5 feet above ground level and the troughs 1.0 feet below ground level.

Design: Operational changes only.

Location: Southern portion of the Everglades Agricultural Area, north of Water Conservation Area 3A in Palm Beach County.

Assumption and Related Considerations: Water deliveries made to Rotenberger Wildlife Management Area from Stormwater Treatment Area 5 are assumed to be of acceptable water quality.

Component FF4 - Construction of S-356 A & B Structures

Study Region: Lower East Coast

Map: Refer to Component Map 7

Purpose: To improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3.

Operation: Redirect S-357 outfall from L-31N to the mid-point of the Modified Water Deliveries (MWD) mitigation canal northwest of the 8.5 Square Mile Area. Operate new S-356 pumps to direct seepage collection from Water Conservation Areas and water deliveries from Central Lake Belt Storage Area to Northeast Shark River Slough.

Design:
Remove MWD S-356.
Relocate MWD S-357.
Add S-356 A & B Structures (900 cfs each) at locations along modified L-31N between G-211 and Tamiami Trail.
Reroute L-31N borrow canal to east side of buffer cell.
Relocate L-31N to east side of buffer cell.
Backfill portion of L-31N where levee moved.
5 foot levee along west side of existing lakes.

Location: L-31N along east side of Northeast Shark River Slough.
Counties: Miami-Dade

Assumption and Related Considerations:
1) Water Quality is not a problem
2) No adverse impacts to areas east of L-31N

Component GG4 - Lake Okeechobee Aquifer Storage and Recovery

Study Region: Lake Okeechobee

Map: Refer to Figure 1

Purpose: Provides additional regional storage while reducing both evapotranspiration losses and the amount of land removed from current land use

(e.g. agriculture) that would normally be associated with construction and operation of above-ground storage facilities (reservoirs);
Increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades;
Manage a portion of regulatory releases from the Lake primarily to improve Everglades hydropatterns, meet environmental targets within the Water Conservation Areas (WCAs), and meet supplemental water supply demands of the Lower East Coast;
Reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee Estuaries;
Maintain existing level of flood protection.

Operation: Water from Lake Okeechobee is to be pumped into the Lake Aquifer Storage and Recovery (ASR) wells when the climate-based inflow forecast projects that the Lake water level will rise significantly above those levels that are desirable for the Lake littoral zone (15.25 - 14.85 feet NGVD; Figure 1). During the dry season, flow may be made back to the Lake from the ASR wells either when the Lake water level is projected to fall to within three-quarters of a foot of the supply-side management line the same dry season, or below 11.75 feet NGVD the upcoming wet season. During the wet season, flow is allowed from the ASR wells to the Lake when climate-based inflow forecast projects less than 1.5 million acre-feet of inflow during the next 6 months, and the Lake water level is either below 11.75 feet (NGVD) during the current wet season, or is projected to be in supply-side management during the upcoming dry season.

Design: 1000 MGD total: 200, 5-MGD ASR wells and associated infrastructure

Location: Glades and Okeechobee Counties

Assumption and Related Considerations:
1) Current United States Environmental Protection Agency and Florida Department of Environmental Protection regulations require that ASR source water meet primary drinking water standards before injection.
2) ASRs will have an approximate recovery rate of 70%, i.e. 30% of water injected to the deep wells is lost due to transmission (injection and recovery) and storage (mixing with deep aquifer saline water, migration of ASR storage flume) losses.

Component HH- (not included in this Alternative)

Component II3 - Pump Station G-404 Modification

Study Region: Everglades Agricultural Area (EAA)

Map: Refer to Component Map 15

Purpose: Increase the capacity of proposed Everglades Construction Project (ECP) pump station G-404 to improve the hydropattern restoration in the northwest corner of Water Conservation Area 3A (WCA 3A) and increase the amount of water available in the west-central region of WCA 3A to reduce dry out periods.

Operation: Pump the maximum Stormwater Treatment Area (STA) 3/4 treated discharge possible across the Miami Canal from the L-5 borrow canal to the L-4 borrow canal to the northwest corner of WCA 3A. The treated discharge will sheet flow across the northern reach of WCA 3A between the Miami Canal and L-28 and flow down the L-28 Canal through structure S-140. This additional water should improve the hydropattern restoration and reduce the number of dry out periods in the central region of WCA 3A. This diversion of water from the northeast section of WCA 3A should reduce the inundation duration and extreme high water depths in this sector of the water conservation area.

Design: Increase the capacity from 1000 cfs to 2000 cfs on this proposed vertical, axial flow, low head, high capacity pump station (may be slightly resized after further hydraulic analyses).

Location: Confluence of Miami Canal, L-5 Borrow Canal and the L-4 Borrow Canal north of the S-8 Pump Station.
Counties : Palm Beach

Assumption and Related Considerations:
1) Land Availability.
2) Compatibility with proposed G-404 design.
3) Modifications to the L-4 and L-5 borrow canals if needed to increase the conveyance capacities to handle the additional conveyance.
4) Preliminary analyses indicate the pump intake elevation for G-404 and S-8 should be about 8.0 feet NGVD to facilitate water supply deliveries west through G-404 and south through S-8.

Component JJ - (not included in this Alternative)

Component KK4 - Loxahatchee National Wildlife Refuge Internal Canal Structures

Study Region: Water Conservation Areas

Map: This component is not mapped.

Purpose: Improve timing and location of water depths in the Refuge.

Operation: Structures would remain closed except to pass Stormwater Treatment Area (STA) 1 East and STA – 1 West outflow and water supply deliveries.

Design:

(1) L-7 borrow canal structure: 1500 cfs gravity structure at 0.5 foot head.
(2) L-40 borrow canal structure: 1500 cfs gravity structure at 0.5 foot head.

Location: The L-7 structure is located at cell R28C50 in the L-7 borrow canal within the Loxahatchee National Wildlife Refuge. The L-40 structure is located at cell R34C50 in the L-40 borrow canal within the refuge.
Counties: Palm Beach

Assumptions and Related Considerations: STA discharges to the Loxahatchee National Wildlife Refuge are assumed to be of acceptable water quality.

Component LL6 - C-51 Regional Groundwater Aquifer Storage and Recovery

Study Region: Lower East Coast

Map: Refer to Component Map 1

Purpose: This is a regional groundwater aquifer storage and recovery (ASR) system which will capture and store excess water during wet periods and recover the water for utilization during dry periods. The ability to use the recovered water during dry periods will increase regional water resources.

Operation: Water will be captured and stored when water is being discharged out of S-155 to tide. Water will be recovered during dry periods based on canal elevations. Recoverable water is limited to 70 % of injected water.

Design: This component consists of 34 well clusters located along the West Palm Beach Canal (C-51 Canal), each being composed of two (2) surficial aquifer wells and one Upper Floridan aquifer ASR well. The surficial aquifer wells will each have a 2.5 MGD withdrawal capacity and be located in proximity to the canal so that the water withdrawn would result in the interception of water that would otherwise go to tide in wet periods. Each upper Floridan aquifer ASR well will have a capacity of 5 MGD (the total injection and recovery capacity of the ASR system is 170 MGD or about 264 cfs.) Water will be injected when stages in the C-51 Canal are above 8.0 feet NGVD. Water will be retrieved from the ASR wells when canal stages are below 7.8 feet NGVD. Recovered water will be discharged to the C-51 Canal.

Location: Along the C-51 Canal in eastern Palm Beach County east of U.S. Route 441.

Assumption and Related Considerations: It is assumed that groundwater ASR in proximity to the C-51 Canal is permittable without treatment.

Component MM4 - (not included in this Alternative)

Component NN3 - (not included in this Alternative)

Component OO4 - Modification to South Dade Conveyance System in Southern Portion of L-31N and C-111

Study Region: Lower East Coast

Map: This component is not mapped.

Purpose: To improve deliveries to Everglades National Park and decrease potential flood risk in the Lower East Coast Service Area.

Operation: Modify C-111 Canal operations by holding lower canal water levels by increasing pumping frequency.

Design:
S-332D at 500 cfs (consistent with Experimental Program for Water Deliveries to Everglades National Park)
Remove S-332B (consistent with recent C-111 detailed project designs)
Add 100 cfs to S-332C (keep total of S-332 A-D < 1200 cfs)
Remove S-332 pump station
Remove S-332D Tieback Canal which provides flow from C-111 to S-332.

Location: South Dade Conveyance System in Miami-Dade County.

Assumption and Related Considerations:
1) Will not cause adverse impacts to ENP and South Dade Agricultural Lands.
2) This component is dependent on Component FF.

Component PP3 - (not included in this Alternative)

Component QQ6_D13R - Decompartmentalization of Water Conservation Area 3

Study Region: Water Conservation Areas and Everglades National Park

Map: Refer to Component Map 17

Purpose: Remove most flow obstructions to achieve unconstrained or passive flow between Water Conservation Areas 3A and 3B and Northeast Shark River Slough and reestablish the ecological and hydrologic connection between these areas.

Operation: Rain-driven trigger gages in Northwest Shark River Slough similar to Alternative 3. Sheetflow to Everglades National Park (refer to Component H6_D13R for Everglades Rain-Driven Operations).

Design:

Structural Changes:
-Backfill the Miami Canal in Water Conservation Area 3 from the east coast protective levee to one to two miles south of the S-8 pump station to maintain flood discharge capability. Water supply deliveries previously made through the Miami Canal will be delivered through the North New River Canal, and improved US 27 borrow canal (see Component SS).
-Remove the L-68A levees (this feature is outside SFWMM model detail).
-Degrade the L-67C levee and backfill the adjacent borrow canal.
-Backfill the L-67A Canal from Tamiami Trail approximately 7.5 miles north.
-Relocate a single S-349 structure at the downstream end of L-67A Canal (upstream of the S-345 structures).
-Remove the L-29 Levee and Canal (south of WCA-3A and 3B) to restore sheetflow into Everglades National Park.
-Remove the L-28 and L-28 Tieback levees and borrow canals from L-28 Tieback south to L-29.
- Elevate Tamiami Trail (U.S. 41) through the installation of a series of bridges between L-31N and L-28 consist with conveyance capacities determined at I-75 and any increases required due to inflows downstream of I-75 and upstream of Tamiami Trail.
-Remove the S-344, S-343A and B and S-12 structures.
-Construct 8 passive weir structures along the entire length of L-67A to promote sheetflow during high flow conditions and locate the S-345s (component AA3) just downstream of the new termination of L-67A Canal.

Operational Changes:
1) Operate WCA-2A import trigger using only 2A-N gage as the trigger rather than using average of 2A-N and 2A-17 gages.
2) The time series target at 2A-N was truncated at 1.25 ft above and 0.5 ft below land surface elevation.
3) The time series target at 3A-NE was truncated at 1.0 ft above and 0.5 ft below land surface elevation.

4) S-345 operations are now based on triggers at R33C26 and the NESRS-1 and NESRS-2 gages (the 3A-4 gage is no longer used).
5) S-349 structure operations are the same as the S-345's operations.

Location: Within the existing boundaries of the Water Conservation Areas and Everglades National Park in Broward and Miami-Dade County.

Assumption and Related Considerations:
1) Potential increases in hydropatterns in dry areas and decrease in hydropatterns in deep water areas.
2) Tradeoff between water levels and hydroperiods in central and south central Water Conservation Area 3A and Everglades National Park.
3) Additional S-345s are needed to ensure that significant dry season flows into WCA-3B and ultimately Everglades National Park can be achieved.
4) Miccosukee Tribal Lands adjacent to L-29 and Tamiami Trail will not be impacted.

Component RR4 - Flow to Central Water Conservation Area 3A (WCA 3A)

Study Region: Water Conservation Areas

Map: Refer to Component Map 15

Purpose: To increase depths and extend hydroperiods in central WCA 3A.

Operation: Relocate pump station S-140 and distribute flows into central WCA 3A. Pump operation will be driven by target stages at the 3A-4 gage.

Design: Relocate S-140 pump station approximately 8 miles south of its current location and increase the capacity from 1300 cfs to 2000 cfs. A spreader system will be needed to distribute the S-140 discharge via sheetflow.

Location: Within the existing boundaries of the Water Conservation in Broward County.

Assumption and Related Considerations:
1) Potential increases in hydropatterns in dry areas and decrease in hydropatterns in deep water areas.
2) Tradeoff between water levels in indicator regions 18 and 17 in central WCA 3A.
3) May require increased flows from Lake Okeechobee to achieve the desired hydropatterns in central WCA 3A.
4) Spreader mechanism required at the point where flows will be introduced into WCA 3.

Component SS4 - Reroute Miami-Dade County Water Supply Deliveries

Study Region: Everglades Agricultural Area and Lower East Coast

Map Refer to Component Map 11

Purpose: Reroute water supply deliveries made to Miami-Dade County from the Miami and Tamiami Canals and Water Conservation Area 3 (WCA 3) to the North New River Canal due to the backfilling of the Miami Canal as part of the decompartmentalization of WCA 3.

Operation: Send water supply deliveries from Lake Okeechobee to Miami-Dade County southeast through the North New River Canal in the Everglades Agricultural Area (EAA) (L-20, L-19, L-18) to S-150. From S-150 send deliveries into L-38W and at the southern terminus of L-38W south through a 1500 cfs pump to the borrow canal along the west side of US 27.

Design:
Double the capacity of the North New River Canal south of the proposed EAA Storage Reservoir (see Component G3) to convey additional water supply deliveries to Miami-Dade County as necessary.
Double the capacity of S-351 and S-150 to pass additional water supply deliveries to Miami-Dade County as necessary.
Improve conveyance in the borrow canal on the west side of US 27 between L-38W and the Miami Canal as necessary to pass the additional flows.
Pump intake at S-7 lowered to elevation 8.0 feet NGVD.

Location: EAA and Water Conservation Area 3 in Palm Beach, Broward, and Miami-Dade County.

Assumption and Related Considerations: Operational flexibility is reduced since there is only one delivery route to Miami-Dade County (back-up routes have been eliminated).

Component TT4 - (not included in this Alternative)

Component UU6_D13R - C-23, C-24, 25 and Northfork and Southfork Basins Storage Reservoirs

Study Region: Upper East Coast

Map: This component is not mapped due to uncertainty in site location.

Purpose: Storage reservoirs to capture local runoff from the C-23, 24, 25, and Northfork and Southfork Basins of the St. Lucie River Estuary. The reservoirs will be designed for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. There is one reservoir in each basin.

Operation:
Inflows from C-23, C-24, C-25, and Northfork and Southfork of the St. Lucie River.

Design:
A total of 39,000 acres at 8 feet maximum depth distributed as follows among these basins: C-23 – 8,400 acres, C-24 – 6,000 acres, C-25 – 12,800 acres, Northfork – 11,800 acres. In the Southfork Basin storage requirements were met using 9,350 acres inundated to a depth of 4 feet.

Inflow pump capacity = 1.0 to 1.5 inches per day
Outflow structure capacity = TBD (initially assumed to not constrain performance)

Location: To be determined – Specific site not necessary for Water Management Model simulation. Conceptually located in Martin and St. Lucie Counties.

Assumption and Related Considerations:
(1) Uncertainty in land availability
(2) Potential water quality benefits by reducing nutrient and sediment loading to the estuary

Component VV6 - Palm Beach County Agricultural Reserve Reservoir

Study Region: Lower East Coast

Map: Refer to Component Map 12

Purpose: Supplement water supply deliveries to central and southern Palm Beach County by capturing and storing water currently discharge to tide. These supplemental deliveries will reduce demands on Lake Okeechobee and the Water Conservation Areas.

Operation: The reservoir will be filled during the wet-season from excess water pumped out of the western portions of the Lake Worth Drainage District (LWDD) (backpumped). Water will be released back to LWDD to maintain canal stages during the dry-season. As with the base cases and the previous alternatives, regional water will be supplied to the LWDD when water level fall below 15.8’

NGVD. Water will be back pumped into the reservoir when water levels are above 16.0 feet NGVD.

Aquifer Storage and Recovery (ASR) capacity was added in Alternative 5 to improve supply during dry seasons and droughts. Fifteen (15), 5-MGD capacity ASR wells (total injection and recovery capacity 75 MGD or about 116 cfs) were added. Water will be injected when depths in the impoundment are above 1 foot. The source of water to be injected is surficial ground water adjacent to the reservoir. Water will be supplied from the reservoir before tapping water from ASR systems. Specifically, the water supplied from the reservoir will be maximized (up to the outflow capacity) before water is supplied from ASR storage.

Design:
1660 acres with a maximum depth of 12 feet (volume of 19920 acre-feet)
Inflow pump capacity = 500 cfs (provided by two 250 cfs pumps)
Outflow structure capacity = 500 cfs @ 4 feet head
Emergency outflow structure = 300 cfs

Location: The western portion of central Palm Beach County.

Assumption and Related Considerations:
1) Excess storage could be discharged to the LWDD during off peak times.
2) Canal conveyance improvements for two secondary canals LWDD's E-1 to the E-2.
3) No operation changes in the LWDD.

Component WW5 - C-111N Spreader Canal

Study Region: Lower East Coast

Map: Refer to Component Map 13

Purpose: To reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Miami-Dade area.

Operation: Water is pumped from C-111 and C-111E into a Stormwater Treatment Area (STA) prior to pumping through S-332E into C-111N Canal to Southern Glades and Model Lands. S-197 and S-18C are removed and C-111 is backfilled.

Design:
Increase S-332E to 500 cfs from 50 cfs (pump when available)
Relocate C-111N to SW theoretical 440th street (approximately 1 section north)
Culvert under US 1

Culvert under Card Sound Road
Canal through triangle area of Model Lands, east of Card Sound Road
Fill in C-111 Canal south of confluence with C-111N to S-197
Remove levees and access roads
Completely backfill C-110
Create STA in triangle land between C-111 and C-111E Canals to clean water prior to putting in Model Lands

Location: South Dade Conveyance System in Miami-Dade County.

Assumption and Related Considerations:
1) Will not cause adverse impacts to South Miami-Dade Agricultural and Urban Lands.
2) Assume clean water from C-111 and C-111E

Component XX6 - North Lake Belt Storage Area

Study Region: Lower East Coast

Map: Refer to Component Map 6A

Purpose: The North Lake Belt Storage Area (NLBSA) is an in-ground reservoir to capture a portion of runoff from C-6, western C-11 and C-9 Basins. The in-ground reservoir, with perimeter seepage barrier, will allow storage of untreated runoff without concerns of ground water contamination. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals and to provide deliveries to Biscayne Bay to aid in meeting salinity targets.

Operation: Inflows from C-6 (west of the turnpike), western C-11, and C-9 Basin runoff are pumped and gravity fed into the in-ground reservoir. Inflow ceases when stages reach ~5.0 feet NGVD (0 feet above adjacent land elevation).

Outflows for water supply are pumped to the C-9 Storm Water Treatment Area (STA)/Impoundment prior to delivery to the C-9, C-6, C-7, C-4 and C-2 Canals.

Water from the reservoir can be withdrawn down to a stage of -15 feet NGVD (up to 20 feet of working storage & maximum head on seepage barrier).

Prioritization of outflows: If water levels in NLBSA are from between +5.0 feet NGVD and 0.0 feet NGVD flows will be discharged to Biscayne Bay via the C-2 Canal. If water levels in NLBSA are from between –10 feet NGVD and 0.0 feet NGVD flows will be discharged to C-9, C-6, C-7, C-4 and C-2 Canals only to prevent salt water intrusion. If water levels in NLBSA drop to levels between –15 feet

NGVD and -10.0 feet NGVD flows will be limited to discharge to the C-9 Canals only to avoid water shortage restrictions.

The storage area is 4500 acres to capture runoff from C-6, C-9 and C-11 basins. (Note: SFWMM simulation assumes 5120 acres of surface area. To simulate equivalent working storage volumes, the simulated water levels are higher from those prescribed here.)

Design:
Reservoir: 4500 acres with subterranean seepage barrier around perimeter to enable drawdown during dry periods, prevent seepage and to prevent water quality impacts. The component also includes 1250 acres of stormwater treatment area.

Inflow Structures:
2500 cfs gravity structure @ 0.5 feet head, from C-11W
600 cfs pump from C-9
300 cfs pump from C-6 west of divide structure
Outflow Structures:1000 cfs pump to C-9 STA/Impoundment for treatment prior to deliveries to C-6, C-7, C-2, C-4 and C-9 to prevent saltwater intrusion in coastal canals. (Stormwater Treatment Area detention time requirements need to be addressed. Pretreatment in reservoir may reduce size requirements of treatment area).

Canal: 800 cfs canal capacity - Water supply discharges are routed to C-4/C-2 via a canal to be located east of the Snapper Creek Canal (Northwest wellfield protection canal system).
2-1400 cfs delivery structures, one each at the new canal's confluence with C-6 and C-4.

Location: Reservoir would be located within the area proposed for rock mining by the Lake Belt Issue Team. It would be sited north of Miami Canal (C-6) and south of the C-9 Canal to minimize impacts to the Northwest Wellfield in Miami-Dade County.

Assumption and Related Considerations:
1) No adverse effect of a subterranean wall on Miami-Dade County's Northwest Wellfield.
2) Treatment facility needed if stored water is backpumped to the Everglades.
3) All water quality considerations will be addressed regarding releases from the reservoir to the water supply wellfields.
4) Impacts on the cone of influence of the Northwest Wellfield and its effect on wetland mitigation around the wellfield.
5) Limestone Filter Treatment system within the Reservoir may be developed through use of compartmentalization of rockmining excavation pattern.

6) Telemetry systems will be required for all operable structures and pump stations.
7) Any specific water quality considerations regarding capture of C-6 Basin runoff will be addressed during the detailed design stage.

Component YY4 - Divert WCA2 flows to Central Lake Belt Storage

Study Region: Lower East Coast

Map: Refer to Component Map 11

Purpose: Capture excess in Water Conservation Area 2B (WCA 2B) to reduce stages above desired target levels in Water Conservation Area 2B and to divert water through improved L-37 and L-33 Borrow Canals to 1) Northeast Shark River Slough (NESRS) to meet targets or 2) Central Lake Belt Storage Area.

Operation: Surface water in WCA 2B above NSM will overflow through 3 structures along L-35 and L-35A to North New River Canal along with seepage from WCA 2B and pumped to L-37. North New River Canal, L-37 and L-33 Borrow Canals will be improved to accept this additional flow along with the seepage collected from WCA 3. This water will be pumped to Northeast Shark River Slough (NESRS) if the Slough is below target levels or into a lined reservoir south of the confluence of L-33 and the C-6 Canal referred to as the Central Lake Belt Storage Area (CLBSA). SEE COMPONENT S.

Design:
3- diversion structures with 120 cfs capacity @0.5 feet of head and 350 cfs capacity @4.0 feet of head along the southern perimeter of WCA 2B.
Intermediate 1500 cfs pump station to divert overflow and seepage from North New River to L-37.
Inverted siphon with 1500 cfs capacity to pass water supply deliveries from L-38 borrow canal to US 27 West borrow canal.
Improved conveyance of L-37 and L-33 to 3000 cfs to handle WCA 2B flows plus seepage from WCA 3.
Remove S-9XN and S-9XS or improve structures to accommodate increased flows.

Location: The overflow structures are located along the southern levee of WCA 2B. L-37 and L-33 borrow canal improvements are located east of the Protective levees and 0.5 miles west of US 27 between North New River Canal and the Miami Canal in Broward County.

Assumption and Related Considerations:
1) Prioritization of use of Central Lake Belt Storage Area water.
2) Telemetry systems will be required for all operable structures and pump stations

Component ZZ5 - Divert WCA 3 flows to Central Lake Belt Storage Area

Map: Refer to Component Map 6

Study Region: Lower East Coast

Purpose: Capture excess in Water Conservation Area 3A (WCA 3A) and WCA 3B to reduce stages above target stages in Water Conservation Area 3 and to divert water through modified structures at S-9 and S-31 to Central Lake Belt Storage Area via the L-33 borrow canal.

Operation: When surface water in WCA 3B exceeds target depths by 0.10 feet it will be diverted to the Central Lake Belt Storage Area via L-33. When surface water in WCA 3A near S-9 exceeds target depths by 1.0 foot, water will be diverted to the Central Lake Belt Storage Area via L-33.

Design:
Outflow Structures - 500 cfs structure @ 2.0 feet of head (new structure) at S-9 (WCA 3A).
700 cfs structure (modify existing S-31 if necessary) (WCA 3B)

Location: The eastern levees of WCA 3.
Counties: Broward and Miami-Dade

Assumption and Related Considerations:
1) Prioritization of use of Central Lake Belt Storage Area water.
2) Telemetry systems will be required for all operable structures and pump stations

Component AAA6 - Lower East Coast Water Conservation

Study Region: Lower East Coast Service Areas

Map: This component is not mapped.

Purpose: The purpose of this component is to reduce the public water supply demands through the full implementation of the South Florida Water Management District's (SFWMD) current mandatory water conservation program. The regional affect from the implementation of water conservation would include greater efficiency of the water utilized by the public water supply utilities and a year round reduction of the volume of water delivered from the regional water resource facilities to recharge coastal canals and wellfields.

Operation: On average, a six percent reduction in the projected 2050 withdrawals will be applied to each service area uniformly over each month of the simulation period. The percentage reduction will be based on the anticipated water conservation measures for each of the service areas.

Design: The current mandatory water conservation program of the SFWMD was applied throughout the service area to the public water supply demand projections using the Institute for Water Resources-Main (IWR-Main) forecasts. The percentage reduction is a result of the conversion of residential end users to ultra-low flow fixtures and daytime restrictions on lawn watering throughout the service areas, both practices are required by existing regulations. The percentage of the population using water-conserving fixtures is increased thereby reducing public water supply demands when compared to the 2050 Base. The percentage reduction is calculated from the 2050 Base that contains a moderate application of conservation techniques. The reduction applied in this component assumes full implementation of the District's water conservation program as predicted by IWR-Main.

The 2050 Base utility demands in the Lower East Coast Service Area were reduced by six percent on average in this Alternative.

Location: Lower East Coast in Palm Beach, Broward and Miami-Dade County.

Assumption and Related Considerations:
1) Water conservation measures apply to all sources of water. It is most likely that demands met by reuse water would not be affected by restrictions in irrigation.

Component BBB6 - South Miami-Dade County

Study Region: Lower East Coast

Map: Refer to Component Map 14

Purpose: The existing South District Wastewater Treatment Plant (SDRWTP) located north of the C-1 Canal will provide wastewater treatment coupled with superior treatment technology to supply reclaimed water to the South Biscayne Bay and Coastal Wetlands Enhancement (SBBCWE) Project. The water will be provided throughout the year to augment water supply to the SBBCWE upon demand. This supplemental water will restore overland flow in the coastal area and recharge groundwater to enhance groundwater discharge to Biscayne Bay. Saltwater intrusion benefits to the southern part of Miami-Dade County are anticipated.

Operation: The SDRWTP with superior treatment technology will be operated when the additional water is needed to supply the SBBCWE. When water is not needed, the SDRWTP will stop treatment beyond secondary treatment standards and will dispose of the secondary treated effluent into the existing deep injection wells.

Design: The SDRWTP will be designed to add on pretreatment and membrane treatment system to the existing secondary treatment facility. The plant will have a capacity of 131 MGD. It is anticipated that phosphorus will be the constituent of concern in the reclaimed water. Therefore, the treatment will be designed to remove total phosphorous to acceptable levels.

The SDRWTP will be located at, or in the vicinity of, the existing SDRWTP. The reclaimed water will be discharged to the C-1 Canal (Black Creek), upstream of S-21A, and then delivered southward towards the C-102 and C-103 Canals, and northward towards the C-100 Canal. The wastewater treatment facility will provide advanced treated water to L-31E. Flow southward in L-31E towards C-102 and C-103 shall be 202 acre-feet per day. Flow northward in L-31E towards C-100 shall be 200 acre-feet per day (through a canal extension). The combined inflow into L-31E shall be 402 acre-feet per day for every day of the simulation. Flows will reach C-102 and C-100 via modifications to L-31E as shown on Component Map 14. Operation of C-102 and C-103 shall be contingent upon Component FFF5.

Location: Miami-Dade County

Assumptions and other considerations:
1) The reuse facility uses advanced treatment resulting in water quality acceptable to the Bay.
2) No adverse impacts to adjacent agricultural or urban areas.
3) Discharge capacity at S-123, S-20F, S-21 and S-21A is sufficient to pass basin runoff and inflows from the reuse facility during storm events.
4) This component is dependent on Component FFF.

Component CCC6 - Big Cypress/L-28 Interceptor Modifications

Study Region: Big Cypress

Map: Refer to Component Map 15

Purpose: Alleviate over drainage in Northeast Big Cypress, Kissimmee Billy and Mullet Slough area and ensure that inflows meet applicable water quality standards.

Operation: Reroute water from West and North Feeder Canals to wetlands in Northeast Big Cypress. Allow flow along the south side of the West Feeder at designated locations and through a new S-190 Pump Station, while maintaining flood protection on Tribal lands and consistency with the Seminole Tribe's Conceptual Water Conservation System master plan. Establish sheetflow south of the West Feeder Canal across the Native Area of the Big Cypress Reservation. Establish sheetflow off the reservation in the Big Cypress National Preserve Addition. Operate pumps for approximate equalization of flows.

Design:
Degrade the levee on the SW side of the L-28 Interceptor Canal below the S-190 structure.
Backfill the L-28 Interceptor Canal at a point south of the Big Cypress Reservation boundary with Big Cypress National Preserve Addition.
Retain levee on NE side of L-28 Interceptor through the Big Cypress Seminole Reservation.
Develop sheetflow along the south side of the West Feeder Canal through three pump stations and spreader canals. The pump station locations shall be adjacent to the discharge points from Water Resource Areas (WRA) 1, 2 and 3 of the Seminole Conceptual Water Conservation System.
Pump station at WRA-1 discharge: 250 cfs
Pump station at WRA-2 discharge: 500 cfs
Pump station at WRA-3 discharge: 750 cfs
Replace S-190 gated structure (existing capacity of 2960 cfs) with a 1460 cfs pump station.
North Feeder stormwater treatment area: 1100 acres at 4-foot maximum depth.
Inflow pump station: 270 cfs
Outflow structure: 100 cfs
West Feeder stormwater treatment area: 800 acres at 4-foot maximum depth.
Inflow pump station: 430 cfs
Outflow structure: 150 cfs

Location: Western Basin, Big Cypress Seminole Reservation, Big Cypress National Preserve Addition in Hendry, Collier, and Broward Counties.

Assumption and Related Considerations:

1) Water quality treatment for runoff entering the West and North Feeder Canals is provided by stormwater treatment areas, if necessary, to meet applicable water quality standards.
2) Design shall be consistent with the Seminole Tribe's Conceptual Water Conservation System master plan.
3) Existing flood protection shall be maintained.
4) Evaluation of flow changes in the area south of the West Feeder Canal and

5) S-190 shall be accomplished by assessing impact on Seminole Tribe's passive use rights.
6) Evaluation of flow changes reflects minimal impact.
7) Component construction occurs after completion of the Seminole Conceptual Water Conservation System.

Component DDD5 - Caloosahatchee Backpumping with Stormwater Treatment Area (STA)

Study Region: Caloosahatchee River

Map: This component is not mapped due to uncertainty of site location

Purpose: Capture excess C-43 Basin runoff to augment the regional system. These facilities will be designed to backpump excess water from C-43 to Lake Okeechobee after treatment through an STA.

Operation: This component operates after estuary and Agricultural/Urban demands have been met in the C-43 Basin and when water levels in the C-43 storage reservoir (Component D5) exceed 6.5 feet. When this situation occurs, water will be released from the reservoir and delivered to the STA at the capacity of the backpumping/treatment system (2000 cfs). The STA water is then backpumped to Lake Okeechobee. An additional requirement for the backpumping to take place is that Lake Okeechobee must be considered to have available storage, i.e. when its levels are below the pulse release zone line shown on Figure 1.

Design: The key components in the design are pumps and a stormwater treatment area. For the design it has been assumed that the STA is located adjacent to Lake Okeechobee. Because it is not known where the reservoir will be located relative to the STA, it has been assumed that water to be delivered to the STA will be released from the reservoir to the Caloosahatchee River and then pumped from the River into the STA. Since no pump to bring water from the lower basin (below S-78) to the upper basin has been included in the reservoir design and since most of the basin runoff is generated in the lower basin, a pump to bring the water from the lower Caloosahatchee Basin to the upper basin has also been included. The STA has been included to meet the anticipated need to improve the quality of the water before it enters Lake Okeechobee. Finally, a pump station will be used to lift the water from the STA to Lake Okeechobee.

Pumps: 1 pump of 2000 cfs capacity to take water from the lower Caloosahatchee Basin to the upper Caloosahatchee Basin; 1 pump of 2000 cfs capacity to take water from the Caloosahatchee River into the STA; and 1 pump of 2000 cfs capacity to discharge water from the STA to Lake Okeechobee.

STA: an STA of approximately 5000 acres is proposed to achieve water quality improvements.

Location(s)TBD - Specific site not necessary for model simulations. Conceptually located in Hendry and Glades Counties.

Assumption and Related Considerations:
1) Uncertainty in land availability.
2) Water quality benefits to the Lake.
3) The Franklin Lock and Dam S-79 time series flow demand for the Caloosahatchee Estuary has been reduced. The Performance Measures were not changed.
4) The model assumes that the backpumping/treatment facility, primarily the STA, functions as a flow-through system.

Component EEE5 - Flows to Eastern Water Conservation Area

Study Region: Water Conservation Areas and Lower East Coast

Map: Refer to Component Map 6 and 11

Purpose: Captured excess surface water and seepage from Water Conservation Area 2B, 3A and 3B in Central Lake Belt Storage Area (CLBSA) delivered to eastern WCA 3B during dryouts.

Operation: Deliveries will be made to maintain 6 inch depths in WCA 3B if NSM hydroperiod indicate WCA 3B water levels should be at or above 6 inches and water is available in CLBSA. Deliveries from CLBSA will occur through a wetland treatment cell and the L-30 borrow canal to a spreader swale system in the eastern areas of WCA 3B.

Design: 500 cfs pump from L-30 to eastern portion of WCA 3B.
Spreader Swale along eastern WCA 3B to convert 500 cfs to sheetflow
Upgrade of 1500 cfs from CLBSA deliveries NESRS to 2000 cfs to accommodate additional flows to WCA 3B (also seen in component S5)

Location: The discharge point from L-30 borrow canal to WCA 3B is at the bend in the canal and is approximately 4.5 miles south of the intersection of the L-30 and the C-6 Canal in Miami-Dade County

Assumption and Related Considerations:
1) Prioritization of use of Central Lake Belt Storage Area water.
2) Telemetry systems will be required for all operable structures and pump stations.

Component FFF5 - Biscayne Bay Coastal Canals

Study Region: Lower East Coast and Biscayne Bay

Map: Refer to Component Map 14

Purpose: Maintain higher stages in C-102 and C-103 for urban and environmental water supply.

Operation: Maintain canal stages in C-102 and C-103 with water provided from local sources. Wet season operation for C-102 between S-21A and S-195 (open at 2.2 feet NGVD, close at 2.0 feet NGVD) and for C-103 between S-20F and S-179 (open at 2.2 feet NGVD, close at 2.0 feet NGVD) will remain unchanged. Dry season operation of C-102, between S-21A and S-195, and C-103 between S-20F and S-179, will both change from opening at 1.4 feet NGVD and closing at 1.2 feet NGVD to opening at 1.6 feet NGVD and closing at 1.5 feet NGVD.
A borrow canal will be constructed west of L-31E which directly connects the downstream reach of C-102 with C-103 to maintain levels in the lower reaches of C-103.

Design: 3.5 mile connection canal

Location: Biscayne Bay Coastal Canals in Miami-Dade County.

Assumption and Related Considerations:
1) Local water source tied to Component BBB5, water reuse.
2) Component simulates overland flow to Biscayne Bay. South Biscayne Bay Coastal Wetlands Components will be included as part of Other Project Elements, since their effect is not measurable with current modeling techniques. The intent of these components is to restore overland flow and groundwater seepage to Biscayne Bay while reducing the frequency of point-source discharges.

Component GGG6 - C-51 and Southern L-8 Reservoir

Study Region: Lower East Coast

Map: Refer to Component Map 16

Purpose: Storage reservoir managed for the environmental and water supply goals listed below:

- Reduce the number of events when discharges to the Lake Worth Lagoon exceed the desired daily average flow rate of 500 cfs.
- Reduce the magnitude of events exceeding the desired flow rate of 500 cfs.

- Reduce the average annual volume discharged to tide (over the S-155 structure) by detaining storm water runoff for subsequent environmental (routing from the West Palm Beach Water Catchment Area to the Northwest Fork of the Loxahatchee River) and water supply needs (providing water to the Lake Worth Drainage District and the West Palm Beach Water Catchment Area).
- Provide increased drainage to the C-51 Basin and the Southern L-8 Basin by lowering the average stages in the C-51 Canal

Operation: The reservoir will be filled, with excess water from the Southern L-8 Basin and the C-51 Basin, when flows over the S155 structure exceed 300 cfs during the wet-season from excess water in C-51 Canal and Southern L-8 (backpumped). Water will be released back to C-51 to help maintain canal stages during the dry-season.

Design:
1200 acres of usable area with a 100-foot deep, 2-foot thick slurry wall for seepage control along the approximate perimeter length of 6 miles (this depth assumes a surficial aquifer thickness of 170 feet, 20 feet of embankment and 10 feet of embedment of the slurry was into the confining layer). The reservoir will have a total storage depth of 40 feet (30 below grade and 10 above grade).
Inflow pump capacity of 1500 cfs at the reservoir.
Emergency outflow structure with a capacity of 1500 cfs when the water level exceeds the maximum operation depth of 40 feet by 2 feet.
Pumped outflow with a maximum rate of 400 cfs at 40 feet and using the discharge schedule shown below.

Depth (feet)	Discharge Rate (cfs)	Storage Volume (acre-feet)
42	1500	50400
41	415	49200
40	400	48000
30	300	36000
20	300	24000
10	300	12000
0	300	0

This component includes a 1000 cfs pump at S-155A, which will be operated when flows through S-155 exceed 300 cfs, and there is capacity in the reservoir.

Location: Immediately west of the L-8 Canal and north of the C-51 Canal in Palm Beach County.

Assumption and Related Considerations:

1) This parcel is owned by Palm Beach Aggregate and is currently an active mining operation with a nominal excavation depth of 40 feet.
2) Slurry wall surrounding perimeter to address seepage and water quality issues due to ancient or connate water with a chloride content of 500 mg/L.
3) The component will include telemetry control and monitoring.

Component HHH6 - West Miami-Dade Reuse

Study Region: Lower East Coast

Map: Refer to Component Map 7

Purpose: The future West Miami-Dade Wastewater Treatment Plant (WDWTP), will be located immediately south of the Bird Drive Recharge Area and east of the relocated L-31 North Protective Levee, will provide wastewater treatment coupled with superior treatment technology to supply reclaimed water to the Bird Drive Recharge Area. The water will be supplied year round as needed to enhance groundwater recharge. Excess water, when available, will be sent as a second priority to the South Dade Conveyance System, to Northeast Shark River Slough as a third priority and to deep injection wells when there are no demands from the three designated priorities.

Operation: The proposed reclaimed water production facility will be operated by Miami-Dade County and has the potential to discharge 100 MGD. As stated previously, the water will be provided to three prioritized demands of 1) Bird Drive Recharge Area, 2) South Dade Conveyance System and 3) Northeast Shark River Slough. When all demands have been met, the WDWTP will stop treatment beyond secondary treatment standards and will dispose of the secondary treated effluent into deep injection wells.

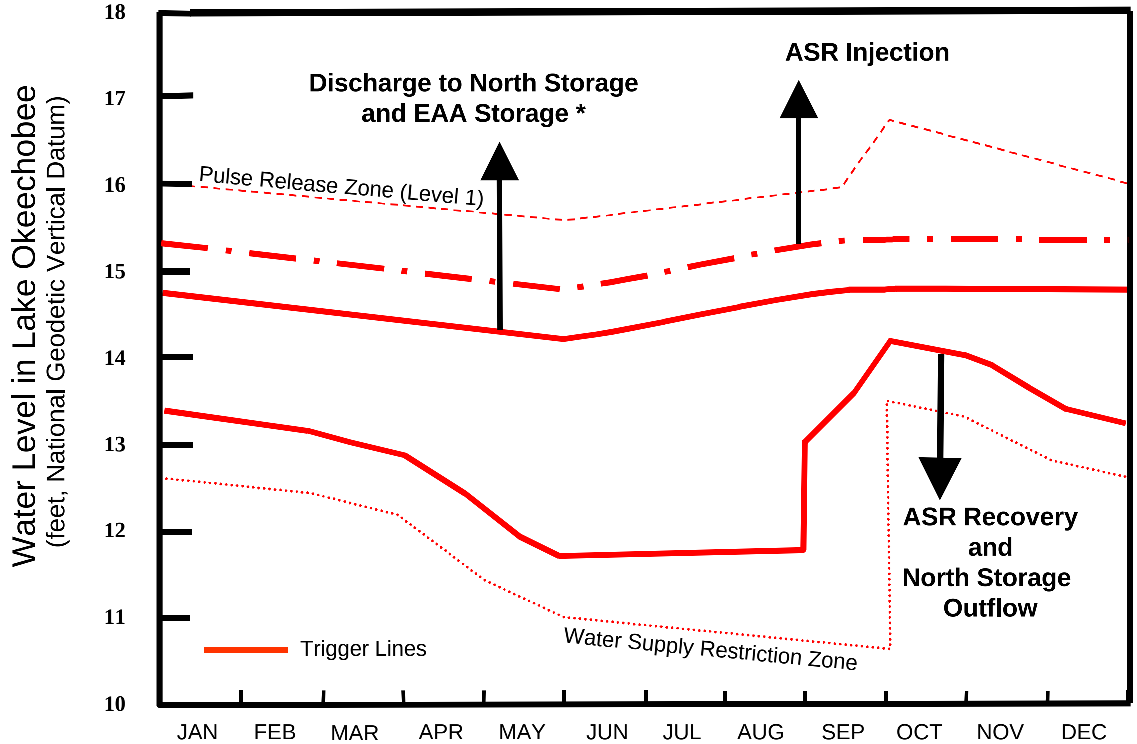
Design: Treatment will be biological nutrient-removal advanced wastewater treatment (AWT) followed by a superior treatment technology using iron salts to lower phosphorus to levels required for Everglades discharges. The iron salt coagulation system would be designed for a constant flow rate of 100 MGD.

The WDWTP will pump superior, advanced treated water to the Bird Drive Recharge Area when the elevation of the Recharge Area is equal to or below 3' above natural ground at a rate of 155 cfs (100 MGD).

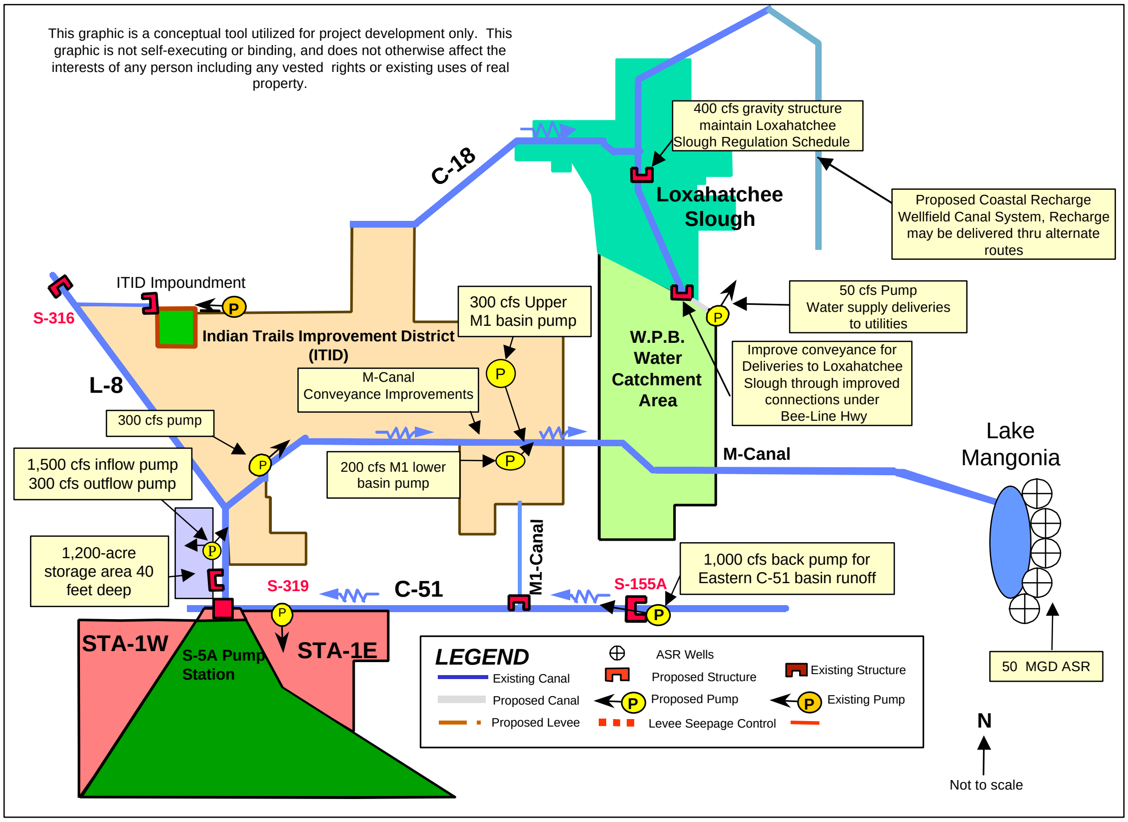
Location: South of the Bird Drive Recharge Area and east of the relocated L-31 North protective levee in Miami-Dade County.

Assumption and Related Considerations: The superior treatment technology will be able to treat the AWT effluent to remove phosphorous and nitrogen to the low levels desired to meet State water quality standards and provide an acceptable water quality for the above priorities.

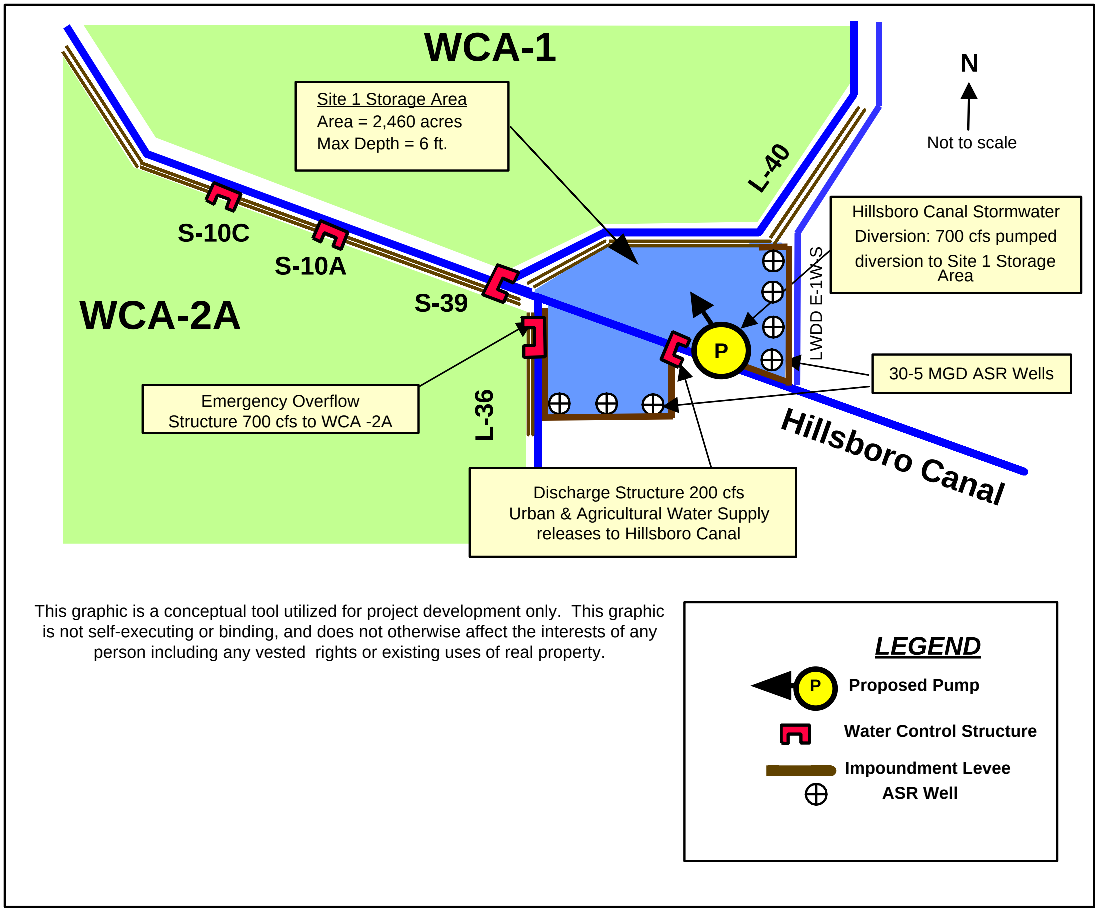
Figure 1. Operation Criteria for Lake Okeechobee and Surrounding Storage Components



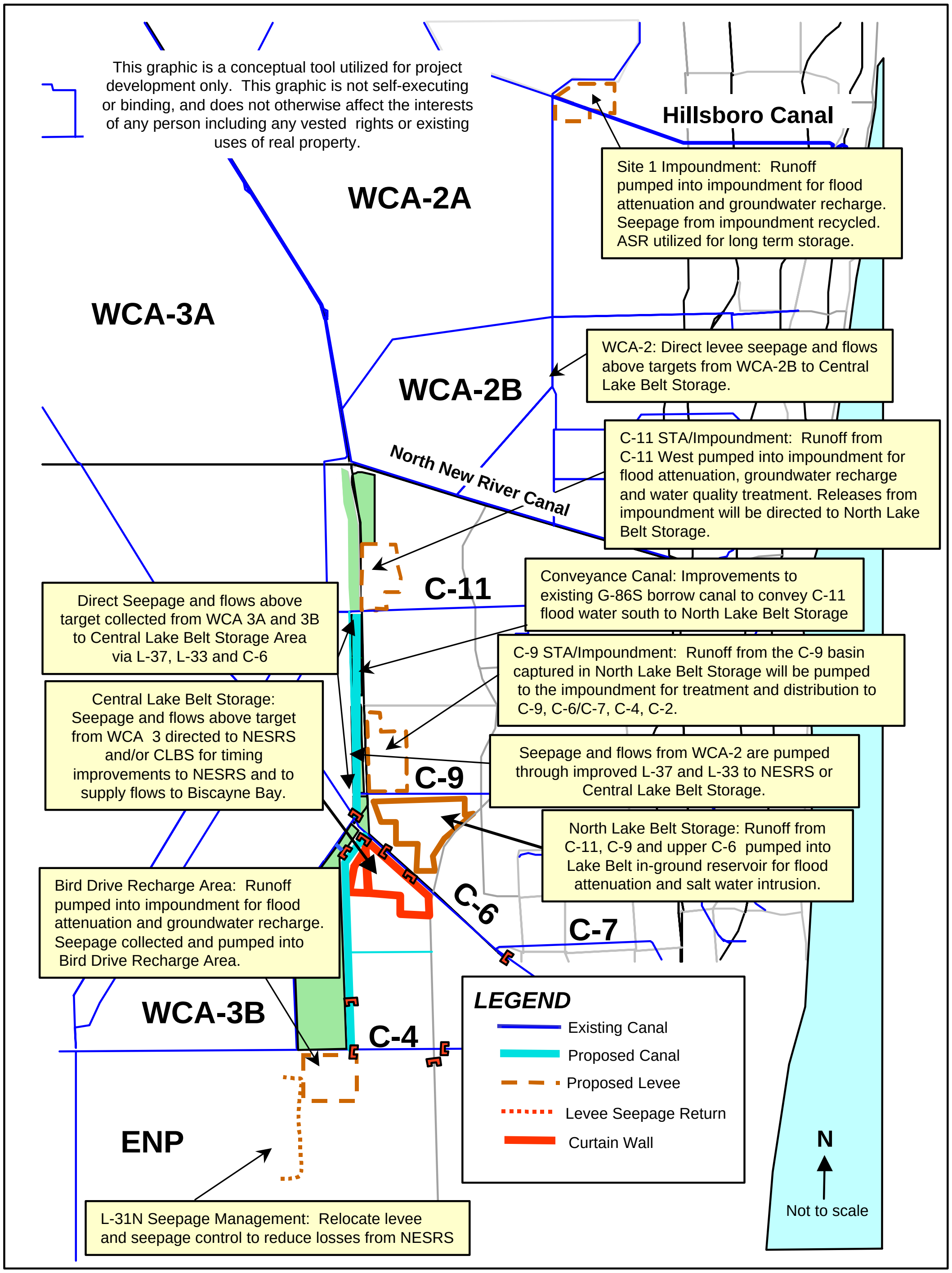
* Discharge to North and EAA Storage if Lake Okeechobee stage is forecasted to be above “Discharge to …Storage” line, or if stage is above Pulse Release Zone (level 1) line.



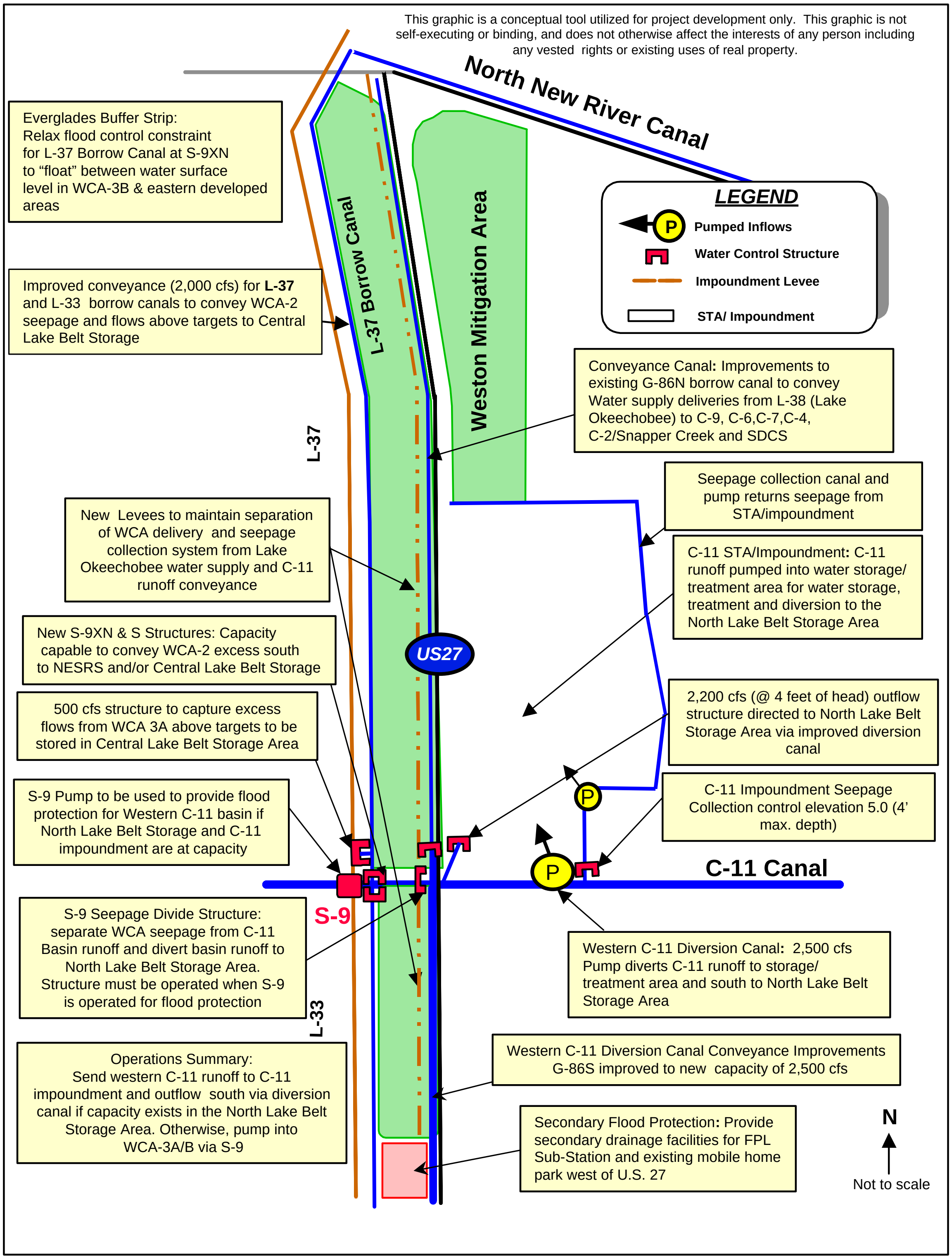
Alternative D13R
Southern L-8 Basin
Component Map 1



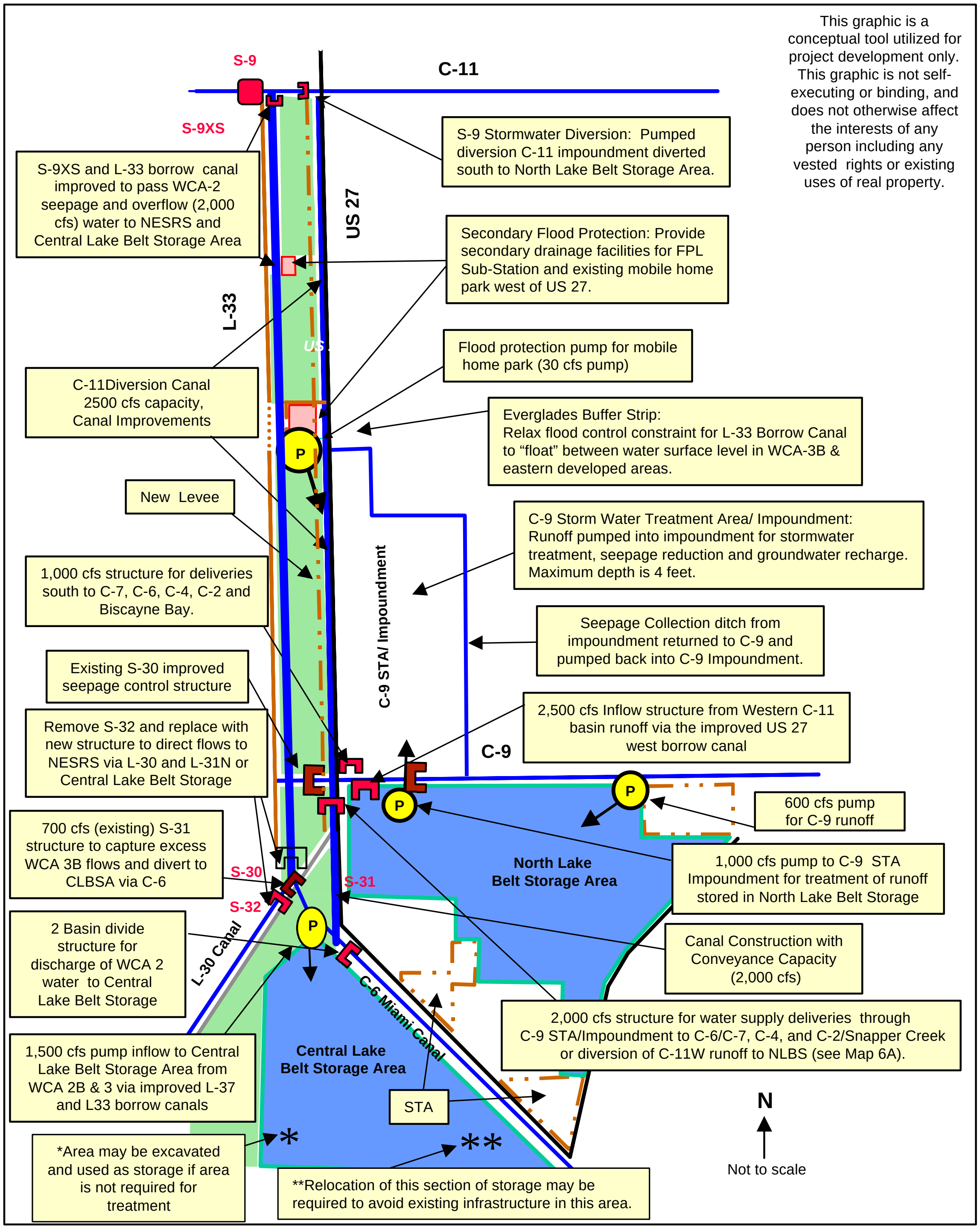
Alternative D13R
Site 1 Impoundment
Component Map 2



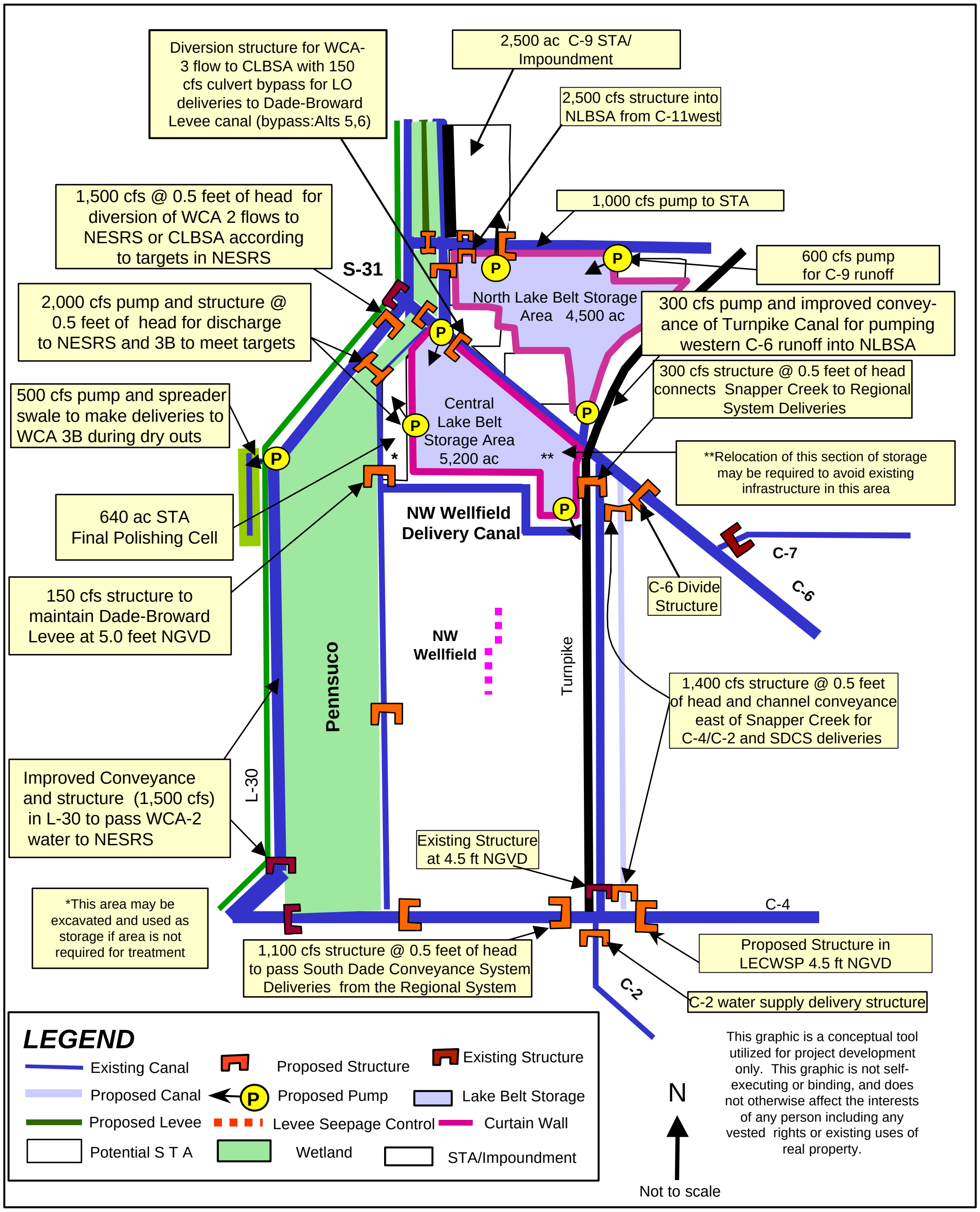
Alternative D13R
General Water Preserve Areas Components
Component Map 3



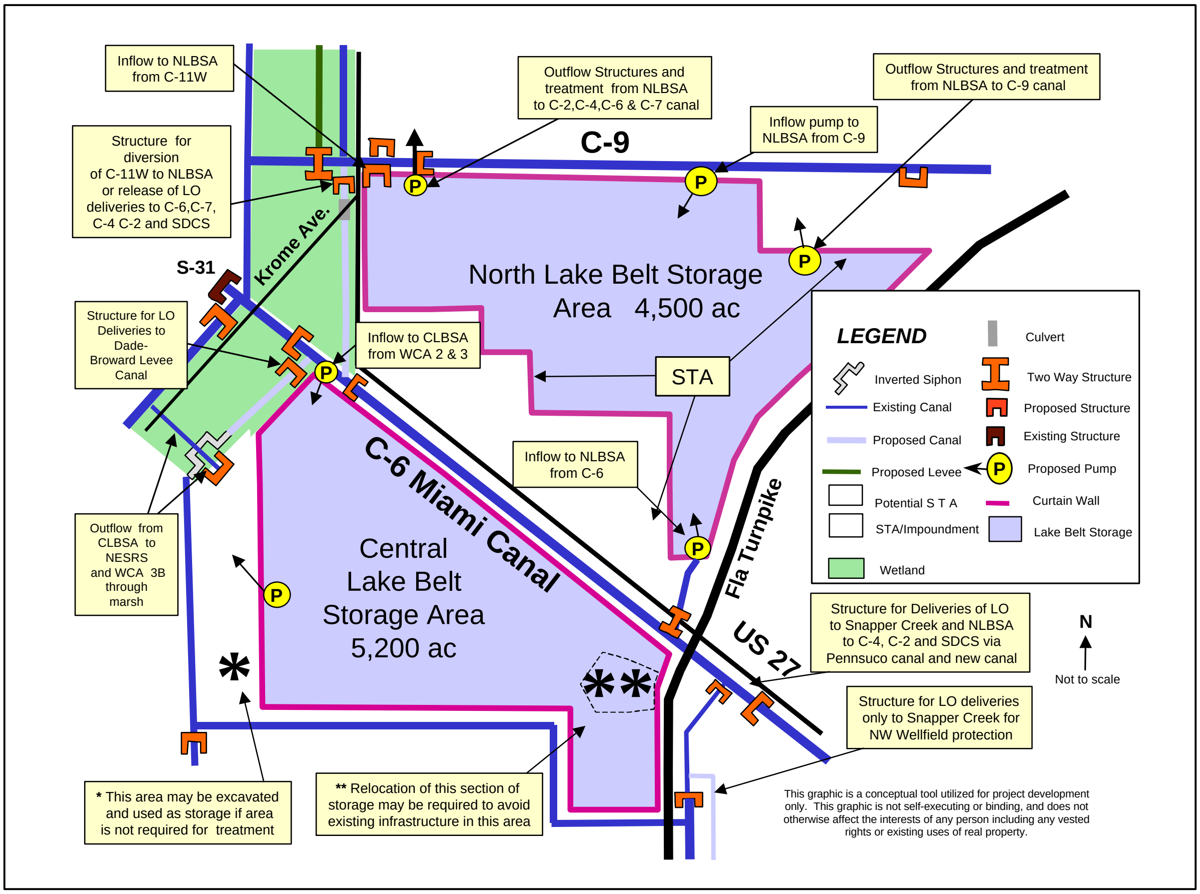
Alternative D13R
Central Broward Area
Component Map 4



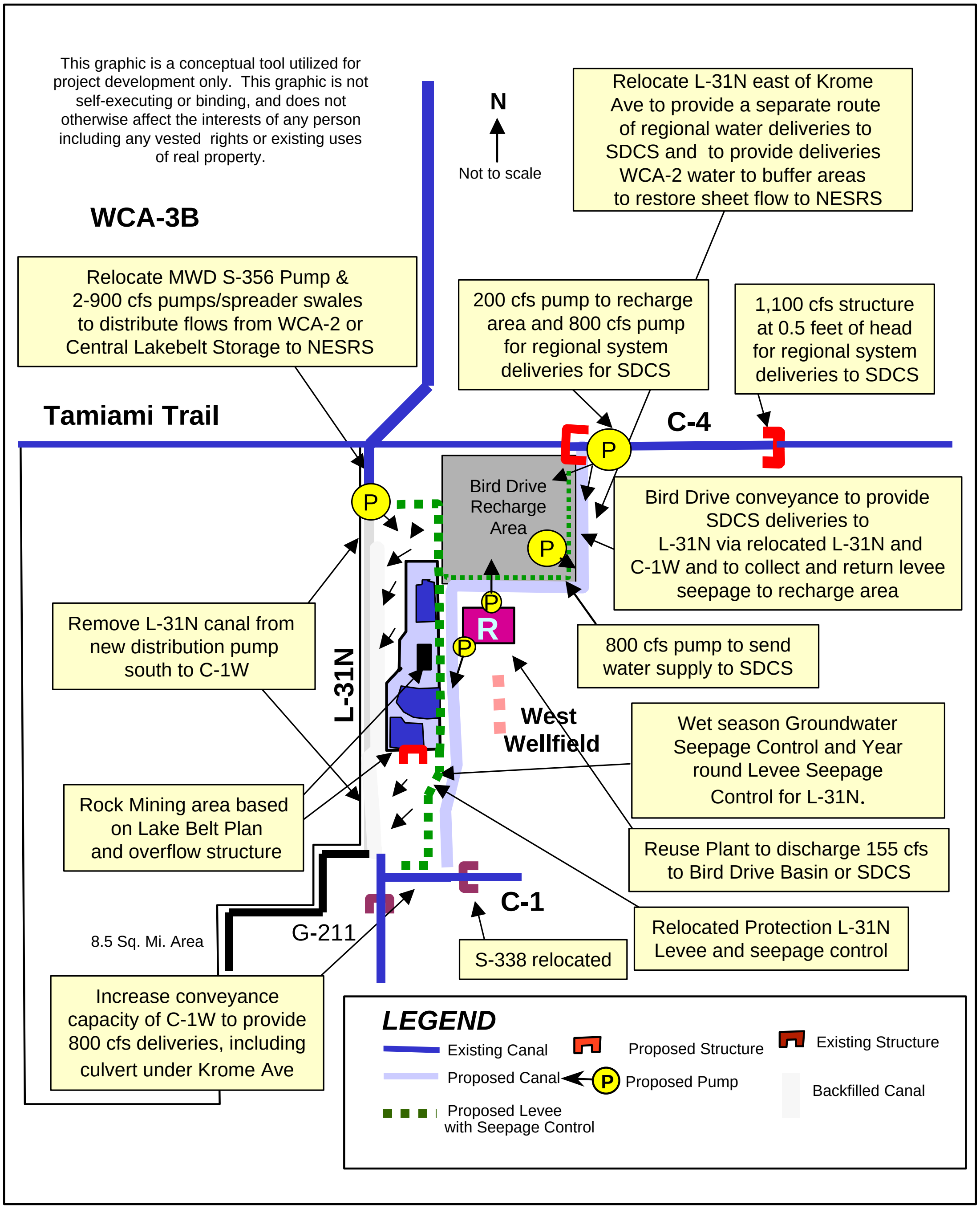
Alternative D13R
Southwest Broward County Area
Component Map 5



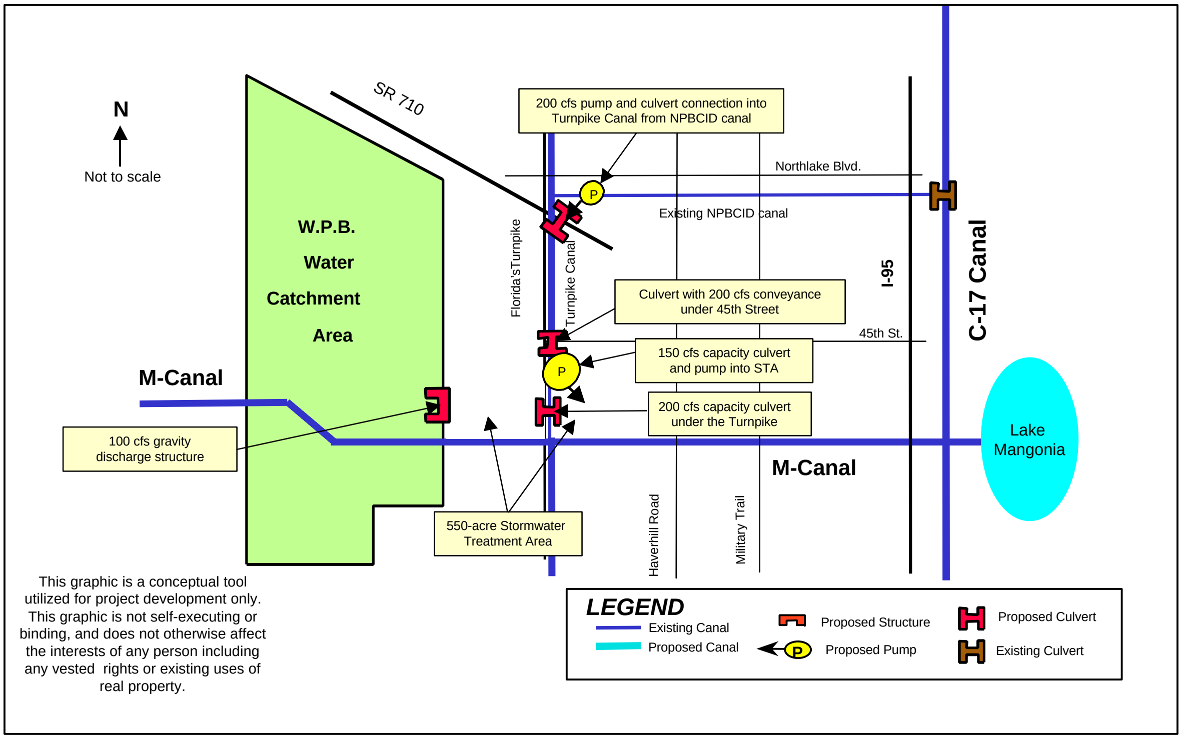
Alternative D13R
North and Central Lake Belt Storage Areas
Component Map 6



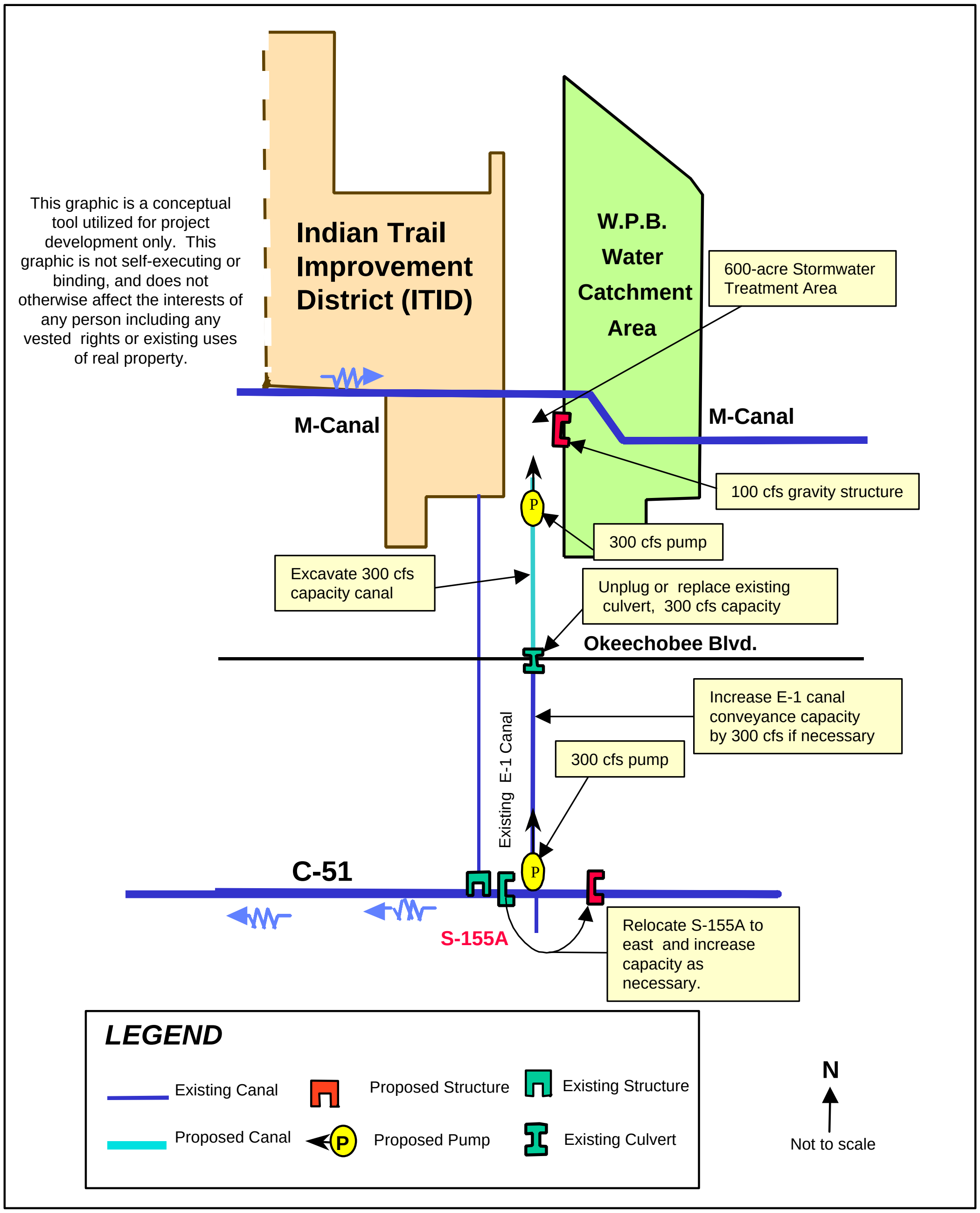
Alternative D13R
Lake Belt Storage Areas
Component Map 6A



Alternative D13R
Bird Drive Basin and L-31N Seepage Management
Component Map 7



Alternative D13R
C-17
Component Map 8



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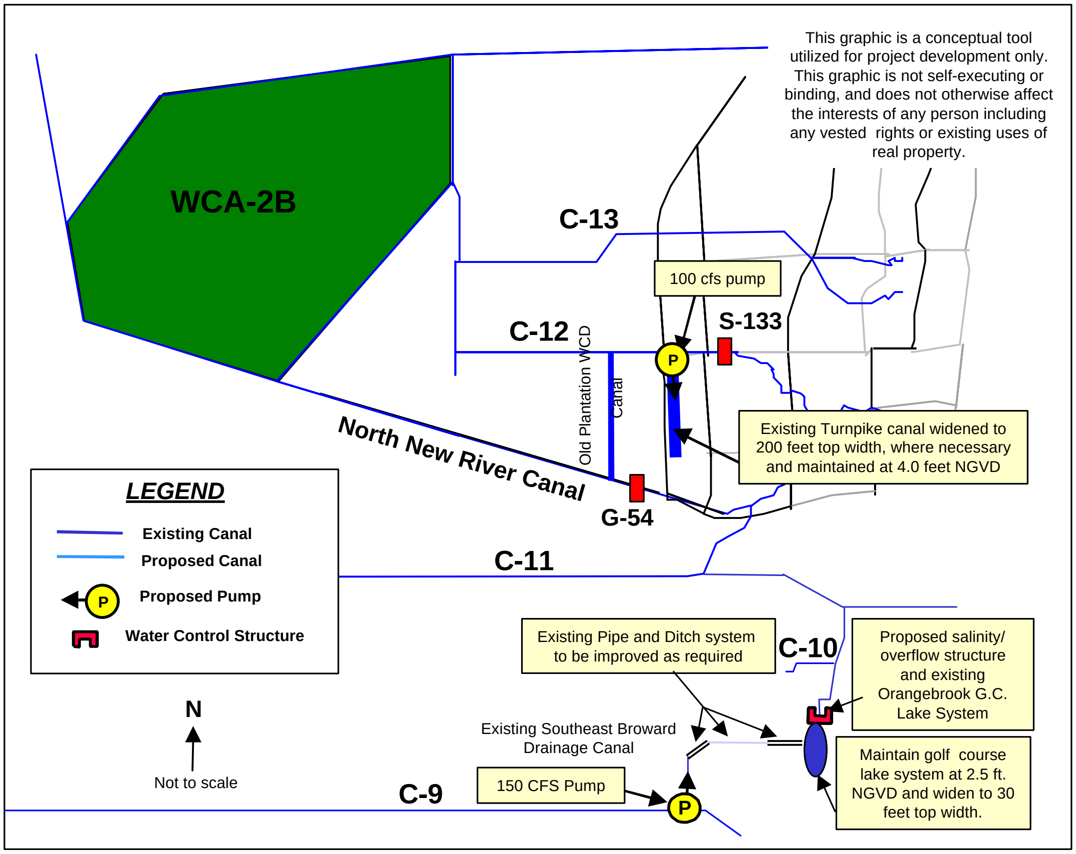

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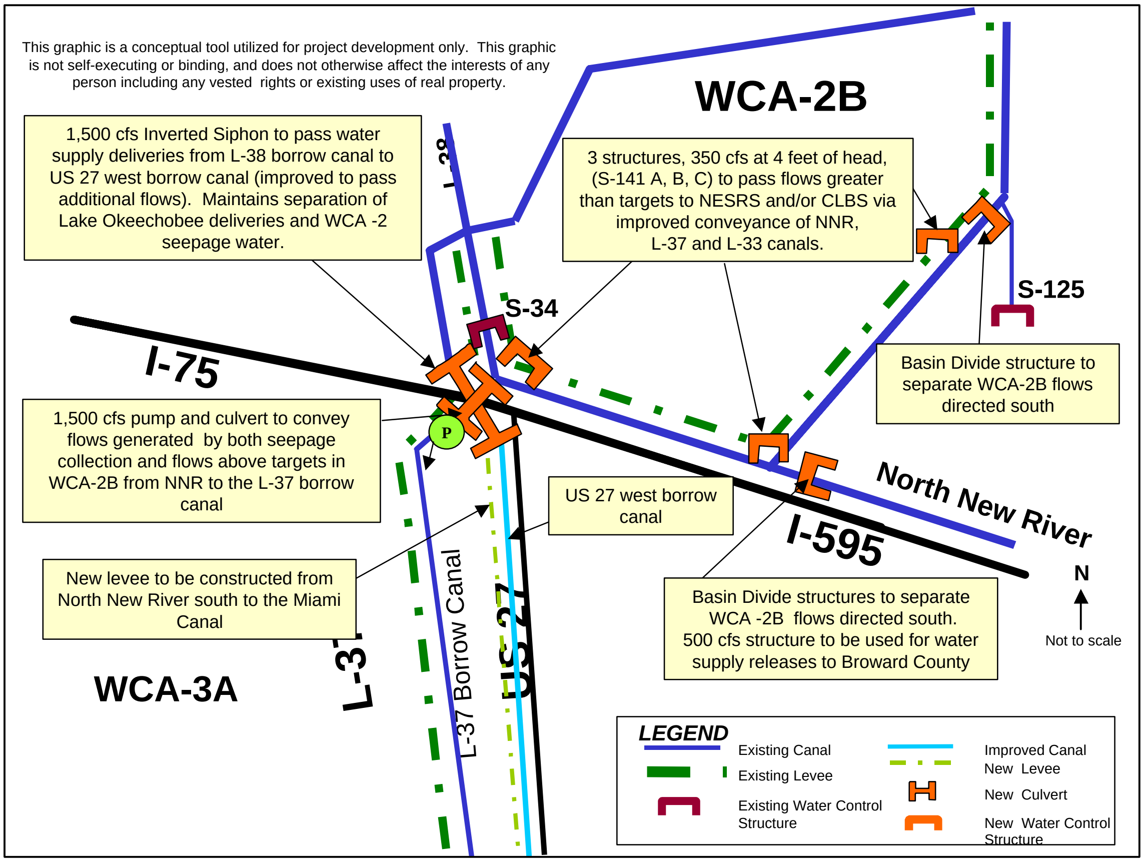

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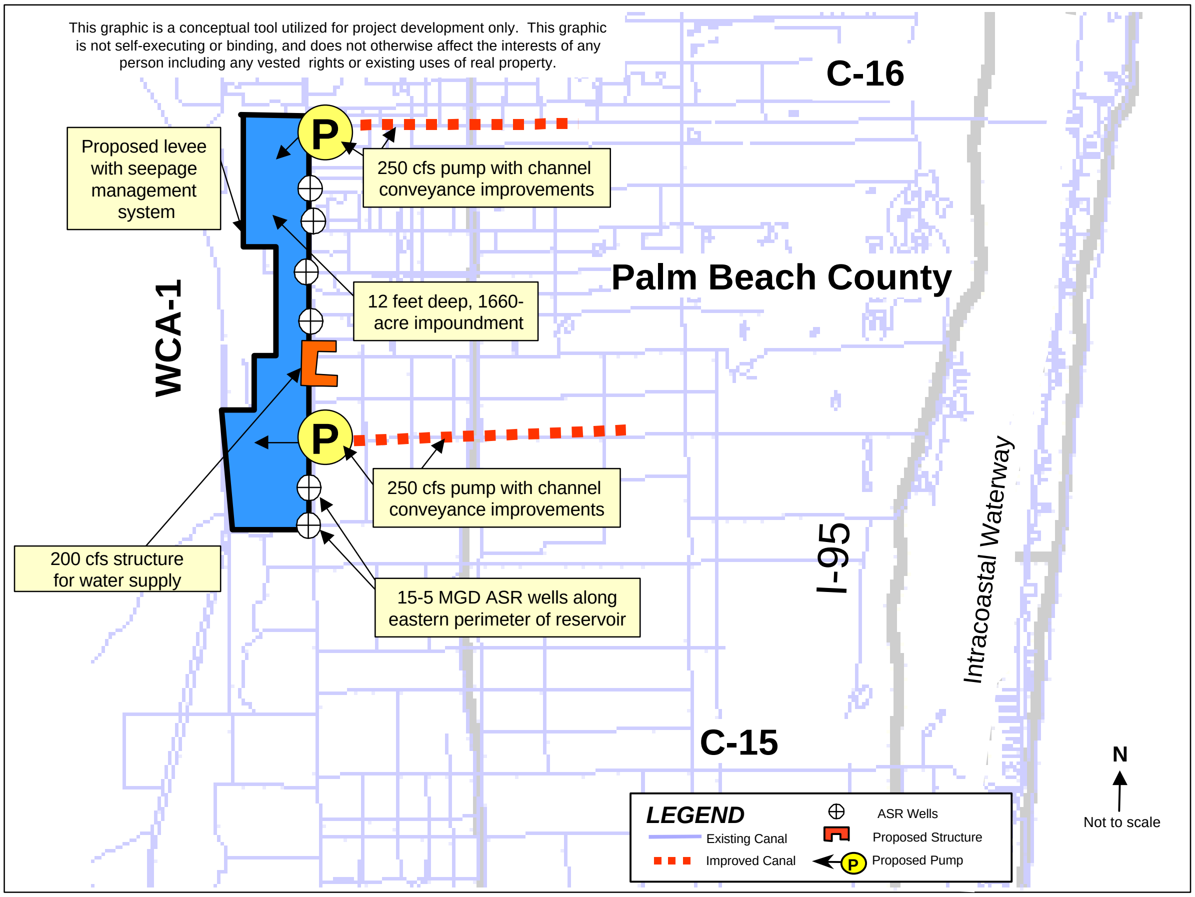

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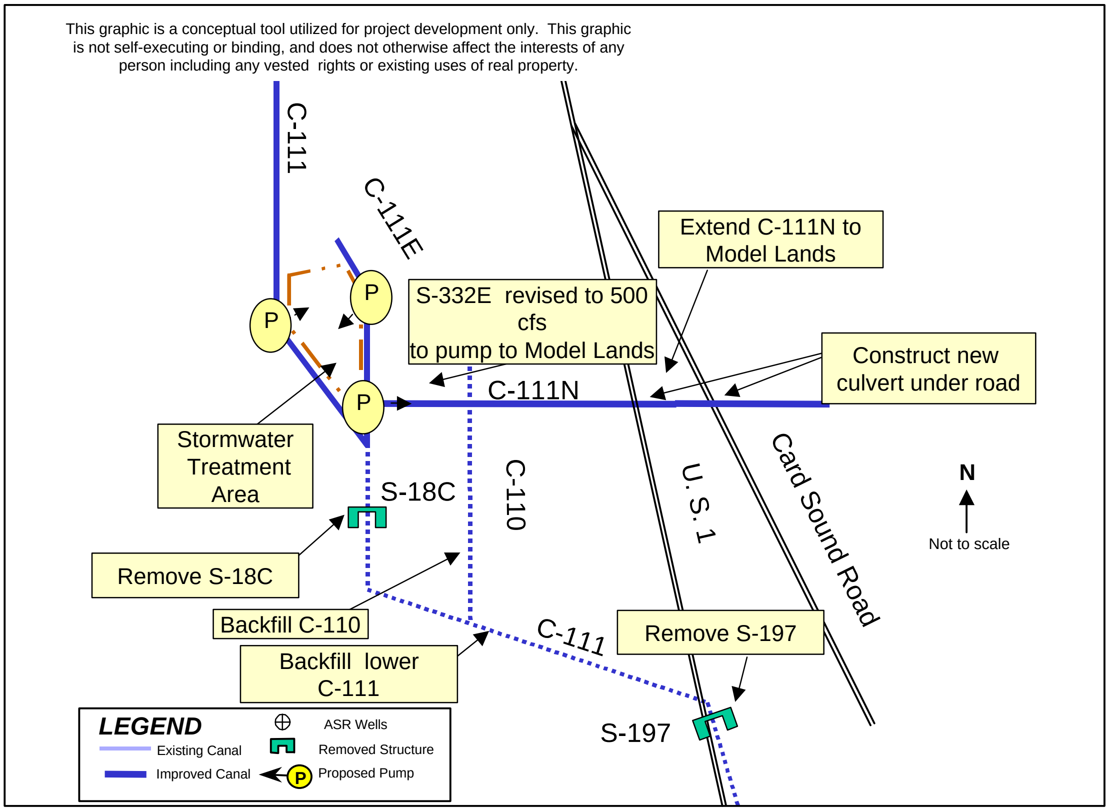

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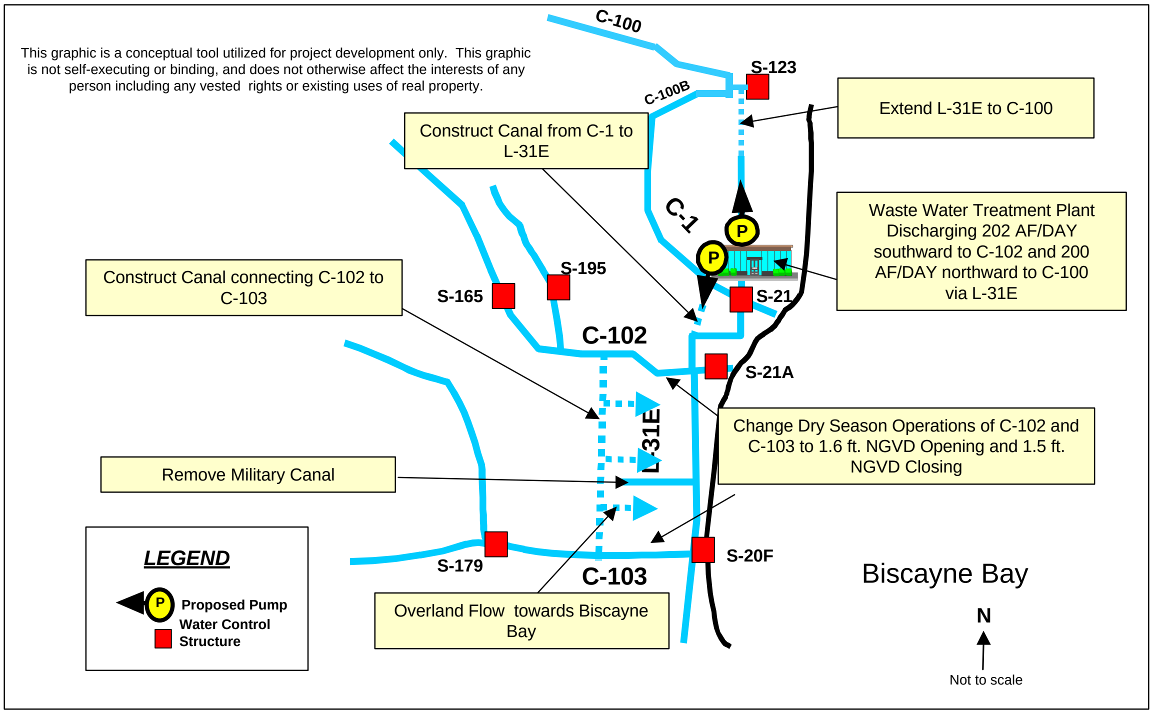

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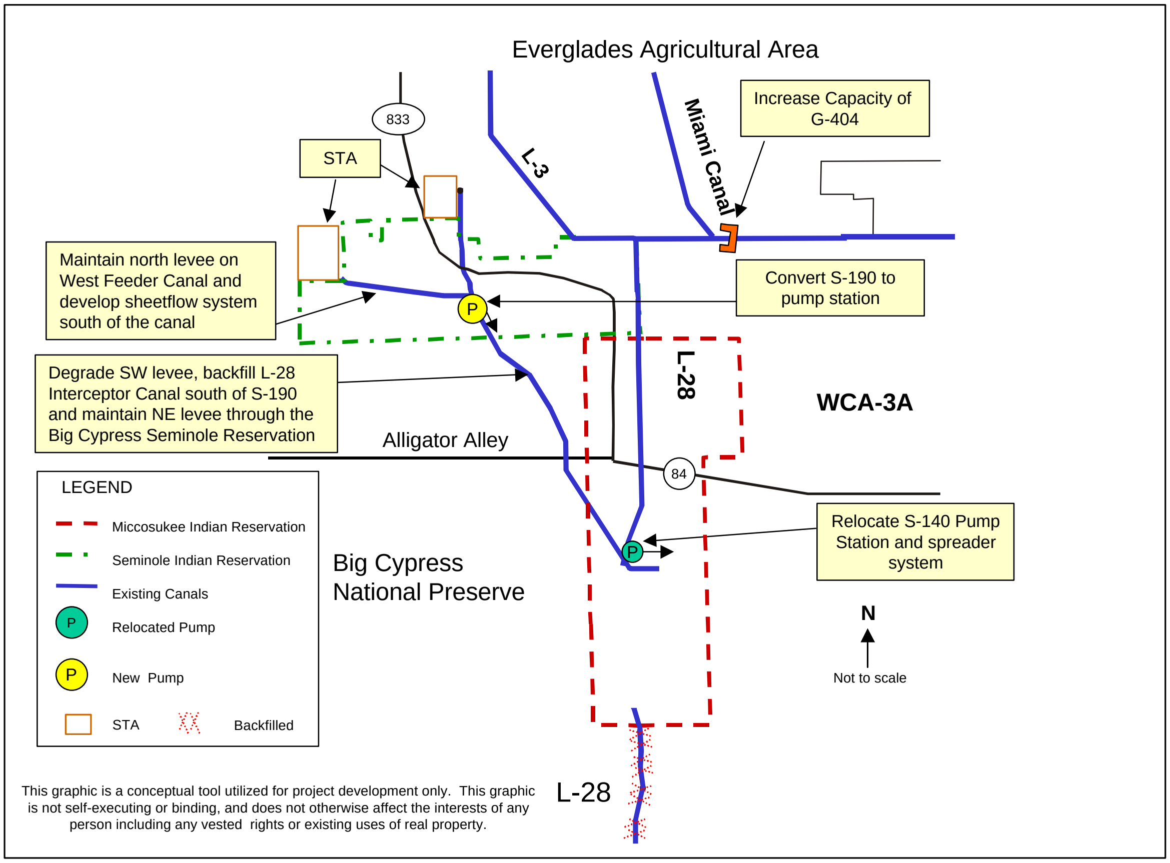

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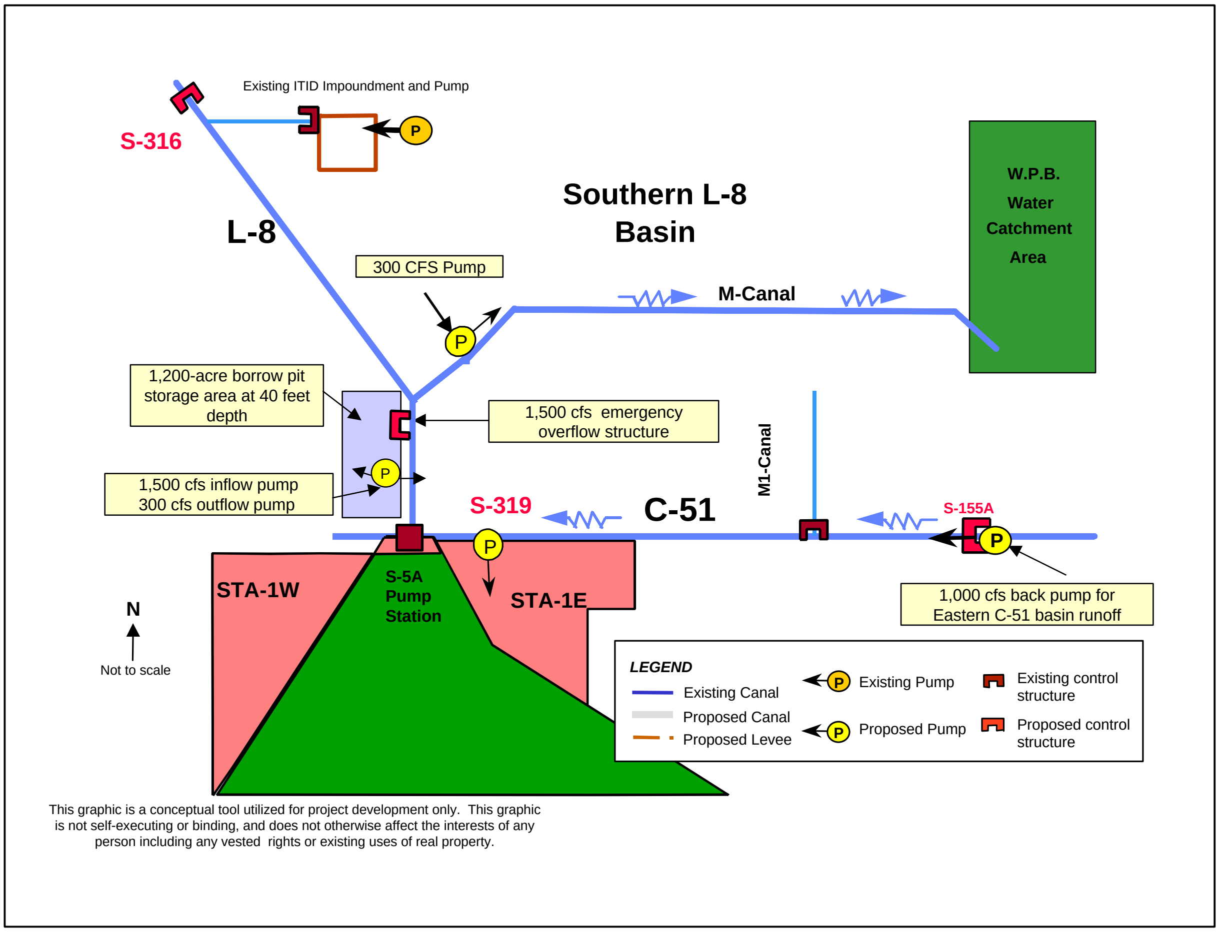
Component Map 15



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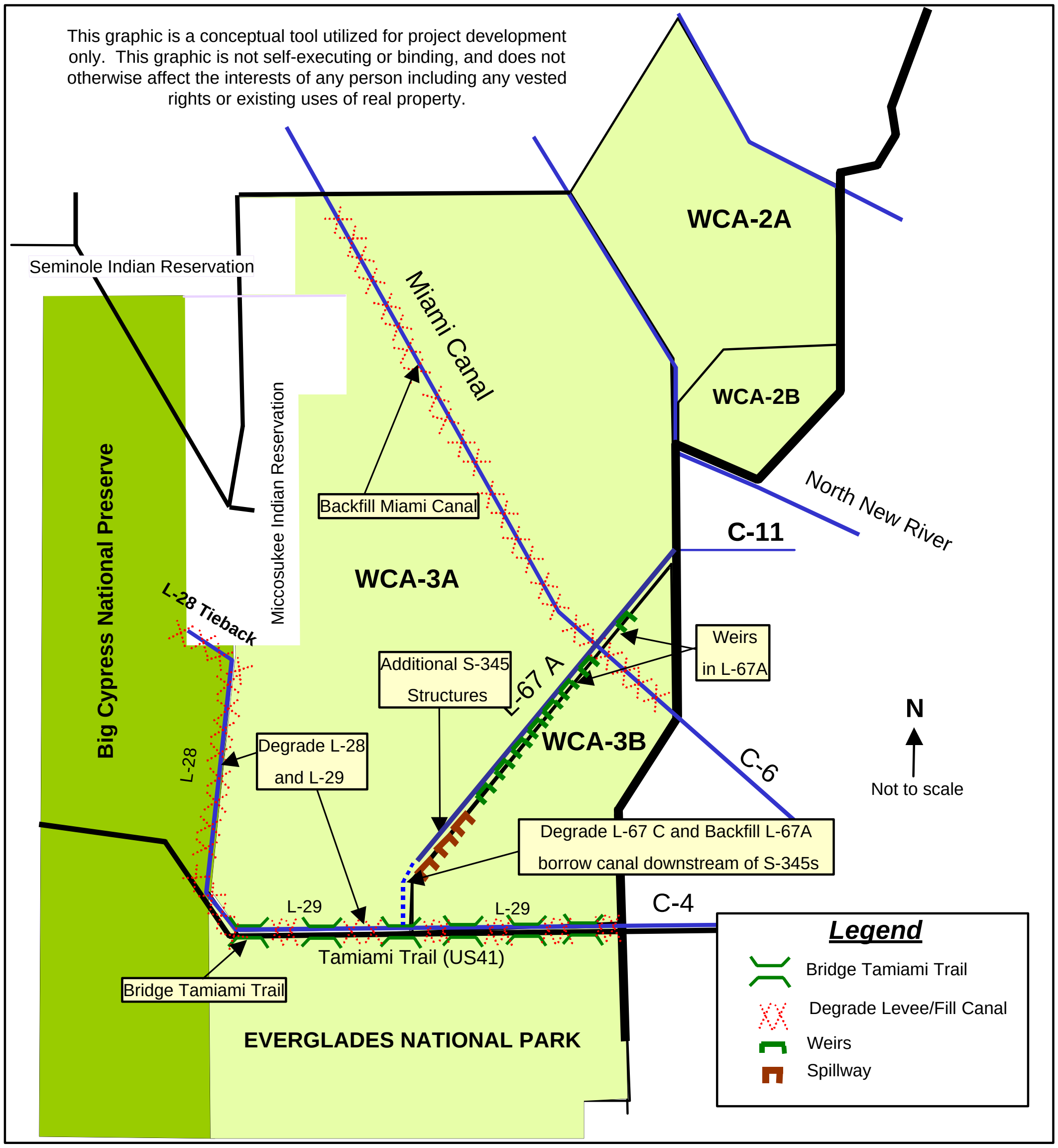

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APPENDIX A5

CRITICAL PROJECTS

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APPENDIX A5
CRITICAL PROJECTS

Section 528 of the Water Resources Development Act (WRDA) of 1996 authorizes the Secretary of the Army to expeditiously implement restoration projects that are deemed critical to the restoration of the south Florida ecosystem. These projects are referred to as Critical Projects. This authority allows the Corps of Engineers (Corps) to implement projects that are needed for restoration in advance of completion of the Comprehensive Plan. Thirty-five candidate Critical Projects were identified and prioritized by the Working Group of the South Florida Ecosystem Restoration Task Force (Working Group) through a process that utilized input from the Governor's Commission for a Sustainable South Florida (Governor's Commission), project proponents, and the public. Based on the priorities recommended by the Working Group, the Corps evaluates each candidate project and submits a short letter report justifying the project to Assistant Secretary of the Army for Civil Works (ASA(CW)). Critical Projects that are approved by the ASA(CW) are implemented through the Critical Projects program. The cumulative cost estimate for all 35 candidate Critical Projects exceeds the current legislatively mandated funding limit. Therefore, it is anticipated that only the top priority candidates will be implemented under this authority. The Restudy addresses all of the Critical Projects nominated by the Working Group to ensure they will be implemented. This appendix briefly explains the Critical Project program, provides narrative summaries of each project and its expected benefits, and explains how each project is addressed in the Restudy.

A5.1 AUTHORITY

The Critical Projects program is authorized by Section 528(b)(3) of the Water Resources Development Act of 1996 (Public Law 104-303) which states:

"(b) RESTORATION ACTIVITIES-

(3) CRITICAL RESTORATION PROJECTS-

(A) IN GENERAL- In addition to the activities described in paragraphs (1) and (2), if the Secretary, in cooperation with the non-Federal project sponsor and the Task Force, determines that a restoration project for the South Florida ecosystem will produce independent, immediate, and substantial restoration, preservation, and protection benefits, and will be generally consistent with the conceptual framework described in paragraph (1)(A)(ii)(II), the Secretary shall proceed expeditiously with the implementation of the restoration project.

(B) INITIATION OF PROJECTS- After September 30, 1999, no new projects may be initiated under subparagraph (A).

(C) AUTHORIZATION OF APPROPRIATIONS-

(i) IN GENERAL- There is authorized to be appropriated to the Department of the Army to pay the Federal share of the cost of carrying out projects under subparagraph (A) $75,000,000 for the period consisting of fiscal years 1997 through 1999.

(ii) FEDERAL SHARE- The Federal share of the cost of carrying out any 1 project under subparagraph (A) shall be not more than $25,000,000."

A5.2 NOMINATION AND RANKING PROCESS

Candidate projects were identified by project proponents and prioritized by the Working Group through a process that utilized input from the Governor's Commission, the project proponents, and the public. Critical Projects were nominated through submittal of a summary sheet to the Working Group. Any agency, organization, or individual could nominate a project. Each Working Group member was requested to solicit input from his or her respective constituencies. The Working Group coordinated the list of projects with the Governor's Commission and the public. After public input, the Working Group revised and prioritized the list and then submitted the top thirty-five candidate projects to the Corps for further evaluation. This process and the results are described below in greater detail.

A5.2.1 CRITICAL PROJECTS NOMINATION AND PRIORITIZATION CRITERIA

Critical Projects must be within the Corps' general authorities for water resources projects. The Corps evaluated the nominated projects to ensure that they met all of the required criteria. The Corps' initial evaluation of the nominated projects was discussed with the Working Group before it was finalized. In order to be qualified, the project must meet all of the following criteria.

- The project produces independent, immediate, and substantial restoration, preservation, and protection benefits.
- The project must be generally consistent with the elements of the Governor's Commission's Conceptual Plan.
- It must be possible to initiate the project prior to 30 September 1999. Project initiation is defined as execution of the Project Cooperation Agreement (PCA) which is the contract between the Corps and the project sponsor.
- The total project cost estimate must be less that $50 million. If the total project cost is estimated to be more than $50 million, the sponsor must agree to provide all funding for the excess costs.

- A potential cost-sharing partner must be identified. The Corps and the sponsor will share all project costs as specified in the PCA.

- The project cannot be an authorized component of the C&SF Project. Additionally, this authority should not be used as an alternative funding source for projects for which a funding source has already been identified and a schedule is in place for accomplishing the work.

A5.2.2 DETERMINING PRIORITIES OF APPLICABLE PROJECTS

The Working Group evaluated and prioritized the list of applicable projects based on the following considerations;

- The level of benefits provided by a candidate project. This was a subjective estimate made by the Working Group.

- Time sensitivity of a candidate project. Congress' intent is to allow near-term implementation of critical, time-sensitive projects and to take advantage of unique opportunities. This authority can be used to avoid penalties that may result from using the normal processes for project implementation. In the prioritization process, consideration was given to whether the project offers a significant benefit (cost savings or ecosystem benefit) from early implementation.

- Visibility of a candidate project. It is also Congress' intent that the authority be used to implement projects that have visible results and benefits. Studies and research will be difficult to justify unless they are short-term and provide tangible, near-term ecosystem benefits.

A5.2.3 NOMINATION AND PRIORITIZATION RESULTS

Table A5-1 displayed on the next page lists the 35 Critical Projects as prioritized by the Working Group. Section A5.5 provides narrative summaries of each project.

Table A5-1
CRITICAL PROJECTS LIST

Critical Projects Nominated by the Working Group	
Rank	**Critical Project Title**
1	East Coast Canal Structures
2	Tamiami Trail Culverts
3	Melaleuca Eradication Project
4	Florida Keys Carrying Capacity Study
5	Western C-11 Water Quality Treatment
6	Seminole Tribe Big Cypress Reservation Water Conservation Plan (west)
7	Southern Golden Gates Hydrologic Restoration
8	South Miami-Dade Agricultural and Rural Land Use and Water Management Plan
9	Southern CREW Project Addition/Imperial River Flowway
10	Lake Okeechobee Water Retention/Phosphorus Removal
11	Ten Mile Creek Water Preserve Area
12	L-28 Modification
13	Loxahatchee Slough Ecosystem Restoration
14	Geodetic Vertical Control Surveys
15	Lake Trafford Restoration
16	L-31East Flow Redistribution
17	Henderson Creek and Belle Meade Restoration
18	Lake Okeechobee Tributary Sediment Dredging
19	Develop & Implement Agricultural BMPs in the C-111 Basin
20	North Fork of the New River Restoration
21	L-8 Canal/Water Catchment Area/Loxahatchee Slough Infrastructure Improvements
22	Florida Keys Tidal Restoration
23	Lake Worth Lagoon Restoration
24	Palm Beach County Wetlands-Based Water Reclamation
25	Lake Okeechobee Demonstration Aquifer Storage and Recovery
26	Miccosukee Water Management Area
27	Six Permanent Water and Meteorological Stations
28	Nutrient Removal and Dosing Studies for Everglades National Park
29	Water Conservation Area 3B Seepage Reduction
30	Hillsboro Pilot Aquifer Storage and Recovery
31	Lakes Park Restoration
32	Town of Ft. Myers Beach
33	Palm Beach County Winsberg Farms Constructed Wetland
34	Spring Creek Reconnection and Rehydration
35	Restoration of Pineland & Tropical Hardwood Hammocks in C-111 Basin

A5.3 APPROVAL PROCESS

Based on the priorities recommended by the Working Group, the Corps evaluates each project and prepares a short letter report (2 to 3 pages) to the ASA(CW). The report is based on available data and includes: 1) a description of the project, 2) an evaluation of how the project addresses each of the selection criteria, 3) a discussion of any environmental concerns, 4) a preliminary project cost estimate, 5) an implementation schedule, and 6) tentative letters of support from a local sponsor and all agencies that must provide approvals or permits for the project. A draft PCA is submitted for approval with the letter report. The report requests approval to expend funds for: 1) finalization and execution of a PCA, 2) preparation of National Environmental Policy Act (NEPA) documentation, and 3) detailed design, permitting, and construction.

A5.4 IMPLEMENTATION

The Corps will utilize the Working Group's priority list as a general guide toward implementing these projects through the Critical Projects program. However, funding or resource constraints of the Critical Projects program may require that some projects on the list be addressed out of sequence. In addition, to ensure that Critical Projects that can not be implemented through the Critical Projects program can be considered through future authorizations, the Restudy addresses all 35 Critical Projects nominated by the Working Group. For additional information regarding implementation of the Critical Projects see Section A5.6 of this Appendix, Appendix M, and Section 10 of the Main Report.

A5.4.1 NATIONAL ENVIRONMENTAL POLICY ACT DOCUMENTATION

Following ASA(CW) approval of the letter report, NEPA documentation will be prepared by the Corps. Individual Critical Projects will undergo environmental review and assessment in accordance with NEPA and other pertinent environmental laws and regulations. This includes coordination with the appropriate Federal, state, and local agencies, the Native American Tribes, interested non-governmental organizations, and the public. For those Critical Projects that can not be implemented through the Critical Projects program, NEPA documentation and coordination will be accomplished through the Project Implementation Report process described in Section 10 of the Main Report.

A5.4.2 DESIGN DOCUMENTATION

The Corps' Jacksonville District will prepare appropriate design documents. In some cases, construction contract plans and specifications will be prepared immediately after approval of the letter report. In other cases that require additional engineering, a design document may be prepared to aid in implementation. Approval of all design documents will be by the Jacksonville District Engineer.

A5.4.3 PROJECT COOPERATION AGREEMENT

A draft PCA is prepared by the Corps and submitted to the ASA(CW) for approval along with the letter report. Delegation of the authority for the Jacksonville District Engineer to execute the PCA is also requested in the letter report. The PCA will be executed following completion of NEPA documentation and compliance with any other applicable Federal laws. The PCA will define the sponsor's allowable credit for inkind services toward the local share of the total project cost.

A5.5 CRITICAL PROJECT DESCRIPTIONS

This section provides a summarized description of each Critical Project as it was nominated to, or revised by, the Working Group. The projects are presented in accordance with the Working Group’s priorities. The relationships of the Critical Projects to the Comprehensive Plan are discussed in Section A5.6 below.

A5.5.1 EAST COAST CANAL STRUCTURES

The project is located in Miami-Dade County, roughly 20 miles due west of Miami. A new structure would be constructed in the C-4 Canal, immediately southeast of the Pennsuco Wetlands. Also to be included in this project will be the removal of the existing G-119 control structure, currently located on the eastern edge of Water Conservation Area 3B. The project purpose is to raise surface and ground water levels to prevent drainage of the Everglades and to reestablish natural hydroperiods. The project would retain, in the Everglades, waters that now drain to the east via the primary conveyance canal system. The project would increase aquifer recharge, and surface and subsurface storage of water, to enhance regional water supplies. Lastly, the project would provide increased habitat for plants and animals that live in the Everglades communities by restoring wetlands and decreasing the potential for the spread of exotic plants.

A5.5.2 TAMIAMI TRAIL CULVERTS

The project is located on the Tamiami Trail (US-41) in Collier County between State Road 92 and 50 Mile Bend (a distance of approximately 43 miles). In 1928, the Tamiami Trail was completed between Miami and Naples. To obtain fill material for the roadbed, a borrow canal was excavated on the northern side of the road alignment. The effect of the Tamiami Trail and adjacent borrow canal has been to intercept existing north-south flowways to the Big Cypress National Preserve, and channelize flows through a few bridges/culverts. Currently, due to the channelization of flowways, some wetland habitats receive too much fresh water, while others do not receive enough. Also, the seasonal hydropatterns (quantity, timing, and distribution of surface water flows) are interrupted. The purpose of this project is to increase the number of north-south flowways by adding water conveyance structures under Tamiami Trail in locations that will restore a more natural hydropattern. In addition, plugs will be installed in the existing borrow canal at appropriate places to reduce east-west flow. This project will help restore a more natural hydropattern to the southern Big Cypress Basin and coastal areas to the south including the Big Cypress National Preserve.

A5.5.3 MELALEUCA ERADICATION PROJECT

Melaleuca and other invasive exotic species are rapidly invading the natural Everglades ecosystem. Even when natural hydrology is restored to the Everglades, species such as Melaleuca will continue to degrade the system by displacing native species and degrading wetlands unless controlled with an integrated plant management strategy. In addition to chemical treatment, mechanical removal, and water manipulation, the use of biological control agents is an important component of a successful plant management strategy. This Melaleuca Eradication Project has three elements that will increase the effectiveness of biological control technologies to manage Melaleuca and other invasive exotic species. Each element is described below:

A5.5.3.1 MELALEUCA ERADICATION PROJECT (PART A) - CONSTRUCT NEW MELALEUCA QUARANTINE AND RESEARCH FACILITY

The purpose of this project is to construct a Melaleuca Quarantine and Research Facility for the testing of candidate organisms for biological control of Melaleuca. This project would enhance and accelerate the highly regulated quarantine process. The facility would be located on one of the following sites:

- University of Florida property, adjacent to the U.S. Department of Agriculture/ Agricultural Research Service (USDA/ARS), Ft. Lauderdale Aquatic Plant Management Laboratory, Davie, Florida.

- University of Florida property, University of Florida Research & Education Center, adjacent to the U.S. Department of Agriculture/Agricultural Research Service Facilities Division, U. S. Horticultural Research Laboratory, Ft. Pierce, Florida.

A5.5.3.2 MELALEUCA ERADICATION PROJECT (PART B) - RENOVATION AND IMPROVEMENTS - BIOLOGICAL CONTROL QUARANTINE AND RESEARCH FACILITY

The project would provide improvements to the Florida Biological Control Laboratory (FBCL) facility in Gainesville, Florida to better meet the needs of testing biological control candidates of exotic aquatic and terrestrial pest plants and arthropod pests of agricultural, native and horticultural plants. The Florida Department of Agriculture and Consumer Services, Division of Plant Industry, is the regulatory agency responsible for protecting Florida's native and commercially grown plants from harmful pests and diseases. The FBCL facility operates in close cooperation with the U.S. Department of Agriculture, Agricultural Research Services, and the University of Florida, Institute of Food and Agricultural Sciences. The primary responsibility of the FBCL is to enforce the quarantine procedures and regulations governing the receipt, handling and release of introduced biological control organisms.

A5.5.3.3 MELALEUCA ERADICATION PROJECT (PART C) - IMPLEMENT BIOLOGICAL CONTROLS

This project calls for the mass rearing, field release, establishment and field monitoring of approved biological control agents for Melaleuca. Production of biological control agents for release requires maintaining large screenhouse colonies at the U.S. Department of Agriculture/Agricultural Research Service (USDA/ARS), Ft. Lauderdale Aquatic Plant Management Laboratory located at Davie, Florida. Melaleuca plants must be continually collected for the colony food source, therefore Melaleuca must be cultured at the laboratory. Insects grown in these screenhouses will be released into Melaleuca stands. Permanent study plots will be established at designated release sites. The 13 existing study plots will be increased to approximately 100 as a result of this project. Periodic monitoring will be conducted in order to quantify the insect's impact upon Melaleuca, thereby evaluating the effectiveness of the biological control agent. Sampling methods will be developed to recover insects for re-release or observation and to estimate the population of insects in the field.

A5.5.4 FLORIDA KEYS CARRYING CAPACITY STUDY

The Florida Keys Carrying Capacity Study (FKCCS) will provide a database and a decision making analysis tool. The analysis tool will be a Carrying Capacity Analysis Model that will determine the impacts of additional land development activities on the Florida Keys ecosystem. The FKCCS will be designed to determine the ability of the ecosystem, and its various components, to withstand impacts of additional land development activities. The carrying capacity analysis will consider aesthetic, socioeconomic (including sustainable tourism), quality of life and community character issues, including the concentration of population, the amount of open space, diversity of habitats and species richness. The analysis will reflect the interconnected nature of the Florida Keys' natural systems, but may consider and analyze the carrying capacity of specific islands or groups of islands and specific ecosystems or habitats, including distinct parts of the Keys' marine system.

A5.5.5 WESTERN C-11 BASIN WATER QUALITY TREATMENT

The purpose of this project is to improve the quality and timing of stormwater discharges to the Everglades Protection Area from the Western C-11 Basin located in south central Broward County. The S-9 pump station currently pumps untreated urban and agricultural stormwater runoff from the Western C-11 Basin directly into Water Conservation Area 3A. The project involves construction of a gated control structure on C-11 to divide western seepage waters (i.e., clean water) from the eastern runoff waters in C-11 canal (i.e., polluted water) and construction of an additional pumping station adjacent to S-9 to pump clean seepage back into the Everglades Protection Area. Both features will be remotely controlled using sponsor-installed telemetry.

A5.5.6 SEMINOLE TRIBE BIG CYPRESS RESERVATION WATER CONSERVATION PLAN

The project is located on the Seminole Tribe Big Cypress Reservation in Hendry County, directly north of the Big Cypress National Preserve and west of Water Conservation Area 3A (WCA 3A). The Big Cypress Reservation is traversed by the L-28 and L-28I canals and the North and West Feeder canals. The proposed comprehensive watershed management system is designed to achieve environmental restoration on the Reservation, the Big Cypress Preserve, and the Central and Southern Everglades. In addition, the project will reduce flood damage and promote water conservation on the Reservation. The overall plan has been divided into east and west portions, each of which can provide independent benefits. Due to the legislated funding limits of the Critical Projects program, only the west portion of this project was nominated as a Critical Project. The Seminole Tribe has also requested the assistance of the Natural Resources Conservation Service (NRCS) to implement the eastern portion of the plan. In light of the uncertainty of the NRCS funding for the east portion and the potential that the west portion may not be funded through the Critical Projects program, the combined project is being recommended as an Other Project Element of the Comprehensive Plan to ensure the complete project will be implemented (see Appendix A6).

A5.5.7 SOUTHERN GOLDEN GATE ESTATES HYDROLOGIC RESTORATION

The Southern Golden Gate Estates (SGGE) project area encompasses approximately ninety-four square miles of sensitive environmental landscape in southwestern Collier County, south of Interstate 75 between the Fakahatchee Strand and Belle Meade watersheds. The project area is an important surface storage and aquifer recharge area with a unique ecology of cypress, wet prairie, pine and hardwood hammock and swamp communities. It also includes three major flowways that contribute freshwater to the Ten Thousand Islands Estuary of the western Everglades watershed. Construction of roads and drainage modifications in the 1960's and 1970's have overdrained the area resulting in reduction of aquifer storage, increased freshwater shock load discharges to the estuaries, invasion of upland vegetation and increased frequency of forest fires. Variations of freshwater discharges at large amplitudes have resulted in large fluctuations of salinity level and have eliminated or displaced a high proportion of the benthic, midwater and fish plankton communities in the estuary. The project involves construction of a combination of spreader channels, canal plugs and pump stations, and removal of roads. Implementation of this plan would accomplish the hydrologic restoration of SGGE by introducing sheetflow, re-establishing the historical flowways, reducing runoff by increased evaporation and groundwater recharge, and replacing point flow discharge through the Faka Union Canal with distributed flow along US 41 into the tidal coastal marshes. The Florida Division of Forestry is responsible for managing the public lands within SGGE and will be a participating partner with the SFWMD through construction of this project.

A5.5.8 SOUTH MIAMI-DADE AGRICULTURAL AND RURAL LAND USE AND WATERS MANAGEMENT PLAN

This project is also known as the "South Miami-Dade Agricultural and Rural Retention Plan and South Biscayne Bay Watershed Management Plan". To avoid confusion the original name in the section heading is used throughout this appendix. The project area is the southern portion of Miami-Dade County covering all lands lying outside Miami-Dade County's Urban Development Boundary designated for agricultural use. The growing demands of the Lower East Coast of Florida are straining the water resources of the area. The development of sustainable, environmentally sensitive agriculture in southern Miami-Dade County would provide a more environmentally superior land use than the prospect of uncontrolled urban expansion throughout these watersheds. In comparison to urban development, agriculture has reduced impacts on water quality and quantity thus minimizing remediation requirements and costs. The purpose of both these initiatives/studies is to develop long range management plans for south Miami-Dade County. The plans will recommend future land use and water resources control within the county. Output will be recommendations that will assist in the regulation of the ever-increasing development/growth in south Miami-Dade County. The rural land use component is an integral part of the overall, larger South Biscayne Bay Watershed Plan. Project work involves the preparation of a study document that will identify and quantify major agribusiness elements (i.e. crop prices, water and soil requirements, production costs, etc.). Combined with socioeconomic information, all parameters will be analyzed to establish economic strategies and incentives to strengthen agriculture. The results will be blended into the South Biscayne Bay Watershed Management Plan.

A5.5.9 SOUTHERN CREW PROJECT ADDITION/IMPERIAL RIVER FLOWWAY

The project is located in southern Lee County, bordering the western boundary of the Corkscrew Regional Ecosystem Watershed (CREW). This environmentally sensitive area east of Bonita Springs has been altered by construction of roads, house pads, agricultural berms, and ditches. These alterations have resulted in restriction of historical sheetflow, unnatural water impoundment and flooding, increased pollutant loading to the Imperial River and Estero River (an Outstanding Florida Water), and disruption of natural wetland functions. Water that historically flowed southwesterly has been partially diverted to the east by roadbeds and single family house pads. This has resulted in decreased hydroperiods (excessive drainage) in wetlands to the west of the CREW and the Corkscrew Sanctuary (Audubon) and increased hydroperiods in the CREW and Corkscrew Sanctuary. The proposed project involves acquisition of approximately 4,670 acres of land and restoration of historic flows over this area. The project will be added to the CREW with perpetual management to maintain natural system qualities. The project will: 1) re-establish historical flow patterns and hydroperiods on the lands proposed for acquisition as well as CREW and Corkscrew Sanctuary wetlands to the east, 2) restore historical storage potential of the Southern CREW lands, 3) reduce excessive freshwater discharges to Estero Bay during the rainy season, 4) decrease saltwater intrusion during the dry season, 5) reduce loading of nutrients and other pollutants to the Imperial River and Estero Bay, 6) increase aquifer recharge, and 7) reduce flooding of homes and private lands west of the project area. This project will also reduce the potential that currently exists for forcing water eastward through the CREW Project and the Corkscrew Swamp Sanctuary and possibly harming these important areas by increasing depth and duration in these natural wetland areas. Hydrologic restoration of this land will include the following modifications: 1) removal of existing road beds, 2) removal of single family homes, 3) removal of junk debris, 4) filling of ditches, and 5) removal of agricultural canals and berms. The Kehl Canal weir located at the headwaters of the Imperial River will be modified. More storage capacity will be provided and gates will be added to allow better water management and control of the Kehl Canal, which flows through the land proposed for acquisition.

A5.5.10 LAKE OKEECHOBEE WATER RETENTION/PHOSPHORUS REMOVAL

This project focuses on specific land parcels (project elements) located within four key basins of the Lake Okeechobee watershed. These four basins are the lower Kissimmee River basins (S-65D Basin, S-65E Basin, and S-154 Basin) and the Taylor Creek-Nubbin Slough basin (S-191). Wetlands account for between 18 and 25 percent of the land classification in these basins (based on data from US Fish and Wildlife Service 1990 National Wetlands Inventory); however, approximately 37 percent of these wetlands have been ditched to drain the land for agriculture (i.e., improved pasture). Many of these wetlands were isolated depressions that once functioned as small water retention areas in the landscape. Others were more expansive and experienced drying from the regional drainage system. The current system causes the accelerated loss of water from the watershed as surface water runoff, which is rapidly transported to the tributary system that drains into Lake Okeechobee. The loss of these isolated wetlands has resulted in various environmental impacts. It has contributed to rapid rises in the stage of Lake Okeechobee resulting in the need for damaging freshwater discharges to the estuaries. There has also been a loss of the water quality treatment function that used to result from retaining water for short periods of time in these wetlands, and the loss of wetland habitat for migratory birds and waterfowl. A two-pronged approach will be taken in this project. The first approach is to restore the hydrology of isolated wetlands by plugging the connection to drainage ditches and the second approach is diversion of the collector canal flows to adjacent wetlands to attenuate peak flows and retain phosphorus in Reservoir-Assisted Stormwater Treatment Areas (RSTAs). The project will result in increased regional water storage north of Lake Okeechobee and restoration of wetland functions in the process. At the sub-basin scale, large land parcels that were once part of the tributary system's historic flood plain will be reflooded to add adjacent and/or isolated wetlands back to the landscape.

A5.5.11 TEN MILE CREEK WATER PRESERVE AREA

The project site is located just south of Ten Mile Creek in St. Lucie County. Ten Mile Creek is the largest subbasin delivering water to the North Fork of the St. Lucie River Estuary (SLE) which has been established as an Outstanding Florida Water (OFW). The SLE discharges into the Indian River Lagoon (IRL) which is also an OFW. The IRL is the most biologically diverse estuary in North America. The entire lagoon is endangered from increased runoff from watershed drainage enhancements. Excess stormwater due to drainage improvements is causing radical fluctuations of the salinity concentration in the SLE. Adverse salinity concentrations are eliminating viable habitat suitable for oysters, seagrasses, and marine fish spawning. The project involves construction of a water preserve area to attenuate flows and improve water quality discharged to the SLE/IRL. The proposed site is approximately 1559 acres. The project includes land acquisition, construction, and operation of an aboveground reservoir with a pump station for filling the reservoir from Ten Mile Creek and a gated water-level control structure for the release of water back to the creek. The foot-print of the reservoir is anticipated to be approximately 550 acres in size with the remaining acreage being utilized as a polishing cell and a natural preserve area. Based upon existing topography, stored water depths average ten feet. Total storage capacity will be approximately 5,000 acre-feet. The project also includes construction of four hydraulic control structures to control intake and discharge from both the deep water storage area and the polishing cell.

A5.5.12 L-28 MODIFICATION

The project is located in the southwest corner of Water Conservation Area (WCA) 3A located in western Broward County. Historic freshwater wetland habitats in south Florida have been reduced spatially, compartmentalized, and hydrologically altered as a result of the C&SF Project. Reestablishing the hydrologic and ecologic continuity of the remaining natural areas is expected to benefit the entire Everglades ecosystem by recovering the pre-drainage functions and habitat values of historic freshwater wetlands, reducing the fragmentation, and restoring more natural hydropatterns including associated sheetflow. The purpose of this project is to re-establish the ecological and hydrological connection between WCA 3A and the Big Cypress National Preserve by removing the L-28 and L-28 Tieback levees and borrow canals.

A5.5.13 LOXAHATCHEE SLOUGH ECOSYSTEM RESTORATION PROJECT

The project area is in Palm Beach County within the C-18 Canal Basin and encompasses approximately 10,000 acres of the original Loxahatchee Slough. The intent of the project is to rehydrate the portion of the Loxahatchee Slough currently being drained by the east leg of C-18. In addition, the project will include the removal of much of the exotic species in the area to be rehydrated. These lands have recently been purchased by Palm Beach County under their Environmentally Sensitive Lands Bond Issue and are targeted for environmental restoration.

A5.5.14 GEODETIC VERTICAL CONTROL SURVEYS

The southern portion of Florida has unique features among which are: 1) very flat topography, 2) a large, highly concentrated human population, and 3) a very unique and fragile ecosystem. Because of this flat topography, a slight change in ground level at one location can significantly impact a large ecosystem. The South Florida Water Management District has found that inconsistencies in water level readings at water gauging stations point to questionable vertical survey bench mark data. As an example, in some cases it has appeared that water is running uphill or there is a station with a lower elevation between two stations with higher elevations, along the same river. This lack of precision in existing vertical control can result in erroneous estimates to important hydrologic variables. Errors can distort data and potentially lead to erroneous water management decisions. The project involves the running of 1,250 miles of second-order class I vertical control over a four-year period. This will consist of approximately 1,250 miles of forward runs and 1,250 miles of back runs, for a total of 2,500 miles. Additionally approximately 250 class “B” bench marks (stainless steel rods driven to refusal) and 1,000 class “C” bench marks (poured concrete monuments 12” by 42” deep with belled bottoms) will be established or recovered.

A5.5.15 LAKE TRAFFORD RESTORATION

Lake Trafford is located in north Collier County and is the largest lake south of Lake Okeechobee with a surface area of approximately 1,494 acres. It is the headwaters of the Corkscrew Swamp Sanctuary to the southwest, the Corkscrew Regional Ecosystem Watershed (CREW) to the west, and the Fakahatchee Strand system, which includes the Florida Panther National Wildlife Refuge, to the south. Lake Trafford has poor water quality, extensive muck accumulations, loss of native submergent plant communities, periodic aquatic weed infestations, and numerous moderate fish kills. A massive fish kill occurred in April 1996 which was caused by poor water quality conditions, including high biological oxygen demand, lethal ammonia levels, and depressed dissolved oxygen content. Poor water quality is attributed to internal nutrient cycling from extensive organic muck deposits throughout the lake basin. The project involves the use of one or more 14-inch portable cutter dredges to accomplish lakewide organic sediment removal. Approximately 8.5 million cubic yards of loose, flocculent, organic materials blanket the bottom of the lake and range from approximately nine inches to nine feet in thickness. The material will be pumped to an upland disposal site on existing farmland less than one mile from the lake. The pipeline to the upland disposal area will be located adjacent to an existing ditch with an easement being provided by the landowner. This ditch will also be used to carry the return flow from the disposal area. The disposal area consists of a 449-acre, diked, agricultural facility, which will be divided into three cells. The sponsors have additional lands identified if, in the design phase, it is determined that additional acreage will be required.

A5.5.16 L-31 EAST FLOW REDISTRIBUTION

The project is located in southern Miami-Dade County adjacent to Biscayne National Park and Biscayne Bay, along a 3.5-mile stretch of the L-31 East levee between structures S-20F and S-21A. Historically, freshwater entered the southern Biscayne Bay Estuary through a series of creeks and sloughs. The L-31 East levee system was constructed in the 1960's and cutoff this natural flow of water. The primary canal system in the southern Biscayne Bay watershed was designed for flood control. Freshwater is indiscriminately discharged from a few control structures into the estuary. Typical estuarine biological communities are not adapted to conditions that allow frequent and wide swings in salinity that currently occur at the mouths of these canals. Studies have documented reduced benthic communities near the canal discharge zones and even destruction of seagrass beds from slugs of freshwater. This project will install a freshwater distribution system to facilitate the restoration of more natural flows of freshwater into Biscayne Bay. Based upon data from ongoing studies, freshwater flow will be restored into the coastal mangrove wetlands at suitable locations such as sloughs or locations identified as historic creeks. The project consists of constructing a freshwater distribution system for the area east of the L-31 East levee. The system will be constructed over a length of approximately 3.5 miles from S-21A to just north of S-

20F. Work will include installing a series of culverts to convey fresh water from the borrow canal along the west side of the levee to the marsh and mangrove area east of the levee. Twelve 36 inch culverts will be placed under the L-31 East levee at locations where historic creeks or sloughs once existed. The culverts will be fitted with flash boards and flap gates and salinity control will be maintained. Freshwater in the spreader ditch will be conveyed into mangrove wetlands fringing Biscayne Bay at appropriate locations to restore historical creeks or sloughs.

A5.5.17 HENDERSON CREEK AND BELLE MEADE RESTORATION

This region of southwest Florida is currently facing a high urban growth rate. Changes in land-use within the primary watersheds that drain into the Rookery Bay Estuary and adjacent waters have been identified in the Rookery Bay National Estuarine Research Reserve (RBNERR) Management Plan as the highest priority resource issue that threatens the long-term preservation of RBNERR estuarine resources. The coastal habitats in Collier County have been impacted by alterations of hydrology and habitat due to channelization of natural systems. Roads, canals, planned unit developments, commercial projects, and agriculture represent primary land-uses within RBNERR watersheds. These alterations have greatly modified the volume, timing and quality of freshwater entering the fragile estuarine ecosystems. In addition, channelized flow in these watersheds has severely restricted the ability of the associated wetlands to filter pollutants. The area known locally as Belle Meade is the primary drainage basin for the Henderson Creek Estuary and is currently targeted for acquisition by the Florida Department of Environmental Protection through the Conservation and Recreation Lands Program. Historically, freshwater traveled across the surface of the land, percolating through wetland flowways before entering Henderson Creek. While channelization and development have disrupted this system, acquisition and restoration of the undeveloped lands surrounding Henderson Creek, which link the watershed and estuary, can stop further hydrologic and habitat disturbance. These estuarine areas provide critical nursery habitat for commercially and recreationally important finfish and shellfish. Land acquisition will assure long-term protection of the upland and wetland communities associated with these parcels. Additionally, the proposed restoration efforts on the acquired lands will return a portion of the historic timing, duration and volume of freshwater inflow, thereby enhancing estuarine habitats.

A5.5.18 LAKE OKEECHOBEE TRIBUTARY SEDIMENT DREDGING

The project would be located in selected tributaries in the Lake Okeechobee watershed. Historically, south Florida waters were low in nutrients (oligotrophic). Elevated phosphorus loading of waterbodies and the resulting increased water phosphorus concentrations (eutrophication) may have various ecological effects. These effects may include increased primary productivity, loss of water column dissolved oxygen, algal blooms, and changes in vegetation and biodiversity. The significance of such phosphorus loading may be the reduction or loss of a waterbody’s habitat and/or recreational values. Sediment found in tributaries to Lake Okeechobee is an important source of phosphorous that contributes to the excessive loading to the lake. This project involves dredging sediments from approximately ten miles of primary canals. As a result, an estimated 150 tons of phosphorous will be removed from potential loading to the lake.

A5.5.19 DEVELOP AND IMPLEMENT AGRICULTURAL BEST MANAGEMENT PRACTICES IN THE C-111 BASIN

Proposed structural and operational changes to the C&SF Project proposed in recommended Comprehensive Plan were evaluated to assess gross changes in regional hydrology. However the temporal and spatial scale of the current modeling tools and the density of the current monitoring system are inadequate to predict and assess the changes in the local water table and localized flooding in the south Miami-Dade agricultural area. This project will: 1) evaluate and enhance the available regional hydrological and water quality data and 2) field calibrate, formulate and develop a model capable of simulating the hydrology in the agricultural area at a spatial and temporal scale that would allow prediction of localized impacts from the proposed structural and operational changes to the C&SF Project.

A5.5.20 NORTH FORK OF THE NEW RIVER RESTORATION

The proposed project is located in the City of Ft. Lauderdale, along the North Fork of the New River between 9th Avenue and Sunrise Boulevard. The North Fork is a shallow, meandering tributary of the New River extending through the northwest section of the City of Fort Lauderdale. Minimal tidal flow within this section of the river results in limited circulatory exchanges of tidal waters. Flow has been restricted by large amounts of sediment and debris. Natural freshwater flow characteristics are further restricted in the upstream section of the North Fork by the S-33 salinity control structure that effectively eliminates freshwater inflow from the western drainage basin. The New River is one of the few naturally occurring surface water bodies in Broward County. Prior to the 1900's, the New River was a prominent drainage feature of the Everglades that seasonally emptied into the Atlantic Ocean. The existing shoreline no longer resembles its historical condition. The shoreline is actively eroding in some places and exotics have replaced native species in some riparian areas. In 1993, Broward County Department of Natural Resource Protection (DNRP) research identified many sources of ongoing and historic pollution. This degradation of water quality and habitat represents a negative impact not only on the environment, but the health and economy of the adjacent communities. DNRP developed "The New River Restoration Plan (1994)" to identify water quality problems, identify the river system's biological diversity, and to develop a plan to create a more natural condition for the inhabitants of this community. The restoration project involves: 1) spot dredging to improve water quality and water circulation, 2) removal of exotic plant species and revegetation with native plants, 3) development of analytical tools, 4) removal of litter and debris, and 5) development of a plan which promotes urban infill consistent with the Eastward Ho! Initiative.

A5.5.21 L-8 CANAL- WATER CATCHMENT AREA LOXAHATCHEE SLOUGH INFRASTRUCTURE IMPROVEMENTS

The project is located in western Palm Beach County along the L-8 Canal. The purpose of the project is to reroute water from the L-8 Canal to the City of West Palm Beach's Water Catchment Area and then into Loxahatchee Slough and Estuary. The project will: 1) benefit approximately 10,000 acres of wetlands in the Loxahatchee Slough, 2) provide additional flow for the restoration of the Loxahatchee River Estuary, and 3) reduce dependency on Lake Okeechobee in dry periods. The project involves: 1) increasing the capacity at Control 2 Pump Station near the intersection of the M-Canal and L-8 Canal, 2) M-Canal dredging and widening to increase conveyance, and 3) removal of a constriction at Control 3 on the M-Canal at the entrance to the Water Catchment Area.

A5.5.22 FLORIDA KEYS TIDAL RESTORATION

The objective of this project is to restore flows to tidal creeks by installing culverts under US Highway 1 at four locations in Monroe County (between mile markers 54 and 57). These projects are similar to a culvert project at Key Colony Beach completed in 1991, which was very successful in improving the near-shore water quality. The individual projects can be described as follows: 1) restore Tarpon Creek just south of mile marker 54 on Fat Deer Key, 2) restore an unnamed creek between Fat Deer Key and Long Point Key south of mile marker 56, 3) restore tidal connection adjacent to Little Crawl Key and 4) restore tidal connection between Florida Bay and the Atlantic Ocean at mile marker 57. The accumulation of organic material in these creeks has resulted in a degradation of water quality and sea grass habitat. Impacts originally occurred as a result of the construction of the Flagler Railroad bed (currently U.S. Highway 1) which blocked tidal flow and circulation in near-shore waters. Restoration benefits expected by installation of these culverts include; 1) enhanced circulation and flushing, 2) improved water quality, and 3) restoration of marine habitats.

A5.5.23 LAKE WORTH LAGOON RESTORATION

In Palm Beach County, the Lake Worth Lagoon Estuary is the receiving water body for most of the urban watershed. Sediment laden flows from C-51 have resulted in accelerated sedimentation of Lake Worth Lagoon (the receiving waters). The restoration project involves three phases. Phase I will examine both the quantity and quality of bottom sediment accumulations within C-51 and the downstream discharge area within the lagoon. Phase II will develop a project plan to provide for sediment removal or capping that could include creating a series of sediment traps along the C-51 where sediment accumulations increase. Phase III will involve the removal of bottom sediments within C-51 as well as implementing a prototype project to either remove or cap the organic bottom layer within the lagoon. The elimination of these sediments from the C-51 discharge will provide for long-term improvements to the lagoon and ensure success of additional habitat restoration projects planned by Palm Beach County.

A5.5.24 PALM BEACH COUNTY WETLANDS-BASED WATER RECLAMATION PROJECT

The Wetlands-Based Water Reclamation Project (WWRP) proposes to treat wastewater from the East Central Regional Wastewater Treatment Facility (ECR) using Advanced Wastewater Treatment (AWT) processes to remove nitrogen and phosphorus. This will then be followed with superior treatment technology to remove phosphorus to approximately 50 parts per billion or less. Phase I of the WWRP will consist of a 10 Million Gallons per Day (MGD) operation with 6 MGD of the water discharged into approximately 1,500 acres of bermed marsh where it will be used to hydrate the marsh as well as manage the hydroperiod and water quality of the wetland environment. The water will then be pumped to another marsh of approximately 300 acres surrounding the City of West Palm Beach wellfield. Infiltration of the water into the wellfield will occur as the wellfield pumps groundwater into the adjacent M Canal where it becomes surface water. The surface water in M Canal will flow towards Clear Lake, which is the surface water source of drinking water for the City of West Palm Beach. At the City's water treatment plant, the surface water will be treated to drinking water standards prior to entering the water supply distribution system for the City as well as the Town of Palm Beach and South Palm Beach. The remaining 4 MGD of the 10 MGD of reclaimed water will be routed from the AWT/superior treatment technology facility to residential lake systems surrounding both the City's wellfield and Palm Beach County's 8W Water Treatment Plant wellfield. The lake systems will be used to recharge the groundwater in the vicinity of both wellfields, thereby decreasing impacts associated with withdrawals from both wellfields.

A5.5.25 LAKE OKEECHOBEE DEMONSTRATION AQUIFER STORAGE AND RECOVERY PROJECT

This project will implement a regional Aquifer Storage and Recovery (ASR) demonstration project at Lake Okeechobee to increase storage in the regional system. This increased storage by itself will provide additional water to meet local agricultural demands in the Everglades Agricultural Area (EAA). Historically, water is brought into the EAA from Lake Okeechobee to supply local agricultural interests. It is the intent of this demonstration project to evaluate the feasibility of storing Class 1 surface water within the basin for use during times of need. The demonstration project will consist of four 5 Million Gallon per Day (MGD) Floridan Aquifer wells and one 20 MGD surface water pump to withdraw water from Lake Okeechobee. Water will be withdrawn from Lake Okeechobee and injected into the Floridan Aquifer System for later retrieval. It is anticipated that extensive discussions with the Environmental Protection Agency and the Florida Department of Environmental Protection will be required for permitting injection of Class 1 surface water into the Floridan Aquifer System. By creating additional storage in the region, less water will be required from the regional system to meet demands of the agricultural areas.

A5.5.26 MICCOSUKEE WATER MANAGEMENT AREA

The Miccosukee Water Management Area (MWMA) is a project to construct a managed wetland on the Miccosukee Tribe’s Alligator Alley Reservation located in western Broward County. The purpose of the project is to provide water storage capacity and water quality enhancement for waters which discharge into the Everglades Protection Area. The project will convert approximately 900 acres of tribally owned cattle pastures into a wetland retention / detention area, which will be designed to filter out harmful nutrients contained in stormwater runoff before the water enters the Everglades Protection Area. Tribal Water Quality Standards dictate a numerical criterion of 10 parts per billion for total phosphorous inside the Everglades Protection Area. The MWMA was sized to treat the nutrient inputs of the Miccosukee Tribal lands.

A5.5.27 SIX PERMANENT WATER AND METEOROLOGICAL STATIONS

The proposal is to establish six permanent water level measuring stations in the Everglades and Biscayne Bay National Parks area. In addition to collecting water levels, all or most of the units will also collect backup water levels (storm surge), wind speed and direction, rainfall, barometric pressure, air and water temperature, relative humidity, solar radiation, and salinity. All data will be transmitted from the field units to the Florida Department of Environmental Protection for data analysis once every three hours via Geostationary Operational Environmental Satellite (GOES). Each station will also be connected to a telephone line or will have a cellular telephone connected to it. The telephone connection will be used for repairs to the units, quality assurance, and transmitting real-time data in emergencies. The units that are hardwired to a telephone line will include a speech synthesis function so the public would have the option of hearing the most current data (real-time) by calling the station. The sites that are located in secured areas with electrical power will also be connected to computers so that Park Service personnel and/or the public will have a real-time graphic display of the data being collected.

A5.5.28 NUTRIENT REMOVAL AND DOSING STUDIES FOR EVERGLADES NATIONAL PARK

The project involves development of water quality standards (i.e., phosphorous thresholds) for waters of Everglades National Park (ENP).

A5.5.29 WATER CONSERVATION AREA 3B SEEPAGE REDUCTION

The project would be located at the southeast corner of Water Conservation Area (WCA) 3B in Miami-Dade County. This project involves installation of an underground seepage barrier using grout technology to a depth of 100 feet. The barrier would be located between two control structures (S-334 and S-335), in an area of extremely steep groundwater gradients. The suggested site is in an area where there are large documented seepage losses out of WCA 3B into the south Miami-Dade canal system. The proposed barrier would significantly reduce these losses and result in improved water deliveries across L-29 to the eastern portion of Everglades National Park.

A5.5.30 HILLSBORO PILOT AQUIFER STORAGE AND RECOVERY PROJECT

The project would be located in Palm Beach County. The project proposes construction of a regional Aquifer Storage and Recovery (ASR) demonstration project in the Hillsboro Canal region to capture and store excess flows that are currently released to tide for later use during dry periods. Recovery of the stored ASR water will be utilized to recharge local utility wellfields helping to prevent further inland migration of the saline interface. Historically, water is brought from the Water Conservation Areas and Lake Okeechobee into the Hillsboro Canal Basin to supply local urban users. The demonstration project would consist of four 5 Million Gallon per Day (MGD) Floridan Aquifer wells and at least eight 2.5 MGD Surficial aquifer wells. Water will be withdrawn from the surficial aquifer and injected into the Floridan Aquifer System for later retrieval. By creating additional storage in the region, less water will be required from the regional system to the urban areas which could then be used to meet restoration needs.

A5.5.31 LAKES PARK RESTORATION

Lakes Park is located east of Cape Coral in Lee County, just west of Highway 41. The park consists of an old rock mine with a series of borrow pit "lakes." The entire area drains south into Hendry Creek, an Outstanding Florida Water, which flows for a few miles before entering Estero Bay. Lee County has developed the area as a regional park with a bathing area along the shoreline of the lakes. Adjacent to the developed area, the remaining natural habitat contains pine flatwoods with some cypress heads. The pits capture runoff from the surrounding developed area (commercial, industrial, and residential). County monitoring has indicated a decline in water quality in the lakes. The lakes are infested with hydrilla and adjacent uplands and islands are covered with exotic plant species such as Australian pine and Brazilian pepper. The project is expected to enhance surface water runoff quality by creating a meandering flowway with shallow littoral zones and removing aquatic and upland exotic vegetation. The littoral zone will be harvested periodically to remove excess nutrients from the system. Exotic vegetation will be removed and replaced with native vegetation on 11 acres of upland.

A5.5.32 TOWN OF FT. MYERS BEACH

The Town of Fort Myers Beach in located on a barrier island of the southwest coast in Lee County. The town has identified the need for the protection of adjacent Estero Bay and local beaches from pollutants transported via stormwater runoff from the island on which the town is located. Most of the town is urbanized and has an inadequate stormwater management system. Components identified for this project include: 1) inventory of stormwater systems, 2) sediment sampling, 3) screening of illicit connections, and 4) implementation of an urban retrofit project. The project is designed to enhance Estero Bay and has received full support of local government and residents of the community. The town has already begun to identify stormwater "hot spots" through inventory and sampling procedures and has converted 48,000 square feet of asphalt to pervious paving materials. Pores in the asphalt of these materials allow runoff from parking lots to flow through the pavement into an underground reservoir of small stones, and then gradually filter into the surrounding soil. Other options for controlling urban runoff that are under consideration include installation of "water quality inlets," which are baffled concrete tanks for solids and oil separation, as well as numerous other best management practices (e.g. encouraging the use of slow-release fertilizers, etc.) The project is expected to provide immediate water quality and ecological benefits to the Estero Bay Aquatic Preserve by reducing pollutant loading to receiving waters.

A5.5.33 WINSBERG FARMS CONSTRUCTED WETLAND

In an effort to reduce the amount of treated water from the Southern Region Water Reclamation Facility (SRWRF) that is currently wasted in deep injection wells, the Palm Beach County Water Utilities Department (PBCWUD) plans to further treat and recycle this water. The PBCWUD has completed construction of a 50-acre constructed wetland located at the County's System 3 site east of Jog Road, just southeast of the Winsberg property. This wetland has been named Wakodahatchee, which is Seminole Indian for "created waters". As part of this wetland, a public access facility with limited parking, boardwalk, kiosks and interpretive signage was designed to educate the public about the importance of wetlands for both treatment of water and creation of wildlife habitat. This project proposes construction of an additional 175 acres of wetlands on the Winsberg property. This will serve to not only recycle and preserve additional water for future use, but will link the Wakodahatchee and Winsberg Farms facilities and provide additional green space in area currently under heavy development. Approximately, 6 to 8 Million Gallons per Day of reclaimed water from the SRWRF would be applied to the area. The wetland would be planted to maximize the diversity of native plant material and habitat for various species of wildlife.

A5.5.34 SPRING CREEK RECONNECTION AND REHYDRATION PROJECT

The project proponent is unclear but appears to be Pueblo Bonito Partnership for Housing, Incorporated, a private developer. The project is located in Lee County. In the early 1960's, a 40-foot wide canal was dug that cut off approximately 2,200 linear feet of Spring Creek which flows into Estero Bay. In 1990, the canal was designated an Outstanding Florida Water (OFW). The project purpose is to restore approximately 2,200 linear feet of the historic Spring Creek floodplain through three components. Reestablish the headwaters of Spring Creek by: 1) constructing a weir to redirect canal inflow into the historic Spring Creek flowway, 2) removing approximately 27,000 cubic yards of spoil which currently segments the floodplain and 3) replanting tress within the restored areas. This project appears to be, at least in part, a compensatory mitigation requirement for permits associated with a private residential development. If so, the ecological benefits of the project are already allocated to offset the adverse impacts of the permitted development. Further analysis is needed to determine the exact scope of this proposal and the allocation of the benefits to be generated.

A5.5.35 RESTORATION OF PINELAND AND TROPICAL HARDWOOD HAMMOCKS IN C-111 BASIN

The project is located in south Miami-Dade County, just east of Everglades National Park, along State Road 9336 in the area known as the Frog Pond. Eighty percent of the Frog Pond was used for agricultural purposes and farmers rock plowed the cap rock to create soil for tomato farming. The Frog Pond has since been purchased by the SFWMD as part of the C-111 Project to restore the Taylor Slough portion of the Everglades. The project involves restoring south Florida slash pine and tropical hardwood hammock species on a 200-foot wide strip on each side of the two miles of State Road 9336 from the C-111 Canal to the L-31W Canal (approximately 50 acres). This project will demonstrate the techniques required to re-establish native conifer and tropical hardwood forests on land that has been rock plowed.

A5.6 CRITICAL PROJECTS IN THE COMPREHENSIVE PLAN

This section describes how the 35 Critical Projects nominated by the Working Group are addressed in the Restudy. Seven Critical Projects are included in the Restudy Without Plan Condition. Three are included as Pilot Projects. Twenty are included as D-13R components or Other Project Elements (OPEs) or sub-features thereof. Five are considered to be stand-alone research or data collection efforts that will be needed during the Preconstruction and Design Phase (PED) of the Project Implementation Report (PIR) process. Two are recommended for additional study. Each of these categories is further described below. (Note: The number of Critical Projects mentioned above totals 37 instead of 35 because; part A of the Melaleuca Eradication Project is listed in the Without Plan Condition while parts B and C are listed as an OPE, and the L-31 East Flow Redistribution project is listed in the Without Plan Condition and as an OPE.)

A5.6.1 FUTURE WITHOUT PLAN CONDITION

With respect to the Critical Projects, the Without Plan Condition is defined as those Critical Projects that have an ASA(CW) approved letter report **and** are anticipated to be funded under the Critical Projects program. As of February 1999, twelve Critical Projects had received ASA(CW) approval:

- East Coast Canal Structures
- Tamiami Trail Culverts
- Melaleuca Eradication Project – New Facility (part A)
- Florida Keys Carrying Capacity Study
- Western C-11 Water Quality Treatment
- Seminole Tribe Big Cypress Water Conservation Plan (west)
- Southern Golden Gate Estates Hydrologic Restoration
- Southern Crew Project Addition/Imperial River Flowways
- Lake Okeechobee Water Retention/Phosphorous Removal
- Ten Mile Creek Water Preserve Area
- Lake Trafford Restoration
- L31 East Flow Redistribution

Of these twelve approved projects, it is anticipated that following seven projects will be funded through the Critical Projects program:

- East Coast Canal Structures
- Tamiami Trail Culverts

- Melaleuca Project – New Facility (part A)
- Florida Keys Carrying Capacity Study
- Western C-11 Water Quality Treatment
- L-31 East Flow Redistribution

Furthermore, it is anticipated that the North Fork of the New River Restoration project will receive ASA(CW) approval and can be funded through the remainder of the Critical Projects program funds. ***Table A5-2*** displays the seven Critical Projects that are included in the Without Plan Condition for the Restudy.

TABLE A5-2
CRITICAL PROJECTS IN THE RESTUDY WITHOUT PLAN CONDITION

Rank	Critical Project Title
1	East Coast Canals
2	Tamiami Trail Culverts
3	Melaleuca Eradication - New Facility (part A)
4	Florida Key Carrying Capacity Study
5	Western C-11 Water Quality Treatment Project
16	L-31East Flow Redistribution
20	North Fork New River Restoration

A5.6.2 PILOT PROJECTS

The Comprehensive Plan includes the early implementation of six demonstration or "pilot" projects. Three of these were nominated as Critical Projects but, in light of the Working Group's priorities and the funding limits of the program, it is not anticipated that they can be implemented through the Critical Projects program. Accordingly, the three Critical Projects listed in ***Table A5-3*** are included in the Comprehensive Plan as pilot projects.

TABLE A5-3
CRITICAL PILOT PROJECTS

Rank	Critical Project Title
25	Lake Okeechobee Aquifer Storage and Recovery Demonstration Project
29	WCA 3B Seepage Reduction
30	Hillsboro Pilot Aquifer Storage and Recovery Project

A5.6.3 D-13R COMPONENTS

The Comprehensive Plan is comprised of the features of Alternative D-13R and the OPEs. The alternative formulation process (described in Section 7 of the Main Report) followed the establishment of the Critical Projects list by the Working Group. As the alternative formulation process progressed, some of the Critical Projects were adopted as D-13R components or sub-features thereof. Detailed design and implementation of the Critical Projects which are included as features and/or concepts of D-13R components will occur during the Project Implementation Report process. ***Table A5-4*** lists the four Critical Projects that are related to D-13R components. Appendix A4 provides detailed descriptions of the D-13R components. The Critical Project features that are included in D-13R components may differ from the original project descriptions provided in Section A5.5 above. This is because the features/concepts were refined during the alternative formulation process.

TABLE A5-4
CRITICAL PROJECTS IN ALTERNATIVE D-13R

Rank	Critical Project Title	D-13R Component Designation and Title
11	Ten Mile Creek Water Preserve Area	UU6 - C-23/24 Northfork and Southfork Reservoirs
12	L-28 Modification	QQ6 - Decompartmentalize WCA 3
13	Loxahatchee Slough Ecosystem Restoration	K6 - Additional L-8 Improvements
21	L-8 Canal/Water Catchment Area/Loxahatchee Slough Infrastructure Improvements	K6 - Additional L-8 Improvements

A5.6.4 OTHER PROJECT ELEMENTS

In addition to the components of Alternative D-13R, the Comprehensive Plan includes a group of projects that could not be evaluated using the modeling tools employed during the iterative alternative plan formulation process. This group of components has been termed Other Project Elements (OPEs). An initial list of potential OPEs was developed from the Critical Projects list; the Governor's Commission's Conceptual Plan, and suggestions by Restudy Team members. ***Table A5-5*** lists the16 Critical Projects that are included in the Comprehensive Plan as OPEs, or sub-features thereof. See Section 9 of the Main Report and Appendix A6 for additional information about OPEs.

TABLE A5-5
CRITICAL PROJECTS INCLUDED IN THE COMPREHENSIVE PLAN AS OPEs

Rank	Other Project Element Title
3	Melaleuca Eradication Project[1] part B – Renovate Existing Facility part C – Implement Biological Controls
6	Seminole Tribe Big Cypress Reservation Water Conservation Plan[2]
7	Southern Golden Gates Hydrologic Restoration
9	Southern CREW Project Addition/Imperial River Flowways
10	Lake Okeechobee Water Quality Treatment Facilities (includes Lake Okeechobee Water Retention/Phosphorus Removal)[3]
15	Lake Trafford Restoration
16	Biscayne Bay Coastal Wetlands (includes L-31 East Flow Redistribution)[4]
17	Henderson Creek and Belle Meade Restoration
18	Lake Okeechobee Tributary Sediment Dredging
22	Florida Keys Tidal Restoration
23	Lake Worth Lagoon Restoration
24	Palm Beach County Wetlands Based Water Reclamation Project
26	Miccosukee Water Management Plan
31	Lakes Park Restoration
33	Winsberg Farms Constructed Wetlands Project
35	Restoration of Pineland & Hardwood Hammocks in C-111 Basin

[1]The New Facility (part A) proposed in the Melaleuca Eradication Project (CP) is included in the Restudy Without Plan condition. The Renovate Existing Facility (part B) and Implement Biological Controls (part C) portions of the Melaleuca Eradication Project (CP) are combined as an OPE.

[2] The west portion of the Seminole Big Cypress Reservation Water Conservation Plan (CP) was combined with the east portion of the project to form a single OPE.

[3] The Lake Okeechobee Water Retention/Phosphorous Removal (CP) project was combined with the proposed OPE titled Lake Okeechobee Watershed Water Quality Treatment Facilities. These are essentially the same type of project thus they were combined as a single OPE.

[4] The L-31 East Flow Redistribution project was incorporated into the Biscayne Bay Coastal Wetlands OPE.

A5.7 PROJECT IMPLEMETATION ACTIVITIES

The five Critical Projects displayed in ***Table A5-6*** are considered to be research or data-collection activities. Some of these activities are expected to provide useful information during the Project Implementation Report (PIR) process for various components of the Comprehensive Plan. Furthermore, some of these activities are expected to improve the region-wide adaptive assessment process. These processes are described in Section 10 of the Main Report and Appendix M.

TABLE A5-6
CRITICAL PROJECTS NEEDED DURING
PROJECT IMPLEMENTAION REPORT PROCESS

Rank	Critical Project Title
8	South Miami-Dade Agricultural and Rural Land Use Water Management Plan
14	Geodetic Vertical Control Surveys
19	Develop and Implement Agricultural BMPs in the C-111 Basin
27	Six Permanent Water and Meteorological Stations
28	Nutrient Removal and Dosing Studies for Everglades National Park

A5.8 ADDITIONAL STUDY

The two projects displayed in ***Table A5-7*** are recommended for additional study through the recommended Southwest Florida Feasibility Study (See Section 10 of the Main Report for additional information).

TABLE A5-7
CRITICAL PROJECTS RECOMMENDED FOR ADDITIONAL STUDY

Rank	Critical Project Title
32	Town of Ft. Myers Beach
34	Spring Creek Reconnection and Rehydration

A5.9 SUMMARY TABLE

Table A5-8 shows how all 35 Critical Projects nominated by the Working Group have been addressed in the Restudy.

TABLE A5-8 CRITICAL PROJECTS IN THE COMPREHENSIVE PLAN

Rank	Critical Project Title	Category
1	East Canal Structures	W/O Plan
2	Tamiami Trail Culverts	W/O Plan
3a	Melaleuca Eradication Project (New Facility)	W/O Plan
3b	Melaleuca Eradication Project (Renovate Existing Facility)	OPE
3c	Melaleuca Eradication Project (Implement Biological Controls)	OPE
4	Florida Keys Carrying Capacity Study	W/O Plan
5	Western C-11 Water Quality Treatment Project	W/O Plan
6	Seminole Tribe Big Cypress Reservation Water Conservation Plan	OPE
7	Southern Golden Gates Hydrologic Restoration	OPE
8	South Miami-Dade Agricultural and Rural Land Use and Water Management Plan	PED
9	Southern Crew Project Addition/Imperial Flowways	OPE
10	Lake Okeechobee Water Retention/Phosphorus Removal	OPE
11	Ten-mile Creek Water Preserve Area	D-13R
12	L-28 Modification	D-13R
13	Loxahatchee Slough Ecosystem Restoration	D-13R
14	Geodetic Vertical Control Surveys	PED
15	Lake Trafford Restoration	OPE
16	L-31East Flow Redistribution *(included in Biscayne Bay Coastal Wetlands OPE)*	W/O Plan +OPE
17	Henderson Creek Belle Meade Restoration	OPE
18	Lake Okeechobee Tributary Sediment Dredging	OPE
19	Develop & Implement Agricultural BMPs in the C-111 Basin	PED
20	North Fork New River Restoration	W/O Plan
21	L-8 Canal- Water Catchment Area Loxahatchee Slough Infrastructure Improvements	D-13R
22	Florida Keys Tidal Restoration	OPE
23	Lake Worth Lagoon Restoration	OPE
24	Palm Beach Co. Wetlands Based Water Reclamation	OPE
25	Lake Okeechobee Aquifer Storage and Recovery	PILOT
26	Miccosukee Water Management Area	OPE
27	Six Permanent Water and Meteorological Stations	PED
28	Nutrient Removal and Dosing Studies for Everglades National Park	PED
29	WCA 3B Seepage Reduction	PILOT
30	Hillsboro Pilot Aquifer Storage and Recovery Project	PILOT
31	Lakes Park Restoration	OPE
32	Town Of Ft. Myers Beach	SWFL Feasibility
33	Palm Beach Co. Winsberg Farms Constructed Wetland	OPE
34	Spring Creek Reconnection and Rehydration Project	SWFL Feasibility
35	Restoration of Pineland & Hardwood Hammocks in C-111 Basin	OPE

APPENDIX A6

DESCRIPTION OF OTHER PROJECT ELEMENTS

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APPENDIX A6
OTHER PROJECT ELEMENTS

The recommended Comprehensive Plan is comprised of the components of Alternative D-13R and a group of projects that could not be evaluated using the modeling tools used during the iterative alternative plan formulation process (See Section 7 of the Main Report). This group of projects has been termed Other Project Elements (OPEs). This Section of the Plan Formulation Appendix describes the OPE formulation and evaluation process.

A6.1 FORMULATION PROCESS

Formulation of the OPEs that are included in the Comprehensive Plan was generally a three-step process. First, a list of potential OPEs was compiled from a variety of sources. Next, an interagency evaluation team conducted an initial evaluation of the OPEs. Finally, in response to comments on the Draft Comprehensive Plan, additional formulation resulted in the array of OPEs included in the recommended Comprehensive Plan. Each of these formulation steps is further described below.

A6.1.1 Initial Screening

The OPEs are defined by the following criteria; 1) the project must be a component that could not be evaluated using the South Florida Water Management Model, 2) the project must support and be consistent with Restudy objectives, 3) the project must have a Federal interest, and 4) the project should not be stand-alone research or data collection. A list of potential OPEs was compiled from the Critical Projects list (see Appendix A5): the Governor's Commission's Conceptual Plan, and suggestions by Restudy Team members. Project proponents were requested to prepare brief "OPE fact sheets" to be used in the evaluation process described in the next section. Information to be provided in the fact sheets included descriptions of: 1) features/operations of the proposed project and its relationship to the Comprehensive Plan, 2) the purpose of the project including a description of the existing condition of the ecosystem in the area, 3) the expected benefits and/or impacts of the project and how they are measured, 4) techniques, models, and procedures that will define project outputs, and, 5) a cost estimate. The resulting list of 38 potential OPEs (the initial list) is displayed in ***Table A6-1***. The table is arranged according to geographic region.

TABLE A6-1 Initial List of Potential Other Project Elements

Kissimmee River Basin and Lake Okeechobee
Additional Storage in Chain of Lakes (above Lake Cypress)
Restore Wetland and Aquatic Habitat at Pool A
Restore Wetland and Aquatic Habitat at Pool E
Restore Wetland and Aquatic Habitat at Paradise Run
Lake Istokpoga Restoration
Lake Okeechobee Tributary Sediment Dredging (CP)
Lake Okeechobee Watershed Water Quality Treatment Facilities (includes CP)
Restoration of Kreamer, Torry, and Ritta Islands
Caloosahatchee River Basin
Restore Natural Flows at Sanibel/Captiva Causeway
Caloosahatchee River Oxbow Restoration
Lower East Coast Region
Pal Mar and Corbett Hydropattern Restoration
Winsberg Farms Constructed Wetland (CP)
Palm Beach County Wetlands-Based Water Reclamation Project (CP)
Central Palm Beach County Water Preserve Area and LNWR Enhancement by Reclaimed Water
West Palm Beach Water Catchment Area Enhancement Reclaimed Water
Acme Basin B Discharge
Protect and Enhance Existing Wetland Systems along LNWR including the Strazzulla Tract
Lake Worth Lagoon Restoration (CP)
North Fork of the New River Restoration (CP)
Northern Broward Regional Reuse
City of Hollywood Reuse
Pond Apple Slough Restoration
South Miami-Dade Agricultural and Rural Area Land Use and Water Management Plan (CP)
Restoration of Pineland and Tropical Hardwood Hammocks in C-111 Basin (CP)
Biscayne Bay Coastal Wetlands (includes L-31E Flow Redistribution (CP))
Western Basin & Big Cypress Basin
Seminole Tribe Big Cypress Reservation Water Conservation Plan (CP)
Henderson Creek Belle Meade Restoration (CP)
Reversing Overdrainage from Barron River Canal
Miccosukee Water Management Area (CP)
Everglades National Park, Florida Bay and Florida Keys
Flamingo Road Improvements to Restore Hydrologic Flows
Restore Natural Flow into Florida Bay by Removal of Causeway at Adams Waterway, MM103,
Florida Keys Tidal Creek Restoration (CP)
Tea Table Fill Removal
Southwest Florida
Lakes Park Restoration (CP)
Southwest Florida Water Management Model
Spring Creek Reconnection and Rehydration Project (CP)
Town of Ft. Myers Beach (CP)
System-wide
Melaleuca Eradication Project (CP) part A – New Facility part B – Renovate Existing Facility part C – Biological Agent Rearing

CP= Critical Project

A6.1.2 Additional Screening And Initial Evaluation

On June 17, 1998, an interdisciplinary team met to evaluate the initial list of potential OPEs. Expected outputs for each project were estimated in four categories: 1) **ecological** outputs based on natural hydrology, spatial extent, habitat quality and improvement in native flora and fauna, 2) urban and agricultural **water supply**, 3) **flood damage reduction**, and 4) **water quality**. The following rating system was used in each of the four output categories:

++ (Major beneficial effect)
+ (Some beneficial effect)
0 (No beneficial or detrimental effect)
- (Some detrimental effect)
- - (Major detrimental effect)

In addition, the team looked at two other parameters 1) **geographic extent** and 2) **significance**. The geographic extent of benefits or detriments was simply designated as having either a Local or Regional effect. The significance parameter reflects the “importance” of the project in support of Alternative D-13R and/or the goals of the Restudy. The significance parameter was rated as High, Moderate, or Low. All six parameters were rated using the team’s collective best professional judgment based on information provided in the fact sheets submitted by the project proponents and/or team members’ personal knowledge of the projects.

The evaluation team began with the initial list of potential OPEs and screened it again based on the sufficiency of the information provided in the fact sheets and personal knowledge of team members. The team recognized that much of the available information about the projects was conceptual. Even so, the team was not able to evaluate eleven of the potential OPEs due to lack of information. Team ratings of the remaining 27 potential OPEs are presented in the matrix displayed in ***Table A6-2***. The eleven potential OPEs that were not rated are included in the matrix and the reasons they could not be rated are noted in the comments column. The table is arranged according to geographic region.

TABLE A6-2
Potential Other Project Elements Evaluation Matrix

OPE TITLE	Geo Extent	Signif-icance	Eco-logical	Water Supply	Flood Control	Water Quality	Comments
Kissimmee River Basin and Lake Okeechobee							
Additional Storage in Chain of Lakes (above Lake Cypress)	REG	HIGH	++	0	-	+	Minimal information in fact sheet. Evaluation based on the concept.
Restore Wetland and Aquatic Habitat at Pool A	REG	HIGH	++	-	0	+	
Restore Wetland and Aquatic Habitat at Pool E	REG	HIGH	++	-	0	+	Evaluation based on FWS OPE report (Draft 16 Jun 98)
Restore Wetland and Aquatic Habitat at Paradise Run	REG	HIGH	++	-	0	+	
Lake Istokpoga Restoration	REG	MOD	++	0	+	0	
Lake Okeechobee Tributary Sediment Dredging (CP) [1]	REG	LOW	+	0	0	+	
Lake Okeechobee Watershed Water Quality Treatment Facilities (incl CP)	REG	MOD	+	0	0	++	
Restoration of Kreamer, Torry, and Ritta Islands	LOC	LOW	+	0	0	0	No fact sheet. Evaluation based on concept that island littoral zones could be rehabilitated to natural emergent vegetation communities.
Caloosahatchee River Basin							

[1] CP = Critical Project.

OPE TITLE	Geo Extent	Signif-icance	Eco-logical	Water Supply	Flood Control	Water Quality	Comments
Restore Natural Flows under Sanibel/Captiva Causeway.	LOC	LOW	++	0	0	+	No fact sheet. Evaluation based on assumption that historic tidal circulation could be restored.
Caloosahatchee River Oxbow Rehabilitation	LOC	MOD	++	0	0	+	
Lower East Coast							
Pal Mar and Corbett Hydropattern Restoration	REG	MOD	++	+	0	+	
Winsberg Farms Constructed Wetland (CP)	LOC	LOW	+	+	0	0	
Palm Beach County Wetlands-Based Water Reclamation Project (CP)	LOC	MOD	+	++	0	0	
Central Palm Beach County Water Preserve Area and LNWR Enhancement by Reclaimed Water							Not enough information to evaluate. Needs regional benefit analysis. Is there a need for this reuse water in the regional system?
West Palm Beach Water Catchment Area Enhancement by Reclaimed Water							Not enough information to evaluate. Needs regional benefit analysis. Is there a need for this reuse water in the regional system?
Acme Basin B Discharge	REG	MOD	+	+	+	+	
Protect and Enhance Existing Wetland Systems along LNWR including the Strazzulla Tract	REG	MOD	+	+	+	+	
Lake Worth Lagoon Restoration (CP)	LOC	LOW	+	0	0	+	

OPE TITLE	Geo Extent	Signif-icance	Eco-logical	Water Supply	Flood Control	Water Quality	Comments
North Fork of the New River Restoration (CP)	LOC	LOW	+	0	0	++	
Northern Broward Regional Reuse							Not enough information to evaluate. Needs regional benefit analysis. Is there a need for this reuse water in the regional system?
City of Hollywood Reuse							Not enough information to evaluate. Needs regional benefit analysis. Is there a need for this reuse water in the regional system?
Pond Apple Slough Restoration	LOC	MOD	+	0	0	+	The purpose of the project is to compensate for potential adverse hydrological effects of D-13R. This is an implementation issue.
South Miami-Dade Agricultural and Rural Land Use and Water Management Plan (CP)							Not evaluated - This is a study not a project.
Restoration of Pineland and Tropical Hardwood Hammocks in C-111 Basin (CP)	LOC	LOW	+	0	0	0	
Biscayne Bay Coastal Wetlands (includes L-31 E Flow Redistribution CP)	REG	HIGH	++	0	0	+	
Western Basin & Big Cypress							

OPE TITLE	Geo Extent	Signif-icance	Eco-logical	Water Supply	Flood Control	Water Quality	Comments
Seminole Tribe Big Cypress Water Conservation Plan (east portion)	REG	HIGH	+	+	+	++	
Henderson Creek Belle Meade Restoration (CP)	REG	MOD	++	+	0	+	
Reversing Overdrainage from Barron River Canal	REG	HIGH	++	+	0	+	
Miccosukee Water Management Area (CP)							Not evaluated - No information available.
Everglades National Park, Florida Bay and Florida Keys							
Flamingo Road Improvements to Restore Hydrologic Flows							Not evaluated - No information available.
Restore tidal flow into Florida Bay at Adams Waterway							Not evaluated – No information available.
Florida Keys Tidal Creek Restoration (CP)	LOC	MOD	++	0	0	+	
Indian Key and Tea Table Fill Removal	REG	HIGH	++	0	0	++	
Southwest Florida							
Lakes Park Restoration (CP)	LOC	LOW	+	0	0	+	No fact sheet. Evaluation based on information from Critical Project summary.
Southwest Florida Water Management Model							Not evaluated - This is an evaluation tool not a project. Necessary for Southwest Florida Feasibility Study.

OPE TITLE	Geo Extent	Signif-icance	Eco-logical	Water Supply	Flood Control	Water Quality	Comments
Spring Creek Reconnection and Rehydration (CP)							Not evaluated - Project may be a compensatory mitigation requirement for permits associated with a private residential development.
Town of Ft. Myers Beach (CP)							Not evaluated - This is a study not a project.
System Wide							
Melaleuca Eradication Project (CP) (parts A,B &C)	REG	HIGH	++	0	0	0	

A6.1.3 Formulation Of The OPEs In The Draft Comprehensive Plan

After initial evaluation of the individual OPEs by the interagency team, the Corps continued the formulation process by considering the team's evaluation findings as well as project costs. This process revealed that the potential OPEs fall into three general categories: 1) cost effective projects with sufficient detail to be included in the Comprehensive Plan, 2) projects recommended for additional study, and 3) projects that are more appropriately defined as Comprehensive Plan implementation activities. The Draft Comprehensive Plan was released for public comment in October 1998. In the Draft Plan, the OPEs on the initial list were distributed among the three categories described above.

A6.1.4 Formulation Of The OPEs In The Final Comprehensive Plan

In the Draft Plan, many of the potential OPEs, including some of the lower-priority Critical Projects, were recommended for additional study under the recommended Feasibility Studies (see Section 9 of the Main Report). In response to public and agency comments recommending that implementation of the Comprehensive Plan be accelerated to expedite ecologic restoration, the plan was modified so that most of the Critical Projects that are not anticipated to be funded through the Critical Projects program are now included as OPEs in the Final Plan.

Assumptions regarding Critical Projects in the Restudy Without Plan Condition were also modified in response to agency comments (See Section 4 of the Main Report and Appendix A5). In the Draft Plan, the ten Critical Projects that had received approval through the Critical Projects program (as of September 1998) were included in the Without Plan Condition. These are displayed in ***Table A6-3*** which also includes columns indicating if a project was included on the initial list of potential OPEs and also how the project was addressed in the Draft Plan.

TABLE A6-3
CRITICAL PROJECTS IN THE WITHOUT PLAN CONDITION (DRAFT)

OPE TITLE	Initial OPE list[1]	Study[2]	D-13R[3]
East Coast Canal Structures			✕
Tamiami Trail Culverts			
Florida Keys Carrying Capacity			
Western C-11 Water Quality Treatment			✕
Seminole Tribe Big Cypress Water Conservation Plan (west)[4]			
Southern Golden Gate Estates Hydrologic Restoration	✕	✕	
Southern CREW Project Addition/Imperial River Flowways	✕	✕	
Lake Okeechobee Water Retention/Phosphorous Removal[5]			
Ten Mile Creek Water Preserve Area			✕
Lake Trafford Restoration			

[1]OPE list = The initial list of potential OPEs evaluated by the team.
[2]Study = Potential OPEs recommended for additional study in the Draft Plan.
[3]D-13R = Project is included in a component of Alternative D-13R.
[4]The east portion of this project is on the initial potential OPE list, see section A6.3.5.1 for details.
[5]This project is similar to the project titled "Lake Okeechobee Water Quality Treatment Facilities" which is on initial list of potential OPEs. See section A6.3.3.3 for details.

In response to agency comments on the Draft Report, the Without Plan Condition was modified to include only the Critical Projects that are both approved **and** are anticipated to be funded through the Critical Projects program. In addition, by February 1999, two more Critical Projects had been approved. These are 1) the New Facility (part A) of the Melaleuca Eradication Project and 2) the L-31 East Flow Redistribution project. At the time this appendix was being written, it was anticipated that seven of the approved Critical Projects will be funded through the Critical Projects program. These are displayed in ***Table A6-4***.

TABLE-A6-4
CRITICAL PROJECTS IN THE WITHOUT PLAN CONDITION (FINAL)

East Coast Canal Structures
Tamiami Trail Culverts
Melaleuca Eradication –New Facility (part A)
Florida Keys Carrying Capacity
Western C-11 Water Quality Treatment
L-31East Flow Redistribution
North Fork of the New River Restoration

The two Critical Projects that were in the Draft Without Plan Condition and on the initial potential OPE list (Southern Golden Gate Estates Hydrologic Restoraiton and Southern CREW Project Addition/Imperial River Flowways) were initially recommended for additional study through the recommended Southwest Florida Feasibility Study. These two are now included in the Final Plan as OPEs. In addition, the west portion of the Seminole Tribe Big Cypress Reservation Water Conservation Plan (the Critical Project) was combined with the east portion of this project which was on the initial list of potential OPEs. Similarly, the Lake Okeechobee Water Retention/Phosphorous Removal Critical Project was combined with the proposed Lake Okeechobee Watershed Water Quality Treatment Facilities OPE. Finally, two Critical Projects: 1) North Fork of the New River Restoration and 2) the New Facility of the Melaleuca Eradication Project (part A) were not included in the final OPE formulation process because they are now included in the Without Plan Condition.

In summary, modification of the Without Plan Condition resulted in the addition of the Lake Trafford Restoration Critical Project to the OPE formulation process and removal of the North Fork of the New River Restoration and part A of the Melaleuca Eradication Project from the process. The Western C-11 Water Quality Treatment and Ten Mile Creek Water Preserve Area Critical Projects are not included in the OPE formulation process because they are included in D-13R components. See Appendix A5 for additional information.

A6.2 FORMULATION CONCLUSIONS

The final OPE formulation process revealed that the potential OPEs again fall into three general categories: 1) cost effective projects with sufficient detail to be included in the Comprehensive Plan, 2) projects recommended for additional study, and 3) projects that are more appropriately defined as Comprehensive Plan implementation activities.

A6.2.1 Other Project Elements In The Comprehensive Plan

The twenty projects displayed in ***Table A6-5*** are now included in the Comprehensive Plan as OPEs

TABLE A6-5
RECOMMENDED OTHER PROJECT ELELMENTS

Melaleuca Eradication Project (CP) – part A) Renovation of Existing Facility part B) Biological Agent Rearing
Seminole Tribe Big Cypress Reservation Water Conservation Plan (combined w/ CP)
Southern Golden Gates Hydrologic Restoration (CP)
Southern Crew Project Addition/Imperial River Flowways (CP)
Lake Okeechobee Watershed Water Quality Treatment Facilities (combined w/ CP)
Lake Trafford Restoration (CP)
Biscayne Bay Coastal Wetlands (includes L-31E Flow Redistribution (CP))
Henderson Creek and Belle Meade Restoration (CP)
Lake Okeechobee Tributary Sediment Dredging (CP)
Florida Keys Tidal Restoration (CP)
Lake Worth Lagoon Restoration (CP)
Palm Beach County Wetlands Based Water Reclamation Project (CP)
Miccosukee Water Management Plan (CP)
Lakes Park Restoration (CP)
Winsberg Farms Constructed Wetlands Project (CP)
Restoration of Pineland & Tropical Hardwood Hammocks in C-111 Basin (CP)
Lake Istokpoga Restoration
Protect & Enhance Existing Wetland Systems along LNWR including Strazzulla Tract
Pal Mar and Corbett Hydropattern Restoration
Acme Basin B Discharge

CP=Critical Project

A6.2.2 OPEs Recommended For Additional Study

Many of the potential OPEs evaluated by the evaluation team are conceptual. Problems and their proposed solutions are described only in general terms in the fact sheets provided by the project proponents. Even so, the evaluation team believes many of these problems should be addressed but more analysis is needed. Problems should be adequately identified and potential alternatives to the proposed OPEs should be evaluated. Accordingly, ten of the potential OPEs are recommended for further study as displayed in ***Table A6-6***.

TABLE A6-6
OTHER PROJECT ELEMENTS RECOMENDED FOR ADDITIONAL STUDY

OPE TITLE	FEASIBILTY STUDY
Restore Natural flows at Sanibel/Captiva Causeway	Southwest Florida
Caloosahatchee River Oxbow Rehabilitation	Southwest Florida
Reversing Overdrainage from Barron River Canal	Southwest Florida
Southwest Florida Water Management Model	Southwest Florida
Spring Creek Reconnection and Rehydration	Southwest Florida
Town of Ft. Myers Beach	Southwest Florida
Restoration of Kreamer, Torry, and Ritta Islands	Comprehensive Integrated Water Quality Plan
Flamingo Road Improvements to Restore Hydrologic Flows	Florida Bay and the Florida Keys
Restore Tidal Flow at Adams Waterway	Florida Bay and the Florida Keys
Indian Key and Tea Table Fill Removal	Florida Bay and the Florida Keys

A6.2.3 Project Implementation Activities

Ten of the projects on the initial OPE list are more appropriately considered as Comprehensive Plan implementation activities rather than stand-alone project features. These projects can be grouped into four categories: 1) wastewater reuse projects that can be considered as contingency water sources, 2) projects that should be considered as water storage options for the conceptual storage areas identified in D-13R, 3) research or data collection activities, and 4) detailed design activities. Each of these categories is further described below.

A6.2.3.1 Potential Water Sources For The Comprehensive Plan

The Comprehensive Plan currently includes the use of reclaimed water from West Miami-Dade Reuse (Component HHH6) and South Miami-Dade Reuse (Component BBB6) facilities. These facilities provide additional water to the regional system and are most important during the dry season. These two reuse components are relatively expensive sources of “new” water, but the benefits to ecosystem restoration and water supply are important to the performance of the Comprehensive Plan. The four projects displayed in ***Table A6-7*** were proposed as OPEs, however, the high cost of reuse could not be justified at this time because less expensive sources of water have been identified. These reuse projects may be able to provide benefits to the regional system should some of the less certain and/or less costly sources in the recommended Comprehensive Plan turn out to be impractical. Accordingly these contingency sources should be considered further in the Project Implementation Report process.

TABLE A6-7
POTENTIAL WATER SOURCE CONTIGENCIES

Central Palm Beach County Water Preserve Area and Loxahatchee National Wildlife Refuge Enhancement by Reclaimed Water
West Palm Beach Water Catchment Area Enhancement Reclaimed Water
Northern Broward Regional Reuse
City of Hollywood Reuse

A6.2.3.2 Potential Storage Alternatives

The proposed OPEs displayed in ***Table* A6-8** should be considered in the appropriate Project Implementation Report (See Section 10 of the Main Report for a complete description of the Implementation Plan). These projects could provide storage in the Kissimmee River Basin as well water quality benefits and increases in the spatial extent of aquatic and wetland habitat.

TABLE A6-8
POTENTIAL STORAGE ALTERNAIVES

Additional Storage in Chain of Lakes (above Lake Cypress)
Restore Wetland and Aquatic Habitat at Pool A
Restore Wetland and Aquatic Habitat at Pool E
Restore Wetland and Aquatic Habitat at Paradise Run

A6.2.3.3 Research And Data Collection Activities

The South Biscayne Bay Watershed Management Plan is considered to be a research and data collection activity that will aid further refinement of the Without Plan Condition for Miami-Dade County. In addition, data collected regarding water quality and development of localized hydrologic models for the area will aid refinement of the performance measures for Biscayne Bay.

A6.2.3.4 Detailed Design Activities

Broward County officials have expressed concern about the effects of the Comprehensive Plan on Pond Apple Slough. Additional modeling of the effects of the proposed hydrologic modifications to flows through S-13 on the slough should be addressed during the Project Implementation Report process.

A6.2.4 Summary Table

Table A6-9 summarizes the results of the OPE formulation process. The table is arranged according to geographic region.

TABLE A6-9 OPEs CONSIDERD IN THE PLAN FORMULATION PROCESS

Kissimmee River Basin and Lake Okeechobee	
Additional Storage in Chain of Lakes (above Lake Cypress)	PIR
Restore Wetland and Aquatic Habitat at Pool A	PIR
Restore Wetland and Aquatic Habitat at Pool E	PIR
Restore Wetland and Aquatic Habitat at Paradise Run	PIR
Lake Istokpoga Restoration	OPE
Lake Okeechobee Tributary Sediment Dredging (CP)	OPE
Lake Okeechobee Watershed Water Quality Treatment Facilities	OPE
Restoration of Kreamer, Torry, and Ritta Islands	CWQ
Caloosahatchee River Basin	
Restore Natural Flows at Sanibel/Captiva Causeway	SWFL
Caloosahatchee River Oxbow Restoration	SWFL
Lower East Coast Region	
Pal Mar and Corbett Hydropattern Restoration	OPE
Winsberg Farms Constructed Wetland (CP)	OPE
Palm Beach County Wetlands-Based Water Reclamation Project (CP)	OPE
Central Palm Beach County Water Preserve Area and Loxahatchee National Wildlife Refuge Enhancement by Reclaimed Water	PIR
West Palm Beach Water Catchment Area Enhancement Reclaimed Water	PIR
Acme Basin B Discharge	OPE
Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including the Strazzulla Tract	OPE
Lake Worth Lagoon Restoration (CP)	OPE
North Fork of the New River Restoration (CP)	W/O
Northern Broward Regional Reuse	PIR
City of Hollywood Reuse	PIR
Pond Apple Slough Restoration	PIR
South Miami-Dade Agricultural and Rural Land Use and Water Management Plan (CP)	PIR
Restoration of Pineland and Tropical Hardwood Hammocks in C-111 Basin (CP)	OPE
Biscayne Bay Coastal Wetlands (includes L-31E Flow Redistribution (CP))	OPE
Western Basin & Big Cypress Basin	
Seminole Tribe Big Cypress Reservation Water Conservation Plan (CP)	OPE
Southern Golden Gate Estates Hydrologic Restoration (CP)	OPE
Southern CREW Project Addition/Imperial River Flowways (CP)	OPE
Henderson Creek Belle Meade Restoration (CP)	OPE
Reversing Overdrainage from Barron River Canal	SWFL
Miccosukee Water Management Area (CP)	OPE
Everglades National Park, Florida Bay and Florida Keys	
Flamingo Road Improvements to Restore Hydrologic Flows	FB
Restore Natural Flow into Florida Bay at Adams Waterway, MM103,	FB
Florida Keys Tidal Creek Restoration (CP)	OPE
Indian Key and Tea Table Fill Removal	FB
Southwest Florida	
Lake Trafford Restoration (CP)	OPE
Lakes Park Restoration (CP)	OPE
Southwest Florida Water Management Model	SWFL
Spring Creek Reconnection and Rehydration Project (CP)	SWFL
Town of Ft. Myers Beach (CP)	SWFL
System-wide	
Melaleuca Eradication Project (CP) part A – New Facility part B – Renovate Existing Facility part C – Biological Agent Rearing	W/O OPE OPE

CP= Critical Project

A6.3 PROJECT DESCRIPTIONS

Each of the potential OPEs that were considered in the formulation process are described in further detail below. The projects are grouped according to geographic region.

A6.3.1 Kissimmee River Basin And Lake Okeechobee

A6.3.1.1 Additional Storage In The Chain Of Lakes Above Lake Cypress

Construction of a water control structure in the C-36 Canal at the outlet of Lake Cypress in the Upper Chain of Lakes would provide additional options in lake stage management. Historically, Lake Cypress had a higher stage than Lake Hatchineha and Lake Kissimmee, but all three are held at roughly the same level. Additional management capabilities in the upper chain could storage requirements in the lower reaches of the Kissimmee River Basin.

A6.3.1.2 Restore Wetland And Aquatic Habitat At Pool "A"

The reach of the Kissimmee River (C-38) from S-65 downstream to S-65A is designated as Pool A. Flow-through marshes could be created adjacent to C-38 by construction of a parallel watercourse separated from C-38 by levees. Culverts and weirs could divert water to the marsh. Approximately 3,000 acres of pasture could be converted to wetlands. Benefits would include additional storage of floodwater and improvement in water quality.

A6.3.1.3 Restore Wetland And Aquatic Habitat At Pool "E"

The reach of the Kissimmee River (C-38) from S-65D downstream to S-65E is designated as Pool E. The restoration of Pool E was originally included in the Kissimmee River Restoration plan, but was not included in the final authorization because of concerns about flooding of homes in the area. This remains a potential storage option within the basin.

A6.3.1.4 Restore Wetland And Aquatic Habitat At Paradise Run

The reach of the Kissimmee River (C-38) from S-65E downstream to the outlet at Lake Okeechobee is known as Paradise Run. Flow-through marshes could be created adjacent to C-38 by construction a parallel watercourse separated from C-38 by levees. Culverts and weirs could divert water to the marsh. Approximately 3,600 acres of pasture could be converted to wetlands. Benefits would include additional storage of floodwater and improvement in water quality.

A6.3.1.5 Lake Istokpoga Restoration

This feature includes development of a plan to address water resource problems in the Lake Istokpoga Basin. Lake Istokpoga is a natural lake located in Highlands County, a tributary of Lake Okeechobee and the Kissimmee River via the C-41A Canal. The major focus of this plan is to create a balance between the environmental needs, water supply and flood control in the Lake Istokpoga Basin. The purpose of this plan is to examine the Istokpoga Basin with a view towards enhancing fish and wildlife benefits and developing a long-term comprehensive management plan. It has been noted that operation of S-68, beginning in 1962, reduced the maximum annual fluctuation of the lake (SFWMD, 1978). While the littoral zone expanded, the amount of quality habitat was reduced by this formation of extensive floating tussocks and dense cattail communities. Persistently lowered lake levels has reduced the natural frequency of seasonal drying and inundation. Without natural dewatering events, germination of diverse aquatic plant seeds is reduced, consolidation and compaction of organic sediments cannot occur, and the formation and expansion of floating mats of water hyacinths and other species common to tussock communities are promoted. These mats reduce overall productivity and diversity of the marsh. The plan will also address the need for flood protection to the perimeter and upstream tributaries, and downstream areas west and east of C-41A. Water supply needs for agriculture and the Seminole Tribe of Florida will also be addressed.

A6.3.1.6 Lake Okeechobee Tributary Sediment Dredging

The project would be located in selected tributaries in the Lake Okeechobee watershed. Historically, south Florida waters were low in nutrients (oligotrophic). Elevated phosphorus loading of waterbodies and the resulting increased water phosphorus concentrations (eutrophication) may have various ecological effects. These effects may include increased primary productivity: loss of water column dissolved oxygen, algal blooms, and changes in vegetation and biodiversity. The significance of such phosphorus loading may be the reduction or loss of a waterbody's habitat and/or recreational values. Sediment found in tributaries to Lake Okeechobee is an important source of phosphorous that contributes to the excessive loading to the lake. This project involves dredging sediments from approximately ten miles of primary canals. As a result, an estimated 150 tons of phosphorous will be removed from potential loading to the lake.

A6.3.1.7 Lake Okeechobee Watershed Water Quality Treatment Facilities

Many of the problems identified in Lake Okeechobee result from poor water quality and altered timing of the runoff from its watershed. Many former wetlands in the watershed have been ditched and drained for agriculture and flood control purposes. In many cases the runoff problems associated with these past modification are best solved at, or near, the individual sources. Restoring the hydrology of selected isolated and riverine wetlands in the region by plugging these drainage ditches will help attenuate peak flows in the basin and retain phosphorus within the restored wetlands. In some basins, construction of reservoir-assisted stormwater treatment areas (RSTAs) will be needed to meet hydrologic and water quality targets. The Critical Project titled Lake Okeechobee Water Retention/Phosphorous Removal employs these concepts. The features of the Critical Project can not exceed the funding cap for individual Critical Projects.

An OPE titled Lake Okeechobee Watershed Water Quality Treatment Facilities was proposed to further the concept of restoring additional wetlands beyond those areas being planned in the Critical Project. In light of the modification to the without plan condition regarding the Critical Projects (see appendix A5), the Critical Project has been combined with the OPE to ensure implementation of these important features.

The combined project focuses on restoring approximately 3,500 acres of wetlands on specific land parcels located within four key lower Kissimmee River Basins (S-65D Basin, S-65E Basin and S-154 Basin) and the Taylor Creek-Nubbin Slough Basin (S-191). Two RSTAs in the basins with the poorest water quality are also planned. The initial design of these RSTAs assumes a 1,775-acre facility in the S-154 Basin in Glades County and a 2,600-acre facility in the S-65D sub-Basin of the Kissimmee River Basin in Highlands and Okeechobee Counties.

A6.3.1.8 Restoration Of Kreamer, Torry, And Ritta Islands

Kreamer, Ritta and Torry Islands are located near the south shore of Lake Okeechobee. These islands have been used for agricultural purposes and small levees and drainage ditches have been constructed. A project plan has not been identified, but restoration of these islands would involve degrading selected levees to allow more natural water levels and transplanting native vegetation. These actions would result in additional habitat for water birds, fish, and other wildlife. Contaminant studies would need to be completed prior to restoration design.

A6.3.2 Caloosahatchee River Basin

A6.3.2.1 Restore Natural Flows At Sanibel/Captiva Causeway

The Sanibel/Captiva causeway consists of two fill sections and three bridge sections connecting Sanibel and Captiva Islands with the mainland at Ft. Myers, in Lee County. The causeway was constructed in the mid-1960s and shortly thereafter, the scallop fishery in San Carlos Bay collapsed. It is uncertain as to what degree this collapse was caused by construction of the causeway, because the Intracoastal Waterway channel and the Franklin Lock (S-79) on the Caloosahatchee River were also completed in the mid-1960s. Coupled with Comprehensive Plan features that will capture regulatory releases from Lake Okeechobee and store excessive runoff from the Caloosahatchee Drainage Basin, removal of the Sanibel Causeway would promote restoration of Pine Island Sound and San Carlos Bay. A coupled circulation and water quality model for the greater Charlotte Harbor Estuary is currently being developed. This model should allow more detailed study of the circulation problems and the formulation of potential solutions.

A6.3.2.2 Caloosahatchee River Oxbow Rehabilitation

Historically, the Caloosahatchee River originated in marshes just west of Lake Okeechobee and meandered slowly to the estuary at San Carlos Bay. Modifications begun in the late 19^{th} century involved construction of a channel to allow navigation to Lake Okeechobee. Construction of the C-43 Canal for navigation and floodwater conveyance involved further channelization of the naturally meandering course of the Caloosahatchee River. Flows within the remnant bends, or oxbows, in the natural river course were reduced or cut off by C-43. The remnant oxbows receive reduced flows and are subject to accelerated bottom sedimentation, deteriorating water quality, exotic/nuisance vegetation invasion, deteriorating habitat function, and diminishing historical value. This project is a rehabilitation effort that will improve ecological conditions within C-43 and will also improve the timing and quality of water delivered to the Caloosahatchee Estuary. The methods tested and shown to be productive in the study of remnant channels of the Kissimmee River Restoration project will be used in this project.

A6.3.3 Lower East Coast Region

A6.3.3.1 Pal Mar And Corbett Hydropattern Restoration

This project involves the acquisition of 3,000 acres between Pal-Mar and the J.W. Corbett Wildlife Management Area (WMA) to extend the spatial extent of protected natural areas. The project will also provide hydrologic connections between the Corbett WMA and: 1) the Moss Property, 2) the C-18 Canal, 3) the Indian Trails Improvement District, and 4) the L-8 Canal. These connections would relieve the detrimental effects on native vegetation frequently experienced during the wet season. Pal-Mar is a large pine flatwood/wet prairie/depression marsh complex located in Palm Beach and Martin Counties, northeast of the Corbett WMA. Acquisition of this remaining privately owned parcel of land consisting of approximately 3,000 acres between Pal-Mar and Corbett would form an unbroken 126,000-acre greenbelt extending from the Dupuis Reserve near Lake Okeechobee across the Corbett WMA, and connecting with Jonathan Dickinson State Park.

A6.3.3.2 Winsberg Farms Constructed Wetland

In an effort to reduce the amount of treated water from the Southern Region Water Reclamation Facility (SRWRF) that is currently wasted in deep injection wells, the Palm Beach County Water Utilities Department (PBCWUD) plans to further treat and recycle this water. The PBCWUD has completed construction of a 50-acre constructed wetland located at the County's System 3 site east of Jog Road, just southeast of the Winsberg property. This wetland has been named Wakodahatchee, which is Seminole Indian for "created waters". As part of this wetland, a public access facility with limited parking, boardwalk, kiosks and interpretive signage was designed to educate the public about the importance of wetlands for both treatment of water and creation of wildlife habitat. This project proposes construction of an additional 175 acres of wetlands on the Winsberg property. This will serve to not only recycle and preserve additional water for future use, but will link the Wakodahatchee and Winsberg Farms facilities and provide additional green space in area currently under heavy development. Approximately, 6 to 8 Million Gallons per Day of reclaimed water from the SRWRF would be applied to the area. The wetland would be planted to maximize the diversity of native plant material and habitat for various species of wildlife.

A6.3.3.3 Palm Beach County Wetlands-Based Water Reclamation Project

The Wetlands-Based Water Reclamation Project (WWRP) proposes to treat wastewater from the East Central Regional Wastewater Treatment Facility (ECR) using Advanced Wastewater Treatment (AWT) processes to remove nitrogen and phosphorus. This will then be followed with superior treatment technology to remove phosphorus to approximately 50 parts per billion or less. Phase I of the WWRP will consist of a 10 Million Gallons per Day (MGD) operation with 6 MGD of the water discharged into approximately 1,500 acres of bermed marsh where it will be used to hydrate the marsh as well as manage the hydroperiod and water quality of the wetland environment. The water will then be pumped to another marsh of approximately 300 acres surrounding the City of West Palm Beach wellfield. Infiltration of the water into the wellfield will occur as the wellfield pumps groundwater into the adjacent M Canal where it becomes surface water. The surface water in M Canal will flow towards Clear Lake, which is the surface water source of drinking water for the City of West Palm Beach. At the City's water treatment plant, the surface water will be treated to drinking water standards prior to entering the water supply distribution system for the City as well as the Town of Palm Beach and South Palm Beach. The remaining 4 MGD of the 10 MGD of reclaimed water will be routed from the AWT/superior treatment technology facility to residential lake systems surrounding both the City's wellfield and Palm Beach County's 8W Water Treatment Plant wellfield. The lake systems will be used to recharge the groundwater in the vicinity of both wellfields, thereby decreasing impacts associated with withdrawals from both wellfields.

A6.3.3.4 Central Palm Beach County Water Preserve Area And Loxahatchee National Wildlife Refuge Enhancement By Reclaimed Water

The project involves the discharge of 45 million gallons per day (MGD) of highly treated reclaimed water from the Southern Region Water Reclamation Facility (SRWRF) to the Central Palm Beach County Water Preserve Area and/or the Loxahatchee National Wildlife Refuge. Reclaimed water discharged to the Central Palm Beach County Water Preserve Area will meet agricultural water supply demands. Reclaimed water discharged to the Loxahatchee National Wildlife Refuge will be for meeting environmental water supply demands. This reclaimed water will be used to augment water availability in the regional system, or to use this reclaimed water instead of water from Loxahatchee National Wildlife Refuge and Lake Okeechobee, thereby keeping additional water in the regional system. Water discharged into the Loxahatchee National Wildlife Refuge will be of suitable quality. This constant flow would occur both during the wet season and the dry season. Excess flows and reject water would be disposed of via deep injection wells (the current disposal method).

A6.3.3.5 West Palm Beach Water Catchment Area Enhancement By Reclaimed Water

The West Palm Beach Water Catchment Area (WPBWCA) is about 20 square miles of sedge and cypress wetlands. It is part of the historical Loxahatchee Slough system that fed both wetlands north of Northlake Boulevard in the Loxahatchee Slough as well as the Everglades to the south. Currently, the WPBWCA is a collection point for rainfall as well as inflows from L-8 Canal and M Canal. Discharge from the WPBWCA presently is to the east to provide urban water supply for the City of West Palm Beach, Town of Palm Beach, and South Palm Beach. In the future, as a consequence of the L-8 Option implementation under the Interim Plan for Lower East Coast Water Supply, the WPCWCA will discharge north to restore wetlands in the Loxahatchee Slough outside of Water Conservation Area 1, as well as providing water for public water supply to Jupiter and Seacoast in addition to the aforementioned cities. This component includes the discharge of 56 MGD on an average daily basis of highly treated reclaimed water into the WPBWCA to meet future demands. This constant flow would occur both during the wet season and the dry season. Excess flows and reject water would be disposed of via deep injection wells (the current disposal method). The flows would be derived from a new state of the art reclaimed water production facility at the East Central Regional Wastewater Facility (ECR) operated by the City of West Palm Beach. The ECR is currently located about two miles from Water Conservation Area 1. The supplemental treatment facility would be built at the site of the existing ECR. A pipeline would be extended west to discharge reclaimed water directly into Water Conservation Area 1 at a continuous rate of 56 MGD.

A6.3.3.6 Acme Basin "B" Discharge

This project involves the construction of a 620-acre temporary storage reservoir and a 310-acre wetland treatment area to treat Acme Basin "B" runoff discharged to the Loxahatchee National Wildlife Refuge. An alternative to the wetland treatment area may be chemical treatment. Estimated runoff discharged from Acme Basin "B" is estimated at 20,000 acre-feet per year. This runoff will be sent to the 620-acre reservoir to attenuate peak flows until such time as the water can be discharged to one of two alternative locations: 1) Component VV6 Palm Beach County Agricultural Reserve Reservoir or 2) Component GGG6 C-51 and Southern L-8 Reservoir. Runoff will be directed to the temporary attenuation storage area until full, then additional runoff will be directed to the treatment area prior to discharge into the LNWR. Once peak flows have dissipated, runoff will be sent to the more feasible of the two alternative locations cited above for storage until the dry season dictates release for water supply purposes to meet regional demands. Discharge to the Palm Beach County Agricultural Reserve Reservoir will require improvement to an existing drainage ditch plus a small pump station. Discharge to the C-51 and Southern L-8 Reservoir will require Acme Canal #25 upgrade plus possibly a new pump station or upgraded existing pump station.

A6.3.3.7 Protect And Enhance Existing Wetland Systems Along Loxahatchee National Wildlife Refuge Including The Strazzulla Tract

This project involves the acquisition of 3,335 acres to expand the spatial extent of protected natural areas. This project will make a hydrologic and ecologic connection to the LNWR and may need water control structures. This land will act as a buffer between higher water stages to the west and agriculture lands to the east that must be drained. This increase in spatial extent will provide vital habitat connectivity for species that require large unfragmented tracts of land for survival. It also contains the only remaining cypress habitat in the eastern Everglades and one of the few remaining sawgrass marshes adjacent to the coastal ridge. This is a unique and endangered habitat that must be protected. This area provides an essential Everglades landscape heterogeneity function.

A6.3.3.8 Lake Worth Lagoon Restoration

This project involves three phases. Phase I will examine both quantity and quality of bottom sediment accumulations within the C-51 Canal and downstream discharge area within the lagoon. Phase II will develop a project plan to provide for sediment removal or capping that could include creating a series of sediment traps along the C-51 where sediment accumulations increase. Phase III will involve the removal of bottom sediments within C-51 Canal as well as implementing a prototype project to either remove or cap the organic bottom layer within the lagoon. The elimination of these sediments from the C-51 discharge will provide for long-term improvements to the lagoon and ensure success of additional habitat restoration projects planned by Palm Beach County.

A6.3.3.9 North Fork Of The New River Restoration

The proposed project is located in the City of Ft. Lauderdale, along the North Fork of the New River between 9th Avenue and Sunrise Boulevard. The North Fork is a shallow, meandering tributary of the New River extending through the northwest section of the City of Fort Lauderdale. Minimal tidal flow within this section of the river results in limited circulatory exchanges of tidal waters. Flow has been restricted by large amounts of sediment and debris. Natural freshwater flow characteristics are further restricted in the upstream section of the North Fork by the S-33 salinity control structure that effectively eliminates freshwater inflow from the western drainage basin. The New River is one of the few naturally occurring surface water bodies in Broward County. Prior to the 1900's, the New River was a prominent drainage feature of the Everglades that seasonally emptied into the Atlantic Ocean. The existing shoreline no longer resembles its historical condition. The shoreline is actively eroding in some places and exotics have replaced native species in some riparian areas. In 1993, Broward County Department of Natural Resource Protecion research identified many sources of ongoing and historic pollution. This degradation of water quality and habitat represents a negative impact not only on the environment, but the health and economy of the adjacent communities. DNRP developed “The New River Restoration Plan (1994)” to identify water quality problems, identify the river system's biological diversity, and to develop a plan to create a more natural condition for the inhabitants of this community. The restoration project involves; 1) spot dredging to improve water quality and water circulation, 2) removal of exotic plant species and revegetation with native plants, 3) development of analytical tools, 4) removal of litter and debris and 5) development of a plan which promotes urban infill consistent with the Eastward Ho! Initiative.

A6.3.3.10 Northern Broward Region Reuse Project

The current treatment capacity of the Broward County North Regional Wastewater Treatment Facility (NRWWTF) is 80 MGD. If the treatment process is upgraded to meet regulatory requirements, the flow could be discharged to the secondary canal systems located in northern and central coastal areas of the County. This would help recharge groundwater, enhance remnant wetlands, and stabilize the saltwater interface.

A6.3.3.11 City Of Hollywood Reuse Project

Currently, the City of Hollywood’s wellfields are threatened by saltwater exfiltration from the C-10 Canal. The recommended Comprehensive Plan includes a structure on C-10 that will provide some relief, but a constant water supply to the canal may be required. The Southern Regional Wastewater Treatment Plant, owned and operated by the City of Hollywood through a partnership with the Cities of Miramar, Pembroke Pines, Pembroke Park, Dania and Hallandale, and with Broward County, may be a source of this supply. The treatment facility serves over 240,000 people. This project could provide water for maintaining coastal canal levels so that saltwater migration toward eastern wellfields could be minimized. The project would provide 50 to 60 MGD to the drainage basin during low flow/precipitation periods. This project was proposed to restore and enhance the amount of water in the C-10 Basin to prevent saltwater intrusion, and to protect coastal wellfields. Implementation of the project would also improve the water quality of coastal wetlands and the Atlantic Ocean by improving water quality from the wastewater facility.

A6.3.3.12 Pond Apple Slough Restoration

The Pond Apple Slough/New River Forest is defined as the remnant freshwater-forested wetlands along the South Fork New River and North New River Canal east of the salinity control structures. Over $20 million of public funds have been spent to acquire, restore and enhance over 200 acres of this freshwater-forested wetland. Broward County is in the early phases of a rehydration project to help offset salinity increases in the adjacent waterways. Approximately 100,000 acre-feet of water per year is presently discharging over the S-13 Structure into the South Fork New River and Dania Cut-off Canal. This freshwater discharge presently reduces the salinity within these water bodies which have grown more saline with the construction of the Dania Cut-off Canal and channelization of the South Fork New River. The reduction of freshwater discharge that is proposed in the recommended Comprehensive Plan will allow increases in salinity within these water bodies and negatively affect the adjacent historic freshwater wetlands which include the Griffey Tract, Secret Woods Nature Center, Florida Power and Light Company's Lauderdale Power Plant Site and adjacent mitigation area for the South County Resource Recovery Plant. The proposed rehydration project, currently underway for the Griffey Tract and Pond Apple Slough, is anticipating redirecting approximately 10 million gallons per day of the freshwater that is presently being discharged through the S-13 Structure into this herbaceous marsh and forested resource before it returns to the South Fork New River through a series of tributaries within the Pond Apple Slough. Broward County is concerned that loss of freshwater inputs from S-13 will further exacerbate the salinity threat that they are currently trying to reverse. The primary components of this project will include: 1) modeling the ecological effect reduced discharges into the South Fork New River and Dania Cut-off Canal through the S-13 Structure will have on the remaining freshwater forested resources along these waterways, 2) determination of the freshwater hydrology needs of the various components of the system and 3) identification of freshwater sources and distribution systems, and surface water management features to meet those needs.

A6.3.3.13 South Miami-Dade Agricultural And Rural Land Use And Water Management Plan

The project area is the southern portion of Miami-Dade County covering all lands lying outside Miami-Dade County's Urban Development Boundary designated for agricultural use. The growing demands of the lower East Coast of Florida are straining the water resources of the area. The development of sustainable, environmentally sensitive agriculture in southern Miami-Dade County would provide a more environmentally superior land use than the prospect of uncontrolled urban expansion throughout these watersheds. In comparison to urban development, agriculture has reduced impacts on water quality and quantity thus minimizing remediation requirements and costs. The purpose of both these initiatives/studies is to develop long range management plans for south Miami-Dade County. The plans will recommend future land use and water resources control within the county. Output will be recommendations that will assist in the regulation of the ever-increasing development/growth in south Miami-Dade County. The rural land use component is an integral part of the overall, larger South Biscayne Bay Watershed Plan. Project work involves the preparation of a study document that will identify and quantify major agribusiness elements (i.e. crop prices, water and soil requirements, production costs, etc.). Combined with socioeconomic information, all parameters will be analyzed to establish economic strategies and incentives to strengthen agriculture. The results will be blended into the South Biscayne Bay Watershed Management Plan.

A6.3.3.14 Restoration Of Pineland And Tropical Hardwood Hammocks In C-111 Basin

The project is located in south Miami-Dade County, just east of Everglades National Park, along State Road 9336 in the area known as the Frog Pond. Eighty percent of the Frog Pond was used for agricultural purposes and farmers rock plowed the cap rock to create soil for tomato farming. The Frog Pond has since been purchased by the SFWMD as part of the C-111 Project to restore the Taylor Slough portion of the Everglades. The project involves restoring south Florida slash pine and tropical hardwood hammock species on a 200-foot wide strip on each side of the two miles of State Road 9336 from the C-111 Canal to the L-31W Canal (approximately 50 acres). This project will demonstrate the techniques required to re-establish native conifer and tropical hardwood forests on land that has been rock plowed.

A6.3.3.15 Biscayne Bay Coastal Wetlands

This project incorporates the L-31 East Flow Redistribution Critical Project list. The ability of the Comprehensive Plan to provide hydrologic benefits to the southern Everglades is supported in large part by the Biscayne Bay Coastal Wetlands Component FFF5 which replaces freshwater inputs to the Biscayne Bay

Estuary that are reduced by some D-13R components (i.e., seepage control components along the protective levee and the capture of other discharges to tide). The project is necessary to properly distribute these additional flows to the estuary. The project has five sub-components located in southeast Miami-Dade County, covering the southwest shoreline of Biscayne Bay from the Deering Estate at C-100C south to Florida Power and Light Company's Turkey Point Power Plant, generally along the L-31 East levee.

- **Sub-component 1 - Deering Estate Flowway** - Operation of this sub-component involves pumping water from the SW 160th Street ditch (a tributary to C- 100C) through property adjacent to the Deering Estate and ultimately into Cutler Drain which runs through the Deering Estate. The design involves: 1) adding a 50-cfs pump station at end of SW 160th Street Canal, 2) filling in mosquito ditches in coastal mangroves, and 3) constructing weirs to delay water passage in Old Cutler Drain.

- **Sub-component 2 - Cutler Wetlands** - Operation of this sub-component involves: 1) routing water south from C-100A to the Cutler Wetlands Proposal Area via a shallow distribution swale on the surface of the marl to C-100B, 2) pumping water from C-100B to a spreader swale, and 3) pumping water from C-100A south into a spreader swale to allow sheetflow to Biscayne Bay. Depending on water quality, flows may need to be routed through Stormwater Treatment Areas (STAs). Design involves constructing: 1) a spreader swale from C-100A south to C-100B, 2) a levee west of the spreader swale, and 3) a 200-cfs pump along the north end of the spreader swale at C-100A. If water quality dictates, the design may also involve construction of: 4) an STA adjacent to C-100B, 5) a 200-cfs pump adjacent to the STA and C100B, and 6) a levee seepage canal along the north and south ends of the STA.

- **Sub-component 3 - L-31 East Flowway** – The purposes of this sub-component are: 1) to reestablish conditions for living oyster bars along the shoreline of the bay and 2) to hydrologically isolate the Miami-Dade County landfill. A flow redistribution system will be created west of L-31 East and existing wetlands will be restored in the area between L-31 East and the western boundary of the redistribution system. A distribution swale with a western levee will be constructed along this boundary. The wetland area west of L-31 East should be used for short-term, shallow ponding of water to maintain wetlands and help drive freshwater flow to the nearshore Bay out of the east bank of L-31 East. Depending on water quality, flows may need to be routed through an STA. Design involves: 1) installation of culverts and risers under L-31 East, 2) construction of a spreader swale east of L-31 East, 3) backfilling Military Canal, 4) construction of a plug in C-100B, 5) construction of a canal west of the landfill to intersect with L-31 East borrow canal, and 6) filling in mosquito ditches. If water quality dictates, the design may also involve construction of: 7) a STA from C-102 to C-103 and east of Homestead Air Force Base, 8) a seepage collection ditch on the west side of the STA, 9) a 200-cfs pump at C-102 to the STA, and 10) a 200-cfs pump at C-103 to the STA.

- **Sub-component 4 - North Canal Flowway** – The operation of this sub-component involves pumping available water from C-103 and Florida City Canal to re-establish sheetflow across freshwater and coastal wetlands to Biscayne Bay. Depending on water quality, flows may need to be routed through an STA. Design involves: 1) construction of a 200-cfs pump on C-103, 2) construction of a 200-cfs pump on Florida City Canal, 3) installation of culverts and risers under the L-31 East levee, 4) construction of a delivery canal from C-103 south to North Canal, 5) construction of a spreader swale east of the L-31 East levee, 6) backfilling North Canal east of SW 112th Avenue and 7) construction of a flowway south from Florida City Canal from SW 127th Avenue to SW 107th Avenue. If water quality dictates, the design may also involve construction of: 8) an STA on the western edge of the coastal wetlands in between C-103 and Florida City Canal, 9) an STA associated with the flowway south of Florida City Canal, and 10) seepage management facilities around the STAs.

- **Sub-component 5 - Barnes Sound Wetlands** – Operation of this sub-component involves pumping available water from Florida City Canal to a shallow east-west spreader canal. Depending on water quality, flows may need to be routed through an STA. Design involves construction of: 1) a 50-cfs pump at Florida City Canal, and 2) a new canal south from Florida City Canal to a shallow spreader swale along the edge of the coastal wetlands. If water quality dictates, the design may also involve construction of an STA and seepage management facility.

There are some general problems or considerations that apply to the entire area. These include existing ditches, which are extensive, the presence of exotic plants and animals, potential water quality problems, and land ownership constraints. The areas under review for restored sheet flow were extensively ditched early in the twentieth century. This cross ditching interferes with providing restored historic flow patterns. For these reasons, the ditches may need to be filled. In addition, the area would require an extensive and possibly ongoing invasive exotic plant removal program. Most of the 13,600 acres of land to be acquired are under current acquisition efforts by the state and county.

A6.3.4 Western Basin And Big Cyress Basin

A6.3.4.1 Seminole Tribe Big Cypress Water Conservation Plan

The project is located on the Seminole Tribe Big Cypress Reservation in Hendry County, directly north of the Big Cypress National Preserve and west of Water Conservation Area 3A (WCA 3A). The Big Cypress Reservation is traversed by the L-28 and L-28I Canals and the North and West Feeder Canals. The proposed comprehensive watershed management system is designed to achieve environmental restoration on the Reservation, the Big Cypress Preserve, and the central and southern Everglades. In addition, the project will reduce flood damage and promote water conservation on the Reservation. The overall plan has been divided into east and west portions, each of which can provide independent benefits. Due to the legislated funding limits of the Critical Projects program, only the west portion of this project was nominated as a Critical Project. The Seminole Tribe has also requested the assistance of the Natural Resources Conservation Service (NRCS) to implement the eastern portion of the plan. In light of the uncertainty of the NRCS funding for the east portion and the potential that the west portion may not be funded through the Critical Projects program, the combined project is being recommended as an OPE.

A6.3.4.2 Southern Golden Gate Estates Hydrologic Restoration

The Southern Golden Gate Estates (SGGE) project area encompasses approximately ninety-four square miles of sensitive environmental landscape in southwestern Collier County, south of Interstate 75 between the Fakahatchee Strand and Belle Meade watersheds. The project area is an important surface storage and aquifer recharge area with a unique ecology of cypress, wet prairie, pine and hardwood hammock and swamp communities. It also includes three major flowways that contribute freshwater to the Ten Thousand Islands Estuary of the western Everglades watershed. Construction of roads and drainage modifications in the 1960’s and 1970’s have overdrained the area resulting in reduction of aquifer storage, increased freshwater shock load discharges to the estuaries, invasion of upland vegetation and increased frequency of forest fires. Variations of freshwater discharges at large amplitudes have resulted in large fluctuations of salinity level and have eliminated or displaced a high proportion of the benthic, midwater and fish plankton communities in the estuary. The project involves construction of a combination of spreader channels, canal plugs and pump stations, and removal of roads. Implementation of this plan would accomplish the hydrologic restoration of SGGE by introducing sheetflow, re-establishing the historical flowways, reducing runoff by increased evaporation and groundwater recharge, and replacing point flow discharge through the Faka Union Canal with distributed flow along US 41 into the tidal coastal marshes. The Florida Division of Forestry is responsible for managing the public lands within SGGE and will be a participating partner with the SFWMD through construction of this project.

A6.3.4.3 Southern Crew Project Addition/Imperial River Flowways

The project is located in southern Lee County, bordering the western boundary of the Corkscrew Regional Ecosystem Watershed (CREW). This environmentally sensitive area east of Bonita Springs has been altered by construction of roads, house pads, agricultural berms, and ditches. These alterations have resulted in restriction of historical sheetflow, unnatural water impoundment and flooding, increased pollutant loading to the Imperial River and Estero River (an Outstanding Florida Water), and disruption of natural wetland functions. Water that historically flowed southwesterly has been partially diverted to the east by roadbeds and single family house pads. This has resulted in decreased hydroperiods (excessive drainage) in wetlands to the west of the CREW and the Corkscrew Sanctuary (Audubon) and increased hydroperiods in the CREW and Corkscrew Sanctuary. The proposed project involves acquisition of approximately 4,670 acres of land and restoration of historic flows over this area. The project will be added to the CREW with perpetual management to maintain natural system qualities. The project will: 1) re-establish historical flow patterns and hydroperiods on the lands proposed for acquisition as well as CREW and Corkscrew Sanctuary wetlands to the east, 2) restore historical storage potential of the Southern CREW lands, 3) reduce excessive freshwater discharges to Estero Bay during the rainy season, 4) decrease saltwater intrusion during the dry season, 5) reduce loading of nutrients and other pollutants to the Imperial River and Estero Bay, 6) increase aquifer recharge, and 7) reduce flooding of homes and private lands west of the project area. This project will also reduce the potential that currently exists for forcing water eastward through the CREW Project and the Corkscrew Swamp Sanctuary and possibly harming these important areas by increasing depth and duration in these natural wetland areas. Hydrologic restoration of this land will include the following modifications: 1) removal of existing road beds, 2) removal of single family homes, 3) removal of junk debris, 4) filling of ditches, and 5) removal of agricultural canals and berms. Also, the Kehl Canal weir located at the headwaters of the Imperial River will be modified. More storage capacity will be provided and gates will be added to allow better water management and control of the Kehl Canal, which flows through the land proposed for acquisition.

A6.3.4.4 Henderson Creek And Belle Meade Restoration

This region of southwest Florida is currently facing a high urban growth rate. Changes in land-use within the primary watersheds that drain into the Rookery Bay Estuary and adjacent waters have been identified in the Rookery Bay National Estuarine Research Reserve (RBNERR) Management Plan as the highest priority resource issue that threatens the long-term preservation of RBNERR estuarine resources. The coastal habitats in Collier County have been impacted by alterations of hydrology and habitat due to channelization of natural systems. Roads, canals, planned unit developments, commercial projects, and agriculture represent primary land-uses within RBNERR watersheds. These alterations have greatly modified the volume, timing and quality of freshwater entering the fragile estuarine ecosystems. In addition, channelized flow in these watersheds has severely restricted the ability of the associated wetlands to filter pollutants. The area known locally as Belle Meade is the primary drainage basin for the Henderson Creek Estuary and is currently targeted for acquisition by the Florida Department of Environmental Protection. Historically, freshwater traveled across the surface of the land, percolating through wetland flowways before entering Henderson Creek. While channelization and development have disrupted this system, acquisition and restoration of the undeveloped lands surrounding Henderson Creek, which link the watershed and estuary, can stop further hydrologic and habitat disturbance. These estuarine areas provide critical nursery habitat for commercially and recreationally important finfish and shellfish. Land acquisition will assure long-term protection of the upland and wetland communities associated with these parcels. Additionally, the proposed restoration efforts on the acquired lands will return a portion of the historic timing, duration and volume of freshwater inflow, thereby enhancing estuarine habitats.

A6.3.4.5 Reversing Overdrainage From Baron River Canal

Big Cypress National Preserve (BCNP) is a unique water-dependent ecosystem. As much as 90 percent of BNCP is inundated to depths ranging from a few inches to more than three feet during the wet season (May to October). During the dry season (November to April) water levels recede, reducing the area of inundation to approximately 10 percent. The ecology of BNCP is finely tuned to the seasonal flow of non-polluted water and changes in this condition can adversely affect this sensitive habitat. Two primary canals, namely the Barron River Canal on the western periphery, and the Turner River Canal in the west central portion of the BCNP allow channelized overdrainage from the watershed. During the dry season, these canal systems can lower the water levels to the point of causing water shortages, increasing fire hazards and allowing salt-water intrusion in freshwater environments. The canals provide a direct hydraulic connection between freshwater wetlands and the saline estuaries within Everglades National Park. The rapid drainage of fresh water also reduces the productivity of cypress forests and wet prairie ecosystems. The project involves plugging or backfilling the canals in order to restore sheetflow over a broad area. This project would provide hydrologic restoration to approximately 500 square miles of impacted wetlands in BNCP. The project area has a unique ecology of cypress, pine, and hardwood hammocks. It contains expansive areas of pristine wilderness and some of the most biologically diverse plant and wildlife communities on the North American continent. The restoration of the historic flowways is expected to reintroduce the historic flora and fauna and eliminate nuisance exotic species. Adjacent sensitive lands, including Everglades National Park, Fakahatchee Strand State Preserve, and the Florida

Panther National Wildlife Refuge, will benefit from this plan with enhanced habitat quality.

A6.3.4.6 Miccosukee Water Management Area

The Miccosukee Water Management Area (MWMA) is a project to construct a managed wetland on the Miccosukee Tribe's Alligator Alley Reservation located in western Broward County. The purpose of the project is to provide water storage capacity and water quality enhancement for waters which discharge into the Everglades Protection Area. The project will convert approximately 900 acres of tribally owned cattle pastures into a wetland retention / detention area, which will be designed to filter out harmful nutrients contained in stormwater runoff before the water enters the Everglades Protection Area. Tribal Water Quality Standards dictate a numerical criterion of 10 parts per billion for total phosphorous inside the Everglades Protection Area. The MWMA was sized to treat the nutrient inputs of the Miccosukee Tribal lands.

A6.3.5 Everglades National Park, Florida Bay, And The Florida Keys

A6.3.5.1 Flamingo Road Improvements To Restore Hydrologic Flows

Flamingo Road is located in Everglades National Park and it currently acts as a levee, impeding sheet flow towards Florida Bay. Although Flamingo Road is located within the domain of the SFWWM, the model resolution is not fine enough to evaluate alternative designs that would restore historic hydropatterns. Further analysis is recommended through hydrologic modeling at the appropriate scale to determine the best options for restoring the desired sheetflow.

A6.3.5.2 Restore Flows To Florida Bay At Adams Waterway

There is no information on this project and the proponent could not be identified.

A6.3.5.3 Florida Keys Tidal Restoration

The objective of this project is to restore flows to tidal creeks by installing culverts under US Highway 1 at four locations in Monroe County (between mile markers 54 and 57). These projects are similar to a culvert project at Key Colony Beach completed in 1991, which was very successful in improving the near-shore water quality. The individual projects can be described as follows: 1) restore Tarpon Creek just south of mile marker 54 on Fat Deer Key, 2) restore an unnamed creek between Fat Deer Key and Long Point Key south of mile marker 56, 3) restore tidal connection adjacent to Little Crawl Key and 4) restore tidal connection between Florida Bay and the Atlantic Ocean at mile marker 57. The accumulation of organic material in these creeks has resulted in a degradation of water quality and sea grass habitat. Impacts originally occurred as a result of the construction of the Flagler Railroad bed (currently U.S. Highway 1) which blocked tidal flow and circulation in near-shore waters. Restoration benefits expected by installation of these culverts include: 1) enhanced circulation and flushing, 2) improved water quality, and 3) restoration of marine habitats.

A6.3.5.4 Indian Key And Tea Table Fill Removal

The proposed project would remove all causeway fills between Upper Matecumbe, Lower Matecumbe, and Long Keys and replace them with bridges.

A6.3.6 Southwest Florida Region

A6.3.6.1 Lake Trafford Restoration

Lake Trafford is located in north Collier County and is the largest lake south of Lake Okeechobee with a surface area of approximately 1,494 acres. It is the headwaters of the Corkscrew Swamp Sanctuary to the southwest, the Corkscrew Regional Ecosystem Watershed (CREW) to the west, and the Fakahatchee Strand system, which includes the Florida Panther National Wildlife Refuge, to the south. Lake Trafford has poor water quality, extensive muck accumulations, loss of native submergent plant communities, periodic aquatic weed infestations, and numerous moderate fish kills. A massive fish kill occurred in April 1996 which was caused by poor water quality conditions, including high biological oxygen demand, lethal ammonia levels, and depressed dissolved oxygen content. Poor water quality is attributed to internal nutrient cycling from extensive organic muck deposits throughout the lake basin. The project involves the use of one or more 14-inch portable cutter dredges to accomplish lakewide organic sediment removal. Approximately 8.5 million cubic yards of loose, flocculent, organic materials blanket the bottom of the lake and range from approximately nine inches to nine feet in thickness. The material will be pumped to an upland disposal site on existing farmland less than one mile from the lake. The pipeline to the upland disposal area will be located adjacent to an existing ditch with an easement being provided by the landowner. This ditch will also be used to carry the return flow from the disposal area. The disposal area consists of a 449-acre, diked, agricultural facility, which will be divided into three cells. The sponsors have additional lands identified if, in the design phase, it is determined that additional acreage will be required.

A6.3.6.2 Lakes Park Restoration

Lakes Park is located east of Cape Coral in Lee County, just west of Highway 41. The park consists of an old rock mine with a series of borrow pit “lakes.” The entire area drains south into Hendry Creek, an Outstanding Florida Water, which flows for a few miles before entering Estero Bay. Lee County has developed the area as a regional park with a bathing area along the shoreline of the lakes. Adjacent to the developed area, the remaining natural habitat contains pine flatwoods with some cypress heads. The pits capture runoff from the surrounding developed area (commercial, industrial, and residential). County monitoring has indicated a decline in water quality in the lakes. The lakes are infested with hydrilla and adjacent uplands and islands are covered with exotic plant species such as Australian pine and Brazilian pepper. The project is expected to enhance surface water runoff quality by creating a meandering flowway with shallow littoral zones and removing aquatic and upland exotic vegetation. The littoral zone will be harvested periodically to remove excess nutrients from the system. Exotic vegetation will be removed and replaced with native vegetation on 11 acres of upland.

A6.3.6.3 Southwest Florida Water Management Model

As part of the south Florida ecosystem restoration initiative, there is a desire to either maintain or reestablish more natural (i.e., pre-drainage) patterns of hydroperiod and water flow in parts of southwest Florida, particularly the Big Cypress National Preserve, the Fakahatchee State Preserve, the Florida Panther National Wildlife Refuge, Southern Golden Gate Estates, Corkscrew Swamp Sanctuary, and the Ten Thousand Islands, including Rookery Bay. Elsewhere in southwest Florida, many changes are being made to the hydrologic system to accommodate growing urban and agricultural uses. These changes could affect neighboring or downstream natural areas. Existing hydrologic models are more geared toward stormwater management and are inadequate in their structure to provide meaningful information about how a change in the hydrologic system will affect the overall ecosystem. Knowledge of hydroperiod effects is essential to evaluating ecosystem effects. Needed for southwest Florida are: 1) a grid-based (spatially explicit) connected surface and surficial groundwater model that contains the existing network of canals and water control structures; and 2) a corollary model without any control structures that approximates the natural response of the system to rainfall. The proposed pair of models for southwest Florida will be like the South Florida Water Management Model (SFWMM) and the Natural System Model (NSM), which presently are being used to evaluate proposed Restudy alternatives. The proposed models will be used to design and evaluate restoration scenarios and other proposed alterations to the hydrologic system (i.e., flood reduction along the Imperial River.) The proposed Southwest Florida Natural System Model could be used to simulate the hydrologic system's natural response to rainfall, flows and hydropatterns if canals and control structures had not been built. This is valuable information because the natural system supported the mixtures of plant communities and wildlife that are objectives of the restoration effort. The proposed Southwest Florida Water Management Model will be used to simulate outcomes of proposed alternative restoration strategies, which could be compared to the proposed Natural System Model output. The coverage of these two models is incomplete in southwest Florida. The South Florida Water Management Model covers the Big Cypress National Preserve and fringing mangrove system to State

Road 29 but does not include most of Hendry County. The existing NSM has broader coverage and includes Hendry County to a longitude that aligns with the southern part of State Road 29, but does not include the part of southwest Florida west of State Road 29. The proposed models would improve the ability to evaluate alternatives in the Restudy and to design restoration and other types of projects for Southwest Florida through the Southwest Florida Feasibility Study. Models developed for southwest Florida should be designed to connect seamlessly to the South Florida Water Management and Natural System Models to minimize boundary effects and to enable reliable addressing of questions near the boundary between these areas or large-scale questions that affect both areas.

A6.3.6.4 Spring Creek Reconnection And Rehydration

The project proponent is unclear but appears to be Pueblo Bonito Partnership for Housing, Incorporated, a private developer. The project is located in Lee County. In the early 1960’s, a 40-foot wide canal was dug that cut off approximately 2,200 linear feet of Spring Creek which flows into Estero Bay. In 1990, the canal was designated an Outstanding Florida Water (OFW). The project purpose is to restore approximately 2,200 linear feet of the historic Spring Creek floodplain through three components. Reestablish the headwaters of Spring Creek by: 1) constructing a weir to redirect canal inflow into the historic Spring Creek flowway, 2) removing approximately 27,000 cubic yards of spoil which currently segments the floodplain and 3) replanting tress within the restored areas. This project appears to be, at least in part, a compensatory mitigation requirement for permits associated with a private residential development. If so, the ecological benefits of the project are already allocated to offset the adverse impacts of the permitted development. Further analysis is needed to determine the exact scope of this proposal and the allocation of the benefits to be generated.

A6.3.6.5 Town Of Ft. Myers Beach

The Town of Fort Myers Beach in located on a barrier island of the southwest coast in Lee County. The town has identified the need for the protection of adjacent Estero Bay and local beaches from pollutants transported via stormwater runoff from the island on which the town is located. Most of the town is urbanized and has an inadequate stormwater management system. Components identified for this project include: 1) inventory of stormwater systems, 2) sediment sampling, 3) screening of illicit connections, and 4) implementation of an urban retrofit project. The project is designed to enhance Estero Bay and has received full support of local government and residents of the community. The town has already begun to identify stormwater “hot spots” through inventory and sampling procedures and has converted 48,000 square feet of asphalt to pervious paving materials. Pores in the asphalt of these materials allow runoff from parking lots to flow through the pavement into an underground reservoir of small stones, and then gradually filter into the surrounding soil. Other options for controlling urban runoff that are under consideration include installation of "water quality inlets," which are baffled concrete tanks for solids and oil separation, as well as numerous other best management practices (e.g. encouraging the use of slow-release fertilizers, etc.) The project is expected to provide immediate water quality and ecological benefits to the Estero Bay Aquatic Preserve by reducing pollutant loading to receiving waters.

A6.3.7 System-Wide

A6.3.7.1 Melaleuca Eradication Project (Part A) – Construct New Melaleuca Quarantine And Research Facility

The purpose of this project is to construct a Melaleuca Quarantine and Research Facility for the testing of candidate organisms for biological control of Melaleuca. This project would enhance and accelerate the highly regulated quarantine process. The facility would be located on one of the following sites:

- University of Florida property, adjacent to the U.S. Department of Agriculture/ Agricultural Research Service (USDA/ARS), Ft. Lauderdale Aquatic Plant Management Laboratory, Davie, Florida.

- University of Florida property, University of Florida Research & Education Center, adjacent to the U.S. Department of Agriculture/Agricultural Research Service Facilities Division, U.S. Horticultural Research Laboratory, Ft. Pierce, Florida.

A6.3.7.2 Melaleuca Eradication Project (Part B) – Renovation And Improvements – Biological Control Quarantine And Research Facility

The project would provide improvements to the Florida Biological Control Laboratory (FBCL) facility in Gainesville, Florida to better meet the needs of testing biological control candidates of exotic aquatic and terrestrial pest plants and arthropod pests of agricultural, native and horticultural plants. The Florida Department of Agriculture and Consumer Services, Division of Plant Industry, is the regulatory agency responsible for protecting Florida's native and commercially grown plants from harmful pests and diseases. The FBCL facility operates in close cooperation with the U.S. Department of Agriculture, Agricultural Research Services, and the University of Florida, Institute of Food and Agricultural Sciences. The primary responsibility of the FBCL is to enforce the quarantine procedures and regulations governing the receipt, handling and release of introduced biological control organisms.

A6.3.7.3 Melaleuca Eradication Project – Implement Biological Controls

This project calls for the mass rearing, field release, establishment and field monitoring of approved biological control agents for Melaleuca. Production of biological control agents for release requires maintaining large screenhouse colonies at the U.S. Department of Agriculture/Agricultural Research Service (USDA/ARS), Ft. Lauderdale Aquatic Plant Management Laboratory located at Davie, Florida. Melaleuca plants must be continually collected for the colony food source, therefore Melaleuca must be cultured at the laboratory. Insects grown in these screenhouses will be released into Melaleuca stands. Permanent study plots will be established at designated release sites. The 13 existing study plots will be increased to approximately 100 as a result of this project. Periodic monitoring will be conducted in order to quantify the insect's impact upon Melaleuca, thereby evaluating the effectiveness of the biological control agent. Sampling methods will be developed to recover insects for re-release or observation and to estimate the population of insects in the field.

APPENDIX B

HYDROLOGY AND HYDRAULICS MODELING

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APPENDIX B
HYDROLOGIC MODELING

B.1 INTRODUCTION

Two methods of hydrological modeling were implemented by the Restudy Team to evaluate alternatives. They are explained in this Appendix. The first method of modeling is referred to as the *screening phase.* This method was scaled to allow a large number of model runs to be performed utilizing various models. The primary purpose of this allowance was to enable evaluation of each component prior to larger scale, integrated system-wide modeling. The second method of modeling is referred to as the *alternative development phase.* This method incorporated the South Florida Water Management Model (denoted herein as SFWMM). The SFWMM met the requirements for a larger scale, integrated system-wide model.

B.2 SCREENING OF COMPONENTS

B.2.1 Introduction

A modeling effort was conducted to evaluate potential project features, or *components*, individually prior to combining them into planning alternatives. The modeling was scaled so that a large number of model runs could be made for each component. This modeling effort was referred to as the screening phase. Components investigated included basin storage reservoirs, Aquifer Storage and Recovery wells (denoted herein as ASR), and seepage management. Explicit investigations were conducted to evaluate the sizing of reservoirs, effectiveness of ASR, and setting of operational guidelines. *Screening investigations were performed to assist the modelers in the development of alternatives rather than to establish absolute criteria for each component.*

The screening effort primarily evaluated one component at a time, for example, storage. The main objective was to understand how each component acted individually within the future base configuration, before combining components together forming alternatives. Additionally, this provided initial size ranges and operational information for each component. However, some modeling investigations did include multiple components.

The strength of the screening models was the capability to perform multiple evaluations in a relatively short time. The screening provided insight into blatant hydrologic realities rather than trying to determine subtle differences. Evaluations included parameter sensitivity, operational scenario, and trend analysis, as well as comparing results from a large number of alternative scenarios. The modeling for the screening phase was intended to provide basic information required for more detailed comprehensive modeling of the alternatives.

Although the screening models and some results were made readily available to the public, the modeling effort itself had limited participation. However, the results of the screening effort were discussed in the Alternative Development Team meetings before they were used in the alternative development phase.

B.2.2 Computer Model Selection

Prior to the Restudy, there were two hydrologic models utilized to evaluate the hydrologic conditions of South Florida: the South Florida Water Management Model (SFWMM) and the South Florida Regional Routing Model (SFRRM). The SFWMM was designed to perform a relatively detailed analysis based on a limited number of runs. The SFRRM is less sophisticated in hydrologic analysis and can be used to quickly evaluate many scenarios of water resource features with less detail. Although the SFRRM approach was more suited to the screening effort, the model did not include potential Restudy components. It was also considered too cumbersome to rewrite for the Restudy. The most recent documentation for the SFWMM was provided in a draft report (SFWMD, 1997. DRAFT Documentation for the South Florida Water Management Model. Hydrologic Systems Modeling division, Planning Department, South Florida Water Management District, West Palm Beach, Florida) and is described further in ***Section B.3.1.1***. Documentation for the SFRRM is provided in two publications: South Florida Regional Routing Model, Technical Publication 86-3, June 1986; and in Lake Okeechobee Regulation Schedule Simulation, Special Report, April 1994. Both are available from the SFWMD. Detailed descriptions of input data, rainfall, evapotranspiration, seepage, existing hydrologic features, rules of operation, and calculation routines are described in the documentation.

For the screening effort, three hydrologic models were developed: the Everglades Screening Model (ESM), the Object-enhanced Screening Model (OSM), and the Central and South Florida Systems Analysis Model (SFSAM). The three models represent three different approaches to the modeling of the south Florida region. The ESM uses a traditional sequential solution technique where variables are determined in the order they are required. Both the OSM and SFSAM include linear programming routines, but with different optimization goals. The OSM optimizes the operation of the system within each time step. The SFSAM uses the entire period of record in one time interval to determine the best operation for that period. Similar to SFRRM, each screening model treats each WCA, lake, and reservoir as a “pot” of water, and only average parameters are used (e.g. average stage of the entire area or average inflow and outflow).

At the initiation of the Feasibility Study, the OSM and SFSAM were developed to be the primary models for the screening effort. When the study period was shortened by WRDA 96, however, the ESM was designated as the primary investigation model, while both OSM and SFSAM were designated as secondary investigation and verification models. Each of the three models provided a unique perspective into the water management response of the C&SF Project.

Water Preserve Areas (WPAs) were not sufficiently defined to be included in the development of the OSM and SFSAM. Therefore, WPAs were not included in the investigations conducted by those models. However, some WPA features were included in the ESM and investigated. ESM, OSM, and SFSAM included the future base condition (future water supply demands, environmental demands, STAs, and all water control features proposed to be in place by the year 2050, including Modified Water Deliveries). The southern limit of these models was the flow line along Tamiami Trail into the ENP. Hence, C-111 features were not included.

B.2.2.1 Object-Enhanced Screening Model

Water Resources Management, Inc developed the OSM. The model uses input data and similar algorithms found in the SFRRM, but utilizes linear programming techniques for operational decisions at a weekly time step. A complete description of the model with investigative results are documented (Object-enhanced Screening Model (OSM) Final Report for the Jacksonville District of the U.S. Army Corps of Engineers, October, 1997).

B.2.2.2 Central and South Florida Systems Analysis Model

The SFSAM is a special application of the Prescriptive Reservoir Model (PRM) developed by the Hydrology Engineering Center, Davis, California. The model uses input data and similar algorithms found in the SFRRM, but incorporates a monthly time-step. SFSAM utilizes a special linear programming technique for making operational decisions for the entire period of record as the “best” operational solution to meet identifiable needs. The rules of operations for storage areas (e.g. Lake Okeechobee, WCAs, and reservoir components) in the model were less constrained than the existing system in order to learn from the solution. A complete description of the model with investigative results are documented (Central and South Florida Systems Analysis Using HEC-PRM, Draft Report for the Jacksonville District of the U.S. Army Corps of Engineers, July, 1998).

B.2.2.3 Everglades Screening Model

The ESM is a rewrite of the SFRRM into an object oriented modeling environment that allows quick and easy development of new components. The ESM uses the same input data set and rule structure as the SFRRM, SFRRM having already been documented and proven. The ESM was developed to quickly explore many structural and operational possibilities, parameter sensitivities, as well as the interaction effects with other major water control features in South Florida (both present and future). Accordingly, the ESM was utilized for screening a large number of alternatives. However, the SFWMM was utilized for high-level detail evaluations for a small number of planning alternatives. At the time of the screening effort, the ESM ran in about six minutes as compared to the six hours required by the SFWMM .

The ESM was developed in a modeling environment called STELLA II (High Performance Systems, Hanover, New Hampshire) and was completed by Dr. Richard Punnett of the Corps of Engineers, Jacksonville District. The rewrite was coordinated with the staff of SFWMD. The time step used for the ESM was one week with a 26-year period of record (1965 to 1990). As ESM was being developed, copies of the model were continuously available for review and comment by any interested party. Additionally, a two-day workshop was held in the summer of 1996 to present and explain the ESM. The workshop was opened to the public. The findings from the ESM are discussed in ***Section B.2.6.***

B.2.3 Hydrologic Historical Perspective

B.2.3.1 Predrainage Flow Patterns

To investigate the natural system, it was necessary to establish some preliminary hydrologic targets and utilize projected future water supply and hydrologic budgets. During the screening phase, the Natural System Model (denoted herein as NSM, version 4.2) was utilized for average stage and flow targets in the ENP and the WCAs. Additionally, the NSM flows to tide were used as a guideline to estimate the volume that could be captured from the flow currently going to tide.

The Technical Advisory Committee of the Governor's Commission for a Sustainable South Florida completed a review of the water budget changes in South Florida and described the findings in a presentation (Everglades Water Budget – Principles and Overview Slide Presentation. Technical Advisory Committee of the Governor's Commission for a Sustainable South Florida, October, 1994). Although the report was based on NSM Version 4.1, it characterizes the overall changes that have been observed between historical and present conditions.

B.2.3.2 Original C&SF Design

In the original C&SF Project report (1949), flood control was recognized as the major impetus of the study by noting that the development of the region was "retarded by destructive floods." Fires were reported as problems during droughts, in addition to that of "too much water." Water conservation was noted as important, but primarily for the maintenance of water levels to combat fire destruction of the muck lands within the Everglades. Other project purposes were addressed to a lesser extent (including the prevention of salt-water intrusion and improvement of water supply, navigation, recreation, and fish and wildlife enhancement). Several other interesting design characteristics were also noted and are mentioned as follows:

- Because the water supply demand on Lake Okeechobee was less, fluctuations in water levels were much less than they are today and were far more ecologically beneficial to the Lake.

- Because the water supply demands on the WCAs were less, there was more water available to flow into the ENP.

Prior to 1928, some flood discharges from Lake Okeechobee were directed to the east and west estuaries. The canals leading to the estuaries were enlarged after the 1949 report.

- Discussions of minimum flow requirements to the natural system were in reference to the prevention of muck fires during droughts.

- Because some of the land south of WCA 3B was privately owned, the flows into the ENP were primarily passed from WCA 3A through the S-12 structures.

- Seepage management from the eastern protective levee consisted primarily of draining the excess seepage water to tide in most areas (L-67 A and C were added later to reduce the stages; therefore, seepage from WCA 3B).

- Lake Okeechobee was the ultimate source of water during dry seasons for water supply; however, no flow demands from the WCAs or ENP were included.

B.2.4 Hydrologic Objectives of the Restudy

B.2.4.1 General

The Restudy objectives that directly relate to hydrology are:

- Natural Hydrologic Patterns
- Flood control
- Water supply

To achieve these objectives, many new components to the C&SF project are required. The screening of the hydrologic components was intended to support these objectives. Although creating storage was not an objective, the need for storage and other water management features to achieve the objectives is self-evident. For example, storage could be used for flood storage to prevent losses and damages to the estuaries, in addition, it can be used for a dry season source of water. The management of water to meet present and future dry season demands requires new sources of water during those times.

B.2.4.2 Hydrologic Pattern Targets

Hydrologic changes in the natural areas have been identified as the major factor in the ecological decline of the system. Key hydrologic indicators are hydroperiod, distribution, timing and quantity of water. The screening effort used NSM values (no substantial historic records were made) as the initial targets for restoring natural hydrologic conditions. In the modeling of each component, several indicators were used to determine if changes were positive and significant. For example, the amount of water added to the ENP (as well as the timing and distribution) could be evaluated for significant improvements to assist in determining the amount of storage needed upstream. Additionally, changes in the average depth of a WCA could be evaluated for improvements in high or low water stage conditions.

The screening models treated the WCAs as individual “pots” of water; therefore, screening investigations of hydropatterns within each WCA was not possible–only average conditions could be evaluated. Nor was it possible to evaluate the internal ponding effects of the *severed flow lines* (flow paths along the eastern side of the WCAs that historically ran southeastward into the LEC). The natural flow paths from the WCAs were permanently altered when the eastern protective levees were constructed. The evaluation of this effect was conducted utilizing the SFWMM while investigating the possibility of either full or partial decompartmentalization of the WCAs.

B.2.4.3 Flood Control

Today, the designated areas for flood control are Lake Okeechobee, the WCAs, the ENP, estuaries, and bays. The wet-season effects of flood control in urban and agricultural areas are higher flows in rivers and estuaries, and higher peak stages in the Lake and WCAs. Conversely, the dry-season effects are lower flows and stages. Water mass moved to tide in the wet seasons, via estuaries or bays, is not available for dry seasons and is thereby lost from the system. With the addition of storage features, both flood control and dry season flows can be enhanced.

Increased seepage management will have incidental effects benefiting flood control by the reduction of water flow through populated areas. Although some seepage management features were included in the screening phase, this flood control benefit was not identified.

Flood control generally meets design requirements in South Florida with few exceptions. Site specific flood control was not evaluated in the screening phase.

B.2.4.4 Water Supply

Perhaps the best-defined water demand of the system is the water supply requirements of the LEC and the EAA. Estimated water demand for the year 2050 was used for the screening effort and water was distributed according to *existing state water allocation rules*. The primary water supply source for the service areas around Lake Okeechobee (EAA, St. Lucie, Caloosahatchee, North Palm Beach Basins, Seminole demands, and peripheral cities) comes from local and groundwater storage. A secondary source is from the receiving of supplemental releases from the WCAs. When the LEC water supply from local groundwater is low, it is supplemented initially by the WCAs before being met by supplemental releases from Lake Okeechobee. Therefore, all urban and agricultural water supply needs are ultimately dependent on Lake Okeechobee.

In contrast, the WCAs and the ENP are not entitled to Lake Okeechobee releases to maintain minimum flows or levels. The ENP is only entitled to water released from the WCAs in accordance with the Rainfall Plan. If the WCAs are low, no water is released to the ENP and the Rainfall Plan requirement is unmet. The minimum flows and levels rules (currently under consideration) only restrict the withdrawal of water from the Lake and WCAs when these areas are at or below a minimum stage/level. The rule does not require a minimum flow of water to maintain minimum stages or levels.

Some evaluations for the screening phase were made assuming potential flow requirements to the ENP, such as a minimum flow rate or flow rates equivalent to NSM conditions.

A state requirement for water management districts to plan for a one year-in-ten drought was not in place during the screening phase and was not evaluated in the screening phase.

B.2.4.5 "New" Water

A blatant hydrological reality is that there is not enough water stored in the system to meet all dry-period water supply demands–past, present or future. The demands come from agriculture, urban, and natural areas. A water manager's definition of a drought should be when dry conditions prevail under which normal water supply demands are not met. Droughts have occurred in the 1970's and 1980's where the demands exceeded the supply. However, the adverse impacts during those events were not severe. Recognizing that water supply demands have increased significantly over time, it is realistic to believe that the same hydrologic conditions of the 1970's and 1980's will have increasingly more severe shortage impacts in the future. Mild hydrologic droughts that have occurred in the past without shortages will have shortages in the future because of these increased demands.

The identification and quantification of potential "new" sources of water were important during the screening phase. Three obvious sources were evaluated: (1) regulatory water released from Lake Okeechobee (LOK) to the estuaries; (2) "excess" runoff in the Caloosahatchee Basin; and (3) water sent to tide along the Lower East Coast. The modeling for the screening phase focused on the capability to create new sources of water from the water currently being lost to tide. Identification and modeling of reuse water as a dry-season source was neither completed nor included during the screening phase.

B.2.5 Descriptions of Hydrologic Components

B.2.5.1 Overview

The components that were investigated in the screening phase included storage north of and in Lake Okeechobee, storage in the Caloosahatchee and St. Lucie Basins, storage in the EAA, storage and seepage management throughout the LEC, and ASR. Additionally, several factors that affect the efficacy of the components were also included in the modeling such as evapotranspiration (ET), seepage, ASR efficiency, storage location, and operational flexibility.

Two of the guiding principles in deciding where to investigate water resource components were: (1) to solve the problem in the basin where the problem exists; and (2) to take advantage of the opportunities in the basins where they exist. For example, it was far more effective to store excess Caloosahatchee River water in the Caloosahatchee River Basin than to transport the water to another basin for storage (e.g. the EAA Basin). Pumping rates are often significantly less in comparison to the magnitudes of flood flow. Not only would pumping to another basin be expensive, but also the rate at which water could be captured would be reduced if canal flow over a distance is necessary. This would be notably true when deliveries back to the original basin were needed for water supply. Although backpumping from the Caloosahatchee River Basin to Lake Okeechobee can be effective in some years, in other years it is not–whereas storage within the Caloosahatchee River Basin is effective almost every year (discussed further in ***Section B.2.6.1***). The actual location *within* a basin was much less important due to the nature of the screening effort. As long as sufficient canal connections to an inflow source were identified, the performance of a reservoir could be investigated.

The problem or opportunity presented often defined the type of water resource component evaluated. For example, if multi-year carry-over of water was needed, then ASR was the most likely candidate to fulfill that function. Another example, if a rapid collection of flood flow was needed, then a reservoir was the most likely candidate. Additionally, the water resource component could be a combination of two or more features (e.g. a reservoir with ASR facilities and seepage management).

Evapotranspiration (denoted herein as ET) was modeled in all water management features except ASR. The method utilized to model ET was that incorporated by SFRRM and was explained in the SFRRM documentation (see ***Section B.2.2***). Simply stated, the incremental ET that would be created by raising water levels to above ground conditions was calculated and subtracted from the water budget. The modeling of marshes was performed identically to that of above-ground reservoirs.

Seepage is critical to the LEC water budget during dry seasons. It is important to note that *not all seepage is a loss*. However, during flood times, it can be considered a loss or even a contributor to downstream flooding conditions. Supplemental releases from the WCAs or LOK are needed for the LEC when seepage does not meet demands. Seepage management along the eastern protective levee was evaluated by utilizing either a step-down water level approach or a backpumping approach. The effects of underground barriers or “curtain walls” along the eastern protective levee were not evaluated in the screening phase since the impacts to the LEC could not be evaluated with the screening models.

Consideration of seepage management was also necessary in scenarios where an above-ground reservoir was modeled. In those cases, it was assumed and included in design estimates that sufficient seepage management facilities would be able to collect and return seepage to the reservoir. This would be particularly important during periods of high water levels; however, the seepage could be used to help meet dry-season demands in the LEC and EAA, for example, reducing the amount of pumping (thereby also reducing costs as an added benefit).

In the modeling of ASR, 70 percent efficiency was assumed with a 30 percent loss. The 70 percent efficiency is consistent with the ASR report as referenced to the Governor’s Commission on a Sustainable South Florida. In some wells of south Florida, much higher efficiencies have been observed (e.g. in Hialeah, Florida), while some ASR wells have not been productive (e.g. in Marathon, Florida). In the Peace River, not only have efficiencies been noted, but also withdrawals from multi-year storage have been demonstrated. Multi-year storage capability was modeled in the screening phase incorporating this technology. The screening effort attempted to determine if significant benefits could be realized rather than to size the amount of ASR needed in a particular basin. The actual sizing would occur in the alternative development phase as the configurations of other features were modeled.

Storage areas with extensive drainage capabilities are able to use the storage more effectively than an area without drainage, unless the land is significantly sloped. Complete use of the storage volume was assumed in reservoirs with drainage features. In reservoirs without drainage features; however, the last half-foot of storage was assumed not available since it could not be pumped readily.

Multi-purpose operations and operational flexibility were two important considerations in the modeling of components. The goals for a management feature must be identified before the rules of operation can be developed. Multiple goals were considered when possible. For example, when determining goals for EAA storage: local flood control, local water supply, reductions in estuary discharges, and reductions of WCA peak stages were also considered. If a single goal of preventing estuary releases was used, then the size of a reservoir would be significantly larger than a reservoir designed only to maximize water supply. Operational flexibility was more important in the development of alternatives when a combination of effects could be evident. Additionally, operational flexibility is an important consideration for adaptive management.

The alternative development phase was not limited to the findings from the screening phase, but it was made more efficient by having some experience in modeling most of the features.

B.2.5.2 North of Lake Okeechobee Storage

The Kissimmee River Basin was once a classic Florida marsh-type river system. As flood control was developed in the basin, the connections between lakes and rivers were enhanced and the river was made straighter and deeper. Thus, peak flows in the river were increased, water travel times were faster, and low flows were reduced. The current restoration effort for the Kissimmee River was assumed to be part of the future base condition and was included in the modeling. The overall increase in flood flow rates into LOK causes an increase of releases to the estuaries from the Lake.

The primary goals for storage north of Lake Okeechobee were to avoid releases to the estuaries on the east and west coasts, reduce high lake stages, and improve dry-season stages in the Lake. Thus, the storage area was filled by capturing floodwater when the Lake was nearing regulatory release stages. When the Lake Okeechobee stage began to recede below regulatory levels, the stored water was released directly to the Lake for water supplies. To reduce the losses associated with ET, the storage would only be used in abnormally wet years. During the dry-to-normal years, the reservoir area may be used for other purposes (e.g. grazing or recreation).

For modeling purposes, it was not necessary to identify a specific location of the storage facility except to determine that it was near the inflow source. In the case noted above, the storage was designed to interact with Lake Okeechobee directly by either taking water from or putting water back into the Lake. If the facility was located further upstream of the Lake, considerations of stream flow may limit the amount of water collectable. However, some flow improvements in the Kissimmee River can be constructed. The need for water quality improvements to LOK inflow had not been identified during the screening phase and storage for that purpose was not evaluated.

A maximum storage depth of 10 feet deep was initially set for the reservoir. The reservoir was modeled as a flat-bottom reservoir. For the Kissimmee River Basin, the actual site may be in a sloped area; therefore, the important design consideration from a modeling standpoint was the overall storage capacity and not the surface area. A smaller surface area is more desirable when considering ET losses.

B.2.5.3 Caloosahatchee Storage

The Caloosahatchee River once had an undistinguishable connection to Lake Okeechobee and probably received overflow from the Lake only in abnormally wet years. The river was shallow and had numerous oxbows. Flooding along the river was common. A viable connection to the Lake was made in the early 1900's and Lake Okeechobee experienced its first major drainage and lowering of its water levels. As flood control was developed in the river basin, high flows to the estuaries were increased while low flows to the estuary diminished. The magnitude of the flood flows from the local basin easily exceeds the magnitude of the regulatory releases from Lake Okeechobee. However, regulatory releases from the Lake increase flows to the estuary and become a part of the salinity-balance problem. The need for dry-season water supply increased with agricultural development in the basin. The diminished low flows of the basin, coupled with the increase in the agricultural water supply demand causes the basin to be highly dependent on water supply releases from Lake Okeechobee in dry seasons.

The primary goals of storage in the Caloosahatchee Basin were to reduce peak flood flows to the estuary; capture excess runoff and help meet dry-season water demand; and provide for minimum flows to the estuary. “Excess” runoff, or water in excess of estuary requirements, has been defined as part of the Lower East Coast Regional Water Supply Plan (LECRWSP). The modeling performed in the screening phase was utilized to evaluate the sizing of the reservoir that could balance the goals. ASR was not included in the basin design during the screening phase. The volume of “excess” water available during the screening phase was significantly less than the volume ultimately used in the alternative development phase. Although backpumping into Lake Okeechobee was evaluated to a minor extent in the screening phase, it became a more important consideration when the volume of excess water increased in the alternative development phase.

A maximum storage depth of 8 feet deep was initially set for the reservoir. The reservoir was modeled as a flat-bottom reservoir and assumed to be in proximity of the Caloosahatchee River. The actual reservoir could be divided into multiple reservoirs to enhance the capture of basin water and to make siting easier, since one contiguous area would not be necessary. Although construction costs would be increased, the land cost may be significantly reduced.

B.2.5.4 St. Lucie Storage

The St. Lucie Basin was once not connected to Lake Okeechobee. Flows from the local basin entered into a basically freshwater lagoon. After a direct opening from the lagoon to the ocean was created and maintained, an estuarine community was established. A canal from Lake Okeechobee was created in the early 1900's that, on occasion, greatly increased the fresh water flows to the estuary. With the development of flood control in the basin, the local basin peak flows to the estuary were increased to the point that the estuary sustains occasional damage from too much fresh water. Today, the regulatory releases from the Lake can far exceed the local basin peak flows and may alone cause damage to the estuary. The diminished low flows of the basin due to flood control, coupled with an increase in agricultural water supply demand, causes the basin to be highly dependent on water supply releases from Lake Okeechobee in dry seasons.

The primary goals of storage in the St. Lucie Basin were to reduce peak flood flows to the estuary; capture excess runoff and help meet dry-season water demand; and provide for minimum flows to the estuary. "Excess" runoff, or water in excess of estuary requirements, has been defined as part of the LECRWSP. The modeling performed in the screening phase was utilized to evaluate the sizing of the reservoir that could balance the goals. ASR was not included in the basin design during the screening phase. The volume of "excess" water available during the screening phase was significantly less than the volume ultimately used in the alternative development phase. No additional backpumping was considered in the screening phase since back flows from the St. Lucie Canal currently exist.

A maximum storage depth of four feet deep was initially set for the reservoir. While the area could support a greater depth, a more marsh-like reservoir with water quality enhancement was desired. From a modeling standpoint, the capacity was the most important design parameter, but clearly greater surface areas would result in increased ET losses. The reservoir was modeled as a flat-bottom reservoir and assumed to be in proximity of the St. Lucie Canal. The actual reservoir could be divided into multiple reservoirs to enhance the capture of basin water and make siting easier, since one contiguous area would not be necessary. Although construction costs would be increased, the land cost may be significantly reduced.

B.2.5.5 EAA Storage

Runoff in the EAA once flowed at a relative low rate southward to the areas now known as the WCAs, to the Everglades National Park, and ultimately to estuarine boundaries with Florida Bay. Contributing, the overflow from Lake Okeechobee flowed southward across the EAA region and combined with the local runoff, thus providing a prolonged flow into the ENP. In today's system; however, the runoff from the EAA is efficiently collected and moved quickly into the WCAs for flood control purposes. Additionally, most of the overflow from Lake Okeechobee is released to estuaries both east and west of the Lake because of flood control concerns in the EAA. While the development of the EAA has created a highly productive and important agrarian community, it also resulted in major changes in the timing and quantity water entering the WCAs, the ENP, and bays. Water passed to the WCAs is supposed to support a natural wetland community, provide some flows to the ENP, and provide dry-season water supply for the LEC. The overall result when compared to predrainage is damaging flows to the estuaries, higher stages in the WCA's during wet periods, and lower stages in the WCAs during dry times.

The primary goals of storage in the EAA were to improve flood control, water supply, and environmental restoration--improved timing of flows to the WCAs and ENP--while reducing the volume of water currently lost to tide. Storage in the EAA can capture flood waters from two sources: local runoff associated with flood control for agriculture, and high-stage releases from Lake Okeechobee. Storage in the EAA was the only viable option available that could store EAA runoff for use in the dry seasons. By the storing of flood waters, both flood control and water supply management can be improved. There is a loss of water due to increased ET as with all reservoirs. Therefore, the rules of operation were evaluated to minimize this loss. However, even a diminished water budget can be important both to human needs and to the environment when stored water is delivered in dry seasons. Investigations within the EAA also included flowways and various ET management approaches.

The screening model was used to evaluate a great number of sizing issues associated with storage in the EAA. The sizing issues included parameter sensitivity analysis and operational rule making evaluations. This was considered necessary since numerous model runs could not be performed in the alternative development phase. More than a hundred runs were completed to evaluate storage in the EAA, as well as many more evaluations of feature combinations with EAA storage.

The location of the reservoir modeled in the screening effort was assumed to be between the Miami and North New River Canals. The potential inflows included the local inflows to those canals and regulatory releases from Lake Okeechobee. Some modeling investigations included the redirection of local runoff from the

Hillsboro and West Palm Beach Canals. The maximum depth was initially set to be six feet.

B.2.5.6 Lake Okeechobee Storage

In Lake Okeechobee water levels, before drainage, only fluctuated about two feet with a maximum stage around 21 to 22 feet above sea level. At the onset of a wet season, the Lake would be below its banks due to ET. Well into the wet season, the Lake would fill causing water to flow freely over the southern rim (about two years out of every three) and begin a slow-flowing trek through the Everglades marshes, wet prairies, and sloughs. The Lake was more expansive and the littoral zone was higher than it is today. Drainage to the Caloosahatchee and St. Lucie estuaries in the 1900's caused profound lake level changes in the Lake and major changes to the water budget of the remaining Everglades. Not only were the high stages reduced, but as water supply demands increased in the surrounding basins, the lower lake levels were also reduced. Accordingly, a new littoral zone was established at a lower zone (roughly 11 to 15 feet above sea level). Today, the Lake normally fluctuates over a seven-foot range with a maximum elevation of about 18 and a lower elevation of about 11 feet (extreme hydrologic events can cause exceedance of the seven-foot range). Lake level fluctuations for extended periods above 15.5 feet and below 12 feet can cause severe damage to the existing littoral zone and create other water quality problems within the Lake.

The goals of evaluating storage in Lake Okeechobee was to prevent discharges to the estuaries, provide water supply, and maintain lake levels consistent with both levee stability and healthy lake conditions. Obviously, these goals are competitive and the effort is primarily a balancing act. At the time of screening, the Lake Okeechobee Regulation Schedule Study (LORSS) was considering a number of potential changes in the rules of operation for the lake. Model investigations in the screening phase were primarily limited to major operational changes, such as the elimination of all regulatory releases by the holding of water in the Lake. As a result of screening efforts, a multi-purpose lake operation was developed and was included in the LORSS as the Corps plan.

B.2.5.7 Water Preserve Areas

The LEC was once characterized by deep water sloughs, an eastern coastal ridge (a few miles wide and suitable for human habitation), and occasional cuts through the ridge that allowed some surface flows to tide. Along with surface flows, seepage through the eastern ridge prevented saltwater intrusion into the underlying Biscayne aquifer. As the LEC was developed, a strip about 20 miles wide was drained by a series of canals east of a protective levee along the WCAs. The seepage through the eastern coastal ridge was reduced and seepage along the protective levee was created. Flood control activities resulted in a quicker and greater removal of rainfall (and WCA seepage) to tide in wet seasons and lower water table levels throughout the year. As the LEC water supply demand increased, management of the local water table required additional flows from the WCAs and Lake Okeechobee during dry periods.

The creation of WPAs is a concept, which consists of several components that are combined to meet five primary goals. The goals are: (1) to preserve existing high-quality wetlands; (2) to provide a buffer between natural and developed areas: (3) to increase regional water supplies by capturing excess water that goes to tide for dry season releases; (4) to maintain natural freshwater flows to estuaries; and (5) to reduce of excess seepage from natural areas such as the WCAs and the ENP. The components could include marshes, step-down water levels, recharge areas, reservoirs, seepage collection systems, curtain walls (impervious underground barriers), and stormwater treatment systems (marsh or filtering facilities). The actual configuration has not been determined as of today; however, the *form should be determined by both function and opportunity*. As part of the Lower East Coast Regional Water Supply Plan (LECRWSP) studies, the SFWMD evaluated the potential of the buffer concept. The buffer concept serves as the first draft of potential WPA sites. Additionally, the National Audubon Society prepared a report (Water Preserve Areas: Defining Biological Functions and Spatial Extent. Draft Workshop Report. National Audubon Society, December, 1996). This analysis provided information concerning the opportunities for components, such as marsh sites and potential reservoir sites, as well as identification of areas where land would not be available. Any potential site was considered to have a potential for multi-purpose operation.

The screening level evaluation of a potential WPA configuration was also studied. The WPA configuration consisted of the marshes just east of the eastern protective levee, seepage collection features, and reservoirs. The WPAs were designed to include backpumping of suitable water to the WCA and the ENP, water supply for the LEC, and reduction of seepage from the WCAs. Although other configurations were not studied, notably configurations that included curtain walls, several significant findings will be discussed.

An initial set of variables was assumed prior to the modeling of any configuration. Consequently, other sets of variables were tested to determine sensitivity. The variables included in this evaluation were maximum depth, surface areas, percent of excess water to tide available for capture, pump capacities, and seepage management. The shape of marshes and reservoirs were assumed to be essentially rectangular surface features. The most sensitive parameters are surface area, depth, percent of retrievable seepage, and percent of tide water available for capture. The development of a good set of operational rules was a critical guide for the effectiveness of the components.

B.2.5.7.1 Surface Area

Initially, the size of the marshes and reservoirs were consistent with the land suitability analysis. Sizes of the reservoirs were then varied ranging from 0.5 to 2.5 times that of the initial size.

B.2.5.7.2 Maximum Depths

Increasing the depth of a reservoir is typically desireable with the perspective to maximize effectiveness and minimize the areal extent. However, in south Florida, deep surface reservoirs are not practical due to high transmissivity rates of the substrate. The maximum depths considered for reservoirs next to the Loxahatchee National Wildlife Refuge (LNWR) were four and six feet. In reservoirs near WCA 3A and northern WCA 3B, the investigated maximum depth was four feet. For reservoirs in Miami-Dade County, the investigated maximum depths were two and four feet. For marshes, the maximum depth was assumed to be either 1.0 or 1.5 feet.

B.2.5.7.3 Percent of “excess water to tide”

About one million acre-feet of water goes to tide each year from C-4 to C-16 Canals. Although both seepage and runoff account for the amount, it is primarily LEC flood control activities that produce the releases to tide. Compared to pre-drainage values, the amount of water that goes to tide each year is about three times greater today according to NSM version 4.4. Theoretically, about 66 percent of the water that is sent to tide is “excess” (greater than predrainage). However, it is unreasonable to assume that such amount is available for capture without some undesirable environmental consequences. For the initial evaluation, the target percentage for capture was assumed to be 40 percent for the upper half of the LEC and 30 percent for the lower half of the LEC.

The amount of water that goes to tide is about two times greater today than pre-drainage values estimated by NSM version 4.5, the version utilized in the alternative development phase.

B.2.5.7.4Location

It was important to consider the reservoir location relative to the source of canal water for the water budget analysis. Location determined where water from the marsh or reservoir would be backpumped or which water supply demand could be augmented. In only one case was a new site considered not previously identified in the land suitability analysis. The sites evaluated in this report may help meet the water supply demands of the sub-region and help capture excess water to tide.

B.2.5.7.5 Pump capacities

The amount of water required to manage the maximum depth of marsh areas, supplied by backpumping, was determined by the model and is subject to change due to varying conditions downstream as well as upstream.

For reservoirs, the pump capacity was a function of reservoir size and depth. It was assumed that the pumps could fill the reservoir during a one-week major event, although the flow to tide was never reduced more than the target percentage for capture (above). Thus the model automatically provided the pump sizing for the screening evaluation. Other factors, such as actual backpumping limitations of the canal system, would have to be considered as well.

Backpumping from the reservoirs to the natural areas was included in the analysis. The backpumping rate was a function of the reservoir storage capacity and was automatically sized by the model to move one-fourth of the volume of storage in a week.

A modeled variable allowed for pumping a percentage of the eastward seepage from marshes and reservoirs to the natural areas. As initial values, a return of 30 percent for the marshes and 15 percent for the reservoirs were assumed. The utilization of these variables characterized the degree of seepage management assumed for the evaluation and greatly enhances the effectiveness of the reservoirs.

B.2.5.7.6 Seepage management

For the initial evaluation, only step-down water levels and backpumping collected seepage were considered. The marshes along the WCA boundaries were assumed to have an eastern berm and a collection canal that would allow for managing water levels and seepage collection. Additionally, marshes along the WCA boundaries provide a step-down water level seepage management benefit. The screening model was not utilized to evaluate underground barriers (curtain walls) because the impact to the LEC water table could not be evaluated with the ESM. The SFWMM was utilized to evaluate the effects of underground barriers for seepage control as part of the alternative development phase.

In reservoir operations, the backpumping of canal water would not only include runoff and seepage from the WCAs, but also seepage from the reservoir itself. This is more a physical reality than design assumption. Any seepage loss from a reservoir during backpumping of canal water would automatically be retrieved. During the periods of time when canal water is not being pumped, seepage alone could be pumped back or be allowed to meet LEC water supply. The modeled assumption was that any eastward seepage became part of the LEC water budget without being counted as water supply. An operational assumption was made that allowed a variable percentage of seepage to be collected and backpumped to WCAs or the ENP. There was a concomitant assumption that either the seepage water would be of suitable water quality for the natural areas or the water would be cleaned to suitable standards.

B.2.5.7.7 Operational Rules

Initially, the marshes were allowed to fluctuate according to hydrologic conditions. Only when the depth in the marsh exceeded the maximum desired depth was backpumping into a WCA or the ENP initiated. Pumping was then assumed to be at a rate to preclude depths greater than the maximum design depth.

For reservoirs, a constant rate of backpumping into WCAs or the ENP was assumed in addition to a percentage of seepage. Backpumping was only allowed when the WCAs were below regulatory schedules or when flow to the ENP was below predrainage values. Any direct backpumping from the reservoir to the Everglades Protection Area (EPA) would most likely have to include water quality treatment. LEC water supply demands were met from the reservoir if water was available.

B.2.5.8 Aquifer Storage and Recovery

ASR is a water management technique that can be applied to any basin where water is “excess” for an extended period of time and a suitable aquifer exists. The concept includes pumping the excess water to an aquifer as underground storage, then reversing the pumps in dry times to meet water supply demands. ASR has advantages and disadvantages over surficial reservoirs. Advantages include no ET losses, long-term storage (multi-year drought management), and a large volume potential. Disadvantages include losses to the aquifer when stored in saline aquifers, and low recharge and recovery rates.

ASR is not sufficient for flood control because of the low flow rates associated with well pumps. For example, a large ASR well may pump up to 15 cubic feet per second (cfs) whereas a flood flow can easily be greater than 3000 cfs. The largest well currently used in south Florida is capable of about 8 cfs. However, when used in conjunction with a storage area, ASR wells can provide some flood protection by making storage available, over time, in the reservoir. Once a storm surge is captured in a reservoir, pumping into an ASR well over several weeks may significantly reduce the reservoir level and make storage space available to capture subsequent flood surges.

A good description of the ASR technology was completed for the Governor’s Commission for a Sustainable South Florida (Aquifer Storage and Recovery (ASR) Presentation. Technical Advisory Committee to the Governor’s Commission for a Sustainable South Florida, May, 1996). Potential uses of ASR were evaluated as part of the screening phase in several locations over the study area.

B.2.5.9 Flowways

A flowway is generally described as a broad shallow marsh area that is used to flow water freely from Lake Okeechobee to one or more of the WCAs. The concept includes creation of an Everglades-type environment having both storage and water quality benefits. Evaluation of the concept shows several erroneous assumptions about the feasibility. Problems with soil subsidence, ET, seepage management, vegetation, timing of flows, and lack of flow events is evident. Addressing other EAA issues would be required if a flowway cuts through and dividing the area, including numerous roads, bridges, and railroad relocations.

Soil subsidence in the EAA has substantially reduced the hydraulic head that drives the southward flow of water; hence, velocities and flow rates are greatly reduced. By spreading the water over shallower areas (as opposed to reservoirs) and maintaining proper hydration of a functioning marsh habitat, the ET loss could easily be doubled. A long, rectangular configuration can have a 75 percent longer levee than a squared one, thus increasing seepage management features. Because nutrient-laden soil would be flooded for the flowway, cattails would most likely dominate the vegetation and not the desirable Everglades habitat. Flowways would not be able to hold back water going to the WCAs. The continuous delivery of that water would exacerbate the already high stages in the northern parts of the WCAs. Thus, the timing of flows from flowways would not be manageable or beneficial for the remaining Everglades. Perhaps the most crucial element–water flowing from the Lake to the WCAs–is not present in dry or even normal years! For example, during the long periods from 1970-1982 or 1985-1994, no significant excess Lake water was available for the flowway. Only demand releases to the Everglades were made from the Lake during those periods. Water delivered to the Everglades on a demand basis <u>through a flowway</u> would not be effective because of increased travel times and increased ET losses. The only years where water could flow for a long duration are wet periods similar to 1969-1970, 1982-1983, and 1994-1995. In those years, the stages in the WCAs are already too high and additional flow from flowways would be damaging, not beneficial.

Summarizing, the flowway is a concept that creates a water supply burden on the system without clear hydrologic benefits. The need for flowways would have to be justified for other reasons rather than hydrology alone.

B.2.6 General Findings

B.2.6.1 Operational Rules

No attempt in the screening phase was made to create a system-wide operational plan since the system is under review by the LECRWSP. Although having storage in all the basins as described, modeling evaluations in the screening phase did not create the water resources necessary to meet all water supply demands and match NSM flow volumes to the ENP. Clearly, operational changes alone cannot catch all the water currently being lost to tide in the Caloosahatchee, St. Lucie, and LEC Basins.

Evaluations of the effects of operational rule changes for individual components were important to the performance of each component. The successful performance of any component was dependent upon a capable set of operational guidelines. It is easier to develop a set of rules that results in poor performance of a reservoir than to develop an effective set. The evaluations discussed in the following sections were extremely valuable to the alternative development phase as a guide to modeling the proposed components.

Before developing operational rules, the evaluation of a potential component first involved an examination of each basin to determine hydrologic opportunities and limitations. Once the goals, limitations and opportunities were identified, the rules could be drafted. The following discussion of Lake Okeechobee provides the kind of hydrologic evaluation that will guide how components can be developed to match goals and opportunities.

Perhaps the most instructive visualization with regard to understanding how Lake Okeechobee behaves is shown in ***Figure B.2-1***. Lake levels over a 31-year period (1965 to 1995) are presented. The upper set of episodic dashed lines represent the regulatory release zones. Different flood discharge rules are invoked when the Lake goes above those lines. The black solid and red dashed lines represent the 1995 Base and 2050 Base cases, respectively. The lower episodic dashed line represents the Supply-Side Management (SSM) zone. Shortages in the basins around the Lake are invoked when the Lake goes below that line. Shortages in the LEC are not directly related to the SSM curve, but are “triggered” by other drought indicators.

Several blatant hydrologic realities with regard to Lake Okeechobee are evident in ***Figure B.2-1***:

- Regulatory releases from the Lake only occur on a periodic basis – not annually. As a result, there is no annual allotment of water that can be saved in the Lake by simply raising the regulatory release zones.

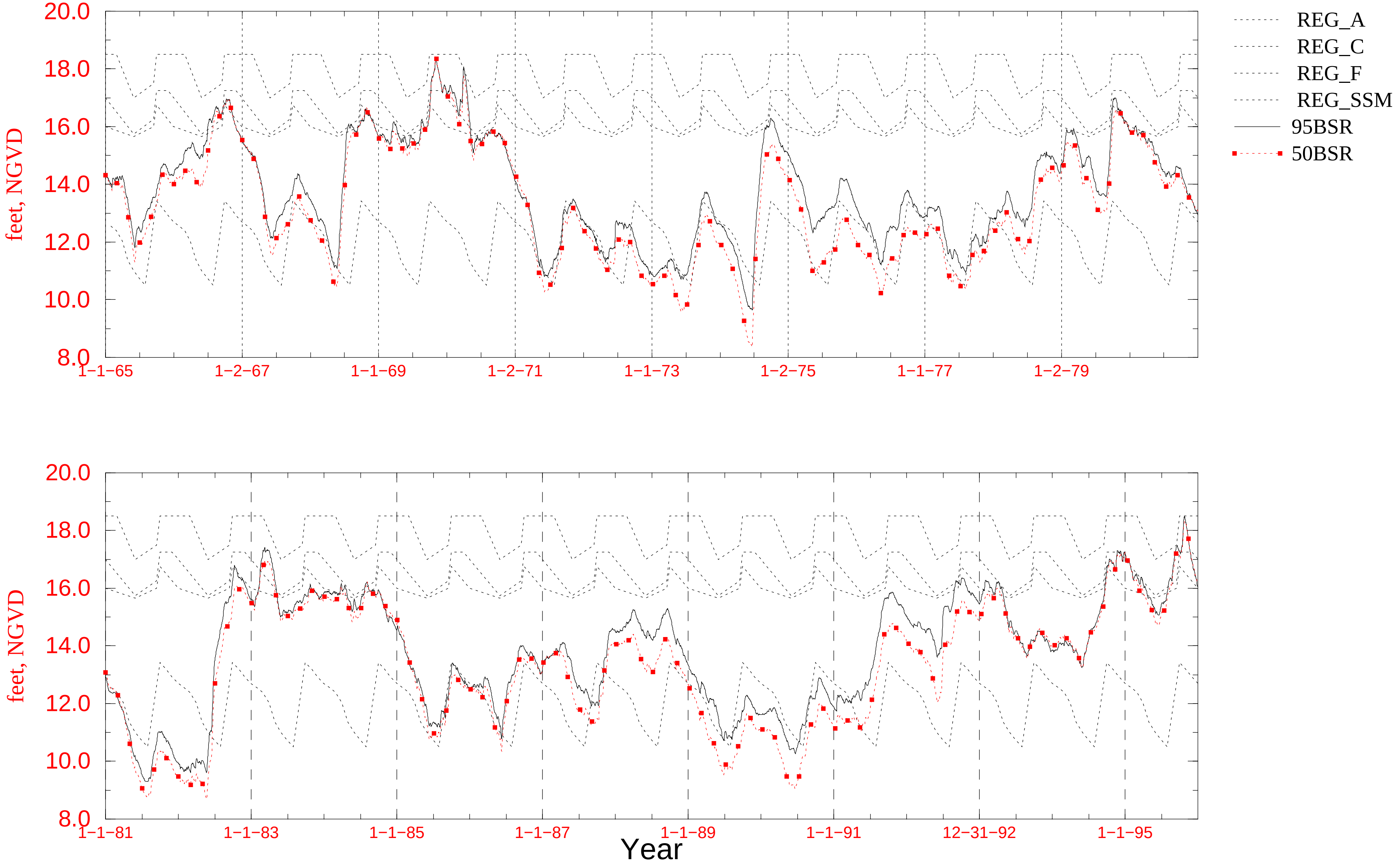
- The frequency of regulatory releases can be significantly reduced by either raising the lowest regulatory zone, storing some lake water in other areas, storing water in ASR wells, or by releasing more water for supply deliveries (e.g. the 2050 Base line). Discharges can be easily eliminated in years similar to 1966, 1974, 1979, 1984, 1992, and 1993 when the Lake crested near the lowest zones; whereas abnormally wet periods similar to 1969-1970, 1982-1983, and 1994-1995 are difficult to eliminate.

- Significant drought periods have followed soon after periods when regulatory releases were made (1966, 1970, 1974, 1980, and 1984). If the discharges could have been saved, the subsequent dry years would have had significant water supply benefits.

- There was no water supply value attached to the backpumping of water into the Lake if a regulatory release was required before the subsequent years enter the SSM zone (e.g. 1969, 1978, 1982, 1991, 1992, and 1994). Any additional water stored in the Lake in some years may have to be released in subsequent years as a regulatory release.

- Reservoirs sized to catch the wettest years (1969-1970, 1982-1983, and 1994-1995) would only be partially filled, if at all, in other years. Reservoirs that rely upon excess water from Lake Okeechobee would only fill periodically and would be unused for storage for several consecutive years.

Figure B.2−1 Daily Stage Hydrographs for Lake Okeechobee



Run date: 06/19/98 01:32:19
For Planning Purposes Only
SFWMM V3.5

Wet seasons (June to October) in other parts of the system (e.g. the Caloosahatchee River Basin, St. Lucie Canal Basin, EAA Basin, and the LEC) produce significant runoff almost annually. Reservoirs in these basins would have water supply benefits almost annually as well. Reservoirs in the Caloosahatchee River, St. Lucie, and EAA Basins could be filled with water from local runoff as well as Lake Okeechobee releases. The goals and operational assumptions for each reservoir can dramatically affect the optimal amount of storage for the area.

B.2.6.2 North of Lake Okeechobee Storage

Generalized discussions of the goals, sources of water, location concerns, and maximum depth considerations are presented in ***Section B.2.5.2***. The section covered important background information about the basin.

Storage north of Lake Okeechobee was effective at reducing regulatory releases from Lake Okeechobee – enough to substantially reduce the need for regulatory discharges to the St. Lucie Basin. However, the site alone could not substantially reduce the regulatory discharges to both estuaries.

Storage sizes from 5,000 to 200,000 acres were investigated. The most efficient size for storage north of the Lake was 20,000 to 40,000 acres, but the upper range was not clearly defined. Essentially, the larger the reservoir, the more water that can be caught in abnormally wet periods (e.g.1969-1970 and 1983-1984); however, the area would only be partially filled, if at all, in most years. Although, a storage area of 20,000 acres with a depth of 10 feet is equivalent to about a half-foot of storage in the Lake, the storage area was effective in storing a significant portion of the regulatory releases that would have been made. In dry years, the reservoir would not be used so that no ET loss would be incurred. In abnormally wet years when the reservoir would fill, the additional ET loss came from the water that would normally have been discharged to tide.

Operationally, filling the area when the Lake is above the regulatory zone and releasing back to the Lake when the Lake is below the zone is not an effective management scheme. Two operational problems were identified. First, the rate of pumping (5,000 cfs – about the size of the S-5A pumping facility) into the reservoir was not sufficient to significantly reduce some regulatory releases to the estuaries. Secondly, pumping reversals would occur when the Lake was near the bottom of the regulatory zone since the Lake could fluctuate up or down on a weekly basis. To solve these problems, water was assumed to have come from the Lake when the Lake level was rising and within 0.5 feet below the first regulatory release zone. The storage area would continue to fill until the Lake level begins to fall if it remained below the regulatory zone. Then, releases from the storage area back to the Lake would not begin until the Lake was at least 1 foot below the regulatory zone. By starting the pumping sooner, more storage was available in the Lake, thereby effectively reducing the discharges to the estuaries. By holding the water until the Lake was lower, a smoother operation (no reversals) was created.

B.2.6.3 Caloosahatchee Storage

Generalized discussions of the goals, sources of water, location concerns, and maximum depth considerations are presented in ***Section B.2.5.3***. The section covered important background information about the basin.

Storage in the Caloosahatchee River Basin was effective at catching excess local basin runoff and improving the water supply to the basin. Storage sizes from 5,000 to 60,000 acres were investigated. The most efficient size for storage of the local basin flows was about 20,000 acres with up to eight feet deep. Essentially, there was a finite amount of excess water and well-defined water supply needs that, consequently, fairly well defined an optimal range. The reservoir was not sized to capture Lake Okeechobee regulatory releases because of the magnitude of the local runoff. In abnormally wet periods, the reservoir would remain full and have little water supply benefits (supply being greater than demand in those years). However, in most years, the reservoir could meet a significant portion of the basin demand, thereby reducing dependency on Lake Okeechobee water supply releases. Only in the abnormally dry years did the reservoir fail to fill.

An additional amount of runoff was declared “excess” during the alternative development phase. At that time, backpumping to Lake Okeechobee was re-evaluated and included in the alternatives.

Although, modeling of storage in the Caloosahatchee River Basin included water supply for the local basin, the storage was never meant to be the only water supply for the basin. However, the storage was considered to be the first source used for water supply when needed. *Lake Okeechobee is considered to be the ultimate source of water supply releases for the Caloosahatchee River Basin.*

B.2.6.4 St. Lucie Storage

Generalized discussions of the goals, problems, opportunities, sources of water, location concerns, and maximum depth considerations are presented in ***Section B.2.5.4.*** The section covered important background information about the basin.

Storage in the St. Lucie Canal Basin (C-44) was effective at catching excess local basin runoff and improving the flow characteristics into the estuary. Storage sizes from 2,000 to 40,000 acres were investigated. The most efficient size for storage of the local basin flows was about 20,000 acres with a maximum four feet depth. There was a finite amount of excess water from runoff; however, because the C-44 Basin flows combine with several other major canals into the estuary, it was difficult to establish a well-defined optimal range. The modeling did not include other canal flows to the estuary such as C-23, C-24, C-25, and the South and North Forks of the St. Lucie River. The reservoir was not sized to capture Lake Okeechobee regulatory releases because of the magnitude of the lake releases. The lake releases are often many times greater than that of the local runoff. The reservoir could meet a portion of the basin water supply demand thereby slightly reducing dependency on Lake Okeechobee water supply releases. The reservoir would have nearly annual benefits.

B.2.6.5 EAA Storage

Generalized discussions of the goals, problems, opportunities, sources of water, location concerns, and maximum depth considerations are presented in ***Section B.2.5.5.*** The section covered important background information about the basin.

Evaluating causes and effect relationships are difficult for the EAA because of its central location in the system. Impacts originating from storage in the EAA literally affect every basin to some degree. As a result, more modeling was done concerning EAA storage than any other component in the screening phase. The operational assumptions for the EAA storage area could easily result in an inefficient operation. However, many significant improvements to water supply, hydropatterns, and reductions of discharges to the estuaries could be accomplished using EAA storage. Storage in the EAA is anticipated to have water quality benefits both within the storage area and in STAs by moderating the inflows. The water quality issues are addressed in Appendix D, Appendix H, and Attachment F.

B.2.6.5.1 Sizing

The goals of storage dramatically affect the sizing of it in the EAA. Assuming all discharges to tide are to be stored only in the EAA could result in the conversion of 200,000 acres to storage; although, it would only be filled two times over the 26-year period of record used in the screening models. Utilizing a multi-objective approach with both environmental and urban/agricultural water supply being optimized, the screening analysis concluded that a storage area ranging from 40,000 to 60,000 acres with a six- foot maximum depth was appropriate. In that range, significant reductions to tide and improvements to water supplies were noted.

B.2.6.5.2 ET Management

Several management techniques were evaluated to minimize ET losses: by dividing storage into separate cells, by only storing excess water, by dry season operations, and by utilizing drainage systems.

By dividing the storage area into two or more compartments, ET can be reduced by more efficient use of the areas. This is because the amount of water stored each year varies and only one cell may fill in drier years. By using one cell to capacity, there will be less ET loss incurred than by spreading the same amount of water over a greater area (shallower depth). By dividing the storage area into two cells, about a 15 percent reduction in ET was realized.

Losses associated with ET can be taken from water not currently used by filling under two conditions only: when Lake Okeechobee would normally make discharges to the estuaries and when the WCAs do not need the EAA runoff. By using these “excess” sources, any additional ET loss would come from water not needed or currently lost during the wet season, as long as this water can be brought and stored in the storage areas.

How a storage area is used during dry periods can also have a dramatic effect on ET. In years when there is not enough runoff available to fill an area, it can either be operated as a dry area or a wetland. If the area is operated as a wetland, there is an associated dry season demand for water to keep it wet. If the rain that falls on the area is kept inside to create marsh-like conditions, that amount of water is removed from the current water budget of the WCAs. Alternatively, if the area is operated as a dry area, there would be little or no additional ET loss and small, if any, reductions to the WCAs. A dry area operation when not needed for wet year storage could be used for recreation or agriculture.

In reservoirs, depending on the bottom characteristics, the last several inches are assumed to be not retrievable. Therefore, the effective storage is somewhat less that the actual volume in the reservoir. However, reservoirs that have a drainage system, the volume of water removed from the reservoir can include groundwater as well. By assuming the storage area incorporated a drainage system, not only would the full volume be available for storage, but also the area could be drained so that no additional ET loss would occur in dry periods.

B.2.6.5.3 Canal Capacities

The existing canal system in the EAA is effective at removing the local runoff while having little capability during wet periods to pass additional lake releases. Additionally, the amount of water in the WCAs (in some years) would also limit the southward releases from the Lake. For this reason, discharges to the estuaries are often the only release path available for Lake Okeechobee. In the modeling of EAA storage, about a three-fold increase in the capacity of the Miami and the North New River Canals was required to pass both, Lake releases and local runoff, to the storage areas simultaneously. This does not assume that the canal would be three times wider, only that the hydraulic capacity was increased.

B.2.6.6 Lake Okeechobee Storage

Generalized discussions of the goals, problems, opportunities, sources of water, location concerns, and maximum depth considerations are presented in ***Section B.2.5.6***. That section, in addition to ***Section B.2.6.1***, covered important background information about the basin.

The LORSS process (discussed in ***Section B.2.5.6***) introduced the problems and opportunities associated with balancing operational changes in Lake Okeechobee in far more detail that could be presented from the screening effort. In the LORSS process, all water management components (both in place and planned) are known; in the Restudy, a large number of potential components are under consideration. The alternative development phase addresses the proper balance of components and changes to the lake regulation schedules. In support of the LORSS, the SFWMD has prepared a draft report that presents detailed findings of several operational scenarios for Lake Okeechobee (DRAFT Simulation of Alternative Operational Schedules for Lake Okeechobee. SFWMD, April, 1997). Because the draft report covers the issues associated with changes to the lake operational rules, the findings in this section will be limited to presenting findings of more extreme considerations.

There is a general recognition that storage in Lake Okeechobee can be maximized at the expense of ecological health for the Lake. Actions supporting maximization would be cost effective and hydrologically efficient; however, there is a concern that the littoral zone of the Lake could not be relocated to help offset the adverse ecological impacts. The effects of storage in Lake Okeechobee were studied in the screening phase by removing all regulatory schedules in the Lake. During the abnormally wet periods, Lake levels can rise to elevations above 24 feet; during prolonged dry periods, Lake levels will fall to about current levels. Assuming the levee on the northwest side of the Lake could be moved back to incorporate a littoral zone, the base elevation would be about 19 feet. As a result, the higher zone would only be flooded occasionally (3 times in 31 years) and would not have the hydrologic characteristics of a littoral zone. Therefore, the higher zone would act more like a marsh adjacent to the Lake instead of a littoral zone. The level of the existing littoral zone would be submerged far more often than under current conditions and for far greater periods of time. Recent floods have demonstrated the damage to the existing littoral zone during high water levels. In short, wider variations in Lake levels would not be conducive to the establishment and preservation of a littoral zone at high or low lake levels. Even extensive shaping of the existing littoral zone by adding several feet of low-nutrient muck soils over 100,000 acres may not create a healthy littoral zone at an intermediate level. Notwithstanding the adverse ecosystem effects caused by adding storage in Lake Okeechobee, both water supply and the health of the estuaries would be greatly improved.

When storage north of the Lake and in the EAA were considered, only minor changes to the lake regulation schedule were needed to significantly reduce all discharges to the St. Lucie Estuary. However, the two storage areas were not sufficient to significantly reduce the Caloosahatchee Estuary discharges as well. This was demonstrated in the screening and alternative development phase.

B.2.6.7 Water Preserve Areas

B.2.6.7.1 General

Generalized discussions of the goals, problems, opportunities, sources of water, location concerns, and maximum depth considerations are presented in ***Section B.2.5.7***. The summary provided in this section was based primarily upon findings related to reservoir performance. The effect of marshes located along the eastern protective levee has been reported as part of the LECRWSP. Additionally, the areas identified by the Land Suitability Report were included in the analysis. In-ground lakes were not evaluated in the screening phase, although information from screening supported the development of such reservoirs. Additionally, potential WPAs north of, and including C-51 were not evaluated in the screening phase. The results of the screening efforts are presented by LEC service areas as follows.

B.2.6.7.2 Service Area 1

Service Area 1 (SA 1) is primarily defined as the LEC area east of WCA1. SA 1 receives water supply releases from the LNWR. Supplemental water releases also come from Lake Okeechobee (via LNWR) when the LNWR is too dry.

The land suitability analysis reports 5,913 acres of high-quality marsh along 10 miles of the eastern protective levee. Additionally, 1,639 acres along LNWR (Site 1), just north of the Hillsboro Canal, have been identified as a potential water management area for a reservoir. Reservoir sizes of 827, 2,440, 3,267, and 4,093 acres were evaluated.

For the reservoir sizes evaluated with four-foot maximum depths, only 14 to 28 percent of the excess water to tide was captured (from 40,000 to 75,000 acre-feet per year). Of that amount, only about half was available for use, the rest was lost to ET and seepage. Backpumping opportunities were limited by the frequency of times that LNWR was full. LEC water supply received the most benefit (about 60 percent of the benefits), with backpumping (about 25 percent of the benefits), and returned seepage being much less backpumped (about 15 percent of the benefits). If the reservoir sizes were evaluated at a six-foot maximum depth, about 25 percent more excess water to tide was captured with about the same effectiveness of use.

For SA 1, the current reservoir site is not located near the potential sources of C-15 and C-16. Since the Site 1 area would only be suitable for capturing 14 percent of the excess flow to tide, an additional site of about 900 acres would be effective for improving the capture to 22 percent. If the reservoir site was adjacent to the LNWR in the Agricultural Reserve area, seepage management, flood control, and local water supply could be enhanced, as well as solving the locality issue of C-15 and C-16 flows.

B.2.6.7.3 Service Area 2

Service Area 2 (SA 2) is primarily defined as the LEC area east of WCA 2A, 2B, 3A, and northern half of 3B. SA 2 receives water supply releases primarily from WCA 2A. Supplemental water releases also come from Lake Okeechobee when WCA 2A is too dry.

The land suitability analysis reports about 6,180 acres of high-quality marsh along 5.5 miles of the eastern protective levee along WCA 3A; another 1,649 acres of high-quality marsh were identified along 5.5 miles of the eastern protective levee bordering WCA 3B. Additionally, 2,880 acres in the area have been identified as potential water management areas for reservoirs. Reservoir sizes of 1,443, 2,880, 4,330, 5,773 and 7216 acres were evaluated.

For the reservoir sizes evaluated at four feet maximum depth, only 14 to 30 percent of the excess water to tide was captured (about 80,000 to 165,000 acre-feet per year). Of that amount, only about 35 to 40 percent were available for use, the rest being lost to ET and seepage. Backpumping was significantly higher when based on “in-kind” releases to WCA 3A since WCA 2A was often full; hence releases to WCA 2A were simply passed on to WCA 3A for potential hydropattern benefits. LEC water supply releases were about 15 percent of the total benefit, while backpumping and backseepage were about 35 percent and 50 percent of the total benefit, respectively.

B.2.6.7.4 Service Area 3

Service Area 3 (SA 3) is primarily defined as the LEC area east of the lower half of WCA 3B and the ENP. SA 3 receives water supply releases primarily from WCA 3A via WCA 3B. Supplemental water releases also come from Lake Okeechobee when WCA 3A is too dry.

The land suitability analysis reports about 12,893 acres of high-quality marsh along 13.5 miles of the eastern protective levee of WCA 3B (PENNSUCO lands). Additionally, up to 2,877 acres have been identified as a potential water management area for a reservoir. Reservoir sizes of 1,408, 2,877, 4,224, 5,632 and 7,040 acres were evaluated.

For the reservoir sizes evaluated at four feet maximum depth, only 15 to 30 percent of the excess water to tide was captured (about 40,000 to 80,000 acre-feet per year). Of that amount, only about 40 to 60 percent were available for use, the rest being lost to ET and seepage. Backpumping benefits from SA 3 were sent to the ENP for potential hydropattern improvements; releases were made when flows across Tamiami Trail were less than "natural" flow patterns (as predicted by the NSM). Because the LEC water supply demands were large in comparison to the storage evaluated, only a percentage of water supply demands were released dependent on reservoir size. LEC water supply releases were about 25 percent of the total benefit. Backpumping and backseepage were about 40 percent and 35 percent of the total benefit, respectively.

Because the identified reservoir site is located just south of C-4, the potential water sources of C-6 through C-8 would have to be connected via an aqueduct from north to south, <u>or</u> some storage would have to be provided in the northern part of SA 3. If the aqueduct solution is pursued, it would have to be lined to prevent interaction with the water in the lake belt area because of water quality concerns and the transmissivity would greatly reduce the effectiveness of the aqueduct.

B.2.6.7.5 Regional Perspective

The amount of benefits derived from the capture and subsequent use of excess water to tide was greatly impacted by the operational assumptions. For example, if the water in the reservoir was held to meet a specific water supply need, the effectiveness of the reservoir would be reduced due to ET and seepage losses. However, by passing some water into the WCAs and the ENP when those areas were below regulatory schedules or natural flows, the use of the captured water was more effective. Future investigations will likely determine better operational strategies.

The reservoir in SA 1 acted like a traditional impoundment with long periods of inundation and most losses being associated with ET. However, the more transmissive nature of SA 3 resulted in a reservoir that behaved more like a dynamic marsh with quick filling and drawdowns. Therefore, resulting in a site that would probably look more like a marsh than an impoundment.

Increases in hydropatterns were evident in the WCAs due to the combination of backpumping, backseepage, and meeting some of the LEC water supply demand from the reservoirs. No specific hydropattern target was used in this analysis.

At the SA 1 and SA 2 sites, the percentages of tide captured were 10 percent less than the target percentages, even at acreage 2.5 time larger than the identified sites. Only in SA 3 was the size of an identified reservoir site approximately suited to capturing the target percent of excess water to tide. Although the returns were diminishing for larger size reservoirs in each SA, benefits still accrued with size for the acreage evaluated.

SA 2 had as much potential to capture canal water as did SA 1 and 3 combined. Not the case for 95BSR and 30BSR). Future evaluations may consider moving part of excess water in the C-9 Basin southward into the reservoir site of SA

3, or move excess water from C-14 northward to SA 1. This analysis did not include the effects of what may happen to the current flows through S-9 into WCA 3A.

The benefits of capturing LEC excess flows to tide are essentially annual, unlike the capture of flood releases from Lake Okeechobee (occurring once every fourth or fifth year). While annual benefits are possible with the WPA reservoirs, the benefits do not carry over to succeeding years. A percentage of the early dry season LEC water supply demands were met from the reservoirs; after which, the water supply demands were met using existing rules, i.e. from WCAs and Lake Okeechobee.

In-ground lakes were not evaluated in the screening phase; however, the need for storage sites was evident in the screening analysis since the maximum surface areas previously identified did not catch all the available water. Additionally, the region where the central and north lake belt sites are located has high transmissivities that make above ground storage less desirable due to high seepage rates.

B.2.6.8 Aquifer Storage and Recovery

B.2.6.8.1 General

Generalized discussions of the goals, problems, opportunities, and sources of water are presented in ***Section B.2.5.8.*** The section covered important background information about the basin.

ASR in the Caloosahatchee River Basin was not evaluated in the screening phase. Additionally, the number of ASR wells in any basin would be highly dependent upon other water management components that would be determined as part of the alternative development phase. Therefore, no effort was made to optimize the number and sizing of the ASR facilities.

B.2.6.8.2 ASR in LEC

ASR was evaluated in association with excessive canal flow periods and with local reservoirs in the screening phase (e.g. Site 1). The potential operation would be consistent with normal ASR operations. Normal being that an ASR system would store (pump down) part of the year and recover (pump up) part of the year. The potential effectiveness varied between service areas. In SA 1, there was a good match between the periods of storing and recovering; thus, a good potential in water supply storage was observed. In SA 2;however, there was more opportunity to pump down than to recover. Thus, the system was not as efficient, although plenty of storage water was available . In SA 3, similar to SA1, there was a fairly good match between periods of storage and recovery. Because flood discharges throughout the LEC tend to come in surges, ASR was not effective in reducing the peak discharges. However, the effectiveness of ASR was greatly improved when used in conjunction with potential reservoirs along the LEC.

B.2.6.8.3 ASR around the Lake

ASR around Lake Okeechobee was not effective at reducing flood peaks in the Lake as initially modeled in the screening phase. This was because of the relatively small pumping rate of ASR wells compared to the rate at which water flowed into the Lake – even when 200 wells (at 5 mgd) were considered.

A different set of rules was screened and demonstrated to be a significantly positive component during the alternative development phase, in terms of managing lake stages, reducing estuary discharges, and meeting water supply. The change in operation involved a substantial lowering of the level at which the ASR wells began operating. The earlier operation in wet periods accounted for an increase in the amount of water that could be stored which helped to reduce high lake stages. By releasing the ASR water back to the Lake during dry times and low stages (Lake levels below 13 feet), improvement in water levels was noted.

B.2.6.8.4 ASR in WCAs

Modeling ASR in association with high stages in the WCAs was conducted but not recommended for four reasons. The first being that ASR wells have little effect on WCA stages Second, water levels in the regulatory zone did not indicate a surplus of water (it was only a signal to send it southward, ultimately to the ENP). Third, reductions in water quality (higher salinity) are less tolerable in the natural system than in urban and agricultural water supplies. Lastly, the WCAs were not in regulatory zones for an effective period of time.

B.3 MODELING OF ALTERNATIVES

B.3.1 Simulation of Alternative Plans

B.3.1.1 Model Used: South Florida Water Management Model (SFWMM)

B.3.1.1.1 Background

The hydrology of South Florida is unique in response to flat topography, high water table, sandy soils, and an extremely transmissive surficial aquifer. Given the complexity of the Everglades system, computer simulation is perhaps the only way to devise long-range water management plans. These plans are needed for sustainable development and balancing the competing water needs of the environment, agriculture, and the urban communities. The South Florida Water Management Model (SFWMM) is the model utilized in simulating alternatives for the Restudy.

The SFWMM is an integrated surface water-groundwater model that simulates the hydrology and existing/proposed water management plans in the South Florida region. The model uses the climatic data for the time period 1965-1995. The model simulates the major components of the hydrologic cycle in South Florida that includes rainfall, evapotranspiration, overland flow, groundwater flow, canal flow, and seepage across levees. Additionally, the model simulates the operations of the C&SF system components including major wellfields in the urbanized east coast, impoundments, canals, pump stations and other water control structures. The ability to simulate key water shortage policies effecting urban, agricultural, and environmental water demands allows the modeler to investigate trade-offs among different users and sub-regions. Two dimensional regional hydrologic processes are simulated on a daily time step utilizing a mesh of 2 mile x 2 mile (3.22 km x 3.22 km) grid cells. The simulation produces an extensive output that can be summarized into numerous indicators and measures of performance for evaluating a plan. In addition, the model simulates inflows from Kissimmee Basin, runoff and managed discharges in the St. Lucie and Caloosahatchee Basins, and inflows to and outflows from Lake Okeechobee.

B.3.1.1.2 Documentation

The most recent documentation for the model is available from the following reference: South Florida Water Management District. 1997. Draft Documentation for the South Florida Water Management Model. Hydrologic Systems Modeling Division, Planning Department, South Florida Water Management District, West Palm Beach, Florida. Additionally, it is currently available on the internet at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm.

B.3.1.1.3 Time Step

A fixed time step of one day is used in the model. The selection of this time step is consistent with the minimum time increment for which hydrologic data such as rainfall, evaporation and structure discharge are generally available. Rainfall and potential evapotranspiration (PET) are the primary driving processes. The longest total simulation time for the model is a function of the available historical rainfall and PET data. The model can be run for time periods ranging from one month to 31 years (between January 1, 1965 and December 31, 1995). The hydrologic processes are modeled sequentially within one time step. To simplify programming and reduce computational time, no iteration is performed between surface water and groundwater routines within a time step. Calculations for more transient phenomena (e.g. channel flow routing) are performed before less transient phenomena (e.g. groundwater flow). The total execution time for a typical Restudy alternative may run approximately 5 hours on a Sun™ Ultra2.

B.3.1.1.4 Scale

The gridded portion of the model domain, south of Lake Okeechobee, describes the extent of the finite difference solution to the governing overland and groundwater flow equations. The network is comprised of 2-mile square grid cells that cover the large coastal urban areas of Palm Beach, Broward and Miami-Dade counties; the Everglades Agricultural Area (EAA); the Water Conservation Areas (WCAs) and Everglades National Park (ENP). The total coverage of the model is 1,746 grid cells. The model assumes homogeneity in physical as well as hydrologic characteristics within each grid cell.

The 2-mile discretization in the SFWMM is sufficiently fine to describe the solution to the overland and groundwater flow equations with reasonable resolution and to prevent excessive numerical errors (Lal, 1998b).

Other areas in the model (e.g. Lake Okeechobee and northern lake service areas) are conceptualized at a different level of detail due to varying degrees of data availability. The SFWMM employs both lumped and distributed modeling techniques. Specifics on these techniques can be found in SFWMD (1997).

B.3.1.1.5 Overland Flow

A diffusion wave approximation to the full equations for overland flow is utilized in the gridded portion of the model. Specifically, the components of the cell-to-cell flow are computed using the following expressions:

$$u = 1.49 \frac{h^{\frac{2}{3}}}{n\sqrt{S_n}} \frac{\partial H}{\partial x} \qquad (1)$$

$$v = 1.49 \frac{h^{\frac{2}{3}}}{n\sqrt{S_n}} \frac{\partial H}{\partial y} \qquad (2)$$

Where u and v are the velocity components in the x and y directions, respectively. Other variables defined: n is the overland flow roughness coefficient that depends on the depth of flow (according to the formula: $n=A*h^{B)}$; S_n is the maximum energy slope; and H is the water level above a given datum. An Alternating Direction Explicit (ADE) scheme with four six-hour time slices is utilized to solve for the overland flow from one cell to another.

B.3.1.1.6 Groundwater Flow

The following vertically-averaged, groundwater flow equation is solved:

$$\frac{\partial}{\partial x}\left(T_{xx}\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(T_{yy}\frac{\partial h}{\partial y}\right) = S\frac{\partial h}{\partial t} - R \qquad (3)$$

Where T is transmissivity, S is storage coefficient, and R is recharge to the groundwater table. The model utilizes a variation of the Saul'yev (1964) method to solve the above equation. This technique is unconditionally stable and explicit. To minimize bias, the numerical formulation is solved in four different directions in four successive time steps. Highly concentrated groundwater flow across levees cannot be simulated with a 2 mile x 2 mile scale model, therefore separate regression equations were developed to simulate levee under-seepage (SFWMD, 1997).

B.3.1.1.7 Canal/Structures Flow

Over 1,400 miles of levees and canals, 18 major pump stations, and more than 180 water control structures are simulated in the model. The SFWMM utilizes a mass balance approach to account for changes of storage in the canal due to inflows and outflows. The model computes flows into and out of canals via water control structures, interaction between the wetlands and the canals, and the groundwater seepage. Canals are assumed to pass through the center of a grid cell or group of grid cells and calculations are performed for each canal reach, i.e. a canal with known or calculated upstream inflow and outflow. A seasonal hydraulic gradient is assumed for each canal reach. For a given canal reach, the model calculates the end-of-day stage at the most downstream grid cell or node. Intermediate grid cells are assumed to have stages proportional to seasonal hydraulic gradient, according to their relative distance from the extreme nodes of the reach. A complex set of release and inflow rules are followed in the model (SFWMD, 1997) to regulate flow into and out of canals and storage areas.

B.3.1.1.8 Rainfall and ET

The SFWMM uses a time-varying (daily), spatial database that has been preprocessed using rainfall records at more than 600 rain gages distributed throughout South Florida. In the absence of a more rigorous and practical spatial interpolation scheme, cell-by-cell rainfall has been estimated using a "nearest station" technique.

The algorithms to calculate actual ET in the model vary geographically. For Lake Okeechobee, the Penman-Monteith (Monteith, 1965) method is used to calculate open water and marsh zone ET. For the EAA, total ET is the sum of it's components from the saturated, unsaturated, and open water zones. For the LEC urban area, unsaturated ET is pre-processed using the Agricultural Field-Scale Irrigation Requirements Simulation model (Smajstrla, 1990) that also computes the irrigation requirements for selected land cover types. The reference-crop (turf grass) evapotranspiration, ET_0, for most areas of the model is computed utilizing the Penman-Monteith formula:

$$l\, ET_0 = \frac{\Delta(R_n - G) + r\, C_p (e_a - e_d) \frac{1}{r_a}}{\Delta + g \left(1 + \frac{r_c}{r_a} \right)} \qquad (4)$$

where,

ΣET_0 = latent heat flux of evaporation, (KJ m^{-2} s^{-1});
ET_0 = mass flux of evapotranspiration, (kg m^{-2} s^{-1});
Σ = latent heat of vaporization, (KJ kg^{-1});
– = slope of vapor pressure curve, (kPa $^oC^{-1}$);
R_n = net radiation flux at surface, (KJ m^{-2} s^{-1});
G = soil heat flux, (KJ m^{-2} s^{-1});
Ψ = atmospheric density, (kg m^{-3});
C_p = specific heat of moist air, (KJ kg^{-1} $^oC^{-1}$);
e_a = saturation vapor pressure at surface temperature, (kPa);
e_d = actual ambient vapor pressure at dew point, (kPa);
(e_a-e_d) = vapor pressure deficit, (kPa);
K = psychometric constant, (kPa $^oC^{-1}$);
r_c = crop canopy resistance, (s m^{-1}); and
r_a = aerodynamic resistance, (s m^{-1}).

Actual ET is related to ET_0, as follows,

$$ET = K * ET_0 \qquad (5)$$

Where K is an adjustment factor that takes into account depth of water above or below the ground surface, land cover type, and the depths of shallow and deep root zones.

B.3.1.1.9 Reservoirs

Water-holding facilities or reservoirs serve a variety of functions. The Holey Land can be modeled as an above-ground reservoir that acts as a wetland preserve. Examples of reservoirs in the Lower East Coast service areas are the West Palm Beach Catchment Area and the Indian Trails Water Control District reservoir. Proposed reservoirs in the EAA are the Stormwater Treatment Areas (STAs) whose function is to improve the quality of runoff generated from the EAA and releases from the Lake as part of the Everglades Construction Project. In the development of the Restudy alternatives two EAA reservoir compartments are proposed. One compartment stores EAA runoff and supplies water to the EAA during dry periods. The other compartment stores excess Lake Okeechobee water and helps meet environmental water supply demands in the Everglades. If a STA and a non-STA (e.g. EAA reservoir) exist in the same EAA Basin, the SFWMM assumes that the non-STA reservoir receives runoff/LOK regulatory releases first while the remainder of the excess water goes directly to the STA reservoir for treatment.

Reservoirs in the Lower East Coast service areas are generally proposed as part of the Water Preserve areas whose two functions are stated. First, store excess water from a drainage basin that may result in improved flood control for the basin and reduced seepage volumes from the Water Conservation areas. Second, release the stored water for water supply purposes and/or environmental enhancement to decrease the dependence of the LEC service areas on Water Conservation area and Lake Okeechobee deliveries. ASR wells may accompany a reservoir to enhance the system's ability to store water and then use the excess water more effectively during times of demand.

All the reservoirs are assumed to have vertical walls for modeling purposes. The model identifies reservoirs by a hydrologic basin number that is assigned to appropriate grid cells. The model accounts for differences in the actual area of the reservoir and the area represented by the grid system, i.e. multiples of four square miles. Since rainfall and evapotranspiration depths are assumed to occur uniformly for each grid cell, their effect on reservoir stage is transformed by a proportionality factor relating reservoir area and the area of the grid cell(s) where the reservoir is located. For a given reservoir,

sfactor = total_reservoir_area / (no of grid cells * grid cell area)
change_reservoir_stage(t) = RF(t) - ET(t) + LSEEP(t) + GWIN(t) - [RF(t)-ET(t)] * [(1 - sfactor)]
where
RF(t) is rainfall into grid cell (ft);
ET(t) is evapotranspiration out of grid cell (ft);
LSEEP(t) is equivalent depth of levee seepage into grid cell; and
GWIN(t) is equivalent depth of net groundwater inflow into grid cell (ft).
reservoir_stage(t) = reservoir_stage(t-1) + change_reservoir_stage(t)

Reservoir_ stage is used in determining available storage in the reservoir. It is also the basis for calculating discharges through inlet and outlet structures of a reservoir. The outlet structures can be managed for water supply, flood control, or environmental enhancement.

B.3.1.1.10 Accuracy

Water budget post-processing tools are available to demonstrate model accuracy and to summarize water budget components on a monthly, seasonal or annual basis for individual grid cells or groups of grid cells. Likewise, routine calibration exercises are performed on the model in order to demonstrate its history-matching capabilities (SFWMD, 1997).

Several publications and presentations have been produced in the past to address model accuracy and model applicability (e.g., Lal, 1998a; Bales, et al., 1997).

B.3.1.1.11 Flood Control Application

The SFWMM has been the primary modeling tool for evaluating regional scale effects of major water management projects associated with the Everglades system. In particular, the model has been used for the following projects:

- Development of Lower East Coast Regional Water Supply Plan
- Everglades Construction Project
- Comprehensive Review Study of the Central and South Florida System.
- Other studies related to the hydrologic restoration of the Everglades
- Development of Regulation Schedules for Lake Okeechobee

The SFWMM is an appropriate tool for evaluating large-scale, long-term hydrologic effects from structural and/or operational changes. Since the model has a coarse scale (2-mile by 2-mile grid cells) and a daily time step, it cannot adequately evaluate local-scale, highly transient events like individual storms and flooding to individual farms or urban developments.

The model can provide a general indication of the potential for increases in groundwater stages for sub-regions. By utilizing the difference between two simulations versus the result of a single simulation, an increase in groundwater stage can indicate a potential increase in flood risk. The peak stage difference maps are a useful performance indicator, which displays a relative comparison. However, more detailed site-specific investigations utilizing finer-resolution tools are necessary to make quantitative estimates of changes in flood risk and associated damages.

B.3.1.2 Specific Assumptions/Routines Developed for Restudy

B.3.1.2.1 Lake Okeechobee Operations

Water levels in Lake Okeechobee (LOK) are managed through regulatory and non-regulatory releases (flood control). Regulatory releases are conducted according to the current regulation schedule named "RUN25". The non-regulatory releases are made to meet: (1) agricultural/irrigation demands in the Lake Okeechobee service area; (2) water supply requirements of the LEC service areas; (3) environmental demands in the Everglades, and Caloosahatchee and St Lucie estuaries; and (4) diversion of water when appropriate into reservoirs and/or ASR wells. Lake Okeechobee is the backup source of water to the Water Conservation areas and proposed reservoirs in meeting environmental and water supply demands. Flood control releases are first made to the WCAs via EAA Canals, subject to conveyance limitations, then to Caloosahatchee and St Lucie estuaries after non-regulatory releases occurred.

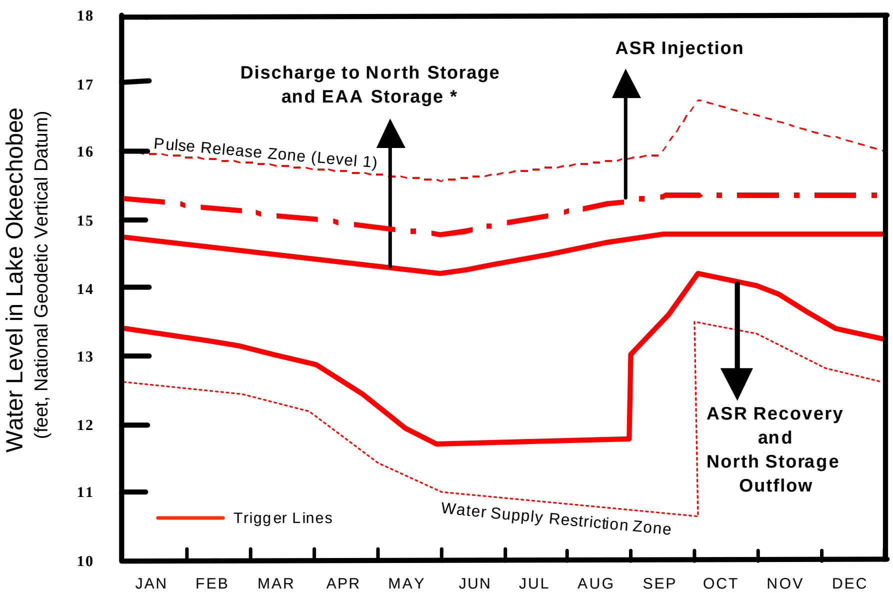
The current regulation schedule, Run 25, is used in the evaluation of alternatives with the exception that all regulatory discharges to St Lucie and Caloosahatchee estuaries are eliminated except Zone A emergency releases. Storage reservoirs north of Lake Okeechobee (North Storage), in Caloosahatchee and St Lucie Basins, in the EAA, and Lake Okeechobee ASR wells are proposed to increase the capacity of the hydrologic system to better meet the water management objectives. These objectives are associated with flood protection, water supply, and environmental enhancement. A climate-based forecast of inflow into Lake Okeechobee is incorporated as a guideline to more effectively divert LOK water to the reservoirs and Lake Okeechobee ASR systems during times of excess and retrieved during dry periods. Zhang and Trimble (1996) developed a methodology for predicting LOK inflows from solar and global indices with the application of an artificial neural network. The forecasts of Lake Okeechobee inflow were preprocessed, and inputted into SFWMM for the simulation period. Although the specific forecast methodology utilized in the real system may differ from the Zhang and Trimble (1996) method, Lake Okeechobee is proposed to be operated with the help of climate based forecasting to more efficiently satisfy competing needs.

Figure B.3-1 summarizes the operation of Lake Okeechobee for reservoir storage and retrieval as well as ASR. Discharge to North Storage and EAA storage generally occurs before ASR injection. If the Lake Okeechobee stage is above the Pulse release zone line (level 1), or forecasted to be above the "Discharge to Storage" line within the next three months, then the lake water is diverted to North Storage and EAA storage (when storage capacity exists). Similarly, if the Lake Okeechobee stage is above the Pulse release zone or forecasted to be above the "ASR Injection" line within three months, the lake water is injected into ASR wells. Water is retrieved from North storage and ASR wells if the lake stage is below, or forecasted to be below the "ASR Recovery and North Storage Outflow" line in six months for recovery during the dry season. During the wet season; however, water is retrieved if the lake stage is below the "ASR Recovery and North Storage Outflow" line and if the climate based inflow forecast is less than 1.5 million acre-ft for the next six months.

Climate-based forecasting is not used in the interaction of Lake Okeechobee with the Caloosahatchee and St Lucie Basins. In ALTD13R excess water is back-pumped from Caloosahatchee reservoir to Lake Okeechobee if the depth of water in the reservoir is greater than six feet and the stage in the Lake is below the Pulse release zone. However, when the stage in the Lake is above the Pulse release zone, water is released from the Lake to the Caloosahatchee reservoir when the depth of water in the reservoir is less than eight feet. Additionally, water is released to the St Lucie reservoir when the depth of water in that reservoir is less than four feet.

Figure B.3-1. Operation Criteria for Lake Okeechobee

and Surrounding Storage Components



* Discharge to North and EAA Storage if Lake Okeechobee stage is forecasted to be above "Discharge to ... Storage" line, or if stage is above Pulse Release Zone (level 1) line.

B.3.1.2.2 Everglades Rain Driven Operations

Historically the operational schedules for the Water Conservation Areas have been calendar-based on an annual cycle. The schedules typically specify the release rules for a Water Conservation Area based on the water level at one or more key gages. Regulation schedules do not contain rules for the importation of water from an upstream source. For Alternative D13R (ALTD13R); however, the rain-driven operational concept includes rules for importing water from upstream sources (i.e. EAA runoff, EAA Storage area, andLake Okeechobee) to the appropriate Water Conservation Areas. Additionally, the rules cover importing and exporting water from the appropriate Water Conservation Areas in order to mimic a desired target stage hydrograph at key locations within the Everglades system. Water Conservation Area 1 is proposed to remain under the current calendar-based regulation schedule rules. Rotenberger and Holey Land Wildlife Management

Areas (WMA's) are also operated under the rain-driven concept. Target stage hydrographs, based on an estimate of the pre-drainage water level response to rainfall using the Natural System Model (NSM), or variations thereof, were used as operational targets for achieving hydrologic restoration of the Everglades.

The term "trigger" refers to a gaged or ungaged location whose water level is utilized to trigger action at an upstream or downstream structure. These water levels or "trigger levels" are related to the target stage hydrographs by simple offsets of ± 1.5 feet. There is one level for the import rules and two levels associated with the exportation of water. The two export trigger levels define two release zones. The lower zone is a conditional release zone such that releases are made only if the downstream area has a "need". The upper zone is an unconditional or flood control release zone such that releases are made in this zone even if the downstream area does not "need" the water.

A general description of the SFWMM implementation of the rainfall-driven operations within the Everglades system is presented in the Draft Documentation of the SFWMM (SFWMD, 1997). A more detailed representation of ALTD13's rainfall delivery scheme in the SFWMM is presented in ***Figure B.3-2*** and ***Table B.3-1***. Deliveries from upstream sources (i.e. EAA runoff, EAA Storage area, andLake Okeechobee) are routed through the Stormwater Treatment Areas (STAs) prior to release into the Water Conservation Areas or the WMA's. The distribution of STA outflow is designed to improve hydropatterns. In ALTD13R, flows to Everglades National Park and Big Cypress National Reserve are represented by flow paths DC1, DC2 and DC3 in ***Figure B.3-2*** The flow paths are uncontrolled since the S-12, S-333, S-355 and S-343A and B structures, as well as L-29, L-28 and L-29 borrow canals were removed to allow overland flow from WCA-3 to these areas.

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Table B.3-1. Description of Proposed Environmental Water Supply Deliveries within the Everglades for ALTD13R

Flow Path	Source	Trigger Location (Source)	Destination	Trigger Location (col,row) (Target)	Additional Comments
A1	LOK	N/A	STA-3 & 4	3A-NE (23,40) or 3A-NW (18,40) or 3A-4 (21,29)	Flow via Miami Canal in EAA
A2	LOK	N/A	STA-2	2A-N (28,45)	Flow via Hillsboro Canal in EAA
B1	STA-3&4	N/A	WCA-3A	3A-NE (23,40)	Flow through gravity structures when stage at 3A-NE is in import zone
B3	STA-3&4	N/A	NW corner of WCA-3A	3A-NW (18,40)	Assume 50% of gravity outflow toward this destination. Flow occurs if stage at 3A-NE (23,40) is > 0.2 ft. above NSM target
B4	STA-3&4	N/A	WCA-3A via G-404 and through S-140A via L-4 and L-28 borrow canal	3A-4 (21,29)	Assume 50% of gravity outflow if have B3 100% of outflow if strictly excess flow (B1 & B3 do not occur)
HL1	Holey Land	(20,43)	WCA-3A	N/A	Flow occurs if stage at 3A-NW (18,40) is above NSM target
HL2	Holey Land	(20,43)	NW corner of WCA-3A	3A-NW (18,40)	
R1	Rotenber-ger	(16,43)	NW Corner of WCA-3A via G-404	3A-NW (18,40)	
R2	Rotenber-ger	(16,43)	Through S-140A via G-404, L-4, L-28	3A-4 (21,29)	Flow occurs if stage at 3A-NW is above NSM target
R3	Rotenber-ger	N/A	Holey Land		Flow occurs if stage in Holey Land is less than 0.2 ft. above NSM target
C1	STA-1W	N/A	WCA-1	N/A	Flow occurs if depth of water in STA-1W exceeds 1.25 ft.
C2	STA-2	N/A	WCA-2A	N/A	Flow occurs if depth of water in STA-1W exceeds 1.25 ft.
D1	WCA-1	1-7 (31,48)	WCA-2A	N/A	Flow through S-10A, S-10B and S-10C. Operations based on calendar based regulation schedule.
D2	WCA-1	1-7 (31,48)	Northern WCA-2A	N/A	Flow through S-10E. Operations based on calendar based regulation schedule.

Table B.3-1. (cont.) Description of Proposed Environmental Water Supply Deliveries within the Everglades for ALTD13R

Flow Path	Source	Trigger Location (Source)	Destination	Trigger Location (col, row) (Target)	Additional Comments
D3	WCA-2A	2-17 (29,40)	WCA-3A	3A-3 (25,37)	Excess flow occurs if stage at 2A-17 is sufficiently above the NSM stage target
D4	WCA-2A	2-17 (29,40)	WCA-2B	N/A	Excess flow occurs if stage at 2A-17 is sufficiently above the NSM stage target
E1	WCA-2B	2B-C (30,36)	NESRS	N/A	Flow through proposed WCA-2B outlet structures and into NESRS via S-356A&B
E2	WCA-3A	3A-E (26,33)	Proposed Central Lake Belt Reservoir	G-1502 (24,17)	Flow through proposed outlet structure near S-9 (WC3TLB)
E3	WCA-3B	3B-N (27,30)	Proposed Central Lake Belt Reservoir	N/A	Flow through S-31 if excess in northern WCA-3B exists
E4	Central Lake Belt Reservoir	N/A	NESRS	G-1502 (24,17)	Flow through proposed 800 cfs structure and into NESRS via S-356A&B
E5	WCA-3A	3A-E (26,33)	WCA-3B	Avg. of stages at NESRS-1 (22,20) and NESRS-2 (25,21)	Flow occurs if stages at 3A-E (26,33) is sufficiently above NSM stage target
S-140A	L-28 borrow canal	N/A	WCA-3A	3A-4 (21,29)	Excess flow occurs even if stage at 3A-4 is above NSM target
ST1	STA-6 Outflow	N/A	NW corner of WCA-3A	N/A	Excess flow to NW corner if stage at 3A-4 is above import zone
ST2	STA-6 Outflow	N/A	WCA-3A	3A-4 (21,29)	Flow occurs if stage at 3A-4 is in import zone, otherwise STA-6 outflow is directed to NW corner of WCA-3A
DC1	WCA-3A	N/A	NESRS	N/A	Overland Flow Path. Levee removed as part of WCA -3A decompartmentalization
DC2	WCA-3A	N/A	NWSRS	N/A	Same as previous
DC3	WCA-3A	N/A	BCNP	N/A	Same as previous

note: WCA Floor elevations (represented by conveyance canal stages)
WCA-3A (S12HW): Minimum (7.5, 3 gage average [3A-3, 3A-4, 3A-28] of NSM stage targets)
WCA-2A (S11BHW): Minimum (10.5, NSM stage at [29,40] 2A-17 gage location)
WCA-1 (S10HW): Minimum (14.0, NSM stage at [31,48] 1-7 gage location)
If (LOK stage > WCA-1 stage - 1.0, at 1-7) then floor elevation is adjusted to represent simulated water level so that water must come from LOK to meet LEC needs in SA1.

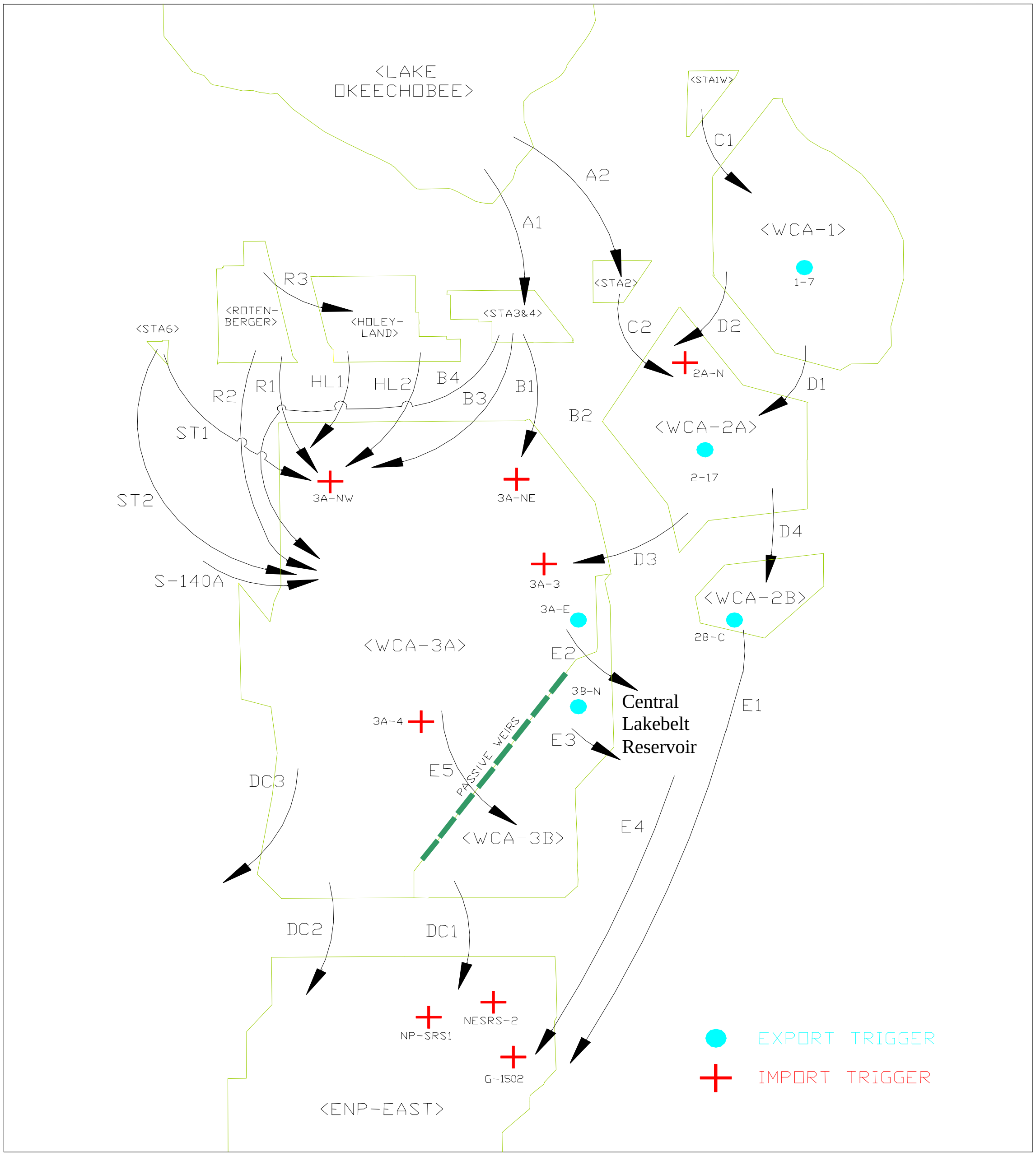


Figure B.3-2. Flow Routing Associated with the Proposed Environmental Deliveries as Implemented in the SFWMM (Restudy ALTD13R)

B.3.1.2.3 Seepage Management

The term "seepage management " refers to controlling groundwater flow underneath levees of various systems (e.g. Water Conservation Areas, Everglades National Park, or proposed reservoirs). Total groundwater flow beneath a levee is the sum of regional groundwater flow and levee seepage. Levee seepage refers to the more localized movement of groundwater beneath a levee into its adjacent borrow canal. The SFWMM's solution to the general groundwater flow equations represents the regional groundwater flow, while empirical levee seepage functions are used to solve for levee seepage from the Water Conservation Areas and Everglades National Park. The empirical equations were derived from the output of a two-dimensional (vertical plane) model; SEEP2D (a.k.a. SEEPN) developed at the U.S. Army Corps of Engineers Waterways Experiment Station. Utilizing stepwise linear regression analysis, ten sets of regression coefficients were derived. The coefficients were fine-tuned during the SFWMM calibration. The form of the equation and the coefficients are presented in the draft Documentation for the SFWMM (SFWMD, 1997).

Levee seepage and regional groundwater flow volumes are significant for the protective levees of WCA-2B,WCA-3 and ENP, and in the surficial aquifers around the coastal areas of southern Palm Beach, Broward, and Miami-Dade counties. Because of large seepage losses, some form of seepage control is necessary for Everglades restoration or when building reservoirs in coastal areas for the purposes of water supply or environmental enhancement. The extent of seepage control depends on the magnitude of the seepage losses, the purpose of the storage area or reservoir, and flood control considerations in nearby areas.

In the SFWMM several options exist for simulating levee seepage and its management. These include; 1) allowing the seepage to occur with no diversion or management, 2) pump the seepage collected in the canal back to the source, 3) divert the seepage collected to another location that would benefit from the added seepage volumes, and 4) impose a barrier that would reduceor eliminate levee seepage losses (e.g. make levee seepage under protective levee(s) equal to zero). Management of levee seepage can be changed temporally at a grid cell location along a levee on a wet season-dry season basis and can vary spatially over the length of the levee as a function of grid cell location.

Total seepage control will require more extensive field technology. The specific technology required for eliminating seepage losses through a boundary or perimeter of a levied system is not a concern in regional modeling for planning purposes. For planning purposes the primary interest is the regional impacts of total seepage control in areas of concern assuming the technology will work. The technology proposed may be total seepage barriers or curtain walls. Total seepage barriers allow; 1) maximum fluctuation of water levels in a reservoir that maximizes a reservoir's effectiveness for water supply and/or environmental enhancement without adversely effecting or being adversely effected by surrounding areas, and 2) hydrologic restoration of the Everglades such as ENP west of L-31N, where seepage losses are high. Total seepage barriers are proposed for the Lakebelt reservoirs year round and along L-31N bordering NESRS in Everglades National Park during the wet season. For modeling purposes seepage barriers, as with levees, are located at the boundaries of grid cells. Seepage barriers are identified in the model by specifying the appropriate boundary faces (east, west, north, or south) of effected grid cell locations (column, row). By temporarily fixing the head in the neighboring grid cell across a seepage barrier to be identical to the head at a computational grid cell, a zero head gradient is established between the two grid cells. The solution of the groundwater flow equations will yield zero flow across the common boundary where the seepage barrier is proposed, but the final end-of-day heads at either grid cell will still respond to the head gradients established at the other boundary faces where no seepage barrier(s) exist.

B.3.1.2.4 St. Lucie Interface

The St. Lucie Estuary receives freshwater inflow from Lake Okeechobee and five local basins: C-23, C-24, Northfork, Southfork and the C-44 Basins. As part of the alternative development effort, salinity conditions in the estuary were maintained to support a range of aquatic vegetation seagrass, invertebrates and fish communities. To achieve this goal, a series of reservoirs and associated operating rules were proposed in all five contributing basins. The SFWMM simulates the operation of the reservoir proposed for the C-44 Basin only. The operation of the other basins and reservoirs are performed off-line and the resulting time series of releases are inputted to the SFWMM. The model then makes decisions on how and when water will be released from Lake Okeechobee and the C-44 Basin/reservoir based on a pre-defined St. Lucie Estuary target inflow time series.

B.3.1.2.5 Passive Weir Structures

The simulation of passive weir structures in the Everglades is a part of component QQ that includes the decompartmentalization of Water Conservation Area 3. Eight weir structures along the entire length of L-67A are proposed to promote sheet-flow during high flow conditions. Iterations were required to determine the size and elevation of the weirs that, in the judgement of the Restudy ADT, have potential to help achieve the goals of the restoration of WCA-3A, WCA-3B, and NESRS.

The algorithm in the SFWMM that computes the flow over the passive weirs is an integral part of the overland flow computations, which are performed at six-hour time steps. The equation used to calculate the flow is:

$$qweir = c*L*(H^{3/2})*[(1 - reduc\_fact)^{(1/4)}]$$

where,

qweir = the weir flow (ft^3/sec);
c = the discharge coefficient for broad crested weirs;
L = the length of the weir crest (ft);
*(for modeling purposes the product c*L is specified as one parameter);
H = the depth of headwater above weir crest (ft);

reduc_fact = (tailwater - crest elevation) / (headwater- crest_elevation);

If tailwater is less than or equal to crest elevation, then reduc_fact is equal to zero making the submergence factor equal to one (free flow). When the tailwater is greater than the crest elevation the submergence factor is approximated by $(1 - \text{reduc\_fact})^{1/4}$**.** Qweir is the volume of flow over the weir (ft^3) for six-hour time step, i.e.

Qweir = qweir * length of time step (seconds).

The mean daily flow over the weirs, in cfs, is the sum of Qweir over 1 day divided by number of seconds in a day (86,400).

Weir inputs to the SFWMM include the grid location of the weir structure(s) (column, row) that corresponds to the headwater location, parameter c*L, weir crest elevation, and direction of flow for the weir structure (eastward, westward, northward, or southward). The weir flow equation governs the flow from the headwater location to the tailwater location (column, row) over each weir structure, since the weirs are assumed to be along levee(s) which prohibit any additional flow of surface water. Since the weirs are passive, reverse-flow can also occur and is computed when the depth of tailwater above the crest is greater than the depth of headwater above the crest. In this case the tailwater is considered the headwater and headwater becomes tailwater in the flow computations and the sign of flow is made negative to indicate flow reversal.

B.3.1.2.6 Wastewater Reuse

The existing South District Reclaimed Wastewater Treatment Plant (SDRWTP) located north of the C-1 Canal will use superior treatment technology to provide reclaimed water of acceptable quality to the South Biscayne Bay and Coastal Wetlands Enhancement (SBBCWE) Project. The reclaimed water will be discharged to the C-1 Canal (Black Creek), upstream of S-21A, and then delivered southward towards the C-102 and C-103 Canals, and northward towards the C-100 Canal. The wastewater treatment facility will provide advanced treated water to L-31E. Flow southward in L-31E towards C-102 and C-103 will be 202 acre-feet per day. Flow northward in L-31E towards C-100 will be 200 acre-feet per day (through a canal extension) for a combined 402 acre-feet per day inflow into L-31E. This supplemental water will restore overland flow in the coastal area and provide groundwater recharge to enhance groundwater discharge into Biscayne Bay. It is anticipated that a reduction of saltwater intrusion in the southern part of Miami-Dade County will occur. Discharge capacity at S-123, S-20F, S-21 and S-21A is assumed to be sufficient to pass basin runoff and inflows from the reuse facility during storm events.

The future West Miami-Dade Wastewater Treatment Plant (WDWTP) will provide wastewater treatment coupled with superior treatment technology to supply reclaimed water to the Bird Drive Recharge Area. The WDWTP will pump the reclaimed water to the Bird Drive Recharge Area at a rate of 307 acre-feet per day when the elevation of the Recharge Area is equal to or less than 3 feet above the natural ground level. The water will be supplied year round as needed to enhance groundwater recharge. Excess water, when available, will be sent as a second priority to the South Dade Conveyance System; as a third priority to Northeast Shark River Slough; and lastly to deep injection wells when there are no other demands from the three designated areas. The superior treatment technology will treat the Advanced Wastewater Treatment (AWT) effluent to remove phosphorous and nitrogen to the low levels desired to meet State water quality standards.

B.3.2 Simulation of Pre-drainage Conditions

B.3.2.1 Model Used: Natural System Model (NSM)

B.3.2.1.1 Background

The Everglades consisted of 3 million acres of subtropical wetlands that covered much of South Florida prior to the major drainage activities that began early this century. The Everglades region was characterized by an extremely low gradient, heterogeneous mosaic landscape that evolved over 5000 years (Science Sub Group Report, 1993). This immense wetland system south of Lake Okeechobee sprawled from the south shore of Lake Okeechobee to the mangrove estuaries of Florida Bay and Gulf of Mexico. The Immokalee Ridge to the west and the coastal ridges to the east generally marked the hydrologic boundaries of the historic Everglades, although numerous connections through the coastal ridge overflowed from the Everglades to the Atlantic Ocean. The primary characteristic of the pre-drainage wetland ecosystem in the Everglades was the hydrologic regime that featured slow sheetflow and natural recession due to storage, large spatial scale, and heterogeneity in habitat.

The Natural System Model (NSM, Van Zee, 1998) simulates the hydrologic response, not the hydrology, of a pre-drained Everglades system to current climatic input. Although one may wish to recreate the hydrologic conditions of the late 1800's or early 1900's, the input data necessary to perform such a simulation does not exist. However, the use of recent input data (e.g. rainfall, potential evapotranspiration, tidal and inflow boundaries) allows for meaningful comparisons between the current managed system and the natural system under identical climatic conditions.

The landscape of present day south Florida has been greatly effected by the land reclamation, flood control and water management activities that have occurred since the early 1900's. The complex network of canals, structures and levees in the current system are replaced in the NSM with the rivers, creeks and transverse glades which were present prior to the construction of drainage canals. The vegetation and topography used by the NSM are based on pre-drainage conditions. The landcover simulated by the NSM is static, i.e. the model does not attempt to simulate vegetation succession.

The NSM is closely linked to the South Florida Water Management Model (SFWMM). The SFWMM is a regional scale hydrologic model that simulates the hydrology and managed water system in south Florida. The design of the SFWMM takes into consideration south Florida's unique hydrologic processes and geologic features, including the integrated surface and ground water hydrology and the operation of the Central and South Florida (C&SF) Project. The NSM uses the same climatic input, model parameters and computational methods as the SFWMM. Physical features, such as topography, vegetation types and river locations are adjusted to represent the pre-drainage condition. Since traditional calibration/verification methods can not be applied to the NSM, model parameters are based on the calibrated and verified SFWMM.

B.3.2.1.2 Physical Data

The NSM encompasses an area from Lake Istokpoga to Florida Bay. The western boundary extends southward from Lake Istokpoga to near the Gulf of Mexico, and continues along the coastal marsh fringe, turning southward to Shark River Slough and Florida Bay. The eastern boundary extends across the northern Indian Prairie Region to the Kissimmee River, and continues around the northern rim of Lake Okeechobee and turning eastward to the Atlantic Ocean. The eastern boundary follows the coastline southward to Biscayne Bay and Florida Bay. The model domain is divided into 2328 (2mi $\times$ 2mi or 3.22 km $\times$ 3.22km) square grid cells. Vegetation class, land surface elevation and aquifer parameters are assigned to each cell and are assumed uniform within each cell.

McVoy and Park (1997) based the vegetation coverage (***Figure B.3-3***) on the estimated landscape of the pre-drained Everglades. Eleven landscape types are identified, based on an evaluation of hydrology (water depth, hydroperiod, flow direction and velocity), vegetation community, soil type and topographic relief. The NSM utilizes vegetation-based parameters to compute ET and overland flow. The utilization of SFWMM parameters implies that the ET and flow characteristics of the current landscape are comparable to the pre-drainage landscape and are transportable, e.g. parameters calibrated in the Everglades National Park can be applied to areas outside of the Park boundaries.

Seven of the eleven pre-drainage landscape types, have been identified in the current system, including mangroves, forested uplands, marsh, sawgrass plains, wet prairie, shrubland and forested wetlands. Parameter values for the non-existent types (ridge and slough, marl marsh, edge marsh and grassland) are based on the landscape most closely resembling them in the current system. The ET characteristics of the ridge and slough landscape most closely resemble the modified ridge and slough of central Water Conservation Area 3A, and the flow characteristics most closely resemble the modified ridge and sawgrass invaded slough in Shark River Slough. The vegetation and flow characteristics of the marl marshes on either side of Shark River Slough most closely resemble the marl prairie now found in those same areas. Edge marsh and grassland most closely resemble the wet prairie and shrubland landscapes identified in the current system.

Surface elevations in the NSM approximate the pre-drainage topography of south Florida. Land surface elevations are generally consistent with current land surface elevations except in areas impacted by soil subsidence. Land surface elevations in the Eastern Flatwoods, Loxahatchee Slough, Atlantic Coastal Ridge, Miami Rock Ridge, Everglades National Park, Big Cypress and Lake Okeechobee are consistent with the SFWMM. Land surface elevations in other non- subsidence areas, including Immokalee Ridge, Caloosahatchee River Basin, Fisheating Creek and Istokpoga / Indian Prairie regions are estimated from U.S.Geologic Service and U.S. Army Corps of Engineers sources.

The most severe soil subsidence occurred along the Okeechobee Rim, Central Everglades and Northern Transverse Glades regions. Land surface elevations in these areas are based on land surface profiles, which were surveyed during or prior to the construction of the drainage canals (***Figure B.3-4***).

The aquifer parameters (i.e. depth, permeability and soil storage coefficient) are consistent with the SFWMM. In areas outside the SFWMM boundaries, aquifer depth and permeability are based on published well log data.

The location of rivers, creeks and transverse glades are described through a series of x-y coordinates. The location of these pre-drainage flow-ways is based on government survey plats completed between 1855 and 1870 and the SFWMD Primary Hydrography Coverage. River cells and associated river segments are identified by the intersection of the grid cell mesh with the river coordinates.

B.3.2.1.3 Time Variant Data

The hydrology of south Florida is primarily rainfall driven and is influenced by other hydrologic processes, e.g. ET, overland and ground water flow. This phenomena is simulated in the NSM by applying external stimuli (i.e. rainfall, potential ET and boundary flow) to effected cells and moving water between cells in response to hydrologic processes.

The NSM utilizes a rainfall database, which contains daily estimated rainfall for each cell in the respective model domain. Estimates for each cell are based on rainfall data collected at the station nearest to the cell center. Rainfall data from 671 stations in ten counties were used to develop the database.

Daily potential ET is computed for eleven stations using a modified Penman - Monteith Method (Giddings and Restrepo, 1994). An inverse distance method is used to weigh the contribution of each station to each cell.

Daily inflows along the northern boundary are defined by a series of inflow points into Lake Istokpoga and Lake Okeechobee. These flows represent the "natural" inflow, which would have occurred under pre-drainage conditions. The Lake Istokpoga and Fisheating Creek Basins have not been greatly altered by water management projects, such as lake regulation schedules, canalization, and impoundments. The rainfall-runoff relationship is assumed to be comparable to that of pre-drainage conditions. Natural inflows from these basins are approximated by observed flows at Arbuckle and Josephine Creeks, and unguaged local inflow at Lake Istokpoga, and Fisheating Creek.

The Kissimmee River Basin has been effected by water management projects, including the connection and regulation of lakes in the upper basin, and canalization of the Kissimmee River. Natural inflow from the Kissimmee Basin is estimated using a rainfall-runoff model calibrated to the earliest available flow data (1934-1942). A set of synthetic flows is generated using 1965-1995 rainfall and potential ET data. Inflow from peripheral basins north of Lake Okeechobee (Nubbins Slough, Taylor Creek and S154) are assumed to be proportional to the lower Kissimmee Basin runoff.

Tidal boundaries are effective flow boundaries, in that water is removed or added as water levels are adjusted to coincide with the tidal stage. Tidal boundaries are established in ocean cells, which include cells along the Atlantic Ocean and Florida Bay. Tidal stages are based on long term monthly averaged tide data at six tidal gaging stations along the Atlantic Ocean, Biscayne Bay and Florida Bay.

B.3.2.1.4 Hydrologic Processes

Water is distributed within the model domain by a set of hydrologic processes. Processes are modeled separately within each time step with more transient phenomena computed before less transient phenomena.

Infiltration and ET processes simulate the vertical movement of water within a cell. The infiltration process simulates the downward movement of water from surface water ponding to the water table. The ET process simulates the release of water from surface water ponding and ground water table to the atmosphere through evaporation and plant transpiration, respectively.

The overland flow process simulates surface water movement between adjacent cells. The NSM utilizes an alternating-direction explicit finite difference method to solve the overland flow equations (SFWMM, 1997, Fennema, 1994, Lal, 1998). No-flow boundaries are established for the non-ocean cells along the northern, eastern, and most of the western limits of the model domain. Fixed head boundaries based on the tidal stage are imposed in ocean cells. Fixed gradient boundaries are imposed in cells along the southwest boundary. Lake Okeechobee, Lake Istokpoga and Lake Hicpochee are treated as level pools.

Ground water flow is simulated by solving for ground water level in a finite difference approximation of the two-dimensional, transient, subsurface flow equation for unconfined aquifers. A zero-gradient ground water boundary condition is established along the perimeter of the model domain. The head values in ocean cells coincide with stages established by the tidal boundary.

The river flow process simulates the influence of rivers on water levels. Rivers are represented as storage volumes in the model. Downstream discharge can be released to a cell, defined as inflow to another river, or removed from the model (tidal release). An iterative bisection technique is utilized to compute the river stage for condition when net inflow is equivalent to change in storage.

B.3.2.1.5 Results

Surface water processes driven by rainfall and ET dominate the hydrology of the pre-drained Everglades.. Water generally moves slowly as surface water from north to south in response to the low hydraulic gradient (***Figure B.3-5***). The buffering capacity required to transform large lake outflows into a slow moving, low gradient release to the south is provided by the large storage capacity of Lake Okeechobee coupled with its long overflow perimeter. Within the Everglades boundary, the magnitude of the overland flow vectors is uniform with a south to southeast direction in the upper/central Everglades. The relatively uniform magnitude of the overland flow vectors begins to concentrate in what is now Water Conservation Area 2B. This concentration continues through the northern transverse glades area south to Shark River Slough and southwest towards the Gulf of Mexico.

Water levels are uniform throughout the upper and central Everglades with median ponding depths between 0.5 and 1.0 ft (***Figure B.3-6***). Water levels are more variable in the lower Everglades with depths up to 4.0 ft in the northern transverse glades region, 2.0 ft in Shark River Slough, and ±0.5 ft of the land surface in the marl wetlands in ENP. Outside the historic Everglades boundary, median water levels generally range from near land surface to more than 4.0 ft below land surface along the Atlantic Coastal Ridge and the Highlands Ridge.

Water levels within the Everglades boundary generally fluctuate between 2.0 and 2.5 ft annually. Water levels fluctuate with a somewhat smaller range (1.75 ft) in Lake Okeechobee, Hillsboro Lakes and Shark River Slough (***Figure B.3-7***). Water levels in virtually all of the Everglades drop below land surface at some point during the simulation. Conversely, virtually all of the Everglades have extended periods (up to 12 months) of inundation. Under these “wet” conditions, annual low water ponding depths between 0.5-1.0 ft and 2.0 ft persist in the upper/central Everglades and Shark River Slough, respectively.

Although much of the Everglades is subject to annual low water levels that drop below land surface, the duration of the dry-down is very short. The median number of days of inundation per year or "hydroperiod" for the Everglades is generally greater than 330 days/year (*Figure B.3-8*). Even under abnormally dry conditions, hydroperiods in the upper/central Everglades are generally greater than 150 days/year and the Shark River Slough to northern transverse glades area still exceed 335 days/year.

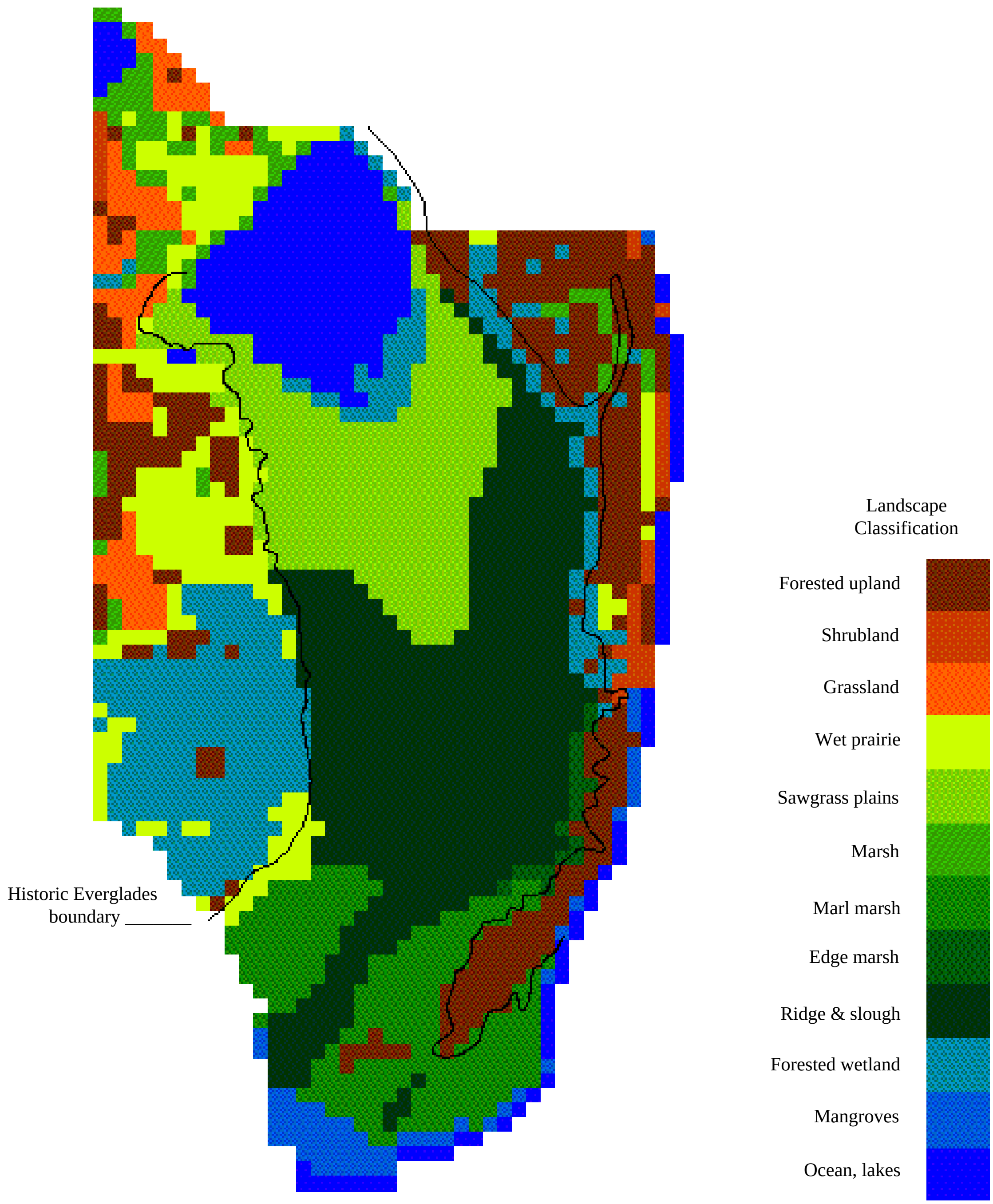


Figure B.3-3 Natural System Model Landscape Map

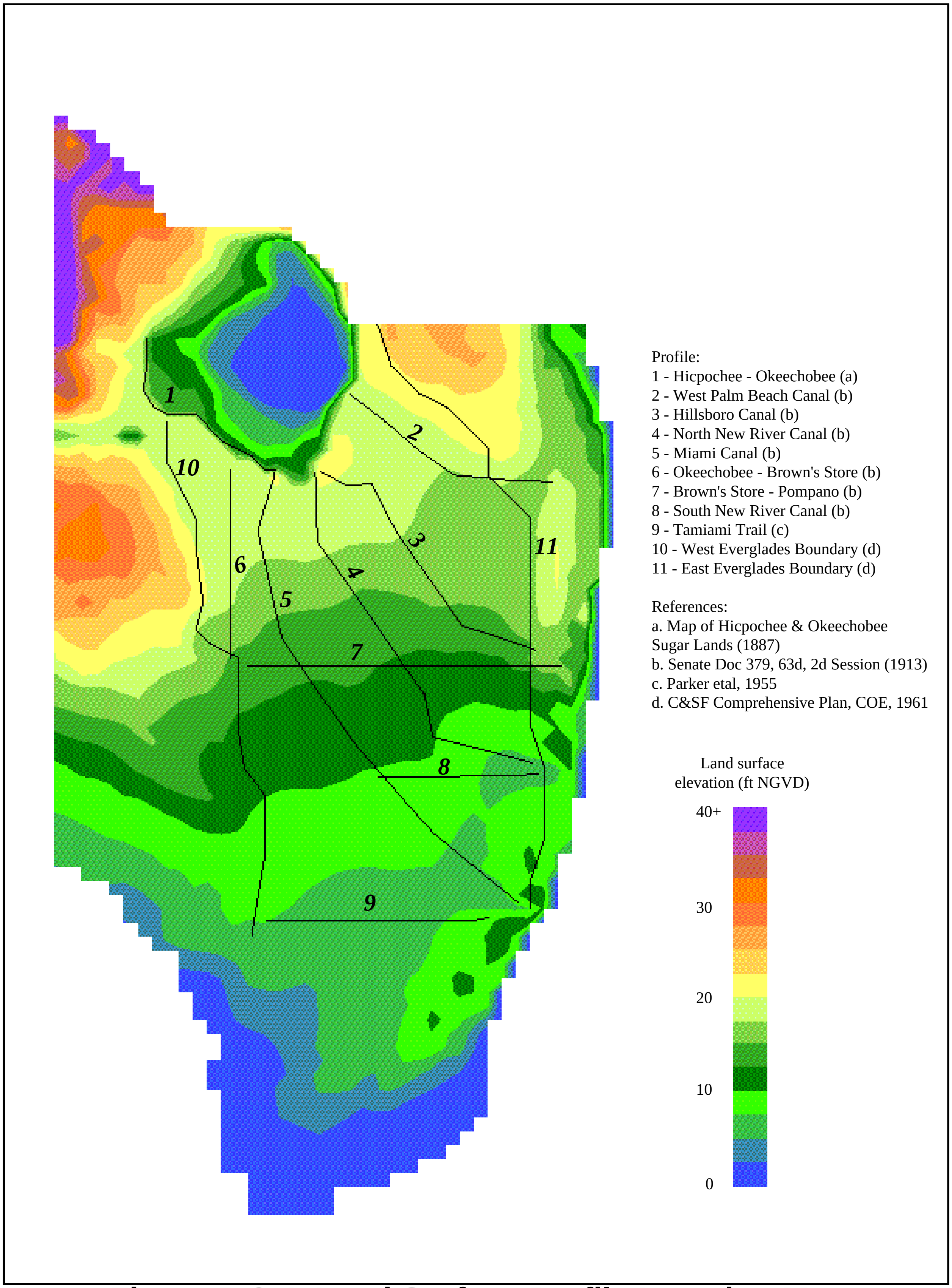


Figure B.3-4 Land Surface Profile Location Map

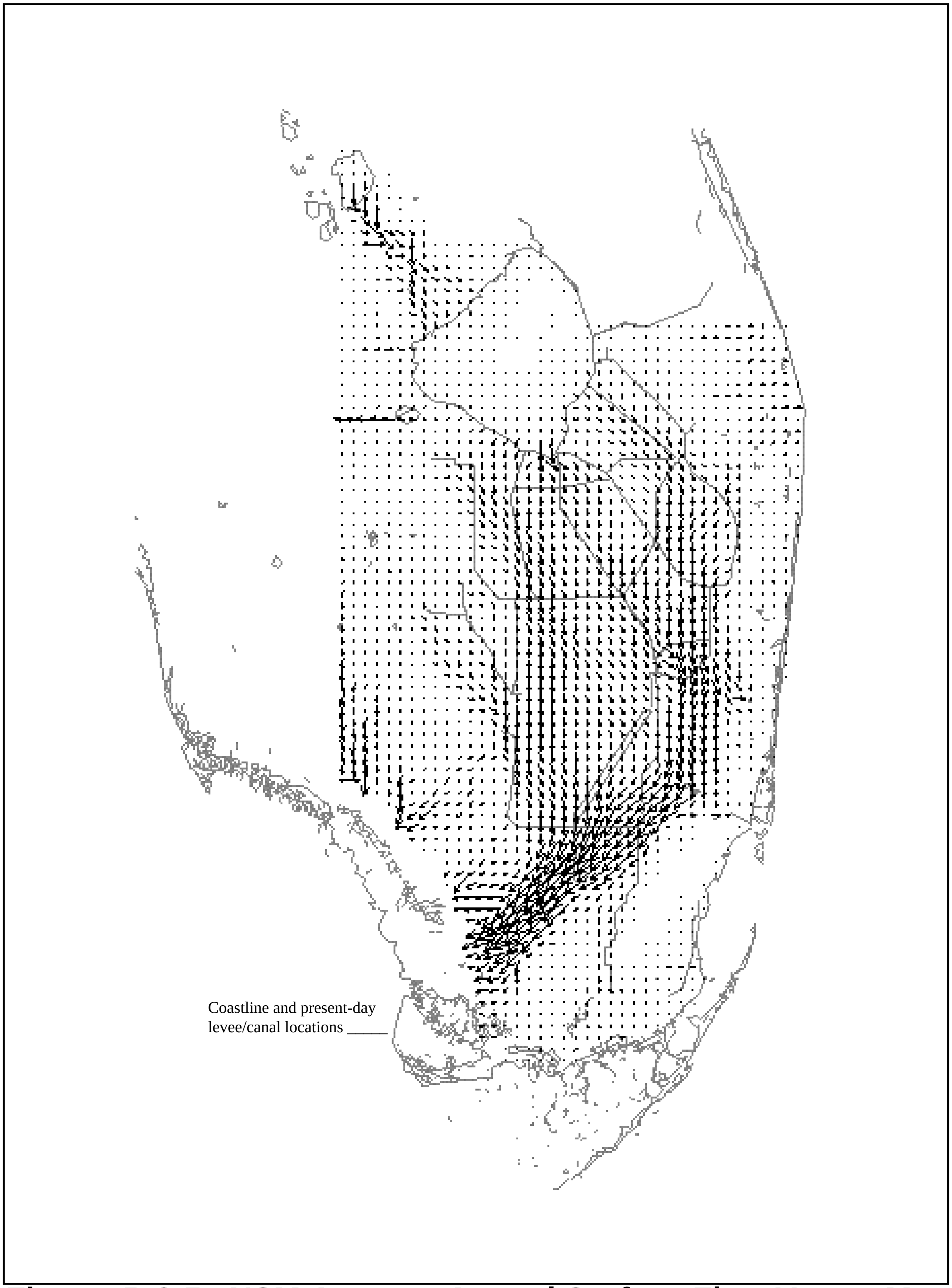


Figure B.3-5. NSM Average Annual Surface Flow Vector Map

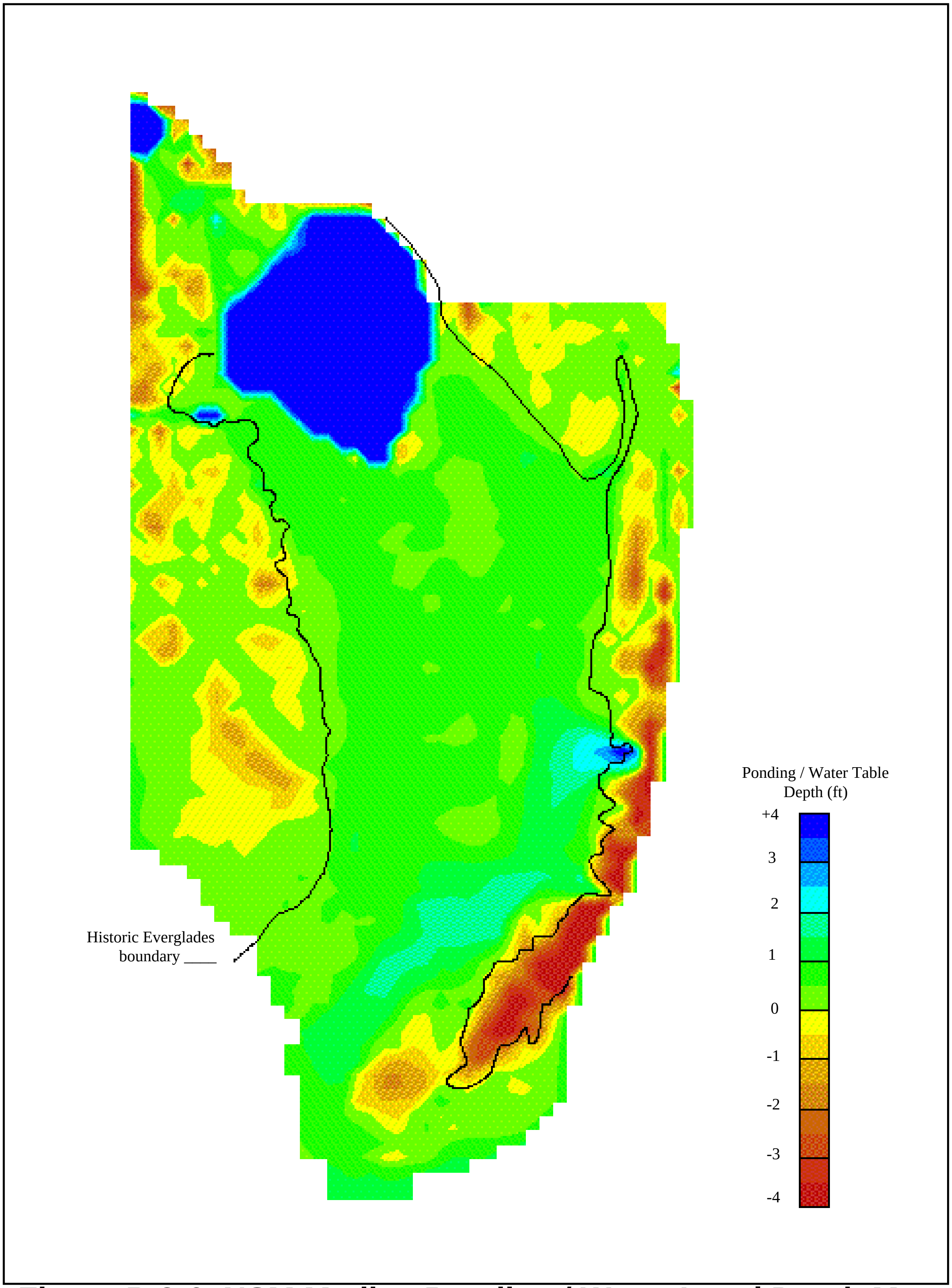


Figure B.3-6 NSM Median Ponding / Water Level Depth Map

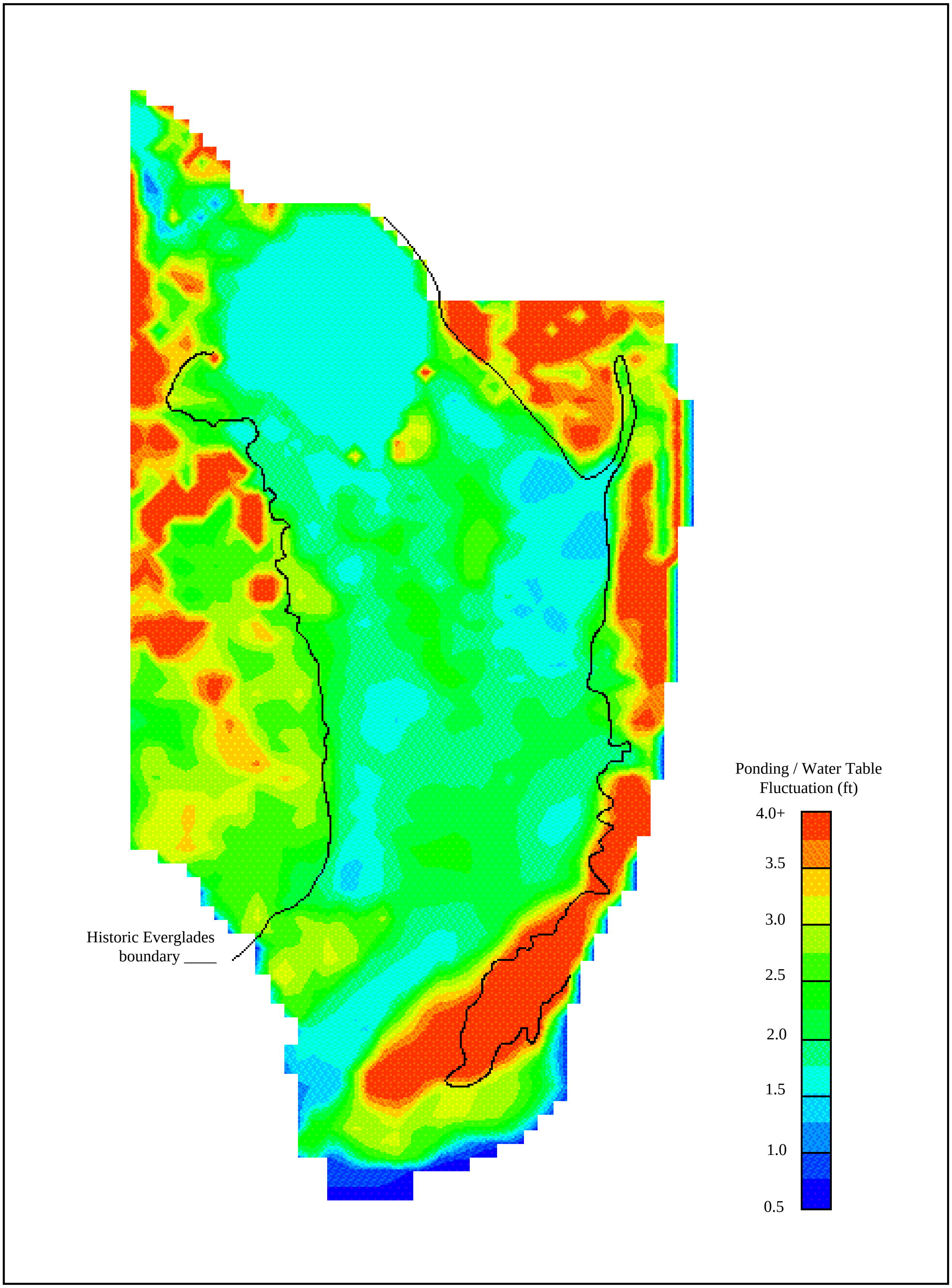


Figure B.3-7 NSM Median Annual Water Level Fluctuation Map

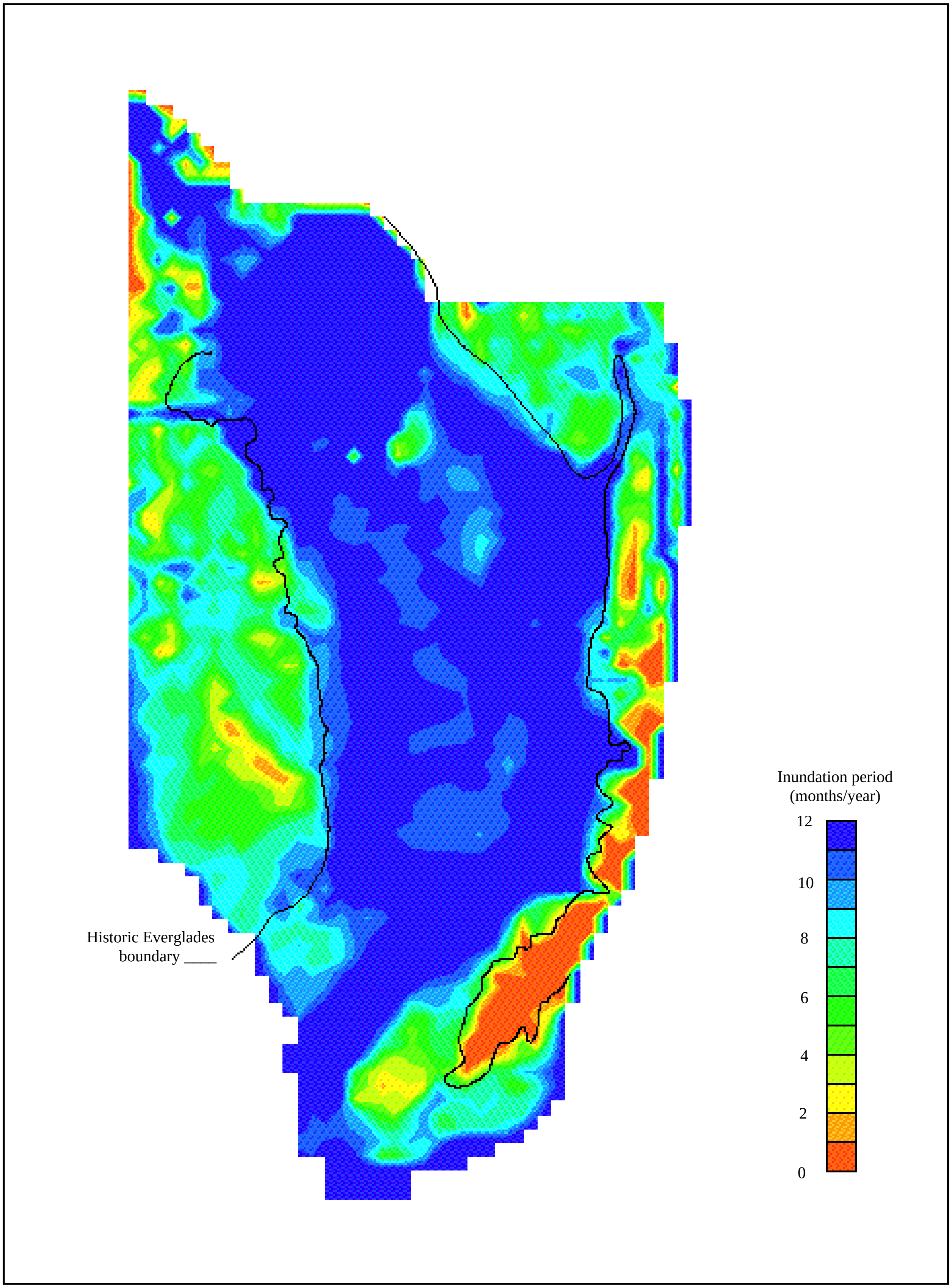


Figure B.3-8 NSM Hydropattern Map (Median Annual Hydroperiod)

B.3.2.2 Modifications to Create NSM v4.5 Final From NSM v4.5 Provisional

When the Restudy process began, a provisional NSMv4.5 was available while undergoing peer review.. The final version of NSMv4.5, referred to herein as NSM45, was implemented after modifications were made in November, 1997. NSM45 was utilized in the evaluations of the final array of alternative development plans. Output maps of NSM45 and the provisional NSM were posted on the hydrologic performance measures (HPM) webpage. The modifications made to establish the final NSM45 are summarized below.

B.3.2.2.1 Overland Flow Resistance Parameters

Ridge and slough (R&S) vegetation is the most extensive Everglades landscape in the NSM. The ET characteristics most closely resemble that of modified ridge and slough (MRS) in central WCA3A. The resistance to flow characteristics most closely resembles that of the modified ridge and sawgrass invaded slough in Shark Slough. This differs from the provisional NSM where both ET and resistance to flow, i.e. Manning's 'n', were based on MRS. Since the calibrated Manning's 'n' in Shark Slough is much lower (0.725 vs. 1.055), there is less resistance to flow in the R&S landscape, thereby contributing to lower ponding depths in central WCA3a and increased flows across Tamiami Trail.

B.3.2.2.2 Rivers/Transverse Glades

Prior to NSM45, the definitions for the river/transverse glades and topography were generally developed independently. River location was based on government survey plats and hydrography coverages. Topography was based on the SFWMM, supplemented by a variety of topography maps and surveys. In NSM45, there is an attempt to reconcile the two and provide a more representative model of the transverse glades. Survey plats typically establish the location of a well-defined river or creek. Since most of the well-defined portions of the rivers and creeks are east of the coastal ridge, the model provided very little direct connection with the Everglades. In reality, rivers were connected to transverse glades, which provided a flow-way through the coastal ridge. NSM45 establishes this connection by extending rivers through the coastal ridge and/or lowering ground surface elevations near the end of the river. In either case, all adjustments are based on soil survey maps, which clearly delineate the location of the transverse glades. Rivers were then "calibrated" by comparing simulated river stages with the Corps estimated average and maximum pre-drainage water levels.

B.3.2.2.3 Topography

Topography for the Everglades south of Lake Okeechobee and north of Tamiami Trail is based on an interpolation of "nearly" pre-drainage land surface profiles--this is true for both the provisional and final version of NSM45. Following the release of NSM45 provisional, these profiles were revised resulting in a revised topography data set. These revisions were relatively minor (generally less than 0.5 ft).

B.3.2.3 Uncertainty

Uncertainty of the Natural System Model develops primarily as a result of three forms of uncertainty; parameter, input, and algorithm or numerical errors.

Parameter uncertainty is an important contributor to total uncertainty, partly because the NSM cannot be calibrated against measured data. NSM stage and flow estimates are therefore less certain than SFWMM flow estimates. Additionally, parameter uncertainty is significant partly due to the spatial and temporal aggregation of parameters that are generally carried out during modeling. The aggregation is carried out in simplifying land use types and assigning simple seasonal estimates. The ET crop coefficient was identified as the parameter that the model output was most sensitive to, followed by the Manning's coefficient (Lal et al., 1994, 1997). With a high parameter uncertainty assumed, output uncertainty in the daily estimates of stage was found to be within 0.3 ft for the ENP and the Water Conservation Areas 90 percent of the time, with few exceptions.

Input uncertainty is due to the uncertainty in rainfall and ET data as calculated when using a sparse network of gages when the spatial variability is high.

Uncertainty due to numerical errors alone have been demonstrated to be very small (Lal, 1998). In areas of deeper water subject to canal level fluctuations, errors are less than 7 percent of the disturbing amplitude.

The total uncertainty of the NSM can not be obtained because the NSM can not be calibrated.. However, an estimate of the likely total uncertainty of the NSM can be obtained by examining the total uncertainty of the SFWMM. The SFWMM estimation is obtained by the linear regression of observed versus simulated values. The standard error estimate of the linear fit was considered to be the total error (uncertainty) in the SFWMM. This method showed that the 90 percent total uncertainty band for stages in a fully calibrated SFWMM is six to seven inches in the Everglades National Park and about six inches for most areas of Water Conservation Area 3 (Lal, 1994). According to the regression method (Flaville, 1992) the SFWMM is capable of explaining about 50-80 percent of the total variance in water levels (Trimble, 1995). Lal (1994) showed that the uncertainty in the estimate of stage was reduced when daily stages were aggregated to longer time periods.

B.3.2.4 Proper Interpretation of Overland Flow

The NSM developers recommend that the NSM be utilized to estimate the spatial patterns and the temporal variability of overland flow, rather than the flow volumes. Relative comparisons of overland flow volumes between alternatives simulated by the SFWMM are also acceptable. This is a typical and appropriate use of a simulation model since model uncertainty, as manifested particularly in data and parameter uncertainty, is relatively consistent between two alternatives –(both simulated with the same model). To compare the exact volumes between the NSM and SFWMM is not appropriate since simulated overland flows from the NSM are subject to larger uncertainties than those of the SFWMM. The NSM has a larger uncertainty in overland flow estimates because overland flow plays a larger role (broader spatial extent) in the NSM relative to the SFWMM, in addition to the inability to calibrate the NSM.

The developers of the NSM caution against using NSM flow volumes as hydrologic restoration targets. They do recommend that it is more appropriate to use water depths and patterns as targets because of the relatively large uncertainty in NSM overland flow estimates as compared to those from the SFWMM. Small changes in flow depths can result in relatively large non-linear changes in overland flow. Although the SFWMM can account for 50 to 80 percent of the variations of low to average discharge, the variability that can be accounted for is much lower for deep water (Lal, 1998). Thus, inaccuracies in stages are magnified when examining corresponding flows. Fennema et al. (1994) suggested that the application of predevelopment flow rates to a modified and much smaller natural system may not necessarily produce a positive ecological response. The maintenance of acceptable water levels and hydroperiods, rather than flows, is probably the key to restoration of the Everglades (Van Lent et al., 1993).

B.3.3 Hydrologic Performance Measures

B.3.3.1 Performance Measures and Indicators

Performance measures are quantitative indicators of how well or poorly an alternative meets a specific objective. Features of good performance measures: are quantifiable; have a specific target; indicate when that target has been reached; or measure the degree of improvement toward the target when it has not been reached. Hydrological performance measures quantify changes in hydrological conditions relative to hydrologic targets. Although it was understood that achieving hydrologic targets did not necessarily guarantee achieving ecological restoration, it was assumed that recapturing the hydrological characteristics of the natural or pre-drained system would provide the maximum opportunity for recovery of the remaining Everglades landscape patterns. Hence, recovery of Everglades wildlife.

Performance Indicators, in contrast to performance measures, do not have a specific target, but are used to provide an indication of the relative behavior of alternatives. Performance measures and performance indicators are herein referred to generically as "performance measures".

B.3.3.2 Process of Developing Performance Measures

Performance measures that were developed as part of the Restudy process were first brought to the Alternative Evaluation Team (AET) for approval. Then, if the performance measure could be produced directly utilizing output from the SFWMM, it was passed to the Hydrologic Systems Modeling Division, SFWMD for development and automation with each model run. If the performance measure could not be produced directly from SFWMM output, it became the responsibility of the developer to produce and post the measure on a web site linked to the Hydrologic Performance Measures Web Page. Many of the performance measures (formerly developed as part of the Lower East Coast Regional Water Supply Plan) were also used in the C& SF Restudy process.

B.3.3.3 Dissemination Via the Hydrologic Performance Measures Web Page

The Hydrologic Performance Measures (HPM) web page was designed to *be the prime communication tool* for the hydrological modeling and alternative evaluation phase of the Restudy feasibility analysis. Participants in the design and evaluation of restoration alternatives for the Restudy included federal and state agencies, environmental groups, the agricultural industry, municipal water utilities, consultants, other interested parties and the general public. The World Wide Web was chosen as the best means to disseminate regional scale hydrological modeling results to, and obtain feedback from, such a wide group of participants. The HPM web page was designed to do the following:

- Allow regular posting of a large number of performance measures. A set of performance measures was generated for selected groups of simulation runs. Each set could compare up to six model simulation runs. Typically one or two alternatives were compared with the existing condition (1995 Base), the future without project condition (2050 Base) and the pre-drained condition as simulated by the NSM. Each performance measure set consisted of more than 900 graphics, maps and tables. Unix shell scripts were used to automate the posting of each performance measure set and the associated maps and tables for the SFWMM runs.

- Require minimum maintenance with each posting. The HPM web page was designed for easy maintenance, with a minimum number of files that needed to be edited manually with the posting of each alternative.

- Permit feedback and evaluation of the alternatives by anyone with a desire to so. An evaluation form provided a means by which all interested parties could provide comments on simulated alternatives. Comments were relayed electronically to the relevant Alternative Evaluation Sub-teams, depending on subject or geographical area to which the comment pertained. Additionally, all comments were sent to the Restudy AET scribe for inclusion in the records.

- Provide details on design of the components utilized in each modeled alternative. After the Restudy Alternative Design Team (ADT) undertook the design of each alternative, following the Restudy Alternative Evaluation Team (AET) evaluation, details of the component designs were posted on the HPM web page.

- Act as a mechanism for disseminating the evaluation of each alternative undertaken by the AET using comments provided by the HPM web page feedback. The AET report for each alternative was posted on the HPM web page. The report provided a complete amalgamation of all the comments received and the AET's analysis of the performance of the particular alternative.

- Provide status updates on new performance measures, posting of modeled scenarios, and information on any model revisions. A “What's New” button was used to provide the latest information on the status and schedule of the Restudy simulation results and posting of alternatives on the HPM web page.

B.3.4 Special Investigations: Summary

Special investigations included modeling to assess the sensitivity of the selected alternative (ALTD13R) to the removal of individual components, and the modeling and evaluation of scenarios proposed at various stages during the restudy alternative development process. Simulation of scenarios was undertaken at various stages in the Restudy alternative development process specifically to assist in the design of the alternatives or investigate particular effects that could not be built into the alternatives. Special investigations that relate the sensitivity of ALTD13R to the removal of components are reported first, followed by the scenarios. Each investigation typically only discusses the performance measures that changed.

It is important to understand that the overall system performance may not change significantly when certain components are removed as indicated by sensitivity analyses. This result does not necessarily mean that the component is not important or needed. Although no operational modifications or structural components were explicitly added to replace the function of the removed components, closer inspection of the analyses reveal that one or more of the other components are typically utilized more extensively in an effort to compensate for the deficit.

This section comprises a summary of the special investigations. A more detailed description of each investigation follows later.

B.3.4.1 Caloosahatchee Basin Aquifer Storage and Recovery (ASR)

B.3.4.1.1 Purpose

To estimate system-wide impacts particular to the Caloosahatchee Basin (water supply and estuary criteria) caused by reducing the ASR recovery efficiency and by removing the ASR component.

B.3.4.1.2 General Assumptions

Three simulations were evaluated; ALTD13R and two scenarios based on ALTD13R. The first scenario reduced the ASR recovery efficiency from 70 to 35 percent. The second scenario removed the ASR component. The C-43 Basin reservoir and Lake Okeechobee backpumping components were kept in the simulations.

B.3.4.1.3 Major Findings

- ASR injection volumes do not change with recovery efficiency.
- The 35 percent ASR scenario and the no-ASR scenario decrease the ASR supplies to the C-43 Basin. The deficit is made-up by Lake Okeechobee and the proposed C-43 reservoir.
- The ASR reduction scenarios decrease the ASR supplies to the Caloosahatchee Estuary. The deficit is somewhat compensated by Lake Okeechobee. The total exceedances of low and high flow criteria remain within the acceptable targets.
- The no-ASR scenario allows for an increase in C-43 backpumping to Lake Okeechobee, since the C-43 reservoir has more water available for backpumping purposes.

B.3.4.2 Lake Okeechobee Aquifer Storage and Recovery (ASR)

B.3.4.2.1 Purpose

To estimate system-wide impacts particular to the Lake Service Area (water supply and estuary criteria) caused by reducing the ASR recovery efficiency and by removing the ASR component.

B.3.4.2.2 General Assumptions

Three simulations were evaluated: Alternative D-13R (ALTD13R) and two scenarios based on ALTD13R. The first scenario reduced the Lake ASR recovery efficiency from 70 to 35 percent (REDEFF). The second scenario removed the Lake ASR component (NoASR). All other components of ALTD13R were kept in the scenarios.

B.3.4.2.3 Major Findings

- Injection volumes for the 35 percent efficiency scenario were similar to that of ALTD13R (250 kac-ft/yr) since the ASR injections do not depend on the recovery efficiencies.

- Recovery volumes were 136 kac-ft/yr, 55 kac-ft/yr and 0, for the ALTD13R, 35 percent efficiency, and NoASR scenarios, respectively.

- Higher high and lower low Lake Okeechobee stages resulted without ASR. There were 5 additional occurrences of ecologically undesirable stage events without ASR. With the reduced ASR efficiency there was only one additional undesirable Lake stage event.

- Southward discharges from the Lake to the EAA surge tanks and WCA's increased by 67,000 ac-ft/yr or 15 percent (from 380,000 ac-ft/yr to 447,000 af/yr).

- Water shortages in the LOSA (measured as mean annual demands not met) increased from about 6 to 11 percent for both the NoASR and the 35 percent efficiency scenarios. During major drought years only a 1 to 2 percent increase was resulted.

- Without the Lake ASR component, the number of Zone A discharges to the Caloosahatchee Estuary more than tripled (31 to 95 days), and discharges to the St. Lucie Estuary more than doubled (24 to 65 days).

- The number of LECSA water restriction months increased due to the increase in Lake Okeechobee-triggered restrictions. Locally-triggered restrictions did not change significantly.

- Flows to ENP increased slightly under the NoASR scenario. NESRS undesirable low stage events increased by 1.

B.3.4.3 Everglades Agricultural Area Storage Reservoirs

B.3.4.3.1 Purpose

To estimate the sensitivity of regional system performance to changes in the configuration and size of the EAA reservoir component.

B.3.4.3.2 General Assumptions

Four scenarios based on ALTD13R were simulated and compared to ALTD13R. ALTD13R has three reservoir compartments: one 20kac for capturing EAA runoff and supplying EAA irrigation needs, and two 20kac surge tanks for storing flood control releases from Lake Okeechobee and supplying the Everglades. The first scenario (SGT4020) increased the size of the first surge tank from 20kac to 40kac. The second scenario (SGT1x20) removed the second surge tank. The third scenario (EAARS) removed both surge tanks. And the fourth scenario (NEAARS) removed all three reservoir compartments.

B.3.4.3.3 Major Findings

Other components of ALTD13R helped to compensate for deficiencies caused by changing the size or configuration of the reservoirs. The resulting system-wide performance of the scenarios depends on full implementation and efficient operation of all the other ALTD13R components. Thus, any conclusions from these analyses regarding the importance of the EAA reservoir component must be made with care.

Impacts to hydropatterns were summarized from a hydrological perspective. The ecological effects of these hydrologic changes should be assessed to determine their significance.

*Scenario SGT4020 resulted in:

- A decrease in EAA runoff and a slight decrease in total flows to the EPA.
- No change in EAA water supply performance.
- An increase in volume of excess water diverted from Lake Okeechobee to the surge tank, a similar decrease in environmental water deliveries from the Lake, and an increase in flows from the surge tanks to the WCAs.
- Reduced utilization of the Lake Okeechobee ASR component.

* Scenario SGT1x20 resulted in:

- An increase in EAA runoff and slight increase in total flows to the EPA.
- No change in EAA water supply performance.

- A decrease in volume of excess water diverted from Lake Okeechobee to the surge tank, an increase in volume of environmental water deliveries from the Lake, and a decrease in flows from the surge tank to the WCAs.
- No change in volume injected into Lake Okeechobee ASR system.

* Scenario EAARS resulted in:
  - An increase in EAA runoff to the EPA.
  - 250kac-ft/yr average reduction in discharges of excess Lake water to surge tanks.
  - An increase in utility of the Lake ASR system, both injection and recovery volumes.
  - Higher stages in Lake Okeechobee, even during drought years; but no significant change in number of ecologically undesirable lake stage events.
  - An increase in flood control discharges to the St. Lucie and Caloosahatchee Estuaries, but no increase in the number of exceedances of the salinity envelope criteria.
  - The percentage of EAA demands met was better than any of the other scenarios.
  - Significant increases in the dependence on Lake Okeechobee for Everglades water supply deliveries.
  - The volume of flows to the EPA was lower than any of the other scenarios and resulted in slightly lower water levels; the significance of which should be evaluated by the ecologists.

* Scenario NEAARS resulted in:
  - Significant increase in EAA runoff to the EPA.
  - Significant increases in the dependence on Lake Okeechobee for Everglades water supply delivery.
  - The volume of flows to the EPA was higher than any of the other scenarios, and resulted in higher water levels in WCA-3A during wet periods.
  - An increase in exceedances of high and low water criteria in the WCAs; the significance of which should be evaluated by the ecologists.
  - An increase in diversions of excess water in WCA-3A to the Central Lake Belt Storage Area.
  - An increased contribution of dry season deliveries to NESRS from the Central Lake Belt Storage Area.
  - Deliveries from Lake Okeechobee to meet EAA irrigation demands more than doubles, but the percentage of EAA demands met decreases due to lower Lake stages during dry periods.
  - An increase in number of months of LECSA cutbacks due to lower Lake stages results.

B.3.4.4 L-8/C-51 Reservoir

B.3.4.4.1 Purpose

To estimate impacts to LECSA-1 water supply and Lake Worth Lagoon caused by removing the L-8/C-51 reservoir component.

B.3.4.4.2 General Assumptions

The 1200-acre L-8/C-51 reservoir was removed from ALTD13R. The runoff from the southern L-8 and western C-51 Basins that was diverted to the reservoir in ALTD13R was discharged to the Lake Worth Lagoon.

B.3.4.4.3 Major Findings

- Reductions in dry period inflows to, and lower low stages within the WPB WCA.
- Increase in dependence on C-51 ASR, WCA-1 and Lake Okeechobee for recharging canals in LECSA-1.
- An increase in flows to the Lake Worth Lagoon on average of 52,000 acre-feet per year; 90 percent of the increase occurred during the wet season.

B.3.4.5 Lower East Coast Aquifer Storage and Recovery (ASR)

B.3.4.5.1 Purpose

To estimate impacts particular to Lower East Coast (water supply and discharges to tide) caused by reducing the LEC ASR recovery efficiencies and by removing LEC ASR components.

B.3.4.5.2 General Assumptions

Three simulations were evaluated; ALTD13R and two scenarios based on ALTD13R. The first scenario reduced the ASR recovery efficiency from 70 to 35 percent for the four LEC ASR components (WPBCAT, C51, CPBRES, and SITE1). The second scenario removed all four LEC ASR components. All other ALTD13R components were kept in the scenarios.

B.3.4.5.3 Major Findings

- ASR injection volumes do not change with recovery efficiency. Thus, flows to tide did not change significantly for the 35 percent efficiency scenario.
- For the no ASR scenario, LECSA-1 discharges to tide increased to 32 percent and 28 percent for the wet and dry seasons, respectively.
- The number of high flow exceedances for the Lake Worth Lagoon increased by 50 percent (from 96 to 144 months) with no ASR.

- Water levels in the Site 1 and Central Palm Beach County reservoirs had virtually no change with the 35 percent efficiency scenario, but increased significantly with the no ASR scenario.
- Locally-triggered water restrictions did not change with the scenarios (zero restrictions).
- On an annual average basis, the 35 percent efficiency scenario required 50 percent more (~14 kac-ft/yr) deliveries from WCA-1 and Lake Okeechobee to maintain canals in LECSA-1. The no ASR scenario required more than a 100 percent increase (~25 kac-ft/yr) in deliveries.
- Slightly lower water levels in the northern region of WCA-1 resulted with both the 35 percent efficiency scenario and the no ASR scenario.
- Lake Okeechobee stages were marginally lower. However, the number of undesirable stage events did not change.
- Water supply performance for the Lake Service Area had no significant change on a mean annual basis or for the five major drought years.

B.3.4.6 North Lake Belt Storage Area

B.3.4.6.1 Purpose

To estimate the impacts to LECSA water supply and Biscayne Bay caused by removing the north Lake Belt storage component.

B.3.4.6.2 General Assumptions

The 4,500-acre north Lake Belt storage area and its associated perimeter seepage barrier were removed from ALTD13R. The runoff from the C-9 and C-6 Basins that was diverted to north storage in ALTD13R was discharged to tide. And the western C-11 Basin runoff that was diverted to north storage was pumped to WCA-3A via S-9.

B.3.4.6.3 Major Findings

- Significant increase (~130 percent) in the surface water deliveries from Lake Okeechobee and WCA-3A to maintain canals in LECSA3.
- Up to a 0.3ft reduction in Lake Okeechobee stages during dry periods; this resulted in a slight increase in Lake Service Area demands not met, and one additional undesirable lake stage event.
- Reduction in ability to maintain stages in C-4, C-6, and C-9; this contributed to an increase of 19 months of water restrictions in LECSA-2.
- A redistribution of canal/structure discharges to Biscayne Bay. Total discharge volumes were not significantly different; however, the removal of the storage area resulted in a shifting of flows from Central Bay to the Miami River and Snake Creek. Additionally, the seasonal distribution shifted more of the Central Bay flows to the wet season, further away from the target wet and dry season distributions.

B.3.4.7 Central Lake Belt Storage Area

B.3.4.7.1 Purpose

To estimate the impacts to Everglades hydropatterns, water deliveries, and discharges to Biscayne Bay caused by removing the central Lake Belt storage component.

B.3.4.7.2 General Assumptions

The 5200-acre central Lake Belt storage area and its associated perimeter seepage barrier were removed from ALTD13R. Excess water from WCA-3A and 3B was still allowed to discharge east and then south to ENP via the proposed S-356's.

B.3.4.7.3 Major Findings

- A significant increase (more than 100 percent or 187,000 af/yr) in eastward diversions of excess water from WCA-3A and 3B resulted since the available storage capacity in central storage was no longer a limiting factor.
- Seepage from WCA-3 to the LECSA increased by 16 percent (~44,000 ac-ft/yr) as a result of the removal of the perimeter seepage barrier.
- Stages in WCA-3A and 3B were lowered as a result of the increased outflow to the east. There was a resulting 10 percent reduction in flows to NESRS across the Tamiami Trail flow section.
- Although total discharge to NESRS via the S-356's did not change significantly, there was a marked change in the seasonal flow distribution (from 63 percent dry season flows to 42 percent).
- Stages in NESRS were reduced up to 0.5 ft during April and May.
- A 28 percent increase in discharges to central Biscayne Bay due to increased seepage from WCA-3.
- No effect on LECSA water restrictions and minimal effect on Lake Okeechobee.

B.3.4.8 Miami-Dade County Wastewater Reuse

B.3.4.8.1 Purpose

To estimate the impacts on LECSA-3 water supply and discharges to Biscayne Bay caused by removing the wastewater reuse components.

B.3.4.8.2 General Assumptions

Three simulations were evaluated; ALTD13R and two scenarios based on ALTD13R. The first scenario removed the western re-use component (component

BBB), and the second scenario removed the southern re-use component (component HHH). All other ALTD13R components were kept in the scenarios.

B.3.4.8.3 Major Findings

- Removal of the western component significantly lowered the stages in the Bird Drive reservoir and in L-31N. Removal of the southern component has insignificant effects on these areas.
- Water deliveries from the regional system to Service Area 3, particularly Lake Okeechobee, increased to compensate for the reduced supply from the re-use components.
- Lake Okeechobee stages are lowered during drought events, more so when the western re-use component is removed. Additional occurrences of ecologically undesirable low Lake stage events resulted.
- Locally-triggered water restrictions in LECSA-3 increase from 5 to 12 when the southern re-use component is removed. No change in locally-triggered restrictions occurs when the western component is removed.
- Lake Okeechobee and dry season - triggered restrictions in all the LECSA's increase slightly when the western reuse component is removed.
- Removal of the southern component reduces discharges to central and southern Biscayne Bay by 12 percent (25 kac-ft/yr), and 34 percent (94 kac-ft/yr), respectively.
- Removal of the western component has lesser impact on Biscayne Bay. Discharges to central and southern sections decrease by 6 percent (13 kac-ft/yr), and 3 percent (8 kac-ft/yr), respectively.
- The removal of the western reuse component results in a decrease in the S-356A&B discharge of about 40 kac-ft/yr (from 264,000 to 224,000). A reduced inflow to ENP from central Shark River Slough also resulted. No difference in ENP inflows occurs when the southern reuse component is removed.
- The number of low water, high water, and inundation events in Northeast Shark River Slough changes marginally when the reuse components are removed.

B.3.4.9 Partitioning Lake Okeechobee Scenario

B.3.4.9.1 Purpose

To estimate region-wide impacts caused by partitioning Lake Okeechobee into two compartments: one for water supply and flood flow storage and one for the preservation of the littoral zone. However, the analysis of this scenario was hydrological only. No ecological, water quality, or engineering analysis has been conducted for this scenario.

B.3.4.9.2 Assumptions

- Three simulations were evaluated: (1) the future without plan condition (aka 2050 Base), and two split-lake scenarios; (2) the 2050 Base with the Lake partitioned but without Supply-side management, and (3) the 2050 Base with the Lake partitioned but with a Supply-side management plan included.
- The SFWMM net inflow time series for the Lake was assumed to be split 60 percent to the western (littoral) compartment and 40 percent to the eastern compartment. Therefore, the areas of the western and eastern compartments were modeled to be 60 percent and 40 percent of the total lake area, respectively.
- The western compartment was managed to provide maximum benefit for the littoral zone. A single line regulation schedule ranging from13.5 -to 15.5 ft, NGVD was assumed. Excess water above this schedule was routed to WCA-3A via STA-3&4. A 4,000-cfs pump was modeled to lift any additional excess water to the reservoir compartment.
- The eastern compartment had no regulatory discharge rule. Its primary purpose is to meet water supply needs for agriculture, urban and environmental uses.

B.3.4.9.3 Major Findings

- Significant reductions in the mean annual percentage of Lake Service Area demands not met.
- Increased carry-over storage capability of the reservoir compartment. Stages ranged from 1 to 34 ft, NGVD.
- Significant improvement in the littoral zone. The number of ecologically undesirable lake stage events decreased from 12 to 5.
- Discharges of excess water to the WCAs more than doubled and there were no discharges of excess water to the St. Lucie or Caloosahatchee estuaries. A greater than 20 percent reduction in the number of months that the high flow criteria for both estuaries was exceeded.
- Hydropatterns in the WCAs and ENP improved.
- The number of LECSA water restrictions triggered by Lake Okeechobee was reduced.

B.3.4.10 Lower East Coast Public Water Supply Scenarios

B.3.4.10.1 Purpose

To investigate the sensitivity of the regional system to different Lower East Coast public water supply demands. Three scenarios utilizing Alternative 5's components were simulated, theses included:

- No LEC public water demands (ALT5NOPWS)
- Reduced public water demands based on the 95 Base (ALT95BSPWS), and
- Alternative 5 demands doubled (ALT52XPWS)

B.3.4.10.2 General Assumptions

- In ALT52XPWS, extractions from the same wells as in Alternative 5 were assumed to satisfy the increased demand.
- LEC irrigation demands were assumed the same as in Alternative 5 in each case.
- The same urban landscape irrigation demand was utilized in all 3 scenarios (turning this demand off in the no public water demand scenario would have resulted in unintended increased groundwater withdrawals to meet unsaturated zone demands).

B.3.4.10.3 Major Findings

- Decreasing the public water demand to zero resulted in relatively small benefits to other parts of the regional system and a large increase in flow to tide.
  - Lake Okeechobee levels increased marginally.
  - Overland flow increased; 5 percent (+43,000 ac-ft/yr) across Tamiami Trail, 12 percent (+123 kac-ft/yr) in Shark River Slough and 8 percent (+13 kac-ft/yr) into Florida Bay. Flow from the LEC through structures to the ENP increased 27 percent (+161 kac-ft/yr).
  - Flow to tide from the LEC Service Areas increased 41 percent (+905 kac-ft/yr) indicating that under Alternative 5 local runoff and local storage are used extensively to recharge the aquifer and supply public demand.
  - LEC water supply from the regional system decreased; 80 percent (-70,000 ac-ft/yr) from the WCA's, 27 percent (-15 kac-ft/yr) from Lake Okeechobee, and 99 percent (-66 kac-ft/yr) from reservoirs.
- Decreasing public water demand to that of 95 Base demands had similar, but less noticeable effects than by reducing the demands to zero.
  - Overland flow increased; 2 percent (+16 kac-ft/yr) across Tamiami Trail, 5 percent (+55 kac-ft/yr) in Shark River Slough and four percent (+6 kac-ft/yr) into Florida Bay. Flow from the LEC through structures to the ENP increased 13 percent (+77 kac-ft/yr).
  - Flow to tide from the LEC Service Areas increased 12 percent (+262 kac-ft/yr)
  - LEC water supply from the regional system decreased; 30 percent (-26 kac-ft/yr) from the WCA's, 20 percent (-11 kac-ft/yr) from Lake Okeechobee, and 45 percent (-30 kac-ft/yr) from reservoirs.

- Doubling the public water demand caused relatively large effects on Lake Okeechobee, the Water Conservation Areas, the ENP and the LEC Service Areas.
  - Lake stages dropped by 1.5 to 2.0 ft on several occasions and the time that the Lake was below 14 ft increased from 14 to 34 percent. The lake regulatory releases decreased by 24 percent (183 kac-ft/yr).
  - Water levels in south WCA-1, WCA-2B, WCA-3B and Shark River Slough were lowered. Hence, improving ponding matches in the WCA's and ponding matches in the ENP.
  - Overland flow decreased; 17 percent (-149 kac-ft/yr) across Tamiami Trail, 22 percent (-242 kac-ft/yr) in Shark River Slough and 12 percent (-20 kac-ft/yr) into Florida Bay. Flow from the LEC through structures to the ENP decreased 40 percent (-239 kac-ft/yr).
  - Flow to tide from the LEC Service Areas decreased by 23 percent (-516 kac-ft/yr)
  - LEC water supply from the regional system increased substantially; nearly four-fold (+250 kac-ft/yr) from the WCA's, 3-fold (+166 kac-ft/yr) from Lake Okeechobee, and 170 percent (+122 kac-ft/yr) from reservoirs.
- The western portions of the regional system such as Holey Land and Rotenberger WMA's, the BCNP, western WCA-3A and the western ENP were unaffected by changes in public water demands.

B.3.4.11 Modification of L-31N and C-111 Canal Stage Operations

B.3.4.11.1 Purpose

To estimate impacts on ENP hydropatterns and south Miami-Dade County water levels caused by lowering the flood control stages in the L-31N and C-111 canals. This effort was performed as part of the development of Restudy Alternative 4. The operational criteria evaluated in this effort were utilized for Alternative 4 and subsequent Restudy alternatives.

B.3.4.11.2 General Assumptions

Two simulations were evaluated; Alt3 and Alt3 with about 0.5 to 1.0 feet lower canal stage operations. G-211 operations were about 0.5 ft lower. S-331, which in Alt3 was closed during the wet season, was opened during the wet season in the L31FC simulation. S-176 operations were lowered about 1.5 ft. S-332A, B, D pumping began about 0.7ft lower. And operations at S-177 and S-18C began about 0.9ft lower. For further details on specific assumptions, refer to ***Table B.3-2*** in the section; Special Investigations: Details (***Section B.3.5***). Note that the canal stage operations for Alt3 were generally higher than those currently used for the actual operations.

B.3.4.11.3 Major Findings

- L-31N Canal stages upstream of S-174 were about 0.5ft lower for 70 percent of the time.
- Increased pumping at the proposed S-332 structures improved hydropatterns in ENP adjacent to the L-31N and C-111 Canals south of S-331. However, much of the increased pumpage was due to an increase in seepage from ENP eastward to L-31N, particularly during the wet season. More-detailed analyses of the localized impacts to marsh hydropatterns near the canals are necessary.
- Water budget results indicate a net increase in flow to ENP as a result of lower canal stage operations.
- Peak stages increased in marshes west of L-31N and in the marshes east of C-111 south of Florida City. Peak stages east of L-31N in the developed areas were lowered.
- Although the regional-scale simulation (2 mile x 2 mile) is too coarse to assess site-specific changes in flood risk, the results indicate lower water levels in the agricultural lands east of L-31N and C-111. Thus, there may be some decrease in flood risk in the region. Site-specific inferences cannot be made until a more-detailed analysis using finer-scale models is performed.

B.3.4.12 Sea Level Rise

B.3.4.12.1 Purpose

To simulate the effect that a sea level rise of 0.5 feet would have on the 2050 Base case. This effort was performed prior to simulation of the alternatives and was posted on the HPM web page (October 14, 1998). Further details of the scenario are presented in the section, Special Investigations: Details.

B.3.4.12.2 General Assumptions

The sea level boundary condition was adjusted to be 0.5 ft higher than that of the 2050 Base. Coastal canal levels were maintained 0.5 feet higher where feasible, and the initiation of flood control releases were delayed to permit the maintenance of higher canal stages. The water level at which maximum releases were made was not altered. Trigger levels for water use restrictions (cutbacks) were also raised by 0.5 ft except for one interior trigger in Palm Beach County.

B.3.4.12.3 Major findings

- For the Lower East Coast, water use cutbacks increased significantly with sea level rise, particularly in LECSA1 and LECSA2 where the number of months of cutbacks more than doubled.

- Water supply deliveries increased significantly in order to maintain the canals at higher stages.
- Mean groundwater levels and peak stages were increased in the lower East Coast flood protection area indicating a potential increase in flood risk with sea level rise.
- The hydrology of the interior regions was largely unaffected by sea level rise
- Estuaries would likely be impacted by sea level rise, but the additional volume of water that would be needed by the estuaries to maintain 2050 Base salinity levels was not determined.

B.3.4.13 Water Conservation Area Decompartmentalization Scenarios

To assist with the design of components for Alternative 4, three WCA decompartmentalization scenarios were developed and simulated utilizing the SFWMM. These 3 scenarios are intended to provide preliminary indications of the benefits and possible inadvertent consequences of removing levees and water control structures from the C&SF Project. The three scenarios progressively remove more C&SF Project components and use Alternative 3 as the base to build from. Alternative 3 was utilized since it contains the necessary upstream storage facilities, levee under-seepage, and groundwater management features for L-30 and L-31N. Alternative 3 also has the most relevant operational rules for the rain-driven delivery component. The full set of performance measures comparing the three decompartmentalization scenarios was posted on the HPM web page (January 30, 1998). A summary of the results was presented during the Restudy Team meeting in West Palm Beach, February 9, 1998. Hence, details of these decompartmentalization scenarios are not presented in the section, Special Investigations: Details.

Following Alternative 4 (WCA-2A and WCA-2B were still compartmentalized), another scenario was simulated to illustrate the severity of inadvertent consequences that would result by removing the levee, L-35B (separating WCA-2A from WCA-2B). The results were posted on the HPM web page (February 25, 1998). Hence, it is not presented in the section, Special Investigations: Details.

In the process of building Alternative 6, two other decompartmentalization scenarios were simulated based on Alternative 5. These are referred to as Alternative 5 Decomp scenario 1 (DCMP1) and Alternative 5 Decomp scenario 2 (DCMP2). They were posted on the HPM web page on March 31, and April 7, 1998 respectively. They are not presented in the section; Special Investigations: Details.

B.3.4.13.1 Description of Scenarios

B.3.4.13.1.1 WCA 3 Decompartmentalization

Denoted as SO3ALR on performance measure graphics (SOuthern WCA-3A Levee Removal).

This scenario uses the same assumptions and components as Alternative 3, but includes the removal of the following levees, canals, and associated water control structures:

a. L-28 and L-28tieback, L-28 borrow canal, and structures S-344, S-343A&B.

b. L-29 and L-29 Canal, S-12's, S-333, S-334, S-355, S-356 (already relocated to L-31N as part of Alternative3.

c. L-67A&C and L-67A Canal up to the Miami Canal, and structures S-345 and S-151.

The Miami Canal was not removed since it is a necessary feature for providing water supply to Miami-Dade County and the South Dade Conveyance System. The Miami Canal also plays an important role in making environmental water supply deliveries to the north central portion of WCA-3A (north of S-339 and S-340).

Operational changes from Alternative 3 included:

a. Removal of rain-driven trigger gages in northeast and northwest Shark River Slough. These were no longer considered useful since control at L-29 was removed.

b. Removal of the 3A-28 import trigger for bringing water from Lake Okeechobee (note that all the other northern and central WCA triggers were not changed from Alt 3.

B.3.4.13.1.2 WCA 3 and 2 Decompartmentalization

Denoted as CA2ALR on performance measure graphics (WCA-2A Levee Removal).

This scenario used the same assumptions and components as the WCA3 Decompartmentalization scenario, but includes the removal of the following levees, canals, and associated water control structures:

L-38E, L-38W, and L-35B, and structures S11, S-144, S-145, S-146, S-141, S-142, and S-143 (S-34 remains for providing water supply deliveries to LECSA-2).

There were no operational changes from the WCA3 Decompartmentalization scenario.

B.3.4.13.1.3 WCA 3 and 2 and 1 Decompartmentalization

Denoted as SCA1LR on performance measure graphics (Southern WCA-1 Levee Removal).

This scenario used the same assumptions and components as the WCA3&2 Decompartmentalization scenario, but included the removal of the levee that separates the Loxahatchee National Wildlife Refuge (LNWR) from WCA-2A and the associated water control structures:

L-39, and structures S-10A, C, D and E, (Hillsboro Canal and S-39 left intact to provide water supply deliveries to LECSA-1).

Operational changes from the WCA3&2 Decompartmentalization scenario included:

Removing the rule that limited LECSA-1 water supply deliveries based on the difference between WCA-1 stages and Lake Okeechobee stages (this rule is described on the current interim regulation schedule for WCA-1).

B.3.4.13.1.4 L-35B Removal

The scenario denoted as NOL35B on the graphics and maps, was posted to illustrate the severity of the inadvertent consequences that would result from removing the levee, L-35B (separating WCA-2A from WCA-2B). It compares Alternative 4 with the scenario denoted as Alternative 4 with L-35B Removed. A full set of performance measures for this scenario was posted on the HPM web page (February 25, 1998).

B.3.4.13.1.5 Alt 5 Decompartmentalization Scenario 1 (DCMP1)

This scenario utilized the same components as Alternative 5 except for the following:

- Alt 5 was more decompartmentalized by the removal of the weirs between WCA 3A and 3B.
- The Miami, Hillsboro and North New River Canals were removed from the EAA southward.
- WCA-2B water was routed via existing conveyance to NESRS with increased conveyance capacity.
- Interior canals within the Loxahatchee National Wildlife Refuge were removed. The LNWR remained connected to the Lake via WPB Canal with existing capacity

- A conceptual pipeline along the filled in North New River Canal was used for LEC water supply

B.3.4.13.1.6 Alt 5 Decompartmentalization Scenario 2 (DCMP2)

This scenario utilized the same components as Alternative 5 except for the following:

- There are no Lake Okeechobee ASR wells,
- WCA-2B excess discharges are sent to NESRS versus stored in the central Lake Belt storage.
- East-central WCA-3A excess water was stored inside the WCAs (no diversion to central Lake Belt storage area).
- WCA-3B excess was stored inside the WCA's versus diverted to central Lake Belt storage.
- Targets were modified as follows: Discharges to meet target stages in NESRS (average of gages 1 and 2) were provided by S-345 and S-140 discharges. S-140 discharges were triggered by either 3A-4 or NESRS targets.

B.3.5 Special Investigations: Details

B.3.5.1 Caloosahatchee Basin Aquifer Storage and Recovery Sensitivity

B.3.5.1.1 Description of Simulations

A sensitivity analysis of the proposed ASR system in the Caloosahatchee (C-43) Basin was completed using the SFWMM. Model outputs from three simulation runs: (1) 220-MGD Caloosahatchee ASR with 70 percent efficiency; (2) no Caloosahatchee ASR; (3) 220-MGD and Caloosahatchee ASR with 35 percent efficiency; were summarized and compared using the same set of performance measure graphics used in the Restudy. The first or reference model run corresponds to the Restudy ALTD13R that was posted on the Restudy HPM Web page (June 19, 1998). This alternative proposes an ASR wellfield with a total of 22, 10-MGD ASR wells (equal inflow and outflow capacities). The other two models are scenarios derived from the first. Scenario 1 was simulated by having ASR injection and withdrawal capacities equal to zero MGD. The configuration and rules governing the operation of the Caloosahatchee ASR as simulated in ALTD13R was maintained in scenario 2--only the efficiency was changed from 70 to 35 percent. In the SFWMM, the Caloosahatchee ASR efficiencies are applied upon injection so that the size of the ASR "bubble" at the end of each time step truly represents the available storage in the ASR well. The intent or purpose of the Caloosahatchee ASR is defined in the description of Component D5 in ALTD13R.

B.3.5.1.2 Assumptions

For both scenarios , no operational adjustments or physical components were added or substituted to compensate for the reduction in efficiency or elimination of the Caloosahatchee ASR. The remaining components utilized in the scenario runs were identical to the ones incorporated in ALTD13R.

B.3.5.1.3 Summary of Results

Performance measure graphics comparing selected model output summaries are presented next. The reference run is designated as ALTD13R. Scenario 1 (without ASR) and scenario 2 (ASR with 35 percent efficiency) are designated NOCASR and 35CASR, respectively, in the attached graphics. Unless otherwise noted, trends in either scenario are expressed relative to the reference run, e.g. increase in discharge or lowering of stages. The 1995 and 2050 base runs are plotted in all PM graphics for reference only. The major findings in this analysis are shown in the following:

- The annual average injection rate from the reservoir into the ASR well for ALTD13R and 35CASR are similar: approximately 98 kac-ft/yr with a 74/26 percent wet/dry season split. The logic in the model does not reduce or increase the injection of reservoir water into the ASR well as a function of ASR efficiency. (Note: Excess Lake water and C-43 Basin runoff are pumped into the reservoir and not directly into the ASR well.)

- The components of the water budget for the Caloosahatchee reservoir in 35CASR did not significantly change from ALTD13R. Outflow into the ASR well remained fairly constant (see preceding bullet). The water budget for NOCASR; however, shows a more significant change relative to ALTD13R. Reservoir water in ALTD13R that went to the ASR well (98.0 kac-ft/yr) was redirected in NOCASR primarily to: 1) Lake Okeechobee (54.1 kac-ft/yr or +35.4 percent), 2) C-43 Basin (7.1 kac-ft/yr or +16 percent); and 3) C-43 Estuary (4.5 kac-ft/yr or +11.0 percent). Losses due to evapotranspiration, seepage and spillover also increased for the NOCASR scenario (7.6 kac-ft/yr or +5.7 percent). Excess basin runoff pumped into the reservoir decreased (21.7 kac-ft/yr or -5.8 percent) while the lake inflow decreased (2.9 kac-ft/yr or -14.7 percent).

- The average annual supplemental irrigation demand for C-43 Basin is 125.3 kac-ft/yr. Reduction in ASR efficiency by one-half, i.e., from 70 to 35 percent, resulted in a reduction of ASR contribution in meeting basin demand from 31.5 kac-ft/yr to 21.1 kac-ft/yr or about -33 percent. Mean annual deliveries from Lake Okeechobee (36.8 kac-ft/yr in ALTD13R) to C-43 Basin increased by a factor of 25 percent in 35CASR (46.1 kac-ft/yr) and by 64 percent in NOCASR (60.5 kac-ft/yr). Mean annual contribution from the Caloosahatchee reservoir (43.5 kac-ft/yr in ALTD13R) to C-43 Basin did not significantly change in 35CASR but increased by a factor of 16 percent in

NOCASR (50.6 kac-ft/yr). ***Figure B.3-9*** shows C-43 Basin demand-not-met of 2.6 percent, 3.1 percent and 3.6 percent for ALTD13R, NOCASR and 35CASR, respectively. The reservoir-LOK configuration simulated in ALTD13R, given the same set of operating rules, is more effective in meeting C-43 Basin demand than a reservoir-LOK configuration with a less efficient ASR system as simulated in 35CASR.

- On an annual average basis, the Caloosahatchee ASR in ALTD13R released 16.0 kac-ft/yr to meet estuarine requirements. It decreased by 34.7 percent in 35CASR and its contribution was zero in NOCASR. More significantly, both scenarios resulted in four more months with low flow violations (<300 cfs, top graph in ***Figure B.3-10***), and extended dry conditions in terms of maximum consecutive months with flows below 300 cfs (ALTD13R, four months; and NOCASR or 35CASR, six months at the bottom graph in ***Figure B.3-10***). Even with the decrease in performance due to the changes incorporated into the scenario runs, the number of low and high flow exceedances are still better than the recommended targets (***Figures B.3-10*** and *B.3-11*).

- ***Figure B.3-12*** shows the stage duration curve for Lake Okeechobee. (note: The ALTD13R line is located between the lines describing the two scenario runs.) An increased withdrawal from the Lake to meet basin demand (ALTD13R, 78.1 kac-ft/yr; 35CASR, 87.5 kac-ft/yr; NOCASR, 105.1 kac-ft/yr) and satisfy estuarine requirements occurred (ALTD13R, 22.7 kac-ft/yr; 35CASR, 28.4 kac-ft/yr; NOCASR, 33.9 kac-ft/yr). The stage duration curve corresponding to 35CASR is slightly below ALTD13R, which is consistent with the above noted trends in the lake water supply releases to the basin and estuary. However, the lake stage duration curve for NOCASR is slightly above ALTD13R. This occurrence can be explained by an increase from ALTD13R to NOCASR, in the backpumping of excess Caloosahatchee runoff into the Lake (ALTD13R, 153.0 kac-ft/yr; 35CASR, 151.7 kac-ft/yr; NOCASR, 207.1 kac-ft/yr) that more than offsets the increase in a Lake release to meet downstream needs (C-43 Basin and Estuary). The slight increase in Lake storage, from ALTD13R to NOCASR, could have translated into better C-43 Basin and C-43 Estuary performance (refer to Figures B.3-9 and B.3-10, respectively) if a corresponding adjustment in operating rules in conjunction with the removal of the Caloosahatchee ASR had been in place. As mentioned in the first bullet above, the amount of reservoir water injected into the ASR is not a function of the ASR efficiency. More excess water in the C-43 Basin can be diverted into the Lake via the reservoir if there were no ASR, but not with a less efficient ASR.

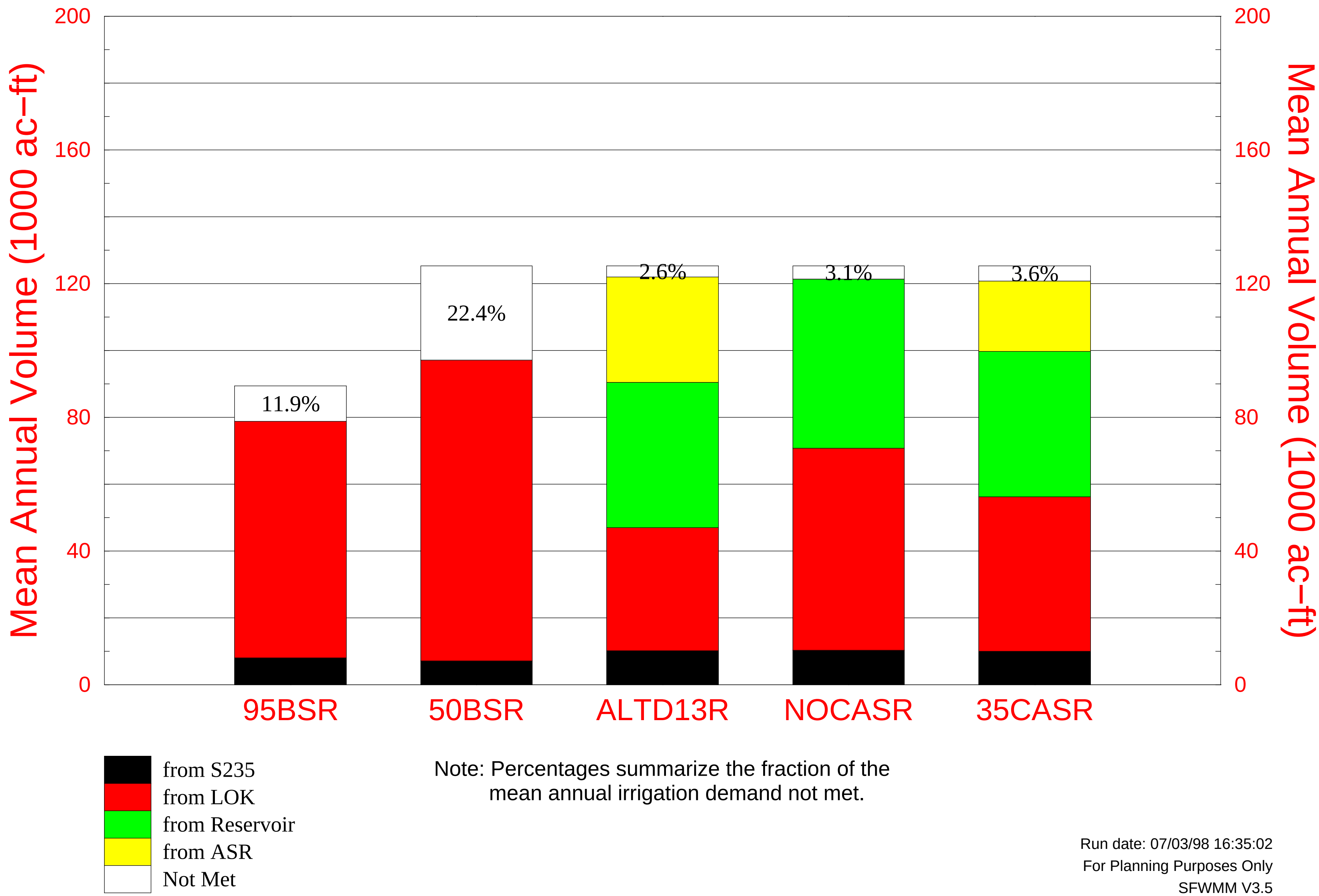
- The trends observed in ***Figure B.3-12*** are consistent with those in ***Figure B.3-13*** that shows a slight decrease (35CASR) and a slight increase (NOCASR) in the total volume of lake regulatory discharges.

- The performance of the St. Lucie (C-44) Basin changed marginally due primarily to the slight decrease (35CASR) or slight increase (NOCASR) in Lake stage. The C-44 Basin supplemental irrigation demand is 27.7 kac-ft/yr. Demand-not-met for the three runs are ALTD13R, 6.7 percent; 35CASR, 6.8 percent; and NOCASR, 5.2 percent (***Figure B.3-14***). No apparent change in the St. Lucie Estuary performance measures resulted from either scenario runs.

- The EAA did not experience a significant change in its performance in terms of mean annual supplemental irrigation and demand-not-met during the entire simulation period (***Figure B.3-15a***), or during the drought years (1971, 1975, 1981, 1985 and 1989, ***Figure B.3-15b***). The top-right graphs in Figures B.3-15a and B.3-15b show the additional dependence on lake water due to the removal and reduction in efficiency of the Caloosahatchee ASR. (Note: The legend "DMD met by RES" denotes the combined water supply deliveries from a reservoir and an ASR, if any.) On an annual average basis for the entire simulation period, the Lake water supply deliveries to the other, i.e. non-EAA, Lake Okeechobee Service Areas (LOSAs) increased by 9.0 kac-ft/yr (+5.0 percent) and 24.0 kac-ft/yr (+13.4 percent) for 35CASR and NOCASR, respectively (***Figure B.3-15a***). (Note: The combined C-43 and C-44 Basin supplemental irrigation requirement accounts for slightly more than one-half the total requirement for the other LOSAs.)

Figure B.3-9 C-43 Basin Regional Irrigation Supply and Demand Not Met

Means for the 1965 to 1995 Simulation Period



Note: Percentages summarize the fraction of the mean annual irrigation demand not met.

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SFWMM V3.5

Figure B.3-10 Number of Times Salinity Envelope Criteria were NOT Met for the Caloosahatchee Estuary (mean monthly flows 1965 - 1995)

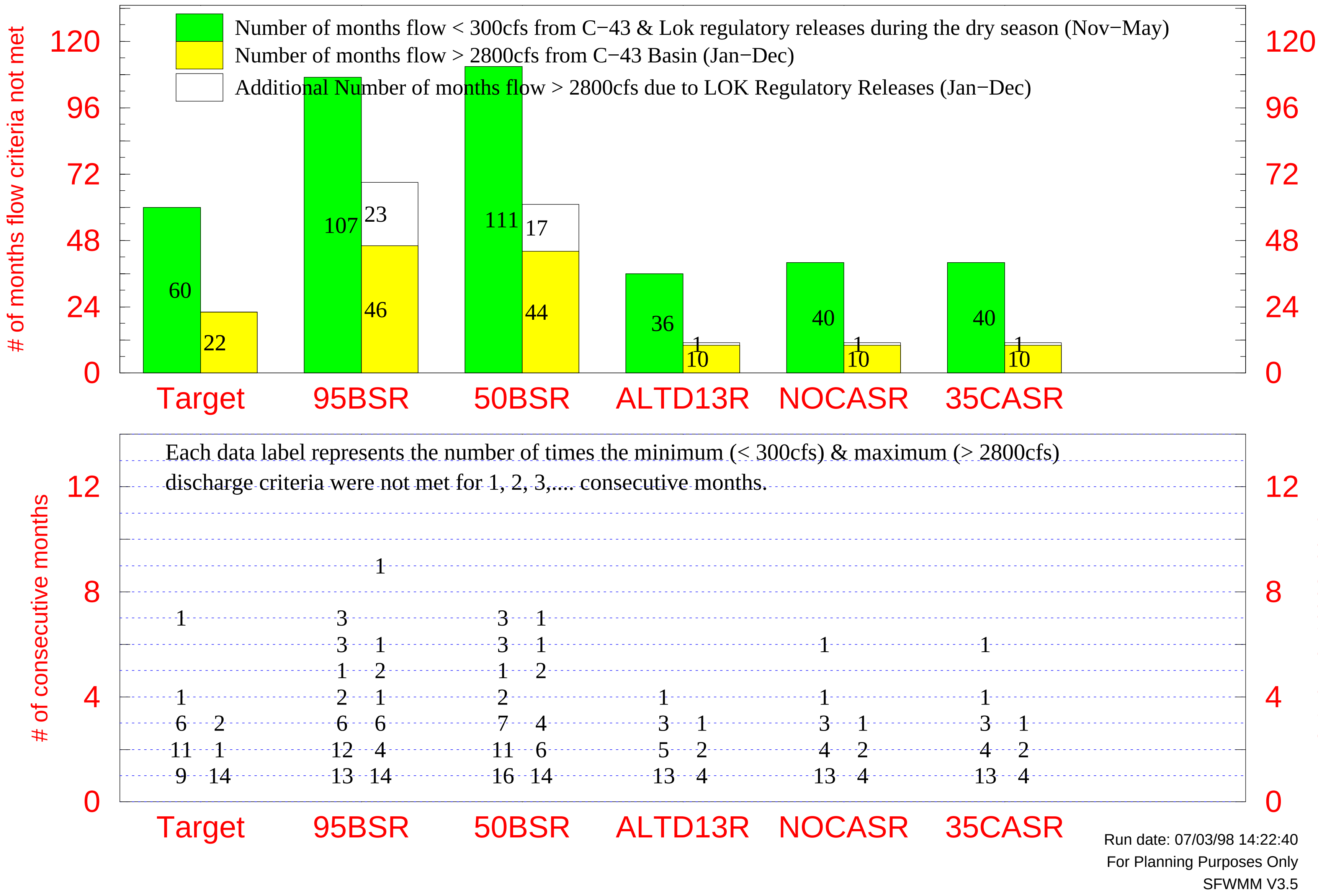

Figure B.3-11 Number of Times High Discharge Criteria (mean monthly flows > 2800 & 4500 cfs) were exceeded for the Caloosahatchee Estuary

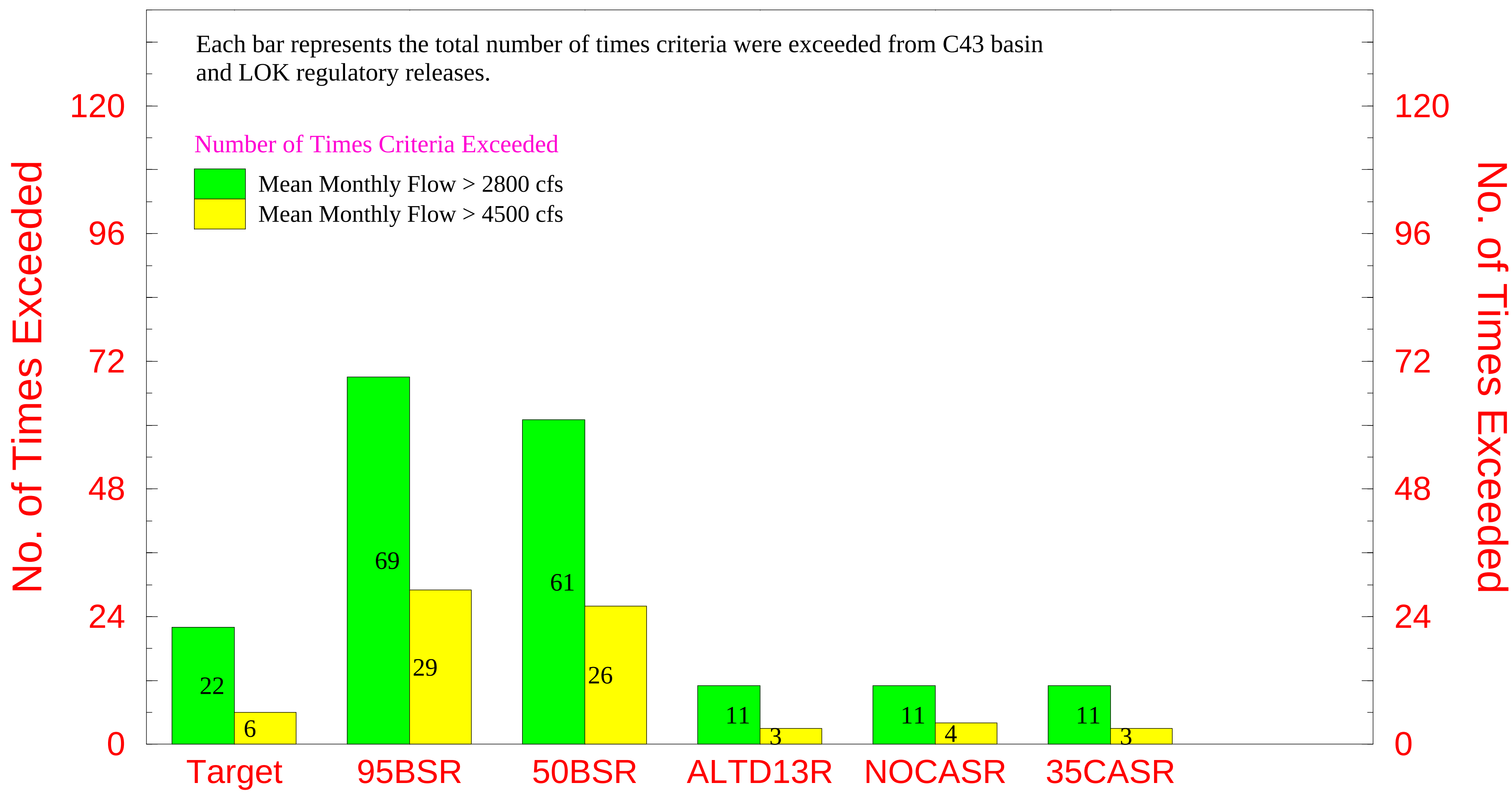

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Figure B.3-12 Lake Okeechobee Stage Duration Curves

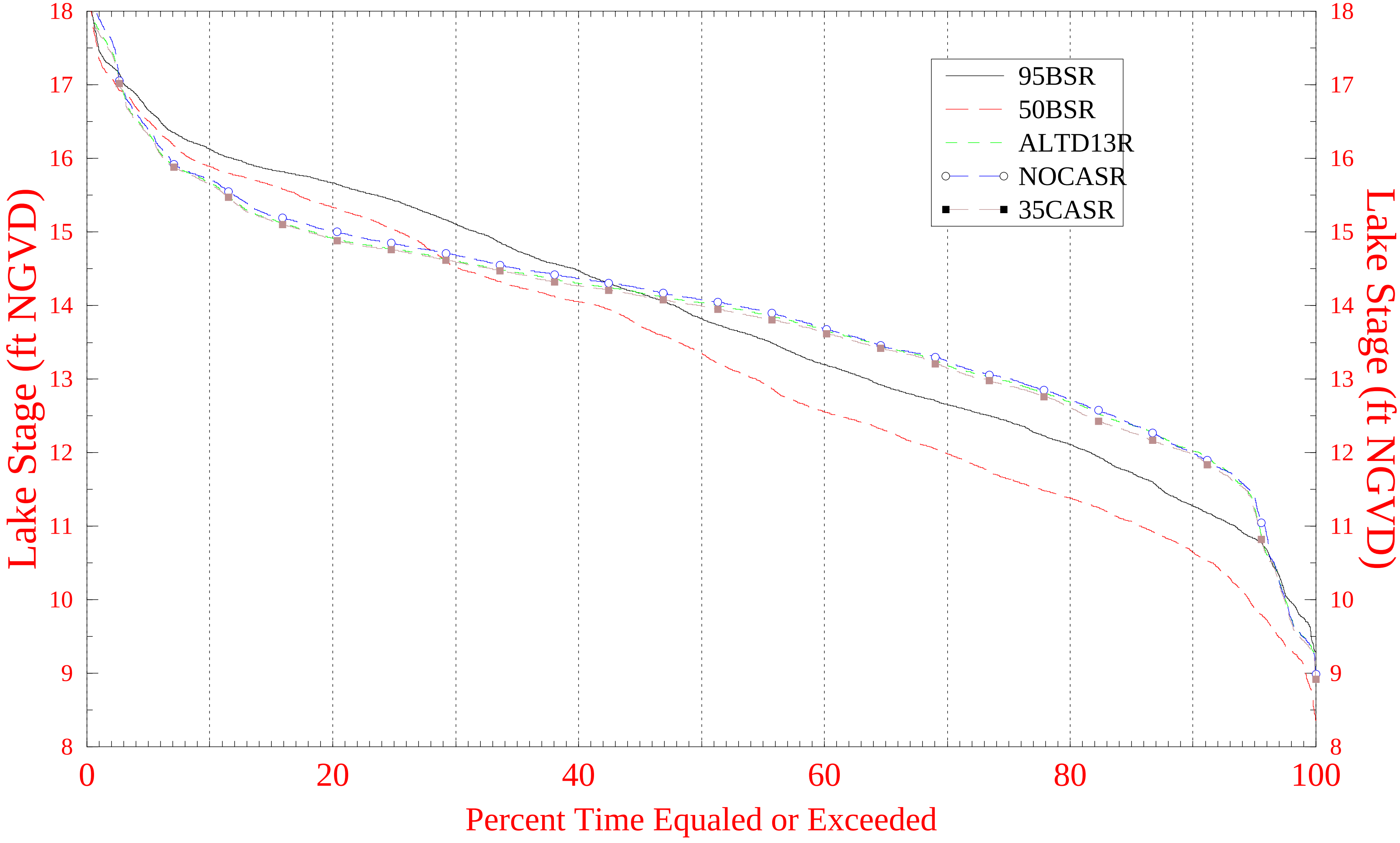

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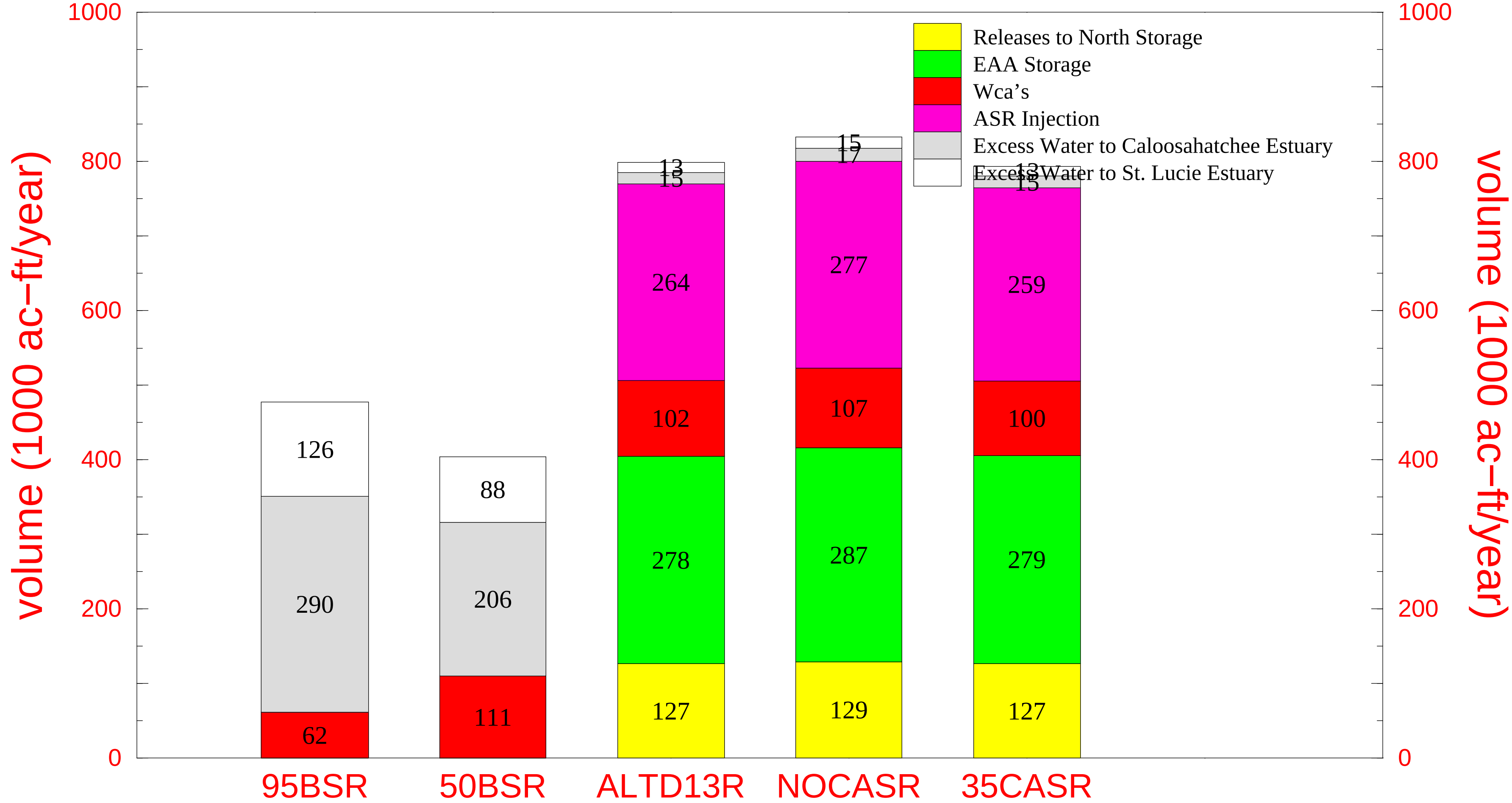
Figure B.3-13 Mean Annual Flood Control Releases from Lake Okeechobee for the 31 yr (1965 - 1995) Simulation



Note: Although regulatory (flood control) discharges are summarized here in mean annual values, they do not occur every year. Typically they occur in 2−4 consecutive years and may not occur for up to 7 consecutive years.

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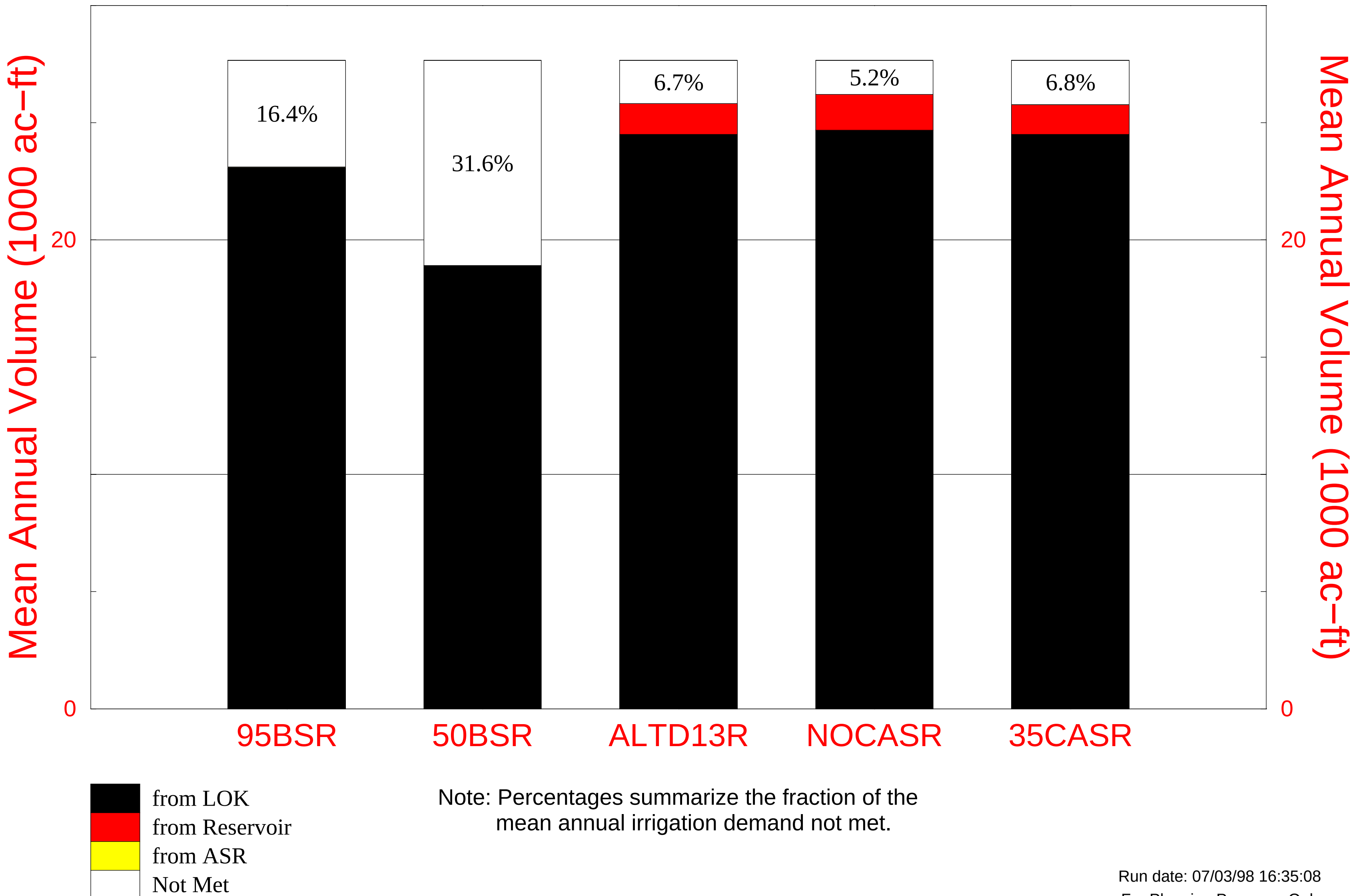
Figure B.3-14 C-44 Basin Regional Irrigation Supply and Demand Not Met

Means for the 1965 to 1995 Simulation Period



Note: Percentages summarize the fraction of the mean annual irrigation demand not met.

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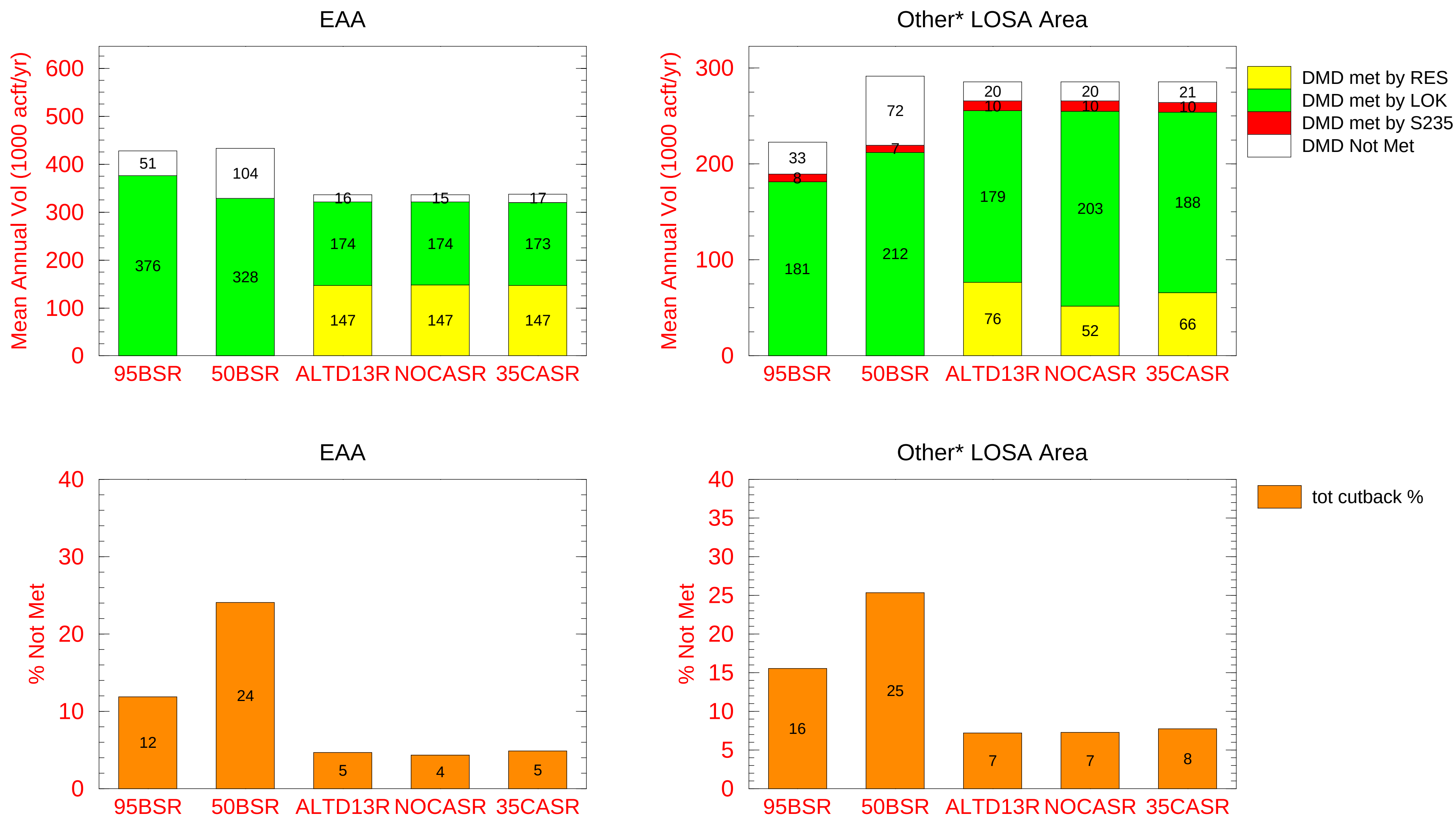
Figure B.3-15a Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met

for the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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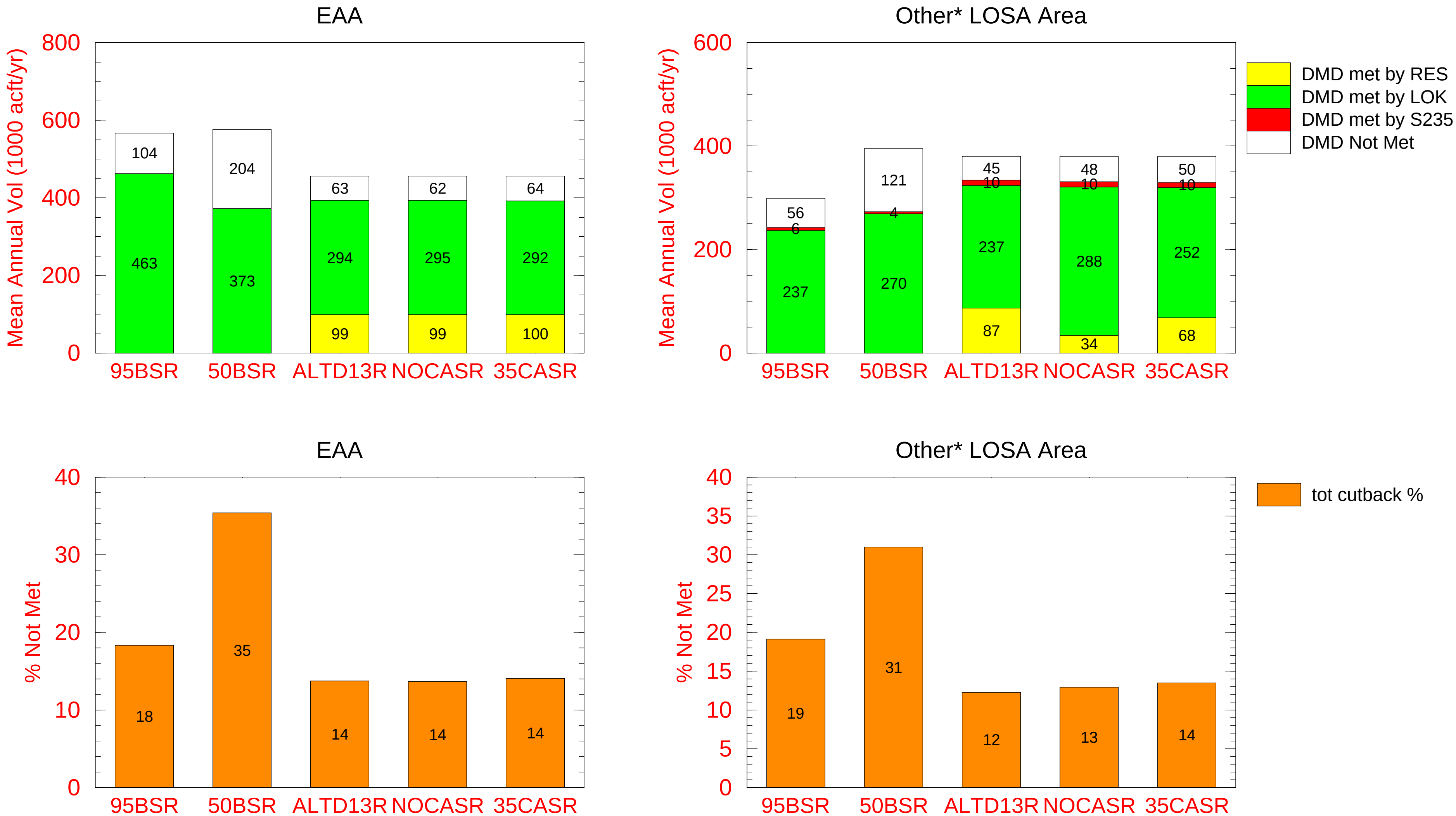
SFWMM V3.5

Figure B.3-15b Mean Annual EAA/LOSA Supplemental Irrigation: Demands and Demands Not Met for the Drought Years: 1971, 1975, 1981, 1985, 1989 within the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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B.3.5.2 Lake Okeechobee Aquifer Storage and Recovery

B.3.5.2.1 Description of Simulations

The objectives of this analysis are two-fold. The first objective is to estimate the portion of the benefits realized in ALTD13R (Restudy HPM Web Page, June 19, 1998) that are associated with the Lake Okeechobee ASR system. The second objective is to estimate the sensitivity of regional hydrologic system performance to the assumed recovery efficiency of this ASR system.

The proposed Lake Okeechobee ASR system in ALTD13R is composed of a 200-well wellfield, each having a pumpage capacity of 5 million gallons a day (MGD) for a total pumpage capacity of 1000 MGD. This pumpage capacity is assumed to be reversible so that maximum flow to and from the ASR system are equal. The reusable recovery efficiency is assumed to be 70 percent in ALTD13R. In the SFWMM (SFWMD, 1998), the efficiency of the ASR is measured so that the computed size of the freshwater aquifer storage (freshwater bubble created by injection) actually represents the available storage for reuse. In the sensitivity analysis the recovery efficiency is reduced by one-half, or to 35 percent. Key performance measures are compared for the 2050 Base Case, ALTD13R, ALTD13R without Lake Okeechobee ASR, and ALTD13R with reduced Lake Okeechobee ASR recovery efficiency.

B.3.5.2.2 Assumptions

Two SFWMM simulation runs were made:

1. ALTD13R with the removal of Lake Okeechobee ASR,

2. ALTD13R with Lake Okeechobee ASR recovery efficiency reduced from 70 (ALTD13R) to 35 percent in this model simulation.

B.3.5.2.3 Summary of Results

Performance measures graphics comparing selected model outputs are attached (***Figures B.3-16 – B.3-22***). The 2050 Base Case, ALTD13R, ALTD13R with no Lake Okeechobee ASR (NOASR) and ALTD13R with Lake Okeechobee ASR recovery efficiency reduced by one-half (REDEFF) are sequentially displayed on each plot. The major findings of this analysis are as follows:

- **Lake Okeechobee ASR Injection Volumes -**

The average annual injection volume for ALTD13R with a reduced ASR recovery efficiency was decreased from 263.6 kac-ft (ALTD13R) to 246.9 kac-ft (REDEFF). This represents a slight decrease of about 6 percent. This decrease is due to the lower water levels in the Lake, meaning less water available for injection. The logic of the model does not alter the injection of Lake water into the ASR as a function of ASR efficiency. The dry season to wet season injected volumes were split 55 percent/45 percent for both ALTD13R and REDEFF.

- **Lake Okeechobee and Lower East Coast Water Supply**

LOSA sub-areas experienced average annual shortages of about 25 percent in the 2050 Base. ALTD13R reduced these shortages to about 6 percent. Removing the Lake Okeechobee ASR increases the shortages to about 11 percent. When the recovery efficiency of the ASR is cut in half, the percentage of demands not met only decreases slightly from the no-ASR scenario (***Figure B.3-16***). During drought years the water shortages reduce from 33 percent in the 2050 Base to 13 percent with ALTD13R. Removing the Lake ASR only slightly increases the volume of water use demands not met for the selected drought years. This is because the Lake ASR storage is depleted during the drought years. The low efficiency ASR results in slightly worse performance than the NOASR scenario during drought years.

The marginal performance of the lower efficiency ASR (***Figure B.3-16*** and ***Figure B.3-17***) may be explained by comparing the average annual volume recovered to that injected for the two Lake ASR simulations. For the lower efficiency ASR the annual average recovery to injection ratio is 55.3/246.9 or a 22 percent actual recovery. (Note: the computed volume efficiency is less than the assumed efficiency because a large volume of ASR storage exists at the end of the simulation). The ratio for the higher efficiency ASR is 135.7/264.6 or about 51 percent. From another perspective, the annual volume gained from the low efficiency ASR (55 kac-ft) is about one-third of that lost (172 kac-ft), while for the more efficient ASR the average volume gained (136 kac-ft) is almost twice that which is lost (79 kac-ft). Of course, the 2050 Base and the ALTD13R with no ASR had no aquifer injection or recovery.

The number of LECSA water use cutbacks was substantially reduced with ALTD13R. In general, the number of cutback months for ALTD13R are less than 20 percent of those of the 2050 Base except for LECSA3 which was about 25 percent of the 2050 Base. Removing the Lake ASR from the ALTD13R reduced this overall benefit; however, the other components of this alternative still allowed significant decreases in cutback months. The number of cutback months were still less than one-third of the 2050 Base in all LEC Services Areas except LECSA3. The cutback months in LECSA3 were 47 percent of the 2050 Base. The reduced efficiency ASR is only slightly better than the Lake no-ASR simulation for reducing the number of months of cutbacks within the LEC Service Areas. ***Figure B.3-18*** summarizes the cutback months for each LEC Service Areas and for each model simulation. Note that locally-triggered cutback months were nearly the same for the three ALTD13R simulations except for a slight increase by one cutback in LECSA2 for the simulation without the Lake ASR.

- **St. Lucie and Caloosahatchee Estuaries**

ALTD13R reduced from 29 to 2 months where the St. Lucie and Caloosahatchee Estuary salinity criteria were not met due to high flows from the Lake. This is due to the redistribution of Lake regulatory discharges away from the estuaries and to other outlets as illustrated in ***Figure B.3-19***. ALTD13R had only six months where the St Lucie Estuary salinity envelope criteria were violated due to high flows from the Lake. A similar pattern of results was obtained for the Caloosahatchee Estuary. Without the Lake ASR, the number of Zone A discharges to the Caloosahatchee Estuary more than tripled (31 to 95 days), and discharges to the St. Lucie Estuary more than doubled (24 to 65 days). Finally, as would be expected, the lower efficiency ASR was just as effective as the high efficiency ASR in reducing the large, high impact discharges to the estuaries. Additionally, the number of days with high impact Zone A discharges was the same or slightly less for the low efficiency ASR. These performance measures are summarized in ***Figure B-3-20a*** and ***B.3-20b*** for the St. Lucie and Caloosahatchee Estuaries respectively.

- **Lake Okeechobee Littoral Zone**

ALTD13R reduced the number of undesirable Lake water levels from 12 events (2050 Base) to 4 events (ALTD13R). This alternative was especially effective in reducing the large number of undesirable low water levels events of less than 11 feet NGVD from 7 (2050 Base) to 1 (ALTD13R). When the ASR is removed from the Lake (NOASR), the overall number of undesirable events increased from 4 to 9. However, only two of these events are associated with extended periods of Lake water levels below 11 feet. The lower efficiency ASR performs similar to the higher efficiency ASR in terms of reducing the undesirable events for Lake Okeechobee. It does contain one additional event associated with extended periods of Lake water levels below 11 feet. These results are summarized in ***Figure B.3-21***.

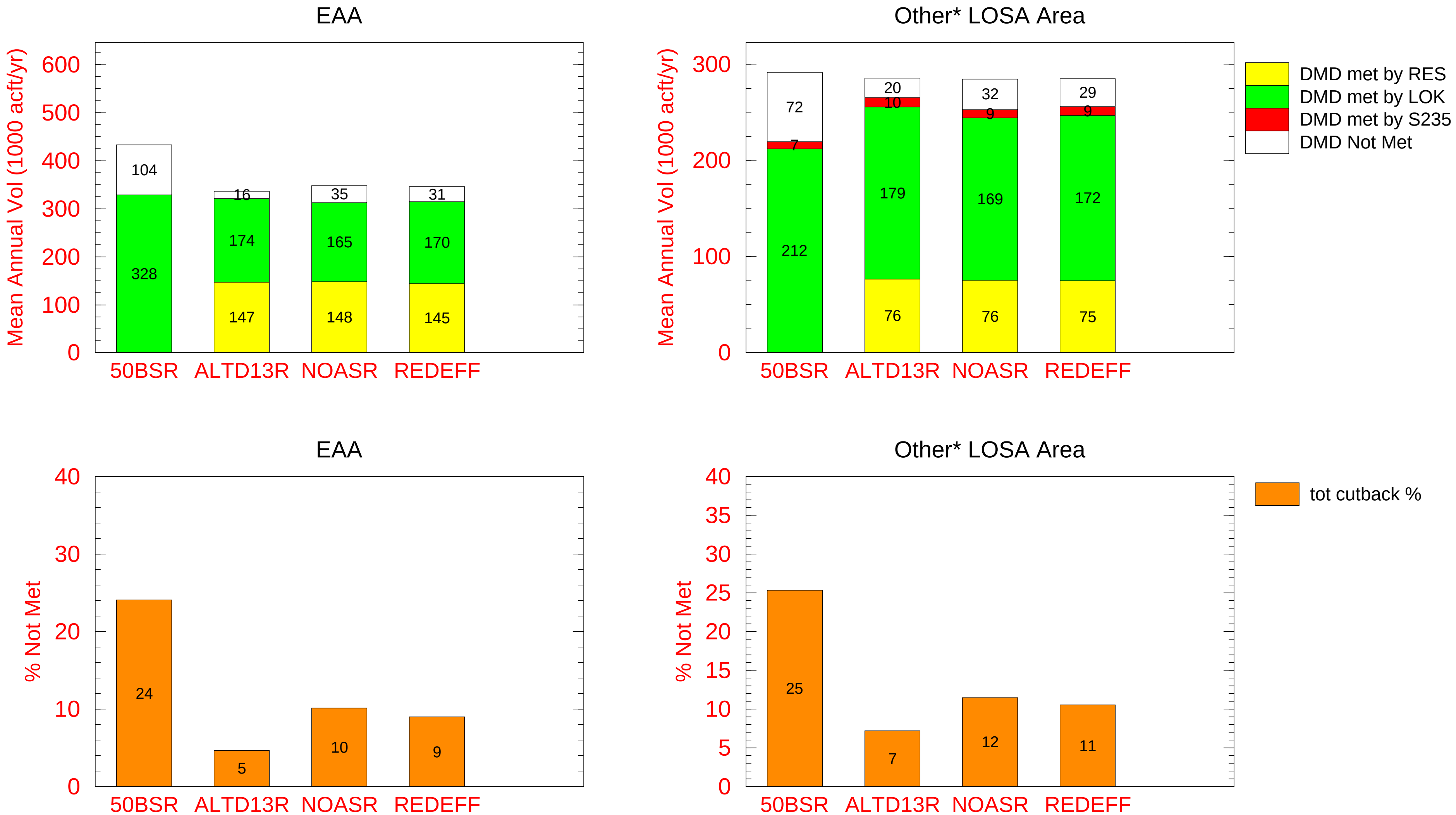
- **Everglades National Park**

ALTD13R significantly improves the spatial distribution of flows to ENP compared to the 2050 Base. Removing the Lake ASR increases this magnitude slightly due to the increase in regulatory releases from the Lake to the Everglades. ***Figure B.3-22*** summarizes the changes in annual average flow across Tamiami Trail for each simulation. NESRS (Indicator Region 11) had a significant reduction in the number of undesirable low water events and average duration of each with ALTD13R. Nine events (2050 Base, average duration 6 weeks) of undesirable low water level was reduced to 3 events (ALTD13R, average duration 2 weeks). Removing the Lake ASR (NOASR) reduced the undesirable low water events by 1 from ALTD13R. The average annual flows from the Lake to the Everglades were 161.6, 149.4, 144.6, and 151.2 kac-ft for the 2050 Base, ALTD13R, NOASR, and REDEFF model simulations, respectively. Flows from the EAA storage reservoirs were 0.0, 273.6, 245.4 and 263.4 kac-ft for the same set of model simulations.
Figures 1-7 go here Figure 1 or 7

Figure B.3-16 Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met

for the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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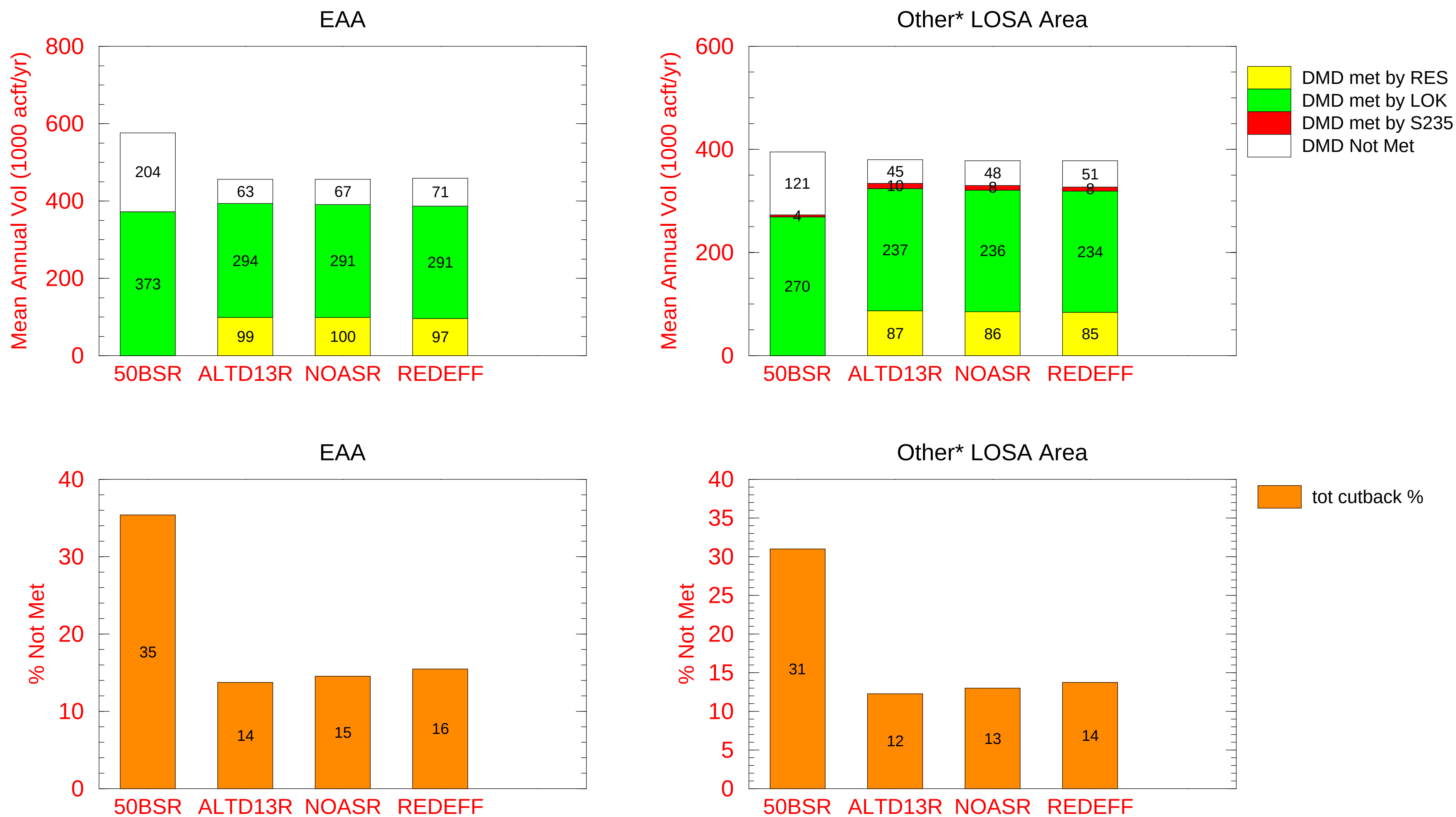
Figure B.3-17 Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met for the Drought Years:

1971, 1975, 1981, 1985, 1989 within the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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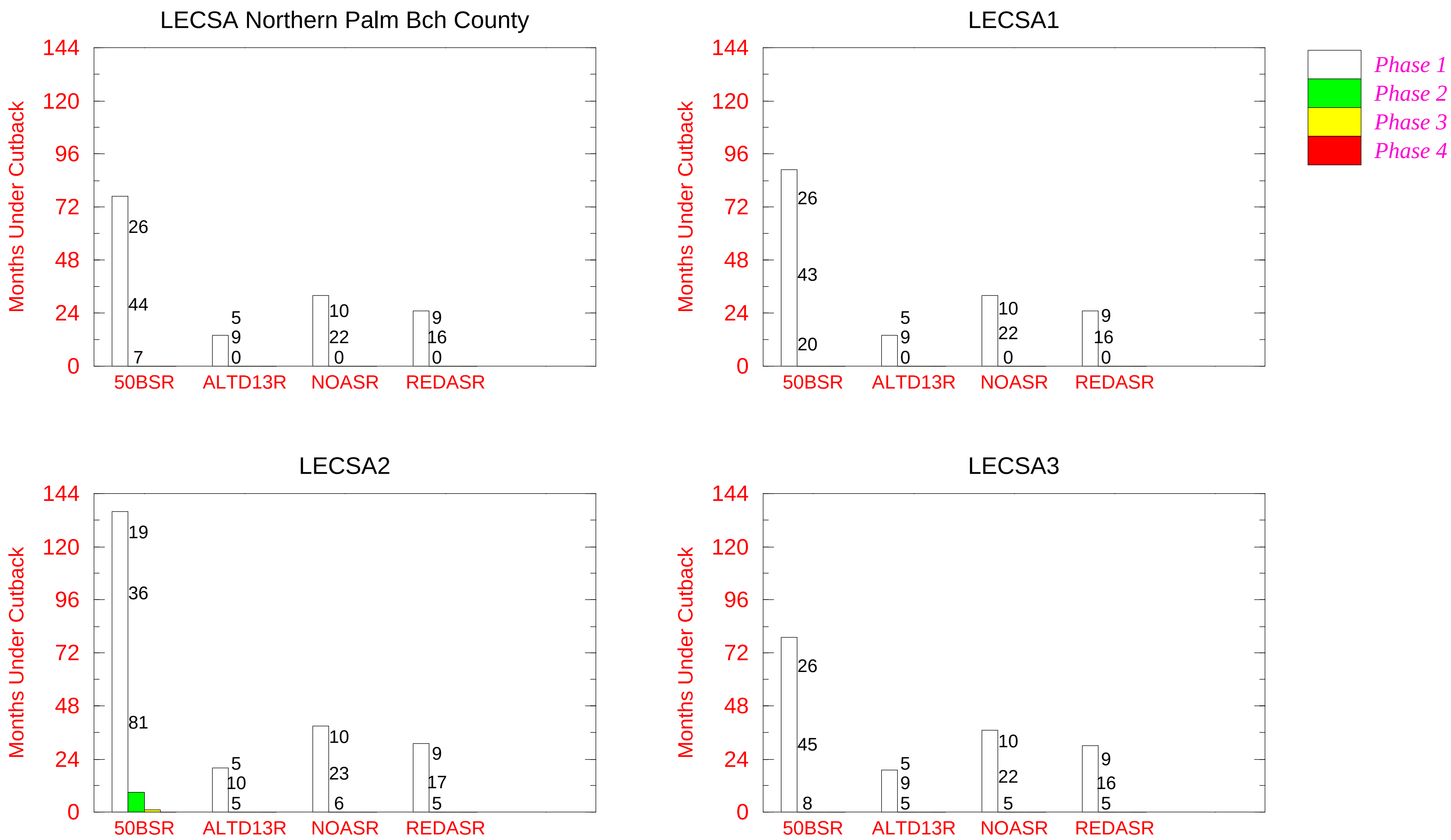
Figure B.3-18 Number of Months of Simulated Water Supply Cutbacks for the 1965 - 1995 Simulation Period



Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).

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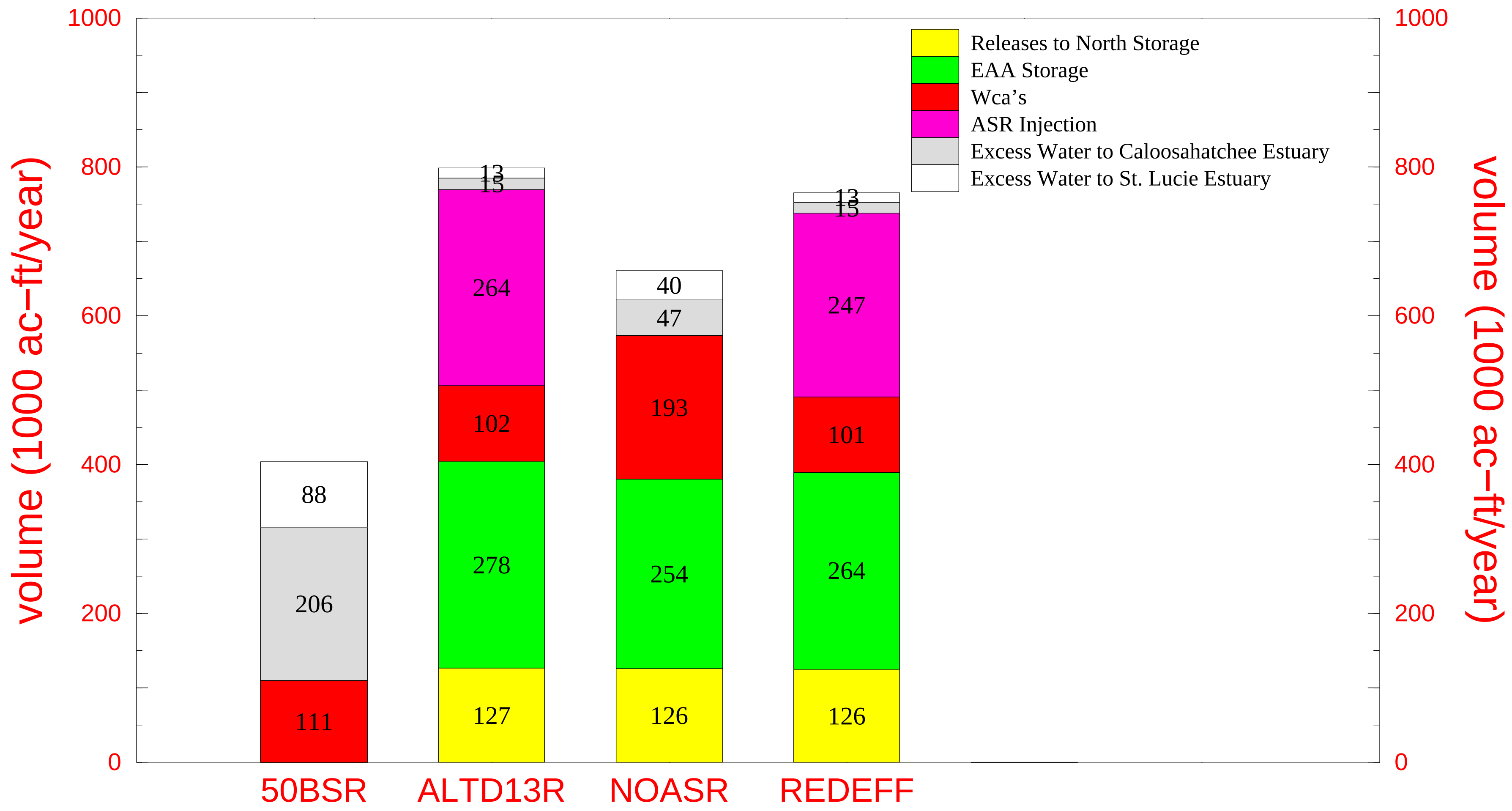
Figure B.3-19 Mean Annual Flood Control Releases from Lake Okeechobee for the 31 yr (1965 - 1995) Simulation



Note: Although regulatory (flood control) discharges are summarized here in mean annual values, they do not occur every year. Typically they occur in 2−4 consecutive years and may not occur for up to 7 consecutive years.

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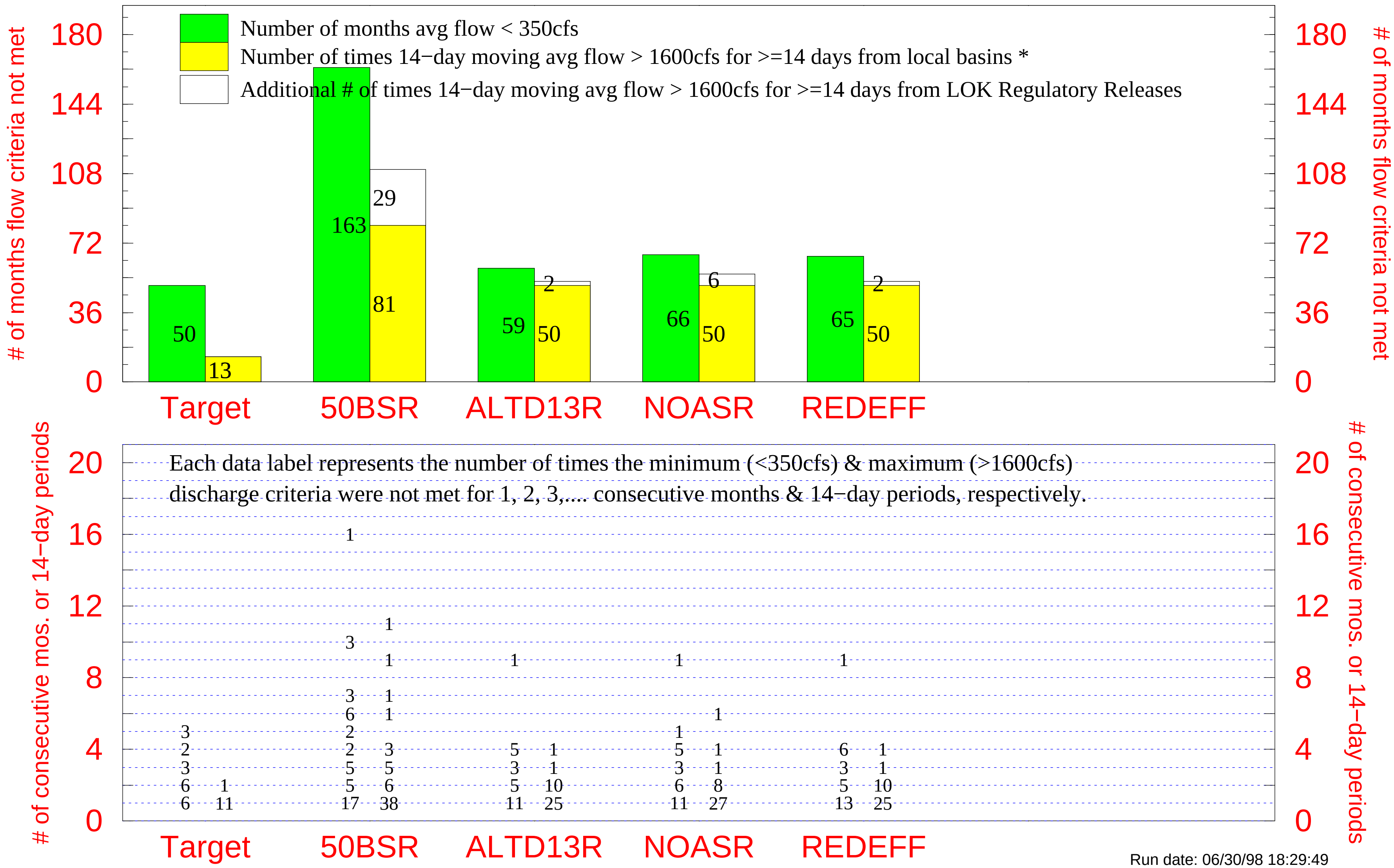
Figure B.3-20a Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary



Note: local basins include the C−44, C−23, C−24, North Fork, and South Fork Basins

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Figure B.3-20b Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary (mean monthly flows 1965 - 1995)

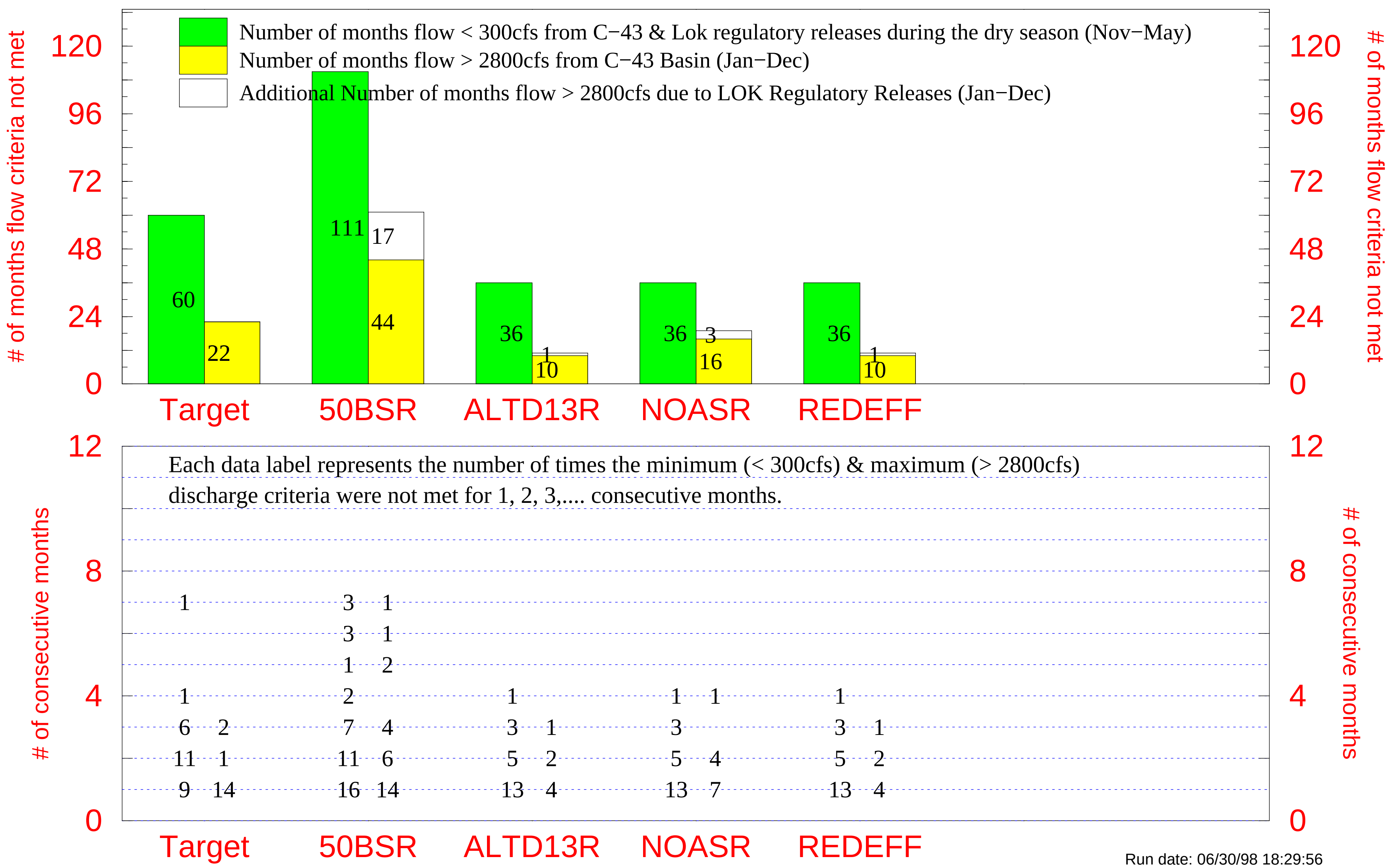

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Figure B.3-21 Number of Undesireable Lake Okeechobee Stage Events

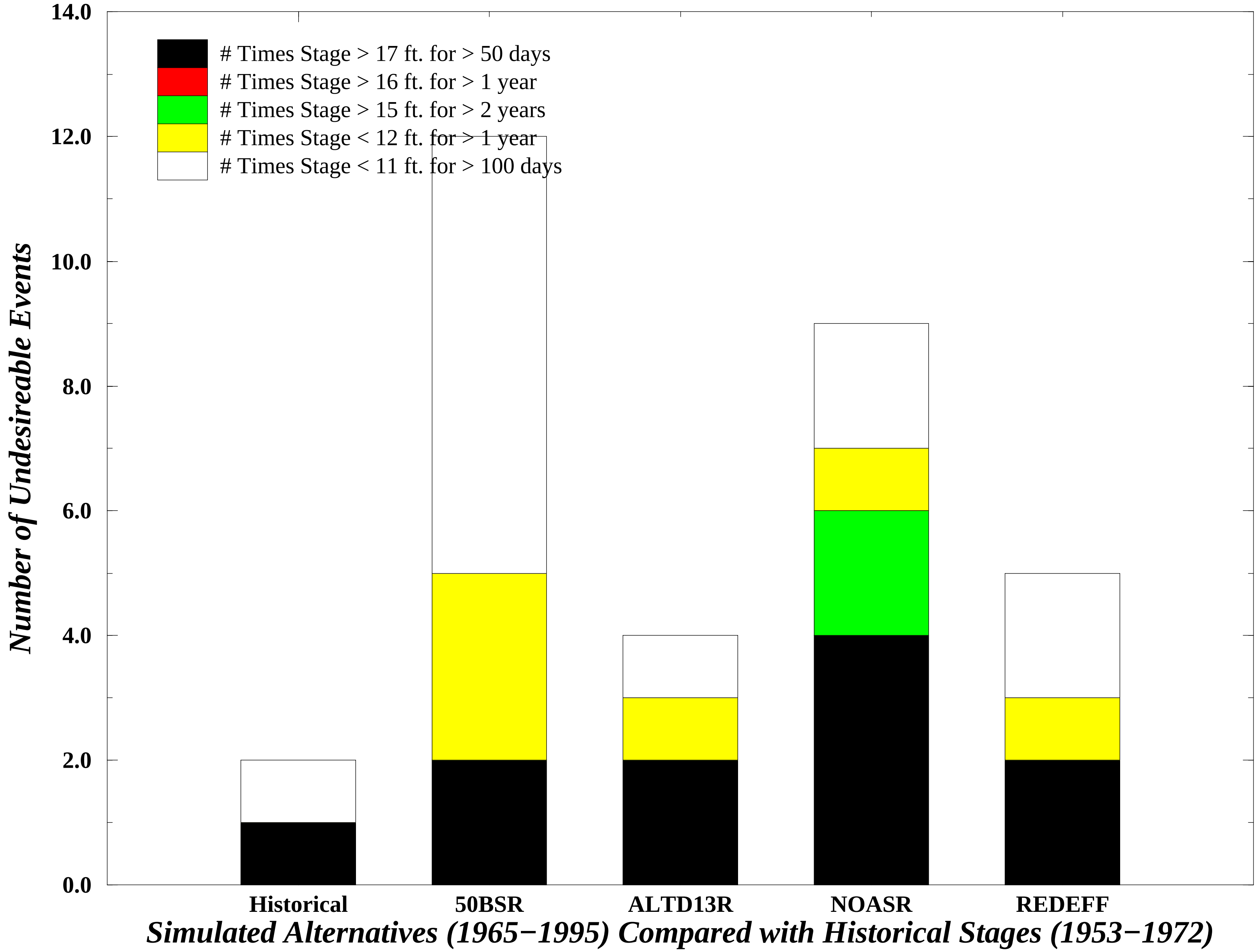
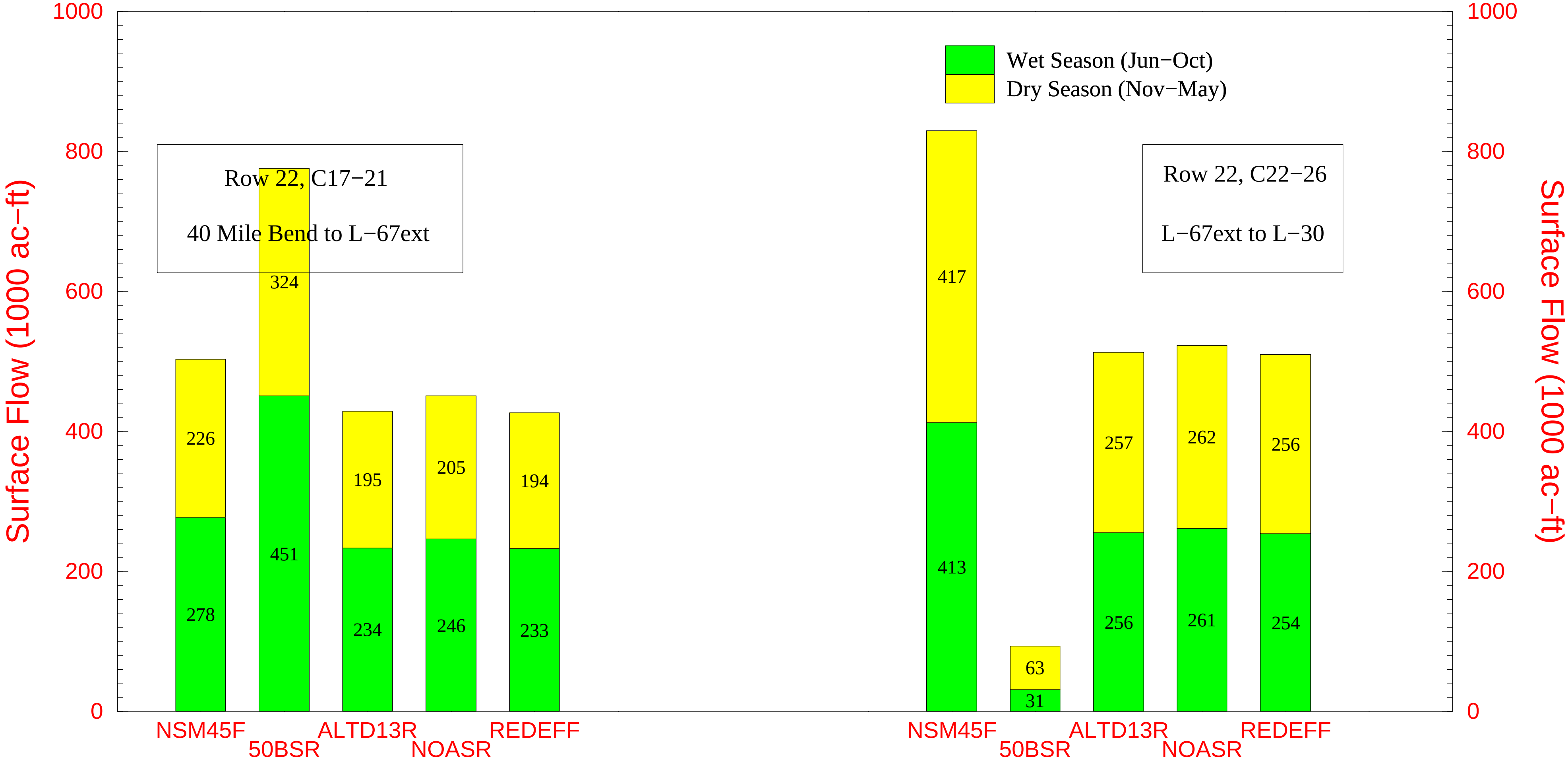


Figure B.3-22 Average Annual Overland Flows to ENP South of Tamiami Trail, West & East of L-67ext for the 31 year simulation period



Note: Flow represents overland flows for cells Row 22 Columns 22 thru 26. NSM water depths at key ENP gage locations are used as operational targets for most alternatives. NSM flows are NOT targets and are shown for comparative purposes only.

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B.3.5.3 Everglades Agricultural Area Storage Reservoirs

B.3.5.3.1 Description of Simulations

The simulated scenarios for reservoirs in the EAA were performed to investigate the sensitivity of the regional system to changes in the configuration and size of the EAA reservoir component, as defined for ALTD13R of the Restudy.

B.3.5.3.2 Assumptions

Note that this sensitivity analysis is performed with the assumption that all the components proposed in ALTD13R are in place and fully operational. Other components of the system in ALTD13R, particularly Lake ASR, increase the system's total storage capacity such that impacts of changes in the EAA reservoirs on key performance indicators are minimized. Because of the uncertainty attributed to some of the components proposed in ALTD13R, decisions or interpretations with regard to the importance of the EAA reservoir component or any part thereof must be made with caution. The simulated impacts of changes in EAA reservoir(s) are highly dependent on the state (condition governed by existing and/or proposed operating policies) of the rest of the system in the simulation. The same is true for all the other components analyzed.

All the simulations related to the EAA reservoirs were derived from ALTD13R input data by modifying the size or by completely removing one or more reservoir compartments in the EAA (Component G5). ***Table B.3-2*** summarizes the conveyance capacity factors for the canals north of the reservoir(s), and the configurations for the reservoirs in each simulation. Compartment 1 supplies water for EAA irrigation requirements only. Compartment 2A provides for environmental demands. If no environmental demands are imposed on 2A then it provides for EAA irrigation demands not met by Compartment 1. Compartment 2B provides only for environmental demands. Compartments 2A and 2B are also known as the surge tanks. The outflow from the surge tanks for environmental demands is routed through STA 3 and 4 before entering WCA-3A. A total of four scenarios were simulated and compared to ALTD13R.

Table B.3-2. Scenario Definitions for the EAA Reservoirs Sensitivity Analysis

Run Legend	Canal Conveyance Factor [1]		Compartment Surface Areas (acres)		
	Miami Canal	NNR Canal	1	2A	2B
ALTD13R	3.0	3.0	20,000	20,000	20,000
SGT4020	3.0	3.0	20,000	40,000	20,000
SGT1x20	3.0	3.0	20,000	20,000	0
EAARS	1.0	2.0	20,000	0	0
NEAARS	1.0	2.0	0	0	0

1 = Canal conveyance factor applies only for the portion of the canals north of the reservoir(s) that convey excess Lake Okeechobee water to appropriate reservoir(s).

For the scenarios where Compartments 2A and 2B do not exist, the canal conveyance factor corresponds to the flow-through capacity for discharges from Lake Okeechobee to the Everglades Protection Area (EPA). The flow-through capacity is the same for all the simulations.

Two of the four scenarios (SGT4020, SGT1x20) involve changing the size of the surge tanks only as indicated in ***Table B.3-2***; no major functional component is removed. It is important to note that Compartment 2A, which is the surge tank used first for excess Lake water, increases 20,000 acres in SGT4020 simulation. Compartment 2B, which is used less often, is removed in the SGT1x20 simulation. The EAARS simulation completely removes the surge tanks altogether. The NEAARS simulation takes a step further by removing Compartment 1 as well, hence, no EAA reservoirs remain.

All reservoirs were kept to maximum depth of six feet. In each case, the addition or removal of 20,000 acres of reservoir surface area generates the conversion of modeling cells to wetland or sugar cane land use types, respectively. When a given reservoir is removed, associated inflow and outflow control structures and internal canals are also removed.

Summary of Results

In this analysis, the simulated scenarios are compared with ALTD13R. Significant findings unique to each scenario will be presented first, then findings common to other scenarios will be presented.

1. Increasing the size of Compartment 2A (north surge tank) from 20,000 acres (ALTD13R) to 40,000 acres (SGT4020) results in the following:

- Increase in the diversion of Lake Okeechobee excess water to the surge tanks by about 40 kac-ft/year (***Figure B.3-31***). The additional storage in the surge tanks translates to 28 kac-ft/year increase in outflow from the surge tanks to meet Everglades needs (***Table B.3-4).***
- Slight decrease (10 kac-ft/year) in environmental water supply releases from Lake Okeechobee (***Table B.3-4*** and ***Figure B.3-28***).
- Decrease in EAA runoff south from 610 to 579 kac-ft/year (***Table B.3-4***) and a decrease in LOK water supply volumes, from 174 to 160 kac-ft/year, in meeting EAA demands due to the decrease in the EAA production area.
- Decrease in injection volumes into LOK ASR from 264 to 249 kac-ft/year as a consequence of the increase in diversion of excess LOK water to surge tanks (***Table B.3-4*** and ***Figure B.3-31***), which decreased stages in LOK (<0.05 ft) enough to marginally decrease the opportunity for ASR injection.

2. Removing Compartment 2B (south surge tank) from ALTD13R results in the following:

- Decrease in the diversion of excess Lake Okeechobee water to EAA storage from 278 to 258 kac-ft/year (***Figure B.3-31***). The 20 kac-ft/year decrease in inflow of LOK water resulting from the removal of Compartment 2B is less than the 39 kac-ft/year increase in inflow of LOK water into EAA storage as a result of increasing the size of Compartment 2A by the same acreage (20,000 acres). This is because Compartment 2A is first priority in receiving excess LOK water and is utilized more often.
- Slight increase by7 kac-ft/year in environmental water supply releases from Lake Okeechobee (***Table B.3-4***).
- Increase in EAA runoff south from 610 to 641 kac-ft/year (***Table B.3-4***) and in LOK deliveries to meet EAA demands from 174 to 182 kac-ft/year due to the 20,000 acre increase in the EAA production.
- No change in injection of LOK water into ASR compared to ALTD13R. The 20 kac-ft/year decrease in the diversion into EAA storage of excess LOK water is largely offset by the increase in LOK releases for environmental water supply and in meeting EAA demands. This results in an insufficient change in LOK storage (or stage) to increase the duration of injection of LOK water into ASR wells.

Thus far the analyses have only involved changing the total area of the surge tanks without removing major components that would significantly affect the storage capacity of the EAA reservoir system. No significant system-wide performance gains or losses were obtained from increasing Compartment 2A size from 20,000 to 40,000 acres or from removing Compartment 2B. Varying the size of the surge tanks produced no change in percent of demand not met in EAA (***Figures B.3-33 and B.3-34***). In general, a decrease in the storage capacity of the surge tanks generated a slight increase in flows to WCA-3A, hence, to the ENP (***Tables***

B.3-4 and ***B.3-5***). However, this does not significantly affect the monthly distribution (timing) of overland flow in northern WCA-3A (***Figure B.3-38*** and ***B.3-39***) or in the ENP (***Figures B.3-40*** and ***B.3-41***).

3. The next scenario run removes Compartments 2A and 2B (EAARS). The total storage capacity of the EAA reservoir is significantly reduced. In addition, the ability to remove excess LOK water is also significantly reduced. The significant findings for the EAARS simulation are the following:

   - The EAARS produces the highest stages in Lake Okeechobee than any of the other scenarios (***Figure B.3-26***). The average increase in LOK stage is about 0.25 feet with a maximum increase of 0.5 feet during drought years when compared to ALTD13R. The main reasons for this are: (1) elimination of releases of excess LOK water to the surge tank(s), which averaged over 250 kac-ft/year (Figure B.3-31), in conjunction with (2) Compartment 1 providing approximately 150 kac-ft/year in meeting EAA demands. The diversion of excess LOK water to the surge tanks in ALTD13R occurred before ASR injection. As a consequence of reducing the capacity of the system to remove excess water from LOK, the LOK stages are forecasted to rise above the ASR injection line more often. This increases the volume injected into ASR wells from 264 kac-ft/year (ALTD13R) to 333 kac-ft/year with surge tanks removed (***Figure B.3-31*** and ***Table B.3-4***). Since most of the water injected into the ASR is assumed to be retrievable, more storage is available during dry times for meeting demands, hence, keeping stages in LOK higher. For example, ***Figure B.3-32*** shows a comparison of annual injections and recoveries for the Lake Okeechobee ASR component (SGT1x20 and EAARS). The EAARS not only stores more water in ASR, but also provides more water from ASR to Lake Okeechobee during the years 1977, 1981, and 1990. Note that this is when the ASR in SGT1x20, and most likely the other simulations with surge tanks could not supply any water. As expected, EAARS exhibits the largest mean LOK ASR recovery volume for the drought years (***Table B.3-4***) since the opportunity for ASR injection is the greatest.
   - The higher Lake Okeechobee stages produced in EAARS reflected into higher stages for the North Storage, C-44, Taylor Creek-Nubbin Slough reservoirs, and slightly higher stages in the C-43 reservoir (Figures B.3-42 to B.3-45). The higher stages for North storage, C-44, and C-43 reservoirs are largely a result of the increased opportunity for excess Lake Okeechobee water to be routed to these reservoirs. In addition, backpumping volumes from the C-43 reservoir to Lake Okeechobee, which occurs only when LOK stage is below the pulse zone, decreases slightly (153 kac-ft/year in ALTD13R to 148 kac-ft/year in EAARS) due to the increased stages in Lake Okeechobee. This decrease in C-43 reservoir backpumping contributes to the increase in stages in C-43 reservoir relative to ALTD13R. Similarly, the increase in stages in the Taylor Creek-Nubbin slough reservoir is due to a decrease in outflow from

the reservoir to Lake Okeechobee (93 to 81 kac-ft/year) because LOK stages in EAARS are below the maximum threshold for outflow from the reservoir less often.

- The number of undesirable Lake Okeechobee stage events having stages below 11.0 feet for longer than 100 days increased from 1 to 2 (Figure B.3-30). This is a misleading statistic, however. The reason for this increase is that EAARS breaks another event lasting from May 1981 to June 1982 in the other simulations into two events below 11.0 feet.
- For water supply to Lake Okeechobee service areas, this scenario performs best. The percent of demand not met for the EAA decreased from 5 percent for simulations with surge tanks, including ALTD13R, to 3 percent in EAARS for the entire simulation period. During the drought years, the percentage decreases from 14 percent for simulations with surge tanks to 9 percent for EAARS(Figures B.3-33 and B.3-34).
- The total number of cutback months triggered by the Lake and by the dry season criteria decreased by 50 percent for all service areas (Figure B.3-35). In response to the decrease in regionally triggered cutbacks, the number of locally triggered cutback months increased by one in Service Area 2.
- The dependence on Lake Okeechobee for environmental water supply to the Everglades increased significantly. The volume of LOK environmental water supply releases increased from 149 kac-ft/year in ALTD13R to 296 kac-ft/year in EAARS (***Table B.3-4***). Additionally, LOK water supply volumes to meet EAA demands increased from 174 to 204 kac-ft/year (***Table B.3-4***) due to the elimination of Compartment 2A and the increase in EAA production area due to the removal of the surge tanks. Compartment 2Aprovided 5 kac-ft/year for meeting EAA demands.,. The average total water supply delivery from Lake Okeechobee to EAA and Everglades increased from 323 kac-ft/year in ALTD13R to 500 kac-ft/year for the simulation period, an increase of 177 kac-ft/year (***Table B.3-4***). However, the diversion of excess water to the surge tanks from LOK (***Figure B.3-31***) averaged 278 kac-ft/year in ALTD13R, which no longer occurs in EAARS. The decrease in outflows from LOK to EPA is evident in ***Figure B.3-27***. The Miami Canal (S-354) was used first in delivering excess water to the EAA surge tanks. As a result, nearly 90 percent of the excess water was delivered to the surge tanks via the Miami Canal through S-354. Thus, S-354 flows were effected much more from the removal of the surge tanks.
- In going from ALTD13R to EAARS, Lake Okeechobee flood control releases to the St. Lucie Estuary, Caloosahatchee Estuary, and WCAs increase by 4 (21 percent), 5 (32 percent) and 13 kac-ft/year (13 percent), respectively (Figure B.3-31). The elimination of Lake Okeechobee flood control releases to the EAA surge tanks (278 kac-ft/year) is compensated mainly by large increases in environmental releases to the Glades (147 kac-ft/year), in LOK ASR injection (69 kac-ft/year), in supplemental irrigation to the EAA (20 kac-ft/yr), in flood control releases (21 kac-ft/year) and in Lake evapotranspiration (12

kac-ft/year). The increase in evapotranspiration is a consequence of the increases in Lake stage.

- Total volumes of upstream inflow into the EPA are the lowest in EAARS. The total flow is 1091 kac-ft/year (EAARS) compared to 1135 kac-ft/year (ALTD13R, ***Table B.3-4*** and ***Figure B.3-28***). The increase in EAA runoff south and in LOK environmental water supply volumes totaling 217 kac-ft/year does not fully compensate for the elimination of environmental water supply releases from the EAA reservoirs provided in ALTD13R (See ***Table B.3-4***).
- The decrease in total structural inflow into the EPA and overland flow volumes across the EPA (***Tables B.3-4*** and ***B.3-5***, ***Figures B.3-39 – B.3-41***) translates to slightly lower stages for several of the indicator regions in the EPA (***Figures B.3-23*** and ***B.3-24*** and ***Table B.3-3***). The lowering of weekly stages never exceeds 0.1 feet on average as indicated in ***Figures B.3-23*** and ***B.3-24.***

4. The last scenario, called NEAARS, completely removes all compartments of the EAA reservoir. The EAA production area is similar to the future without project condition. The consequences of this are the following:

- Significant increases in the EAA runoff south. The EAA runoff south increases from 610 kac-ft/year (ALTD13R) to 870 kac-ft/year (NEAARS, ***Table B.3-4***). This increase was the result of transforming 60,000 acres of reservoir back to agricultural land and removing the diversion of EAA runoff to Compartment 1, which was removed in the NEAARS simulation.
- Significant increase in the dependence on LOK for environmental water supply deliveries. The volume of the deliveries increased from 149 kac-ft/year (ALTD13R) to 251 kac-ft/year (NEAARS). The increase in environmental releases in NEAARS is not as great as in EAARS, mainly because the EAA runoff south is so much greater in NEAARS (200 kac-ft/year greater) due to the removal of Compartment 1, that the demand for environmental water supply deliveries decrease slightly (See ***Table B.3-4***).
- The removal of Compartment 1 increases the percentage of mean annual demand not met in the EAA from 5 percent (ALTD13R) to 8 percent (NEAARS, Figure B.3-33). During the drought years, the percentage increased from 14 to 19 percent (Figure B.3-34). The corresponding figures for the 95 Base are 12 percent for the simulation period and 18 percent during the drought years. In NEAARS, Lake Okeechobee is the sole source of water supply to the EAA. The LOK deliveries in meeting EAA demands more than doubles from 174 kac-ft/year (ALTD13R) to 357 kac-ft/year (NEAARS). As a result, LOK stages significantly decrease (approx. 0.5 feet) during dry periods (Figure B.3-26), thus increasing the demand not met in the Lake Okeechobee service area.

- The total inflow to the EPA is the highest in this scenario (***Table B.3-4*** and *Figure B.3-28*) largely due to the increase in the EAA runoff volume south. The total inflow increases from 1,135 kac-ft/year (ALTD13R) to 1225 acre-ft/year, an increase of 90 kac-ft/year into WCA-3A. The stages in eastern WCA-3A increase about 0.1 to 0.2 ft during wetter times (***Figure B.3-23***). The increase in overland flow in northern WCA-3A compared to ALTD13R occurs in the wet season which reflects the timing of the substantial increase in EAA runoff south (***Figures B.3-38*** and ***B.3-39***). However, during the early part of the dry season (October – December), the overland flow volumes in northern WCA-3A are slightly less than the volumes in the simulations with surge tanks (ALTD13R, STG4020, and STG1x20). This is because NEAARS depends solely on Lake Okeechobee for environmental water supply, while ALTD13R, STG4020 and STG1x20 have storage available in the surge tanks, in addition to Lake Okeechobee during the early dry season for environmental water supply deliveries. The effects of these on stages are evident in Indicator Region 17 (south central WCA-3A), where the average duration of high water violations (>2.5 ft. depth) increases from 9 to 11 weeks due to the increased EAA runoff into WCA-3A. Additionally, the average duration of low water violations (<-1.0 ft. depth) also increase from 2 to 4 weeks (***Table B.3-3***). Moreover, the number of low water violations in the northwest corner of WCA-3A (Indicator Region 22) increases by one (5 to 6) and the average duration of low water violations increases from 3 weeks (ALTD13R) to 5 weeks (NEAARS).
- Due to the remoteness of these indicator regions, they do not receive the benefits of increased storage in areas such as the Central Lake Belt region during the dry periods. ***Table B.3-3*** also shows that for eastern WCA-3A (Indicator Region 19), there are 27 events with an average duration of 12 weeks of high water in ALTD13R; and 30 events with an average duration of 12 weeks of high water in NEAARS . The increased volumes of water into WCA-3A get diverted into Central Lake Belt Storage for use during dry periods (***Figure B.3-25*** and ***Table B.3-4***). Farther south, inflows into the ENP with the help of Central Lake Belt storage, increase in the dry season as well.
- The monthly distribution or timing of flows into the ENP is similar to ALTD13R. The result is a 5 percent increase (46 kac-ft/year) in overland flow across Tamiami Trail and 10 percent (26 kac-ft/year) increase in S-356 A & B flows (***Table B.3-4***). The increased flows into NESRS raised water levels in NESRS during dry times (***Figure B.3-24*** and ***Table B.3-3***, Indicator Region 11).
- The total number of LECSA cutback months triggered by Lake Okeechobee and dry season criteria increased from 15 to 40 for the simulation period (***Figure B.3-35***).

5. Findings common to some or all of the scenario simulations are the following:

- The following performance indicators and components of the system in ALTD13R show practically no sensitivity to changes in EAA reservoir: (1) Biscayne Bay flows, (2) LECSA discharges to tide, and (3) regional water supply deliveries to the LEC service areas, but the total number of water restrictions for all LEC service areas increase.
- With the exception of the releases to the EAA reservoirs and to ASR, the inclusion or exclusion of EAA reservoirs does not have a major effect on the magnitude of other flood control releases from Lake Okeechobee. For examples, to the estuaries, to the WCAs, nor to the North Storage facility (Figure B.3-31).
- The performance of Compartment 1 is basically independent of the other two compartments, since they contribute only 1 to 2 percent of the EAA demands. Compartment 1 has priority in meeting EAA demands. Changes in the EAA production area contribute to the variations (138 kac-ft/year in SGT4020 to 149 kac-ft/year in EAARS) in the mean outflow from Compartment 1. The variations in outflow are quite small, since the storage capacity of Compartment 1 does not vary. Note that the Lake Okeechobee deliveries that back up the EAA reservoir in meeting EAA demands vary more (***Table B.3-4***) as a result of the variations in EAA production area, as expected.
- The number of St. Lucie Estuary low-flow criteria exceedances decrease slightly in comparison of ALTD13R to EAARS (***Figure B.3-36***). The decrease is noted by the number of months average flow is less than 350 cfs and is due to higher LOK stages. The number of estuary high-flow criteria exceedances does not change for the St. Lucie Estuary for any scenario.
- The performance of the Caloosahatchee Estuary in terms of low and high flow violations does not change for any simulation when compared to ALTD13R. Only in EAARS does the number of months for which average flows exceeds 2800 cfs decreased from 10 to 9 (***Figure B.3-37***). The change is in events lasting 1 consecutive month only.
- The number of undesirable stage events for Lake Okeechobee remains the same for all of the simulations (***Figure B.3-30***) excepting EAARS, which was discussed earlier.
- This analysis was performed from a hydrologic perspective. The ecological effects of the hydrologic changes in the EAA reservoir system should be assessed to determine their significance.
- The EAA reservoir components are part of a complex system with many components. In general, the Central and South Florida Project is highly complex and interdependent. Although a component is a separate entity, such as the EAA reservoirs, other components in the system respond to changes to a particular component. Changes in the configuration or operations for the EAA reservoir system, which interacts heavily with Lake Okeechobee, EAA, and the Everglades, have potentially far-reaching

consequences. In ALTD13R, additional storage such as LOK ASR and Lake Belt storage compensate for changes in the EAA reservoir performance, lessening the impact of such changes. Thus, the impact of changes in EAA reservoir on any other component depends on the assumed state of the rest of the system.

Table B.3-3 Inundation Duration Statistics for some Key Indicator Regions (# Events; Average Duration; Percent of Year)

Indicator Region (Figure 24)																					
#	Name	Depth Criterion (ft)	NSM45F			ALTD13R			SGT4020			SGT1X20			EAARS			NEAARS			
Low Water Duration																					
10	Mid SRS	< -1.0	1	1	0	2	2	0	2	2	0	2	2	0	1	1	0	0	0	0	
11	NE SRS	< -1.0	1	1	0	3	2	0	3	2	0	2	2	0	2	2	0	1	2	0	
12	New SRS	< -1.0	17	7	8	13	5	4	13	5	4	13	5	4	14	6	5	13	5	4	
17	South Central WCA-3A	< -1.0	8	7	3	5	2	1	5	2	1	5	3	1	4	4	1	5	4	1	
19	East WCA-3A	< -1.0	10	6	4	8	3	1	8	3	1	9	3	2	8	3	2	7	3	1	
20	NW WCA-3A	< -1.0	6	6	2	9	5	3	9	5	3	10	5	3	10	5	3	9	5	3	
21	NE WCA-3A	< -1.0	15	7	7	15	4	4	13	5	4	13	5	4	14	5	4	14	5	4	
22	NW Corner WCA-3A	< -1.0	7	5	2	5	3	1	5	4	1	5	4	1	5	4	1	6	5	2	
High Water Duration																					
10	Mid SRS	> 2.5	5	11	4	5	6	2	5	6	2	5	7	2	5	7	2	7	6	2	
11	NE SRS	> 2.5	15	10	9	10	6	4	7	7	3	10	6	4	9	6	4	12	6	4	
12	New SRS	Undefined																			
17	South Central WCA-3A	> 2.5	0	0	0	2	9	1	2	9	1	3	7	1	3	7	1	2	11	1	
19	East WCA-3A	> 2.5	0	0	0	27	12	19	25	12	19	31	10	20	24	12	18	30	12	23	
20	NW WCA-3A	> 2.5	0	0	0	1	1	0	0	0	0	1	1	0	2	1	0	2	1	0	
21	NE WCA-3A	> 2.0	2	2	0	6	7	3	6	7	3	6	7	3	6	8	3	6	8	3	
22	NW Corner WCA-3A	> 2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Inundation Duration																					
10	Mid SRS	> 0.0	5	321	100	4	398	99	5	318	99	4	398	99	6	265	99	4	401	100	
11	NE SRS	> 0.0	4	402	100	7	226	98	6	264	98	6	264	98	7	226	98	6	266	99	
12	New SRS	> 0.0	32	42	82	27	52	87	26	54	87	29	48	87	32	43	86	28	50	87	
17	South Central WCA-3A	> 0.0	24	59	87	14	110	95	15	103	96	14	110	95	15	102	95	15	102	95	
19	East WCA-3A	> 0.0	25	55	86	13	115	93	13	116	93	14	107	93	16	93	93	15	100	93	
20	NW WCA-3A	> 0.0	21	70	91	19	75	88	21	68	88	23	62	88	28	50	87	24	59	88	
21	NE WCA-3A	> 0.0	28	49	85	31	44	84	31	44	84	30	45	84	33	40	82	26	53	85	
22	NW Corner WCA-3A	> 0.0	20	73	91	19	81	95	22	69	95	23	66	94	22	69	94	18	84	94	

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Table B.3-4 Mean annual flows for key components, in kac-ft/year

Row	Flow Description	Simulation				
		ALTD13R	SGT4020	SGT1X20	EAARS	NEAARS
1	Overland flow Tamiami Trail	942	934	953	908	988
2	S-356 A & B	263	259	268	266	289
3	Total 1+2 (Inflow ENP)	1205	1193	1221	1174	1277
	– w.r.t. D13R *		-12	16	-31	72
4	Runoff South	610	579	641	680	870
5	LOK Env.	149	139	156	296	251
6	LOK Reg. to WCAs***	102	110	108	115	104
7	EAA Res. to Env.	274	302	247	0	0
8	Total 4 to 7	1135	1130	1152	1091	1225
	– w.r.t. D13R		-5	17	-44	90
9	LOK to EAA Demands	174	160	182	204	357
10	Total 5+9 (LOK WS)	323	299	338	500	608
	– w.r.t. D13R		-24	15	177	285
11	EAA Res. to EAA Demand	147	146	153	149	0
12	LOK ASR Injection	264	249	263	333	291
13	LOK ASR Recovery **	136 (348)	129 (320)	135 (351)	165 (376)	149 (323)
14	CLB Inflow	99	97	101	107	111
15	CLB Outflow	93	92	95	101	105

* Change with respect to Alt. D13R.
** Numbers in parenthesis are the mean for the drought years 1971, 1975, 1981, 1985 and 1989.
***Direct regulatory discharge to WCAs (via STAs). No diversion to surge tanks.

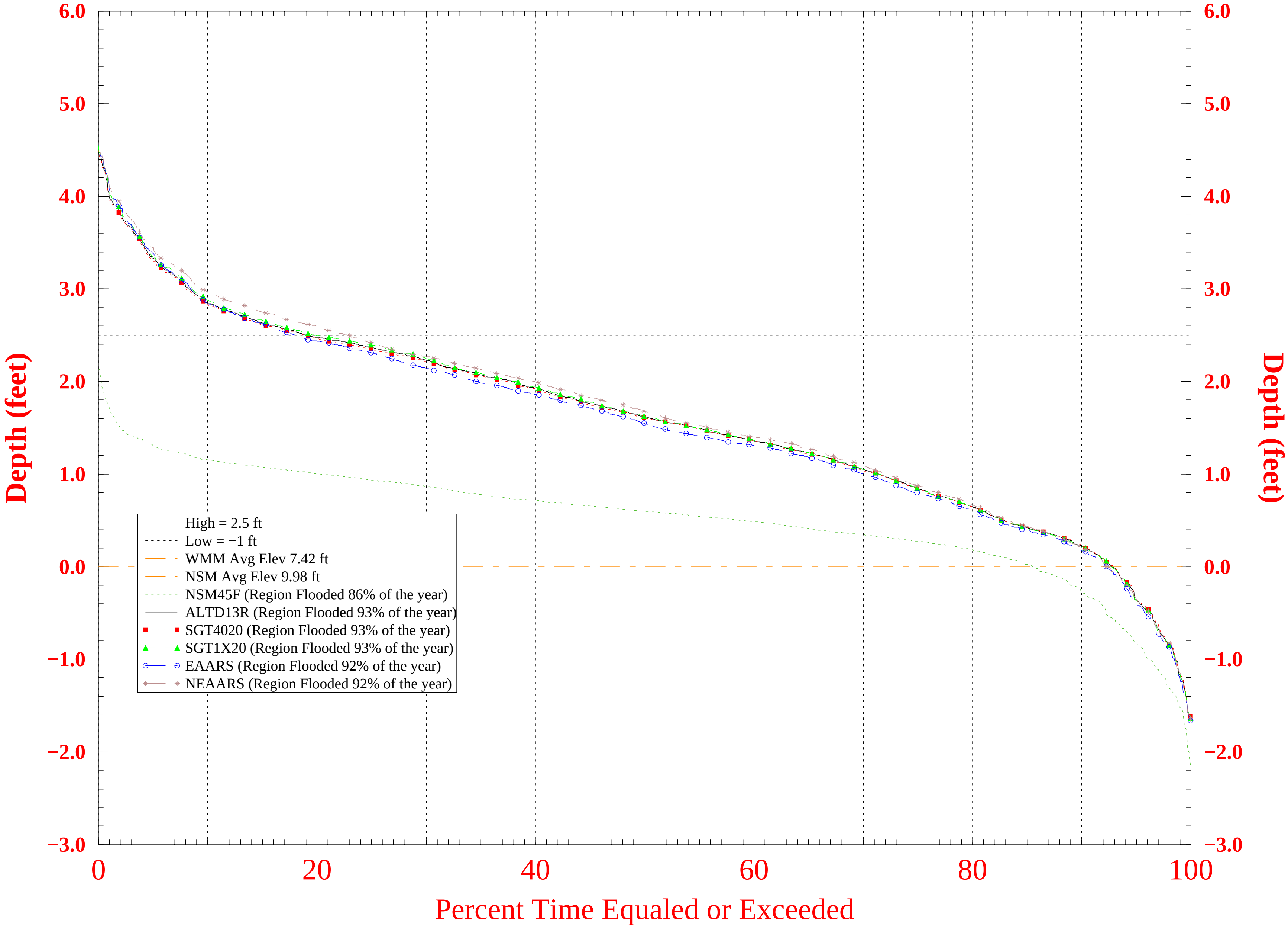
Table B.3-5 Mean annual flows at key transects, in kac-ft/year

Transect *		Simulation				
#	Name	ALTD13R	SGT4020	SGT1X20	EAARS	NEAARS
17	Tamiami Trail W	429	424	436	416	457
18	Tamiami Trail E	508	505	512	486	523
19	ENP, W of L31N	228	224	235	228	250
	Total 17+18+19	1165	1153	1183	1130	1230
	– w.r.t. D13R **		-12	18	-35	65
21	SRS	1098	1088	1109	1072	1150
22	NW SRS	80	78	82	78	88
23	Southern ENP	159	159	161	159	163
	Total 21+22+23	1337	1325	1352	1309	1401
	– w.r.t. D13R		-12	15	-28	64
5	NW WCA-3A	222	221	225	214	236
6	NE WCA-3A	237	237	240	206	259
	Total 5+6	459	458	465	420	495
	– w.r.t. D13R		-1	6	-39	36
7	Alligator Alley W	363	361	367	342	386
8	Alligator Alley E	628	616	643	616	686
	Total 7+8	991	977	1010	958	1072
	– w.r.t. D13R		-14	19	-33	81
12	Southern WCA-3A	747	741	755	717	786

* Transects are shown in Figure B.3-47
** Change with respect to Alt. D13R.

Figure B.3-23 Normalized Weekly Stage Duration Curves for East WCA-3A

Indicator Region 19 (R33C25-27 R34C25-27)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Wed Aug 12 15:18:49 EDT 1998
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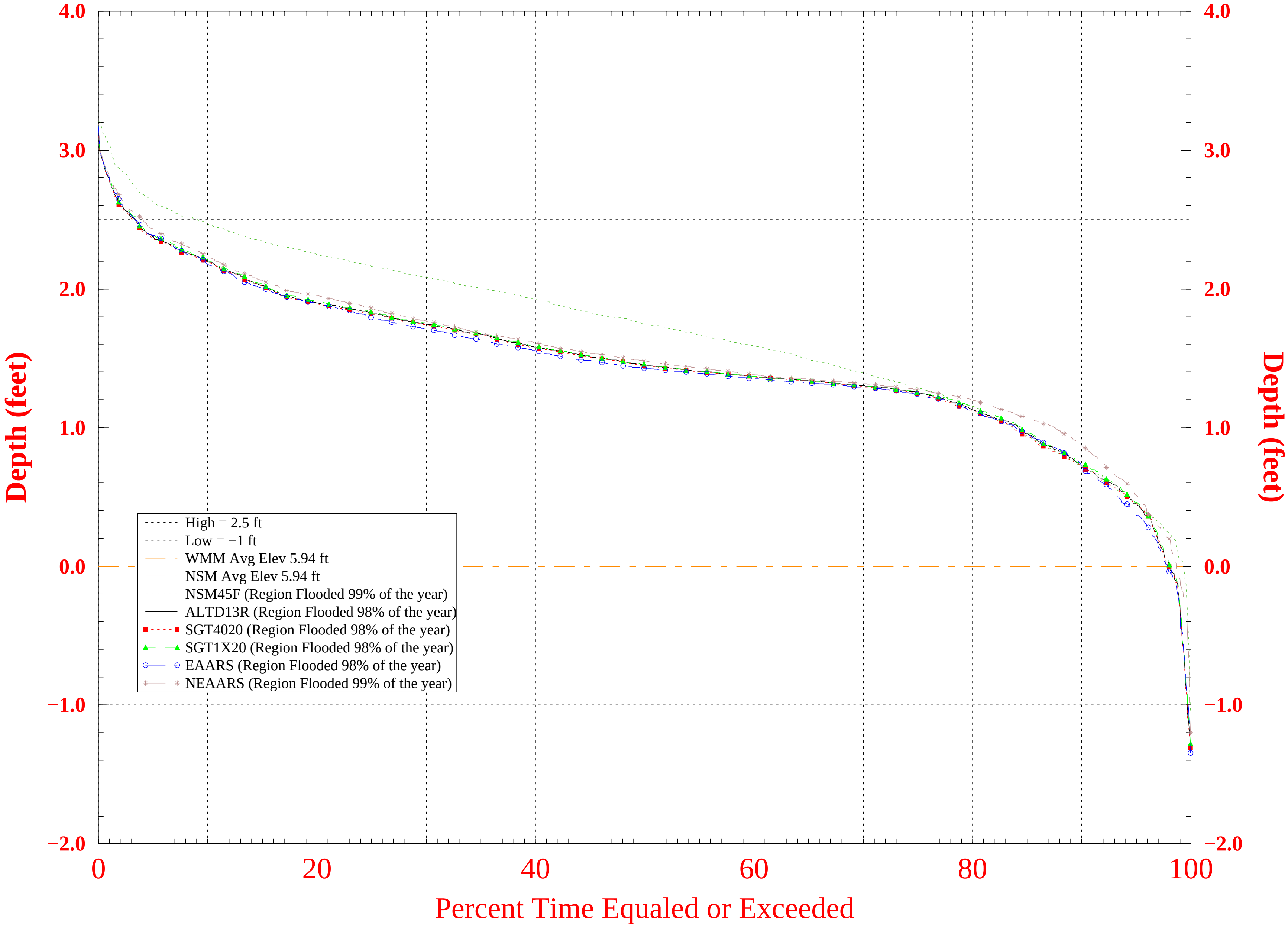
SFWMM V3.4

Figure B.3-24 Normalized Weekly Stage Duration Curves for NE Shark River Slough

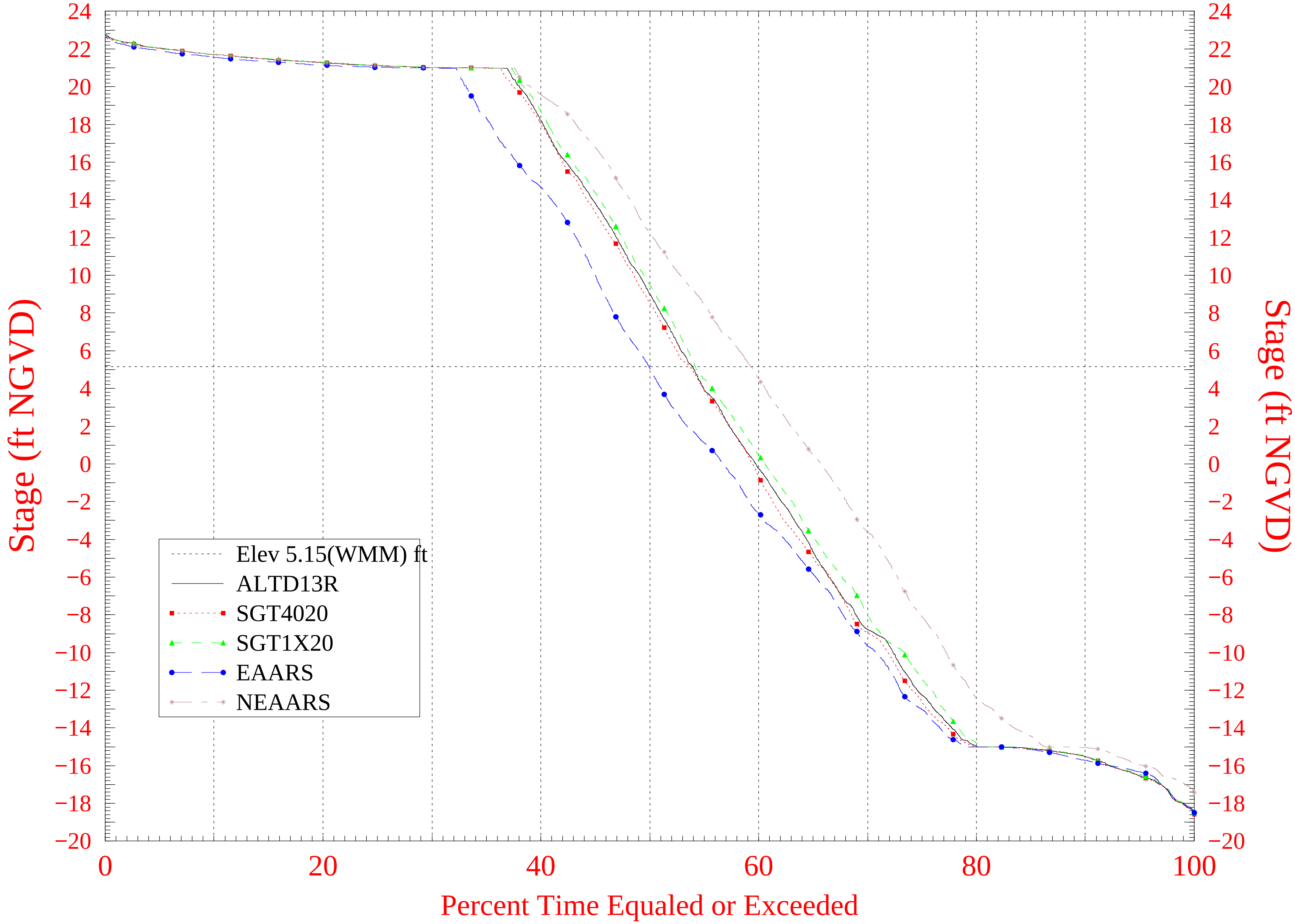
Indicator Region 11 (R19C22-23 R20C22-26 R21C22-26)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

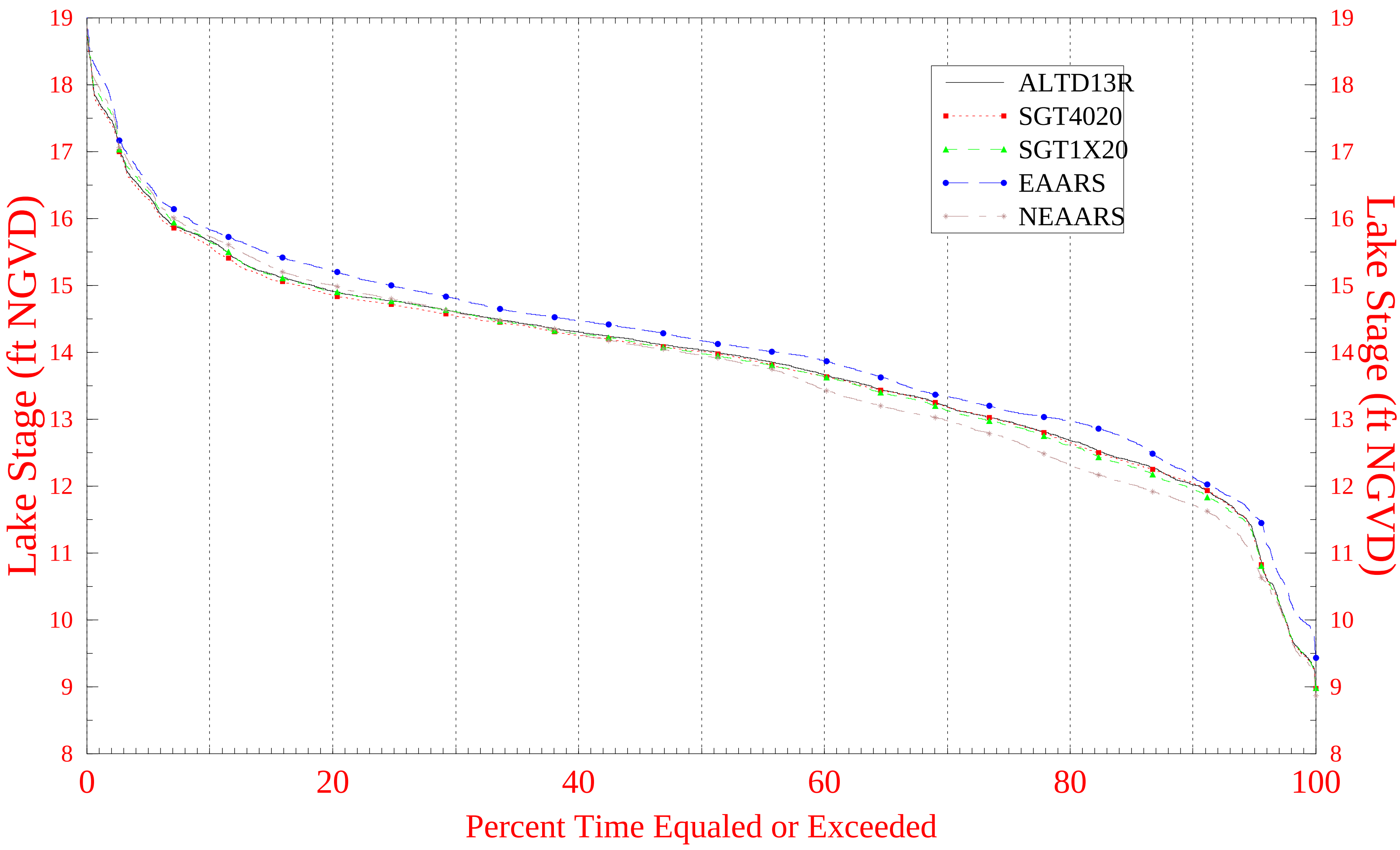
Run date: Wed Aug 12 15:17:15 EDT 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-25 Stage Duration Curves at Central Lake Belt Reservoir



Run date: 08/12/98 12:43:24
For Planning Purposes Only
SFWMM V3.5

Figure B.3-26 Lake Okeechobee Stage Duration Curves



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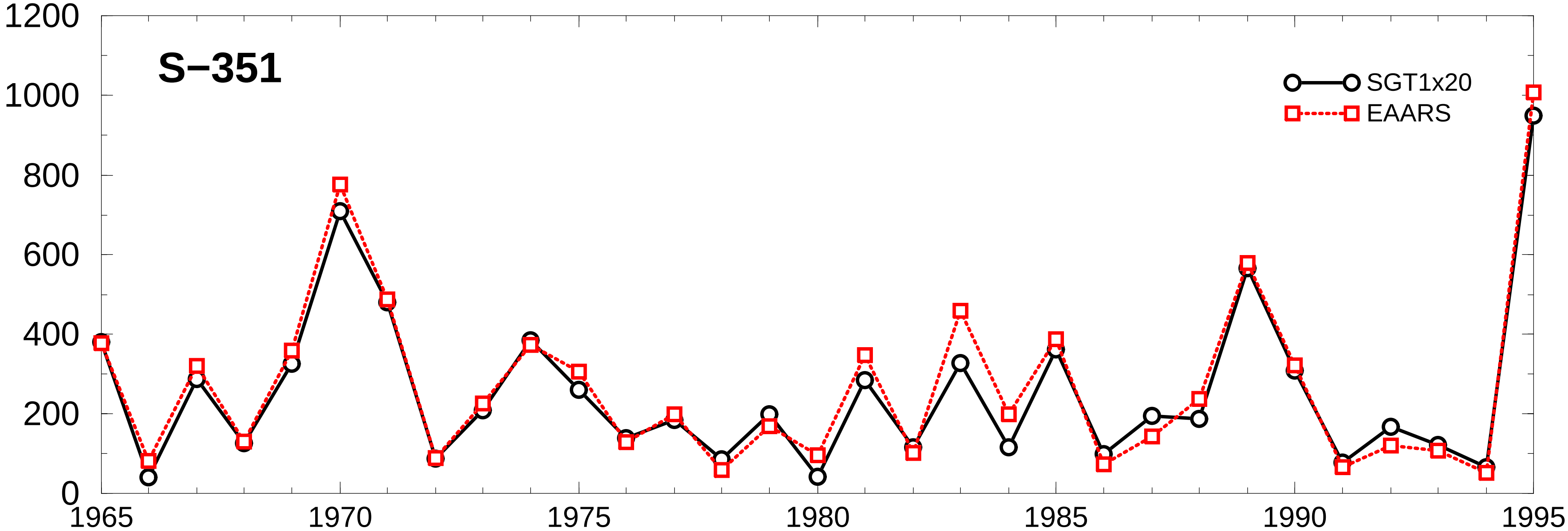
SFWMM V3.5

Figure B.3-27 EAA Reservoir Sensitivity Analysis

Annual Outflows for some Lake Okeechobee Structures



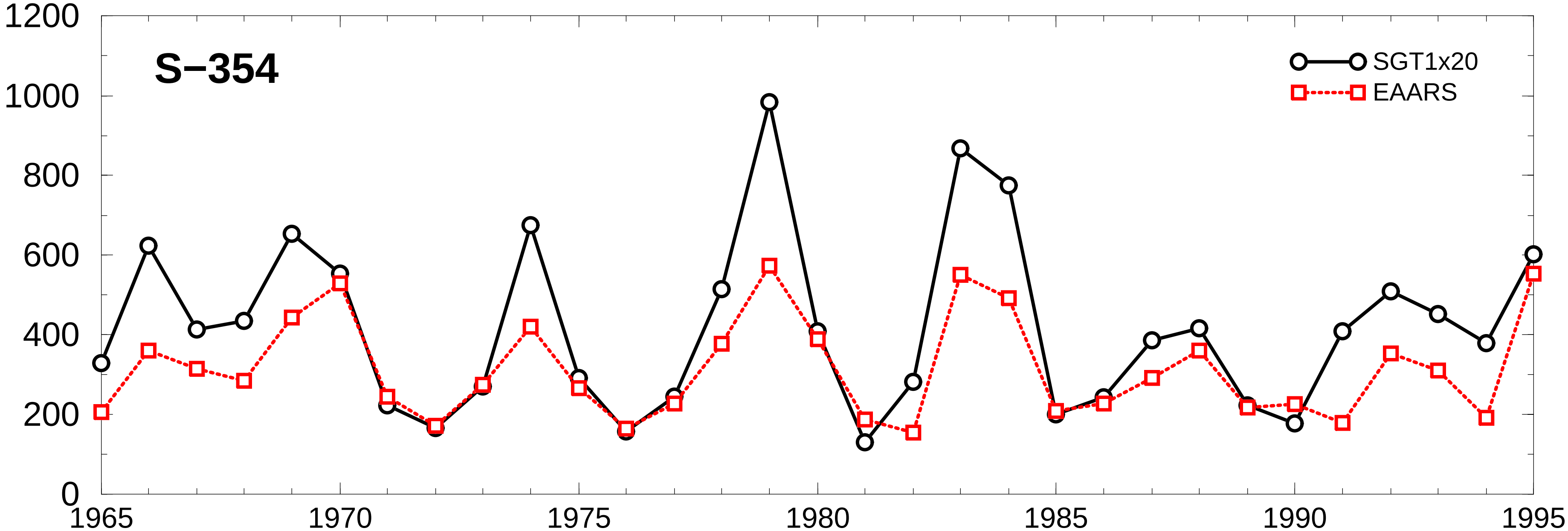
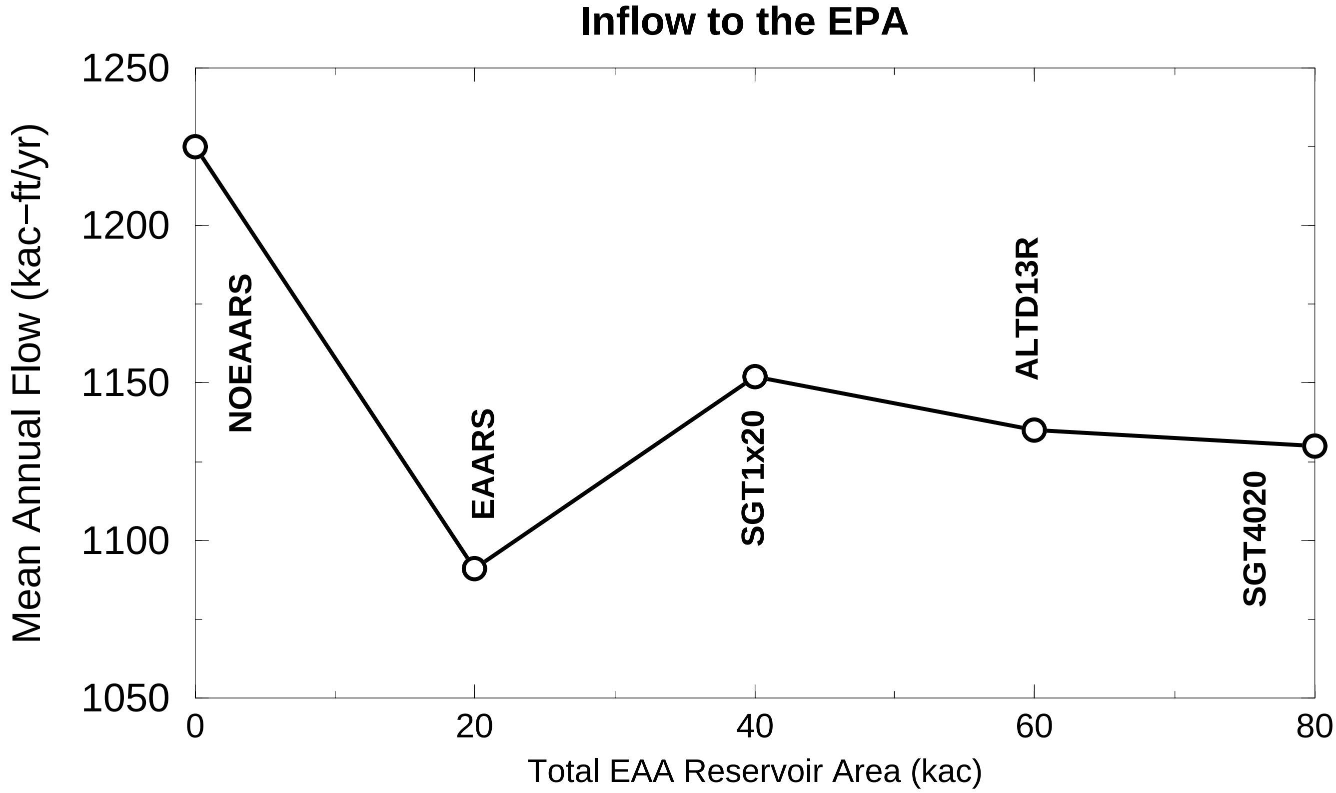


Figure B.3-28 EAA Reservoirs Sensitivity Analysis



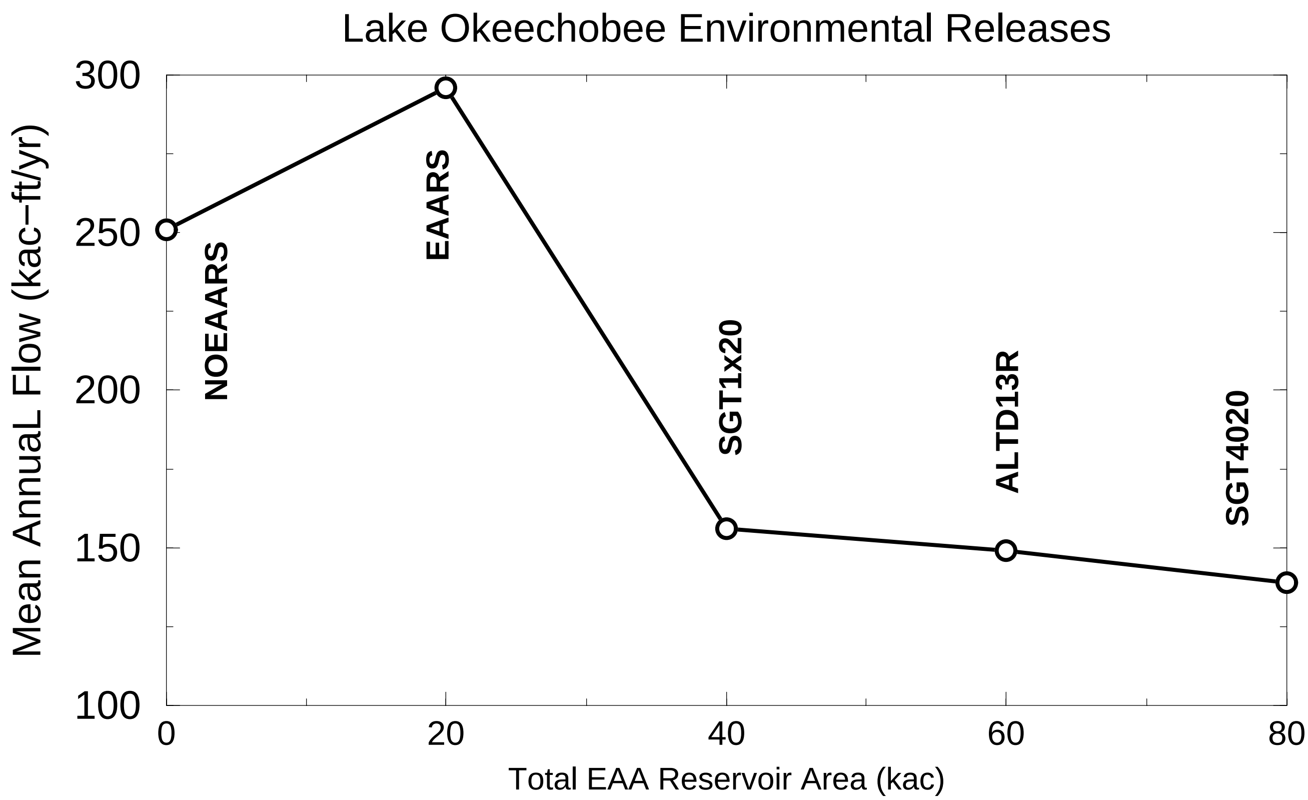
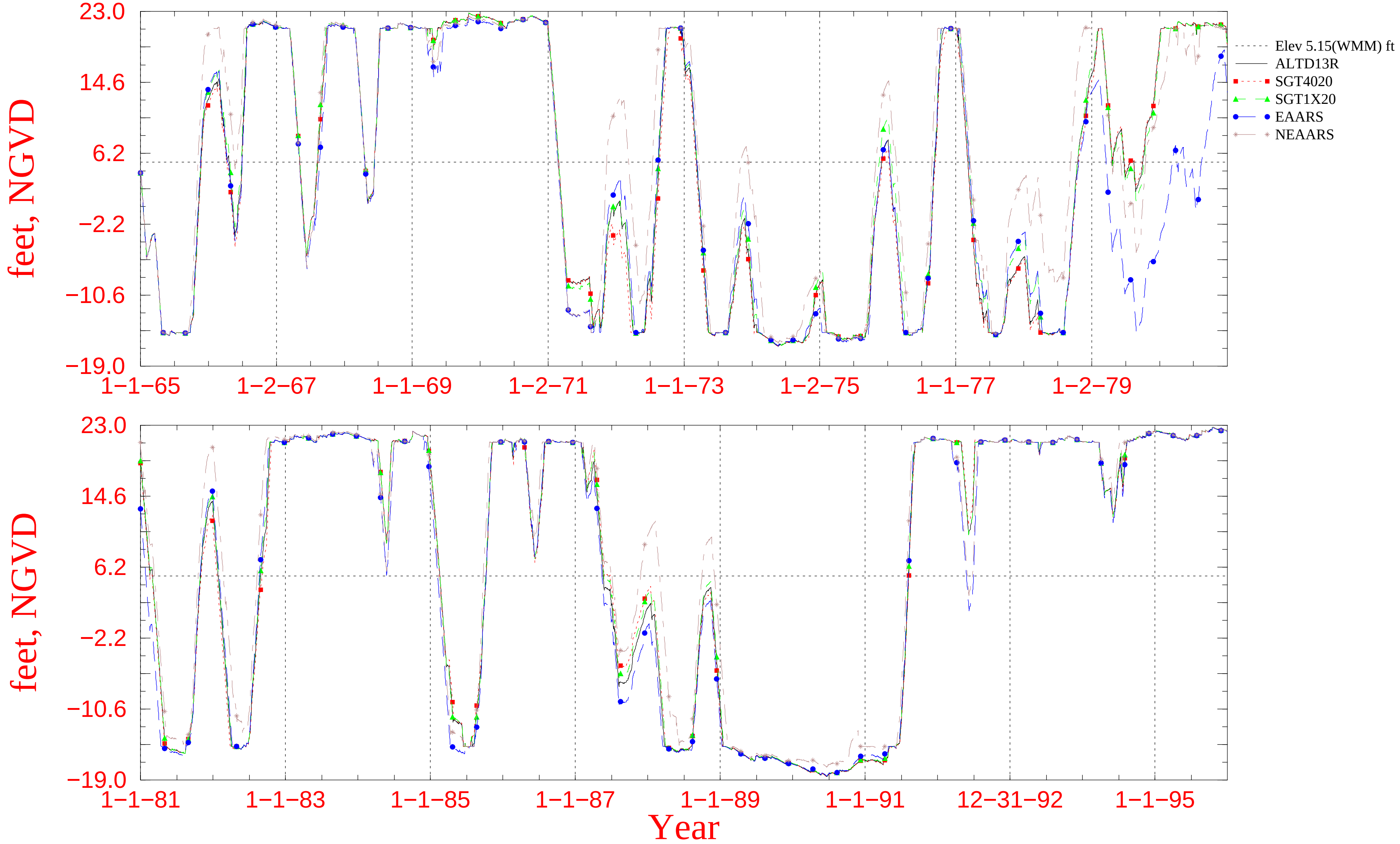
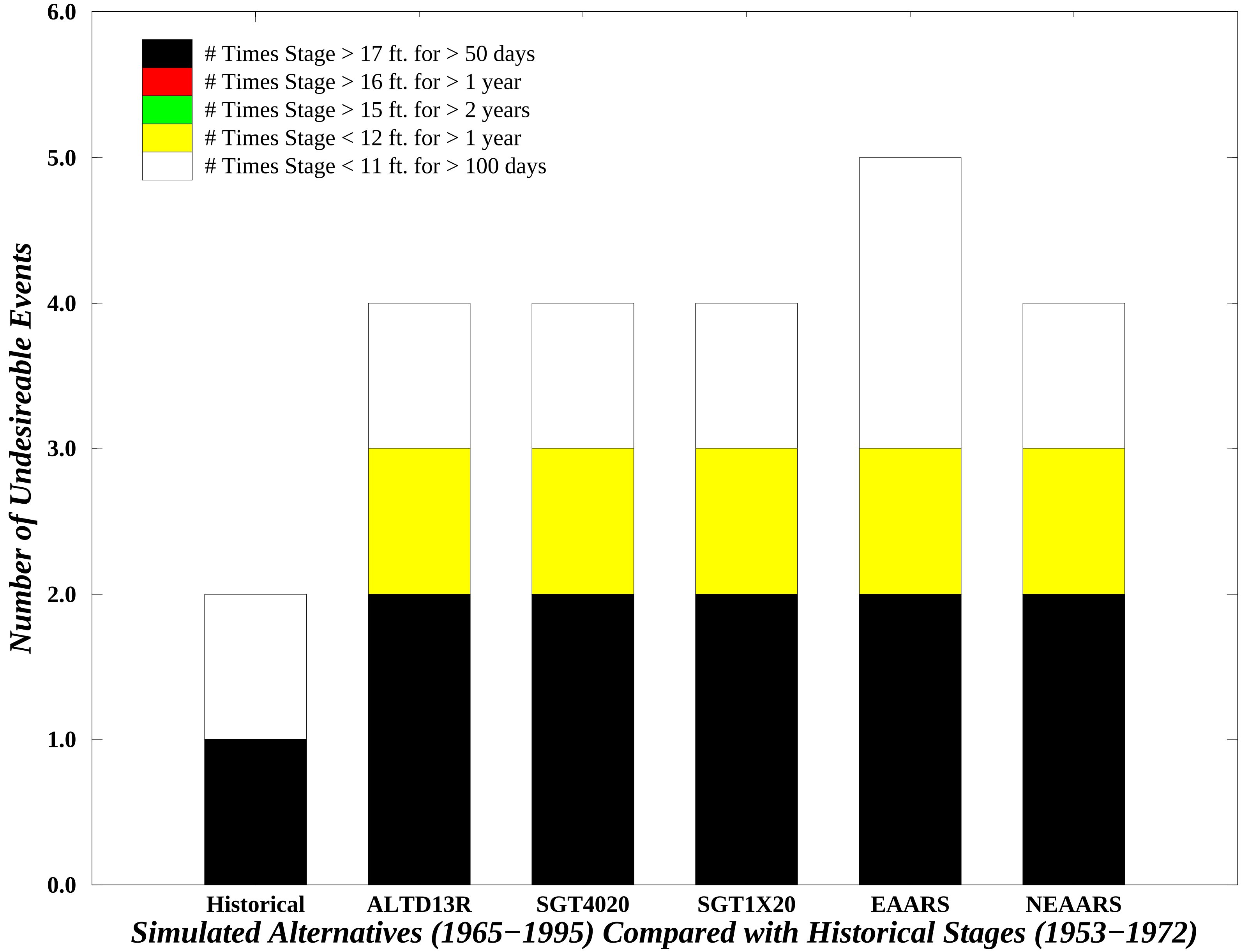


Figure B.3-29 Stage Hydrograph at Central Lake Belt Reservoir



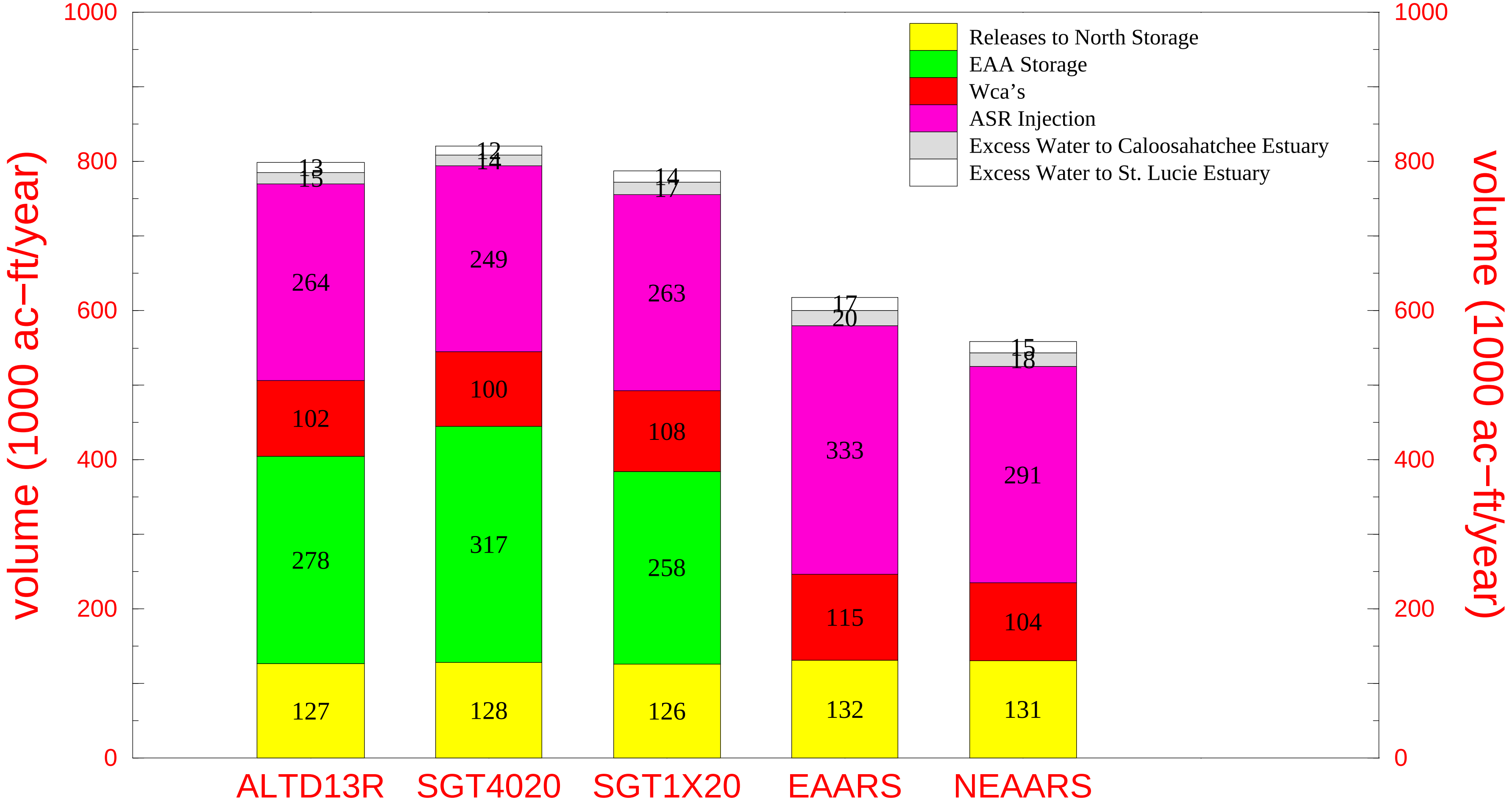
Run date: 08/12/98 12:43:32
For Planning Purposes Only
SFWMM V3.5

Figure B.3-30 Number of Undesireable Lake Okeechobee Stage Events



Run date: 08/12/98 14:50:40
For Planning Purposes Only
SFWMM V3.5

Figure B.3-31 Mean Annual Flood Control Releases from Lake Okeechobee for the 31 yr (1965 - 1995) Simulation



Note: Although regulatory (flood control) discharges are summarized here in mean annual values, they do not occur every year. Typically they occur in 2−4 consecutive years and may not occur for up to 7 consecutive years.

Run date: 08/12/98 09:21:53
For Planning Purposes Only
SFWMM V3.5

Figure B.3-32 EAA Reservoirs Sensitivity Analysis

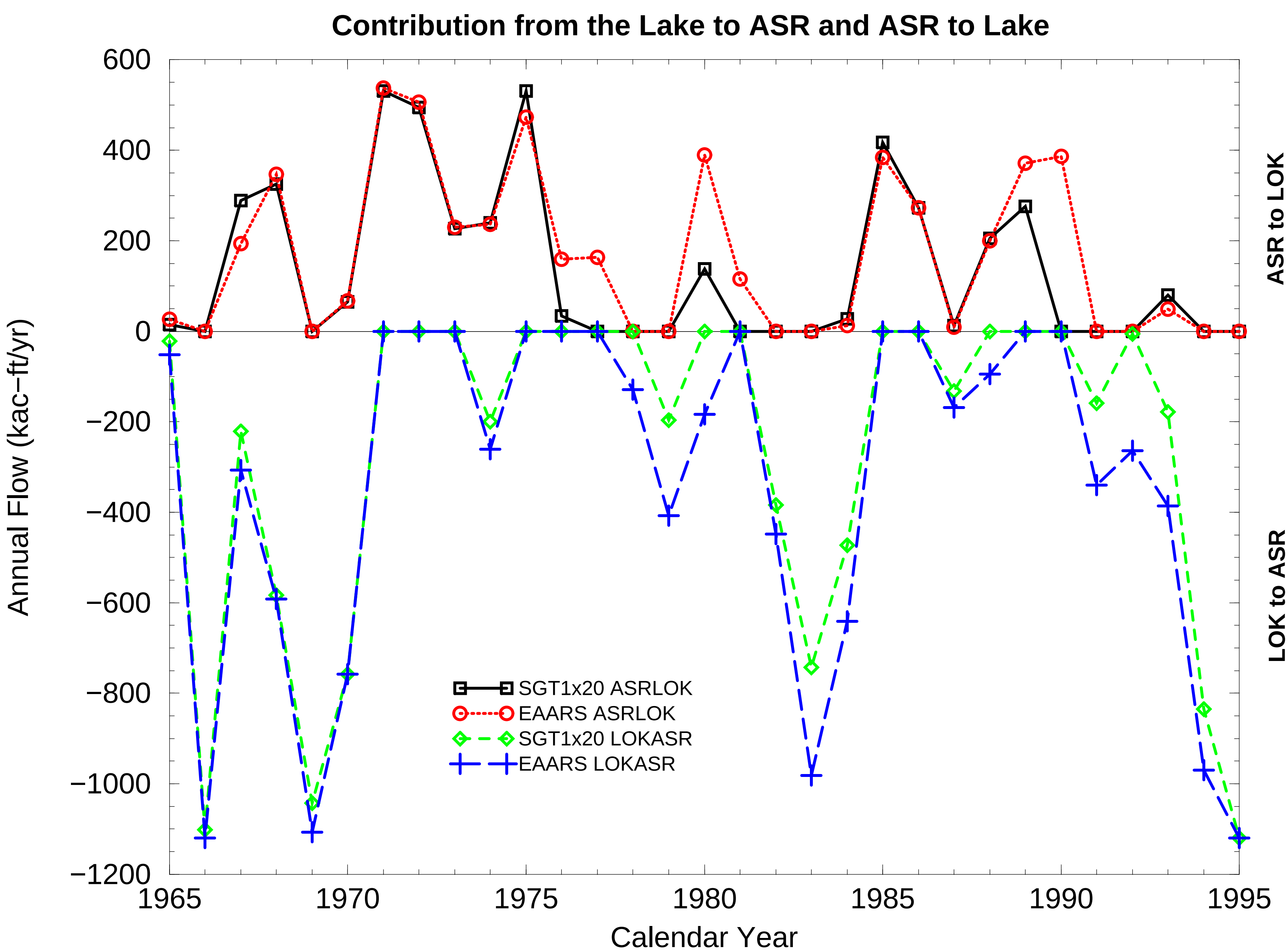
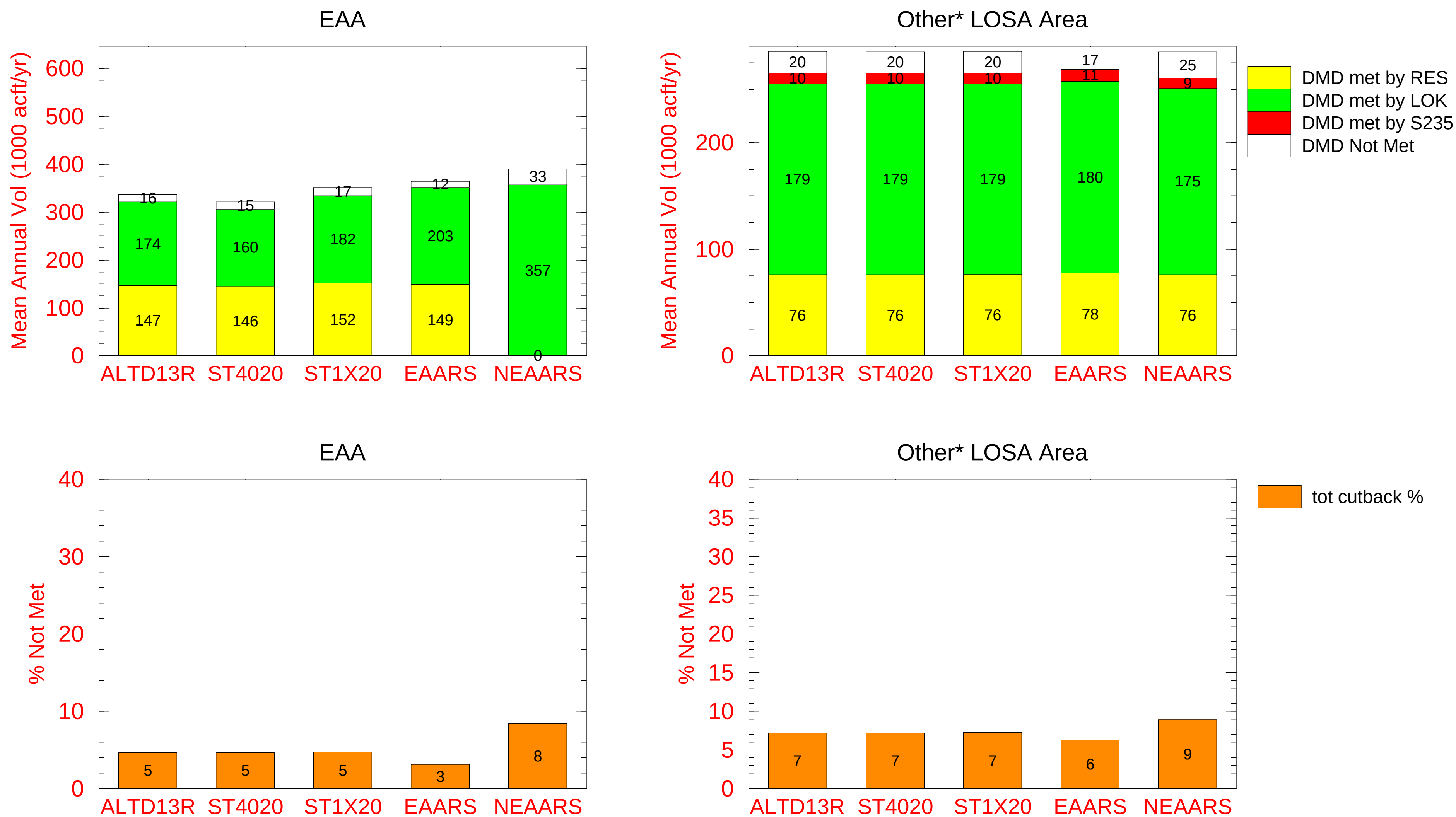


Figure B.3-33 Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met

for the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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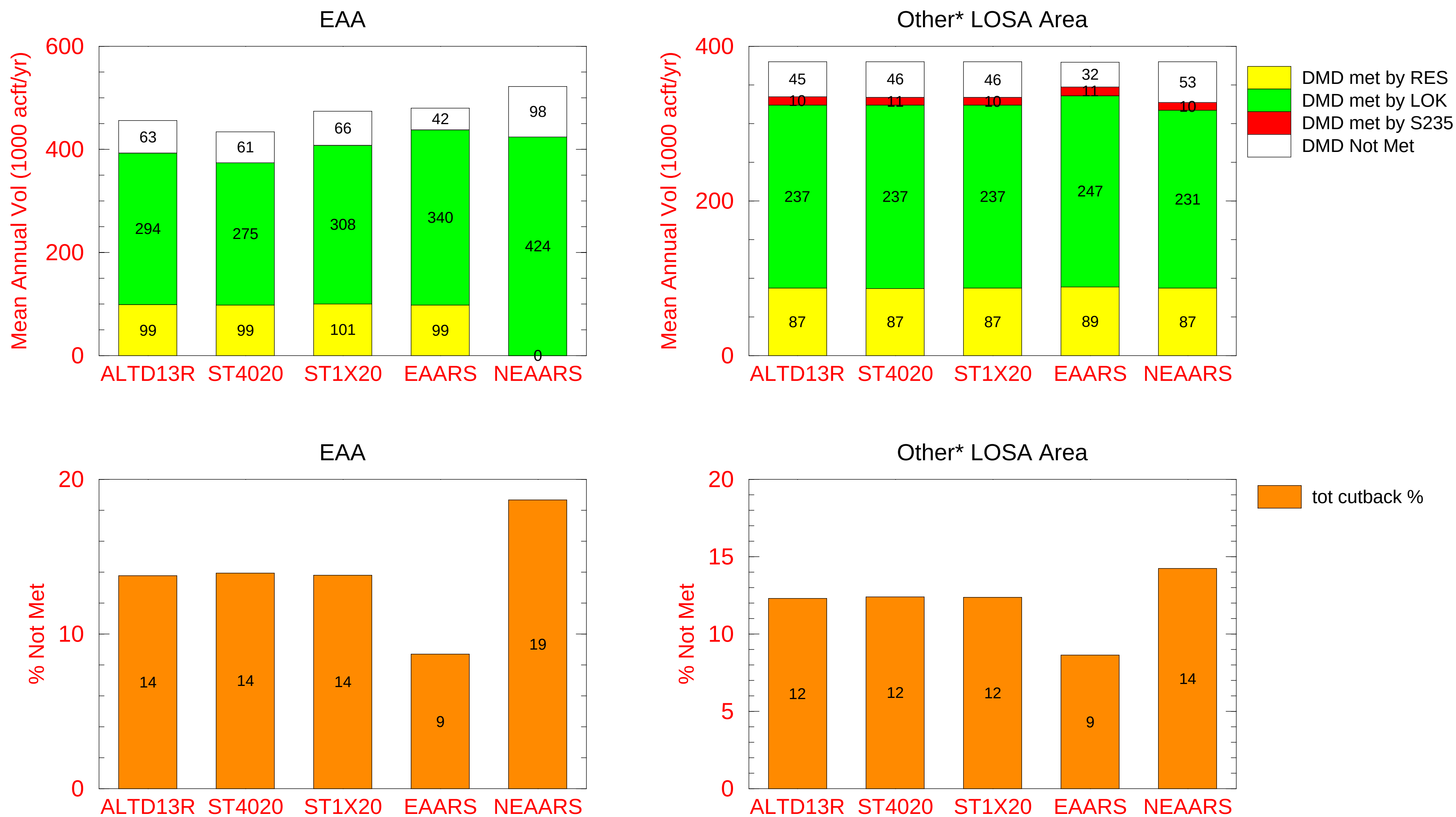
SFWMM V3.5

Figure B.3-34 Mean Annual EAA/LOSA Supplemental Irrigation:
Demands and Demands Not Met for the Drought Years:
1971, 1975, 1981, 1985, 1989 within the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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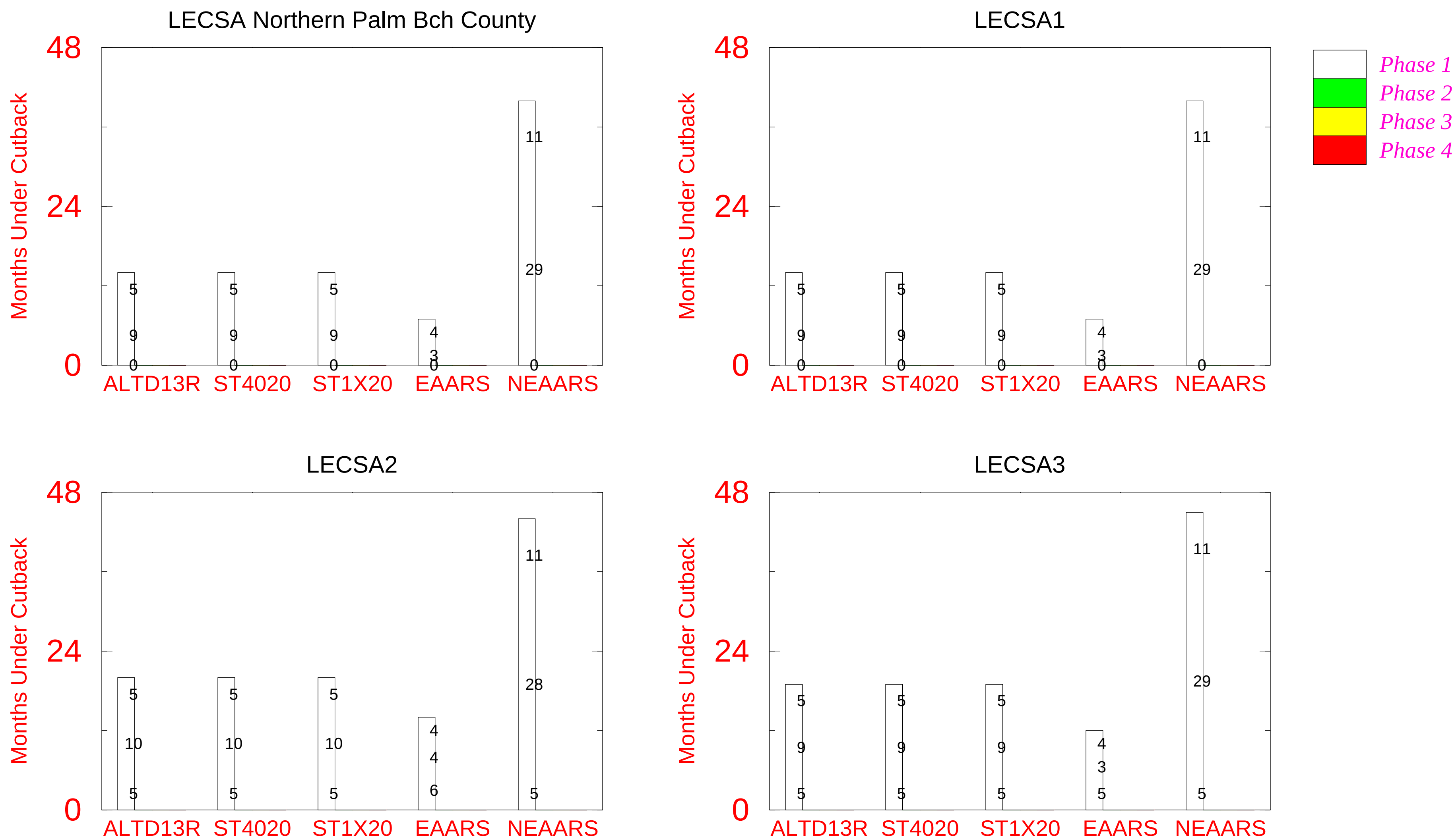
SFWMM V3.5

Figure B.3-35 Number of Months of Simulated Water Supply Cutbacks for the 1965 - 1995 Simulation Period



Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).

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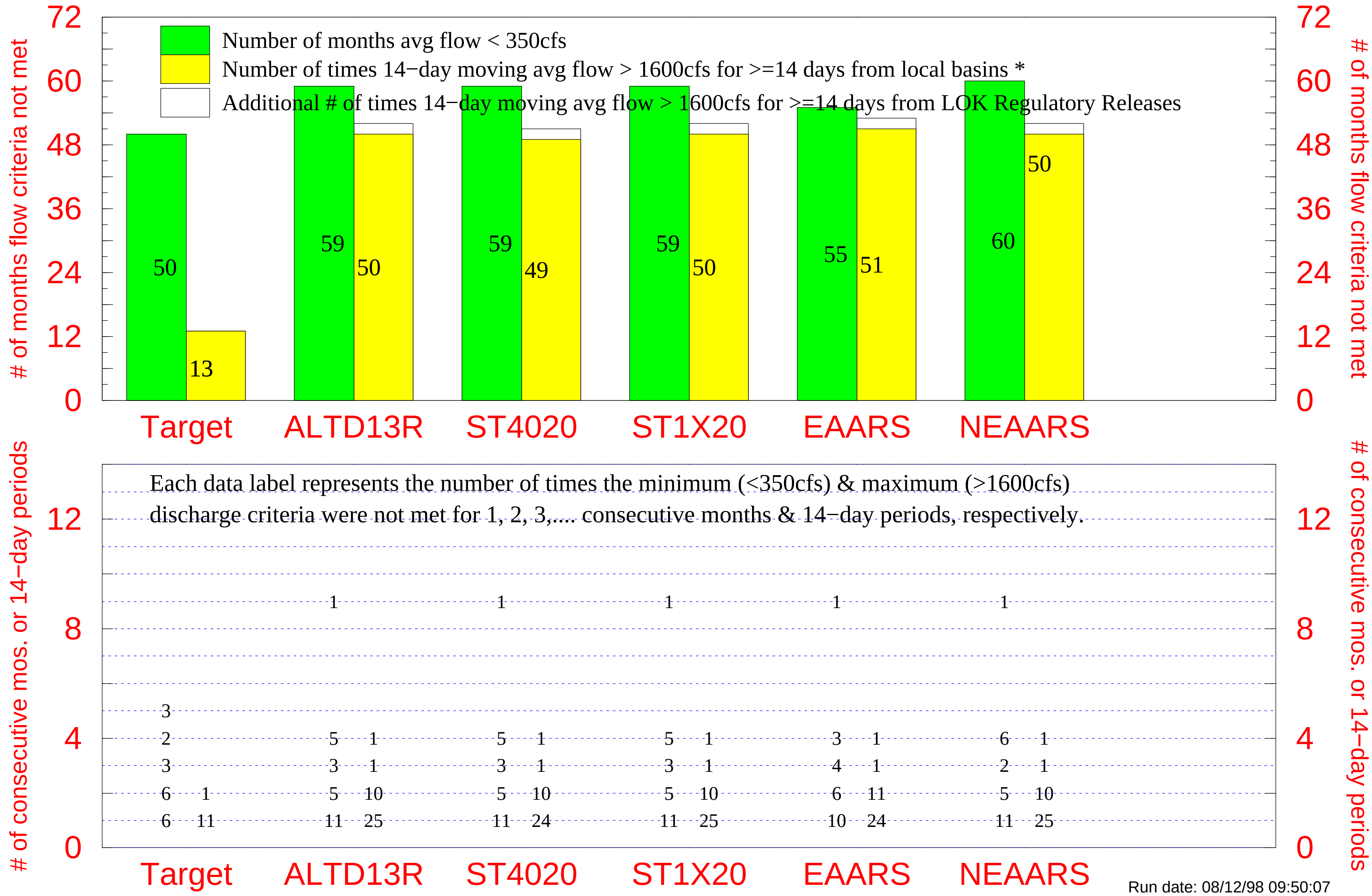
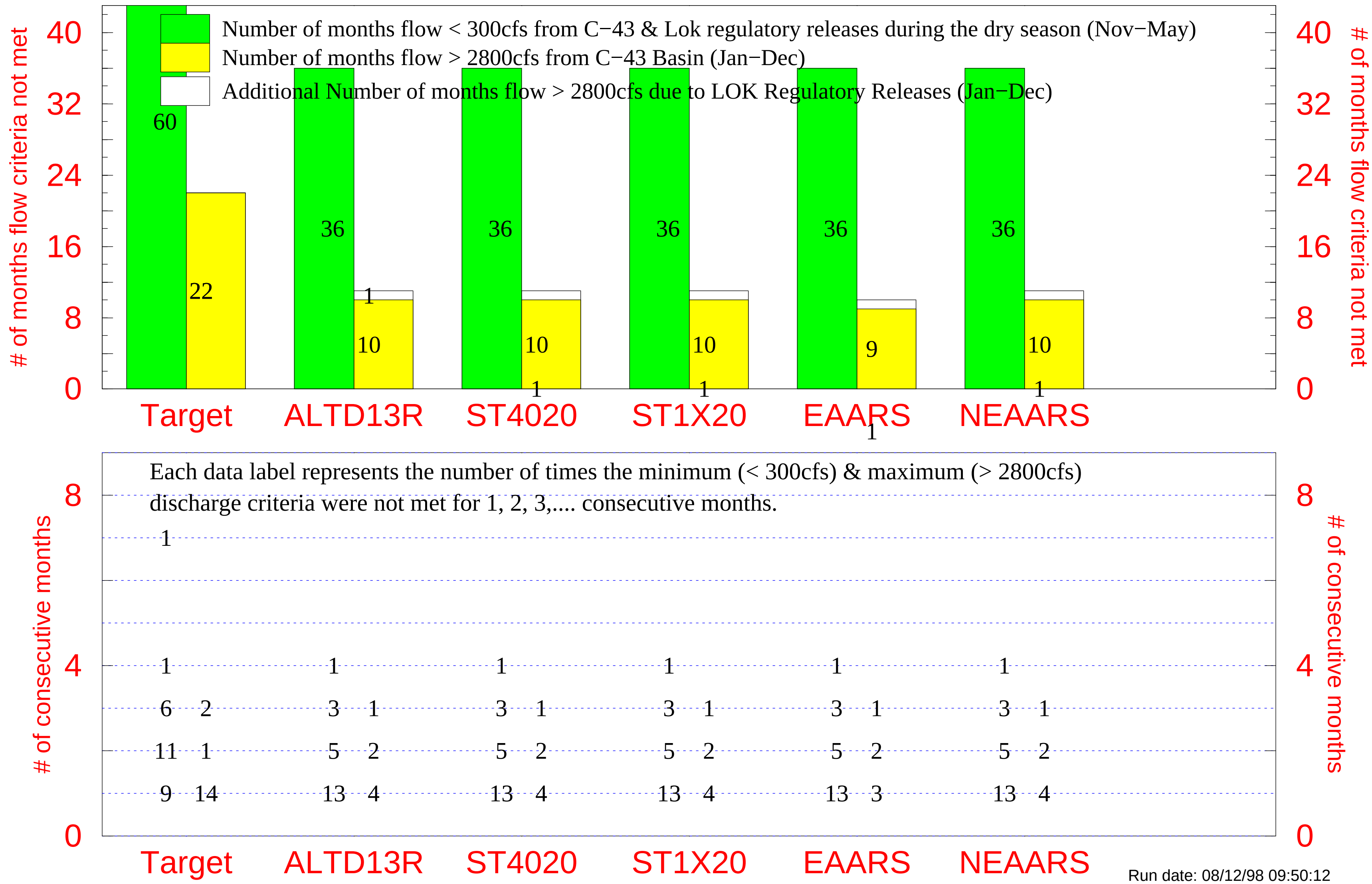
For Planning Purposes Only
SFWMM V3.5

Figure B.3-36 Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary



Run date: 08/12/98 09:50:07
For Planning Purposes Only
SFWMM V3.5

Figure B.3-37 Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary (mean monthly flows 1965 - 1995)



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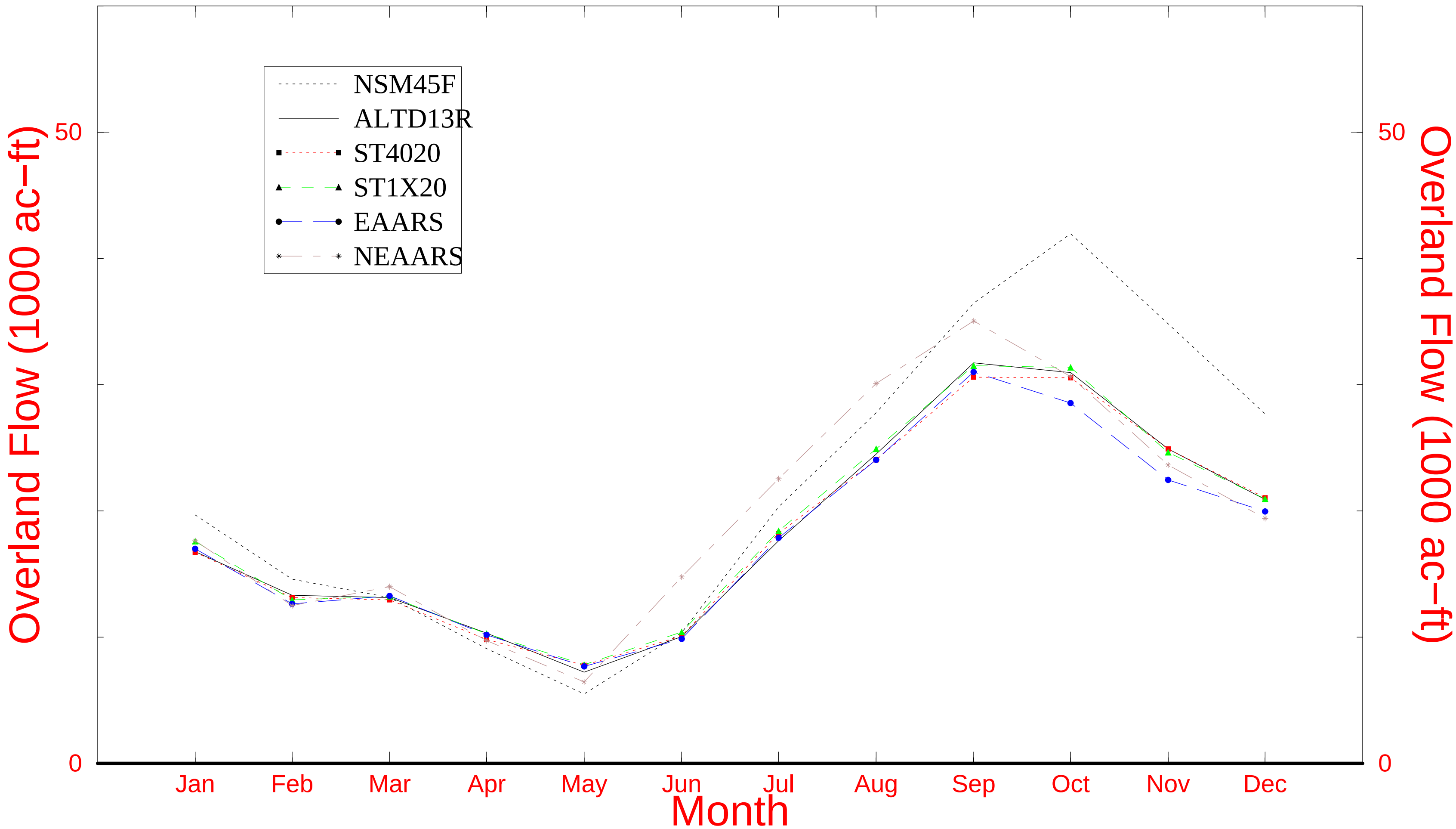
For Planning Purposes Only
SFWMM V3.5

Figure B.3-38 Average Monthly Overland Flows in northwestern WCA-3A T5 (R41, C16-18) for the 31 yr. simulation



Note: NSM flows are NOT targets and are shown for comparative purposes only.

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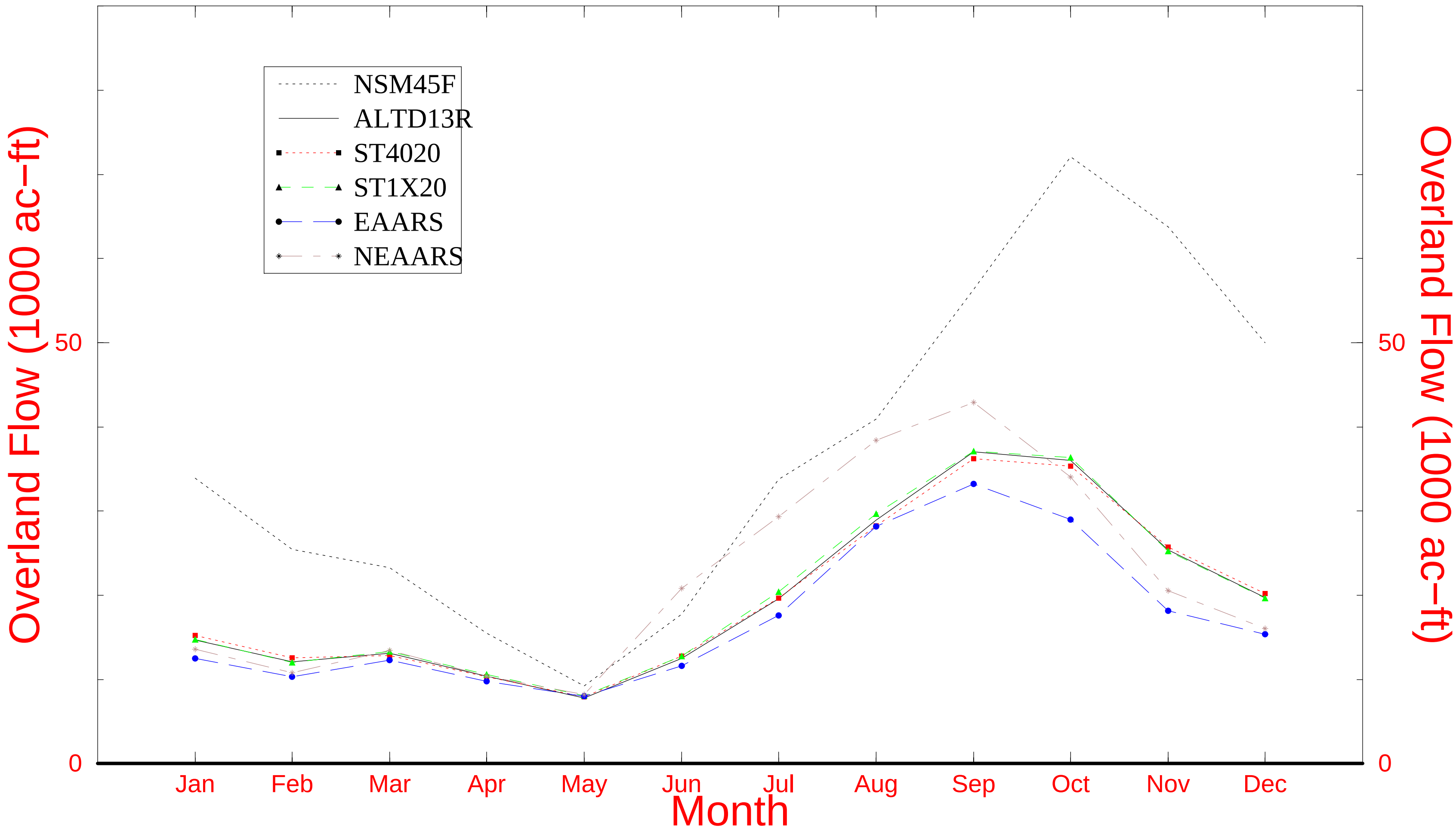
For Planning Purposes Only
SFWMM V3.5

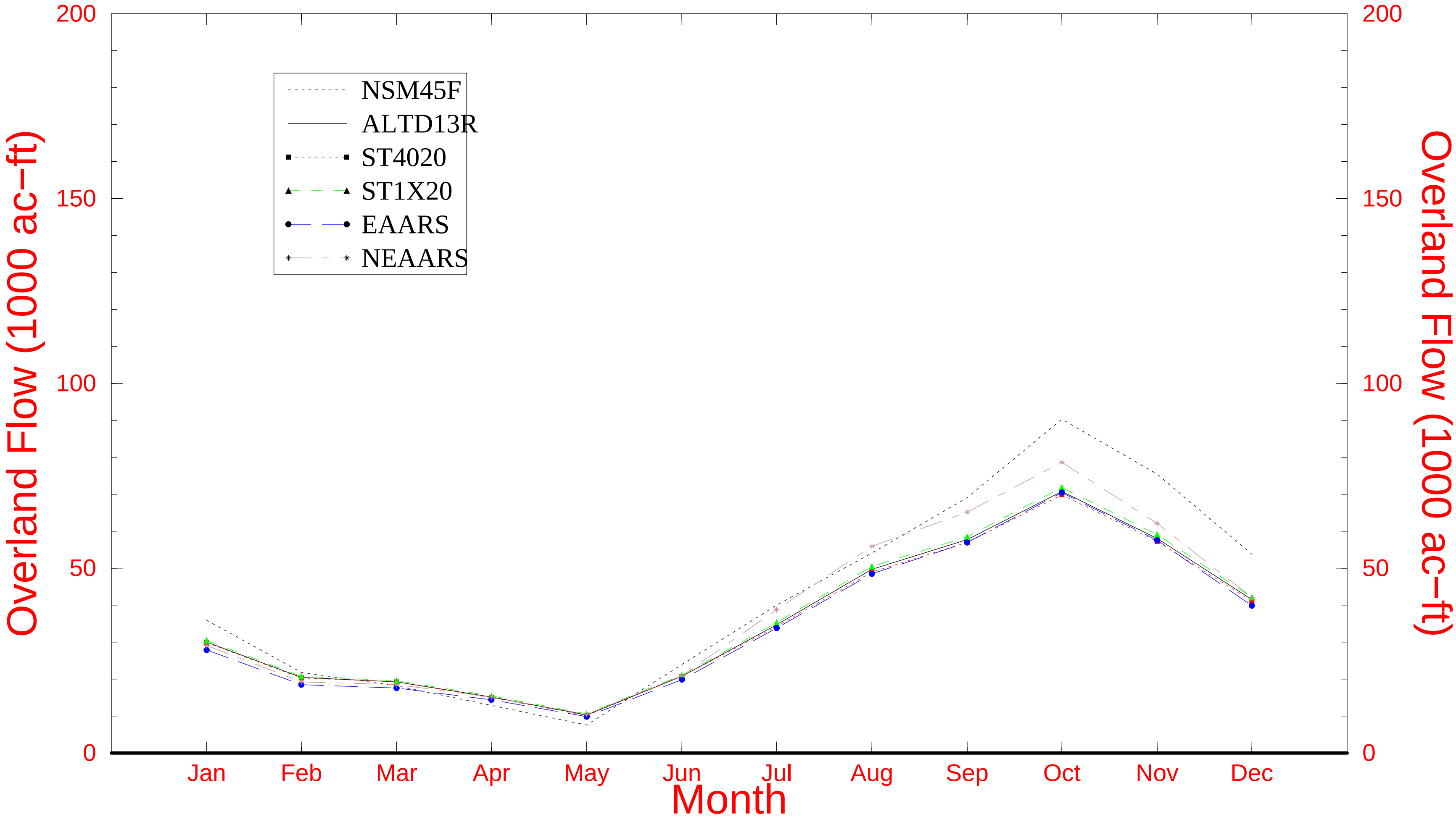
Figure B.3-39 Average Monthly Overland Flows in northeastern WCA-3A T6 (R41, C19-25) for the 31 yr. simulation



Note: NSM flows are NOT targets and are shown for comparative purposes only.

Run date: 08/12/98 12:28:37
For Planning Purposes Only
SFWMM V3.5

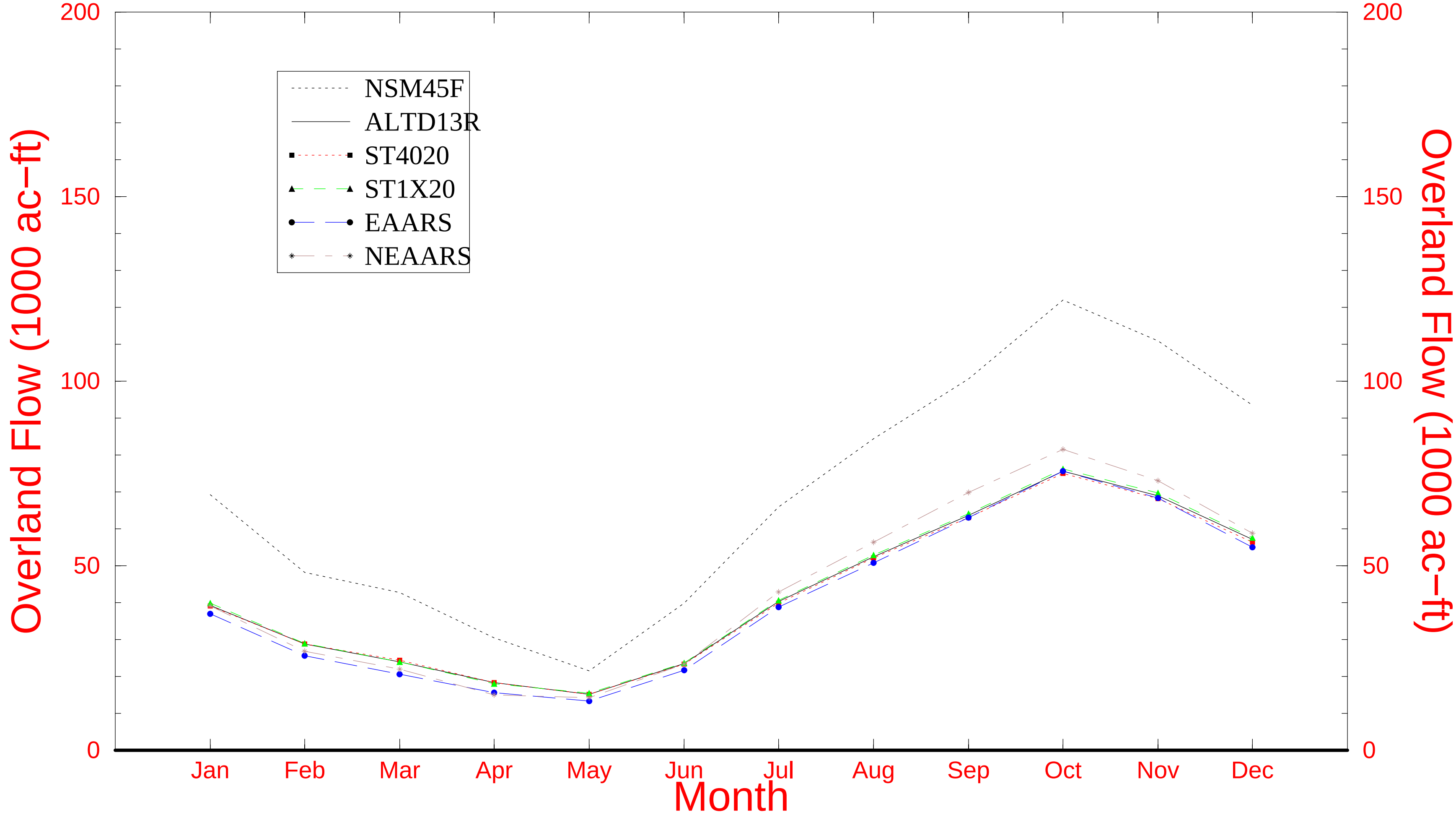
Figure B.3-40 Average Monthly Overland Flows South of Tamiami Trail West of L-67 ext. to ENP T17 (R22, C17-21) for the 31 yr. simulation



Note: NSM flows are NOT targets and are shown for comparative purposes only.

Run date: 08/12/98 12:23:36
For Planning Purposes Only
SFWMM V3.5

Figure B.3-41 Average Monthly Overland Flows South of Tamiami Trail East of L-67 ext. to ENP T18 (R22, C22-26) for the 31 yr. simulation



Note: NSM flows are NOT targets and are shown for comparative purposes only.

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For Planning Purposes Only
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Figure B.3-42 Stage Duration Curves at North Storage Reservoir

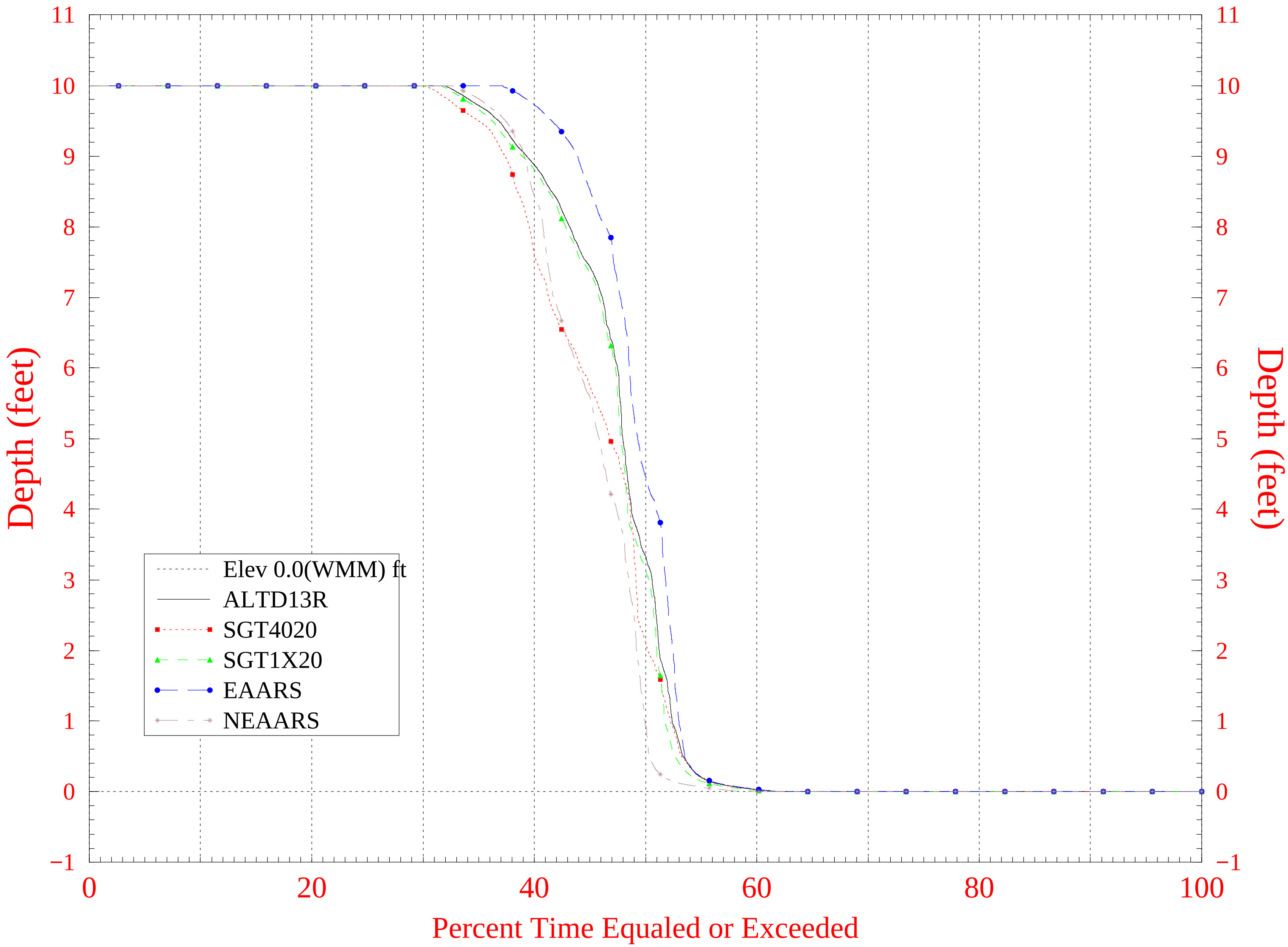

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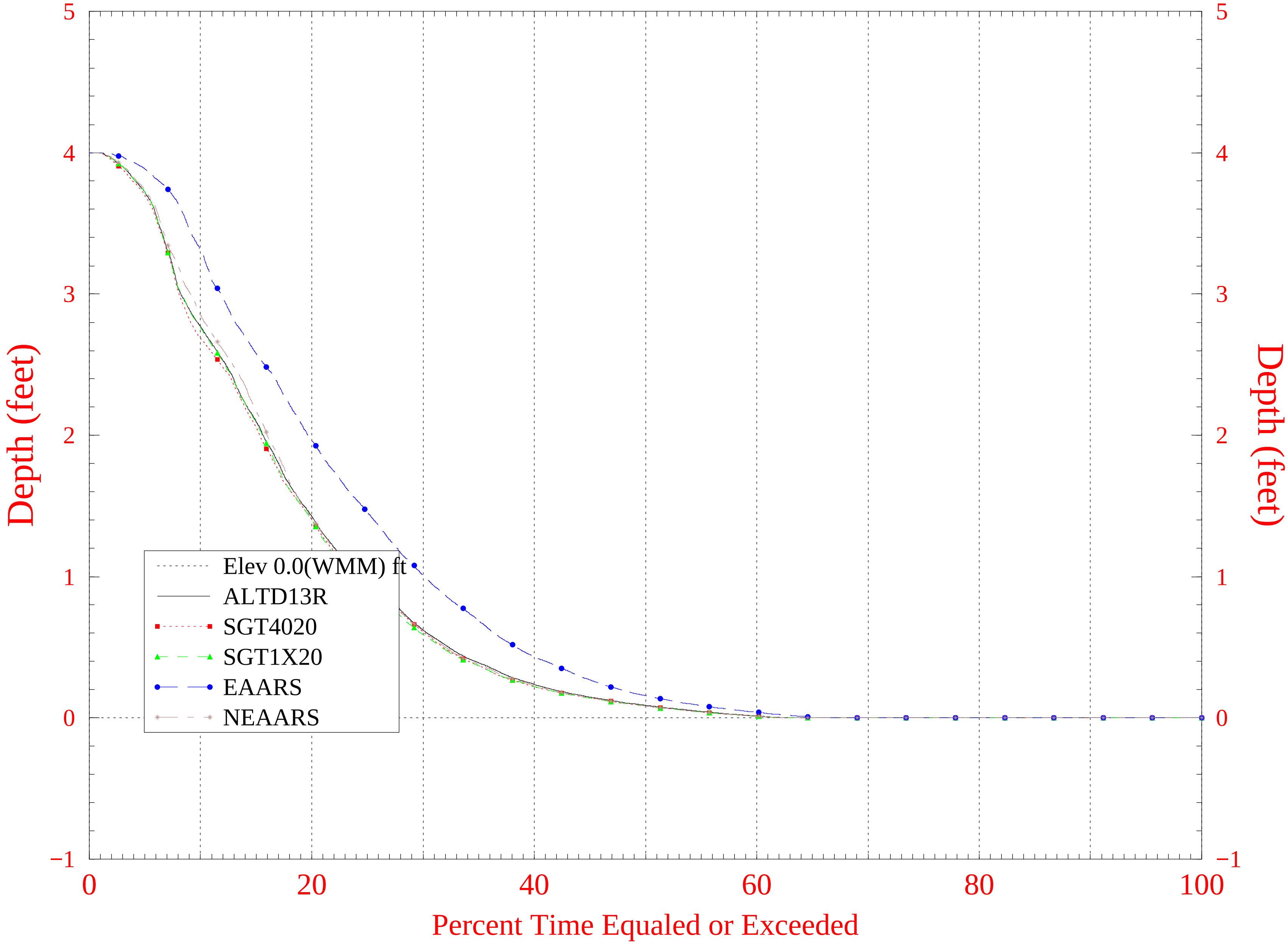
Figure B.3-43 Stage Duration Curves at C-44 Reservoir



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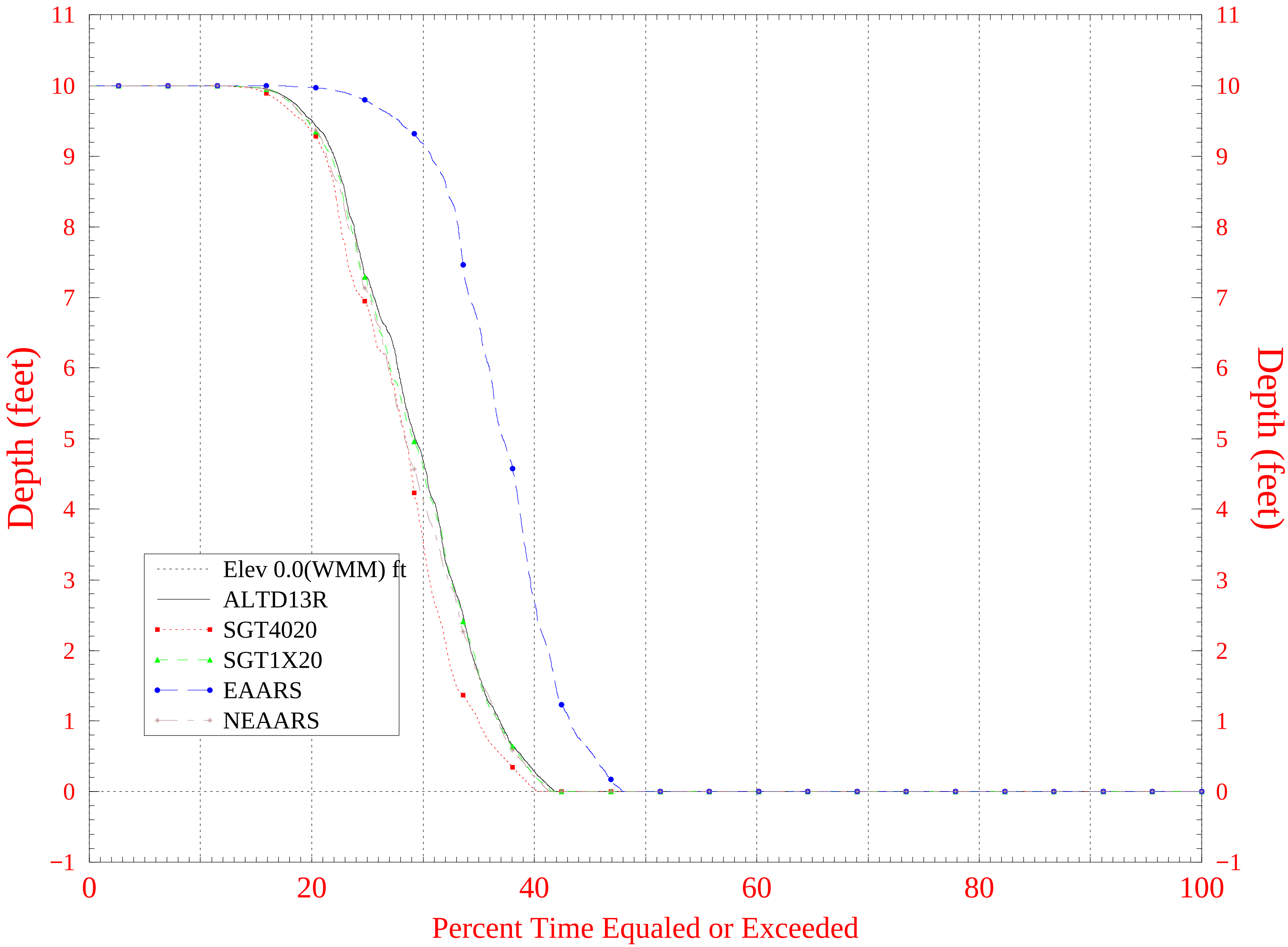
For Planning Purposes Only
SFWMM V3.5

Figure B.3-44 Stage Duration Curves at Taylor Creek-Nubbin Slough Reservoir



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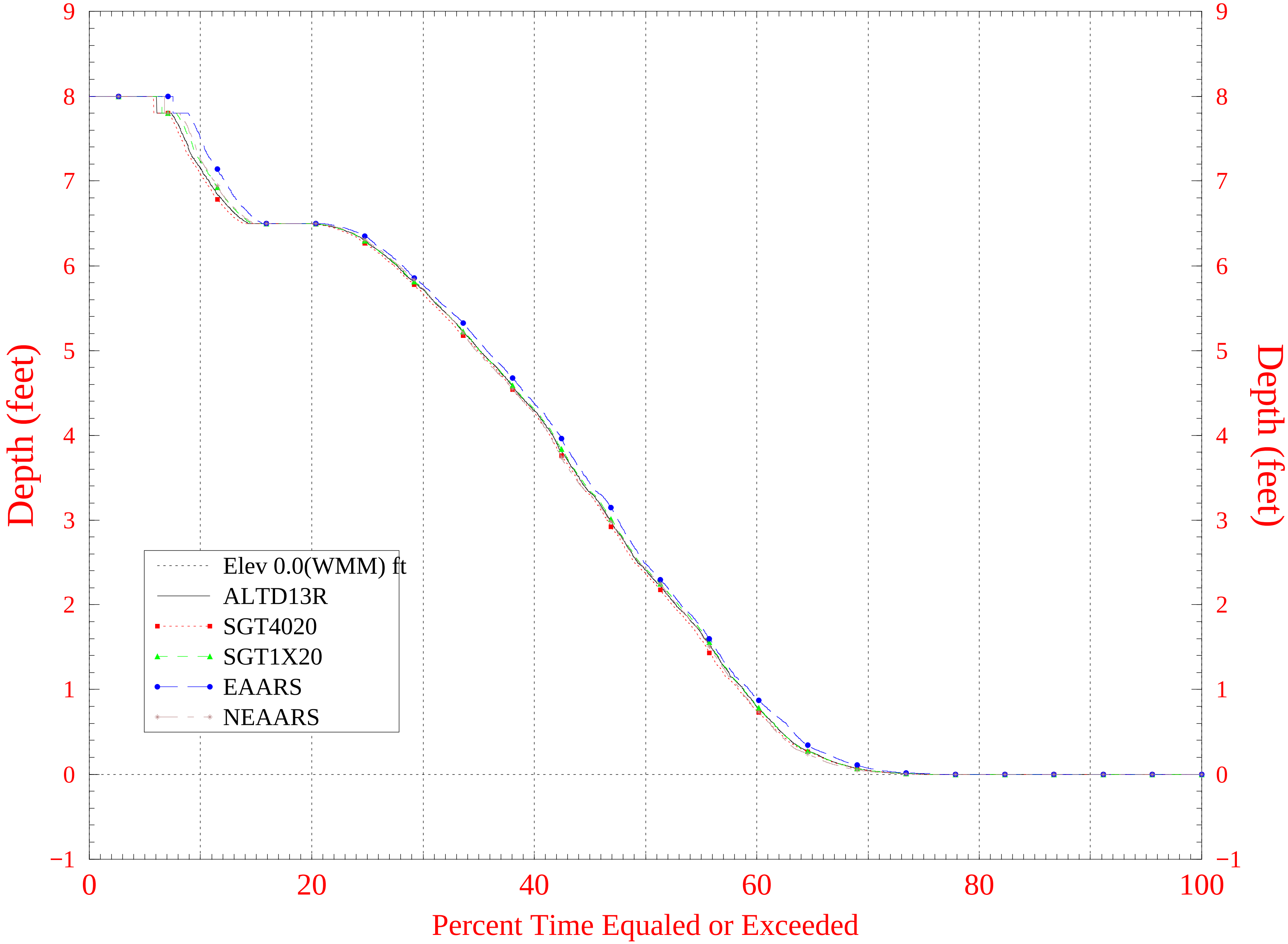
For Planning Purposes Only
SFWMM V3.5

Figure B.3-45 Stage Duration Curves at C-43 Reservoir



Run date: 08/12/98 12:36:43
For Planning Purposes Only
SFWMM V3.5

Figure B.3-46 Indicator Regions

Updated April 13, 1998

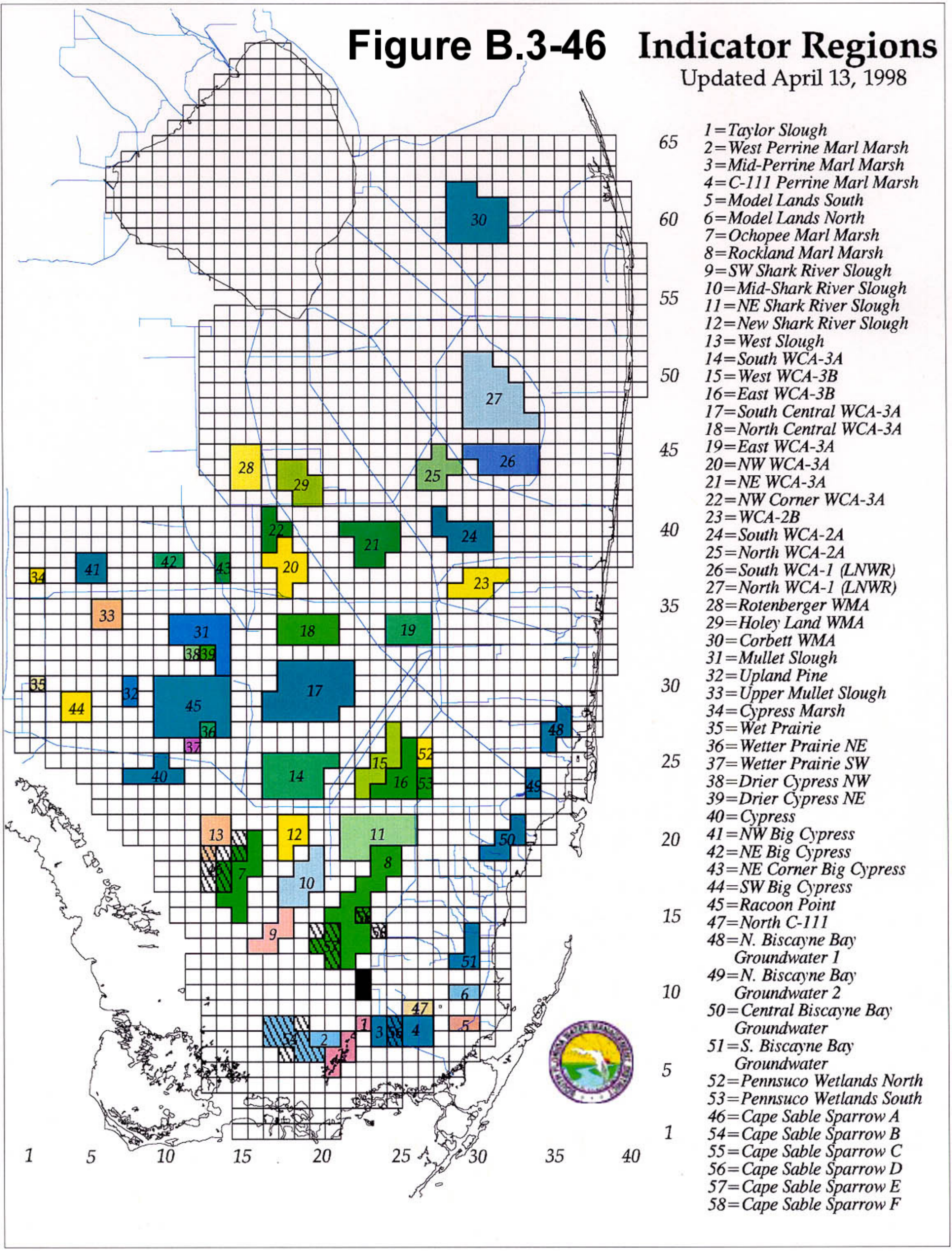
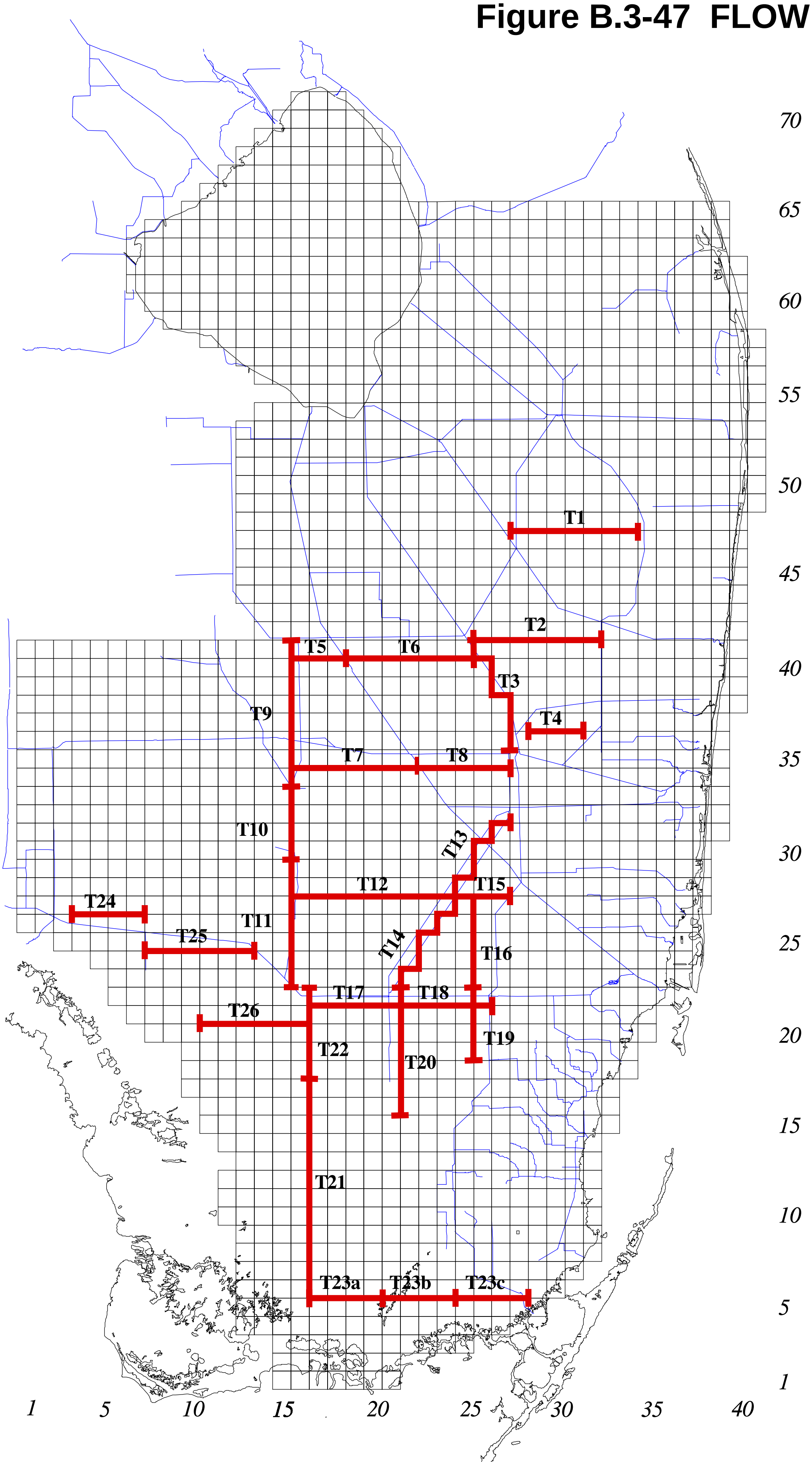


Figure B.3-47 FLOW TRANSECTS



T1 LNWR
T2 WCA-2A
T3 WCA-2/3
T4 WCA-2B
T5 NW WCA-3A
T6 NE WCA-3A
T7 Alligator Alley W
T8 Alligator Alley E
T9 NW WCA-3A boundary
T10 Central WCA-3A boundary
T11 SW WCA-3A boundary
T12 Southern WCA-3A
T13 L-67 North
T14 L-67 South
T15 N WCA-3B
T16 E WCA-3B
T17 Tamiami Trail W
T18 Tamiami Trail E
T19 ENP, W of L31N
T20 L67 Extension
T21 Shark River Slough
T22 NW Shark River Slough
T23 Southern ENP
T24 BCNP West
T25 BCNP East
T26 Lostmans

B.3.5.4 L-8/C-51 Reservoir

B.3.5.4.1 Description of Simulation

Simulation is based on ALTD13R with L-8/C-51 reservoir (component GGG) and its functions completely removed. In ALTD13R the reservoir covers 1,200 acres with a total storage depth of 40 feet. The reservoir is filled with excess water from southern L-8 and C-51 Basins. Subsequently, the water is released from the reservoir to: (1) C-51 when discharges through S-155 are less than 100 cfs (off-peak discharges), and (2) WPB Catchment Area when M-Canal stage is 18 feet NGVD or lower.

B.3.5.4.2 Assumptions

- L-8/C-51 reservoir is removed
- Excess water diverted to the reservoir from L-8 and C-51 Basins in ALTD13R is allowed to go to tide.
- Water supply releases to WPB Catchment Area and C-51 from L-8/C-51 reservoir are now routed from other reservoir/ASR systems or Water Conservation Area 1 and Lake Okeechobee.

B.3.5.4.3 Summary of Results

The removal of L-8/C-51 reservoir results in the following:

- Decrease in water levels by about 0.2 ft. in WPB Catchment Area, as shown in Figure B.3-48. The decrease is not substantial enough to affect stages in Loxahatchee Slough (Figure B.3-49) or the duration of cutbacks in public water use in Northern Palm Beach County (Figure B.3-50).
- Increase in dependence on WCA-1 and Lake Okeechobee for water supply to Service Area 1 (62 to 76 kac-ft/year during drought years, 28 to 38 kac-ft/year over simulation period), as shown in Figures B.3-51 and B.3-52. Figures B.3-51 and B.3-52 also show an increase in recovery from the ASR wells along C-51 with L-8/C-51 reservoir removed. The reservoir provides up to 300 cfs to C-51 when discharges through S-155 are less than 100 cfs, which occurs mostly during the dry season. This causes a decrease in need to recover water from the ASR wells for water supply purposes with the reservoir present, as indicated in ***Table B.3-6***. Note that the total system deliveries to Service Area 1 increase slightly with the reservoir removed. This is because the off-peak discharges the reservoir provided to C-51 are eliminated, resulting in an increase in demand for SA1.
- As seen in ***Table B.3-6***, 67 percent of the diversion of excess C-51 water to the reservoir in ALTD13R occurs in the wet season while over 75 percent of the outflow from the reservoir to C-51 occurs in the dry season. Thus, when L-8/C-51 reservoir is removed, nearly 90 percent of the total increase of 52 kac-ft/year in outflow to Lake Worth Lagoon occurs in the wet season. A comparison of mean daily S-155 discharges during the wet seasons of 1968

and 1995 of the simulations is shown in Figures B.3-53 and B.3-54. Injection of excess water into ASR wells along C-51 increases as well in the wet season (***Table B.3-6***).

Table B.3-6 Average Seasonal Values (thousand acre-feet)

	ALTD13R		NOL8RS	
	Dry Season	Wet Season	Dry Season	Wet Season
Outflow to Lake Worth Lagoon	75	162	81	208
C-51 ASR Injection	38	40	31	47
C-51 ASR Recovery	23	1	31	2
C-51 Diversion to Reservoir	30	61	0	0
Reservoir Outflow to C-51 (off-peak discharges)	65	19	0	0
L-8 Outflow via C-51 to Tide	13	50	20	60

Figure B.3-48 Stage Duration Curves at WPBWCA
(Cell R56 C36)

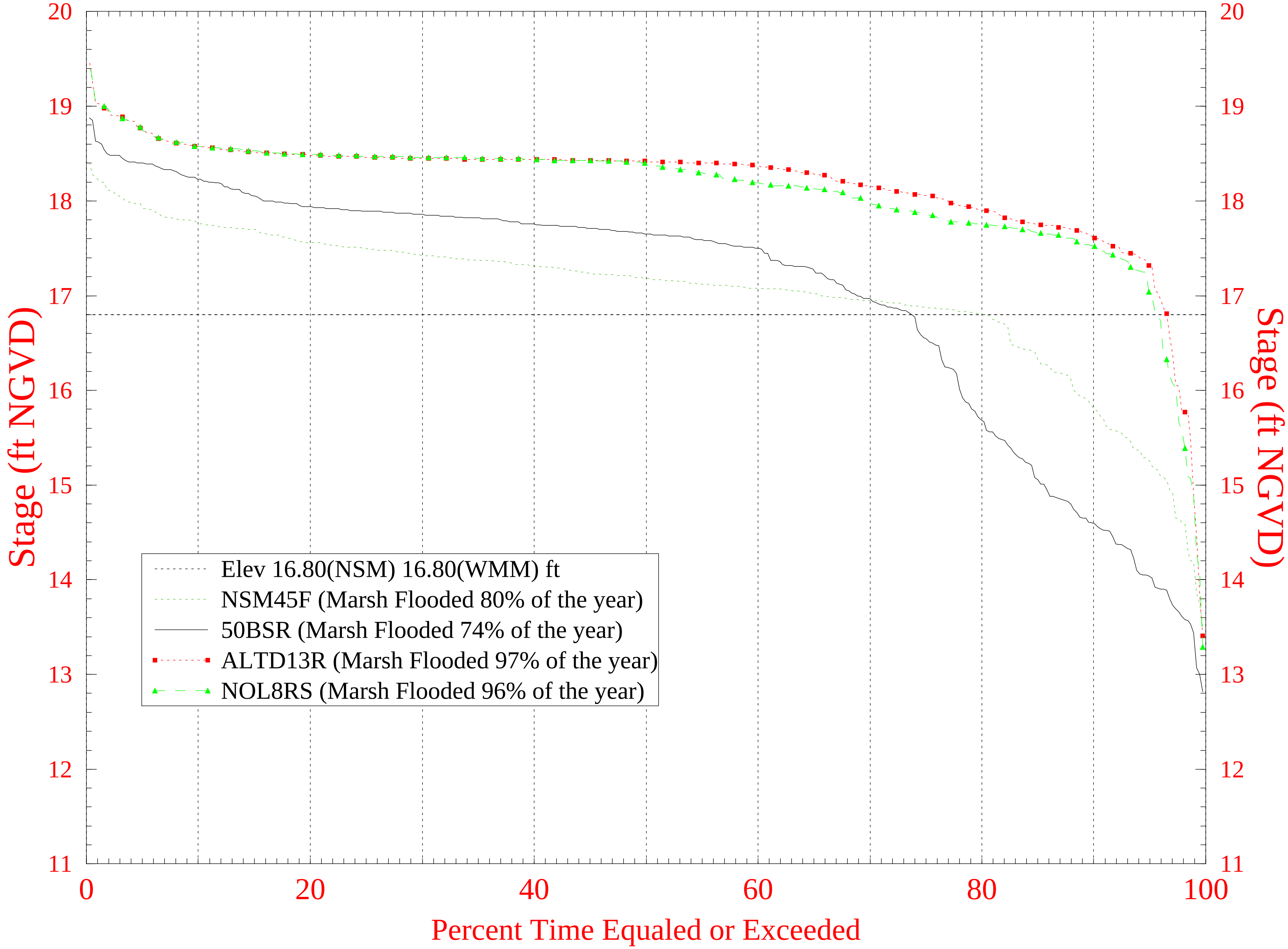


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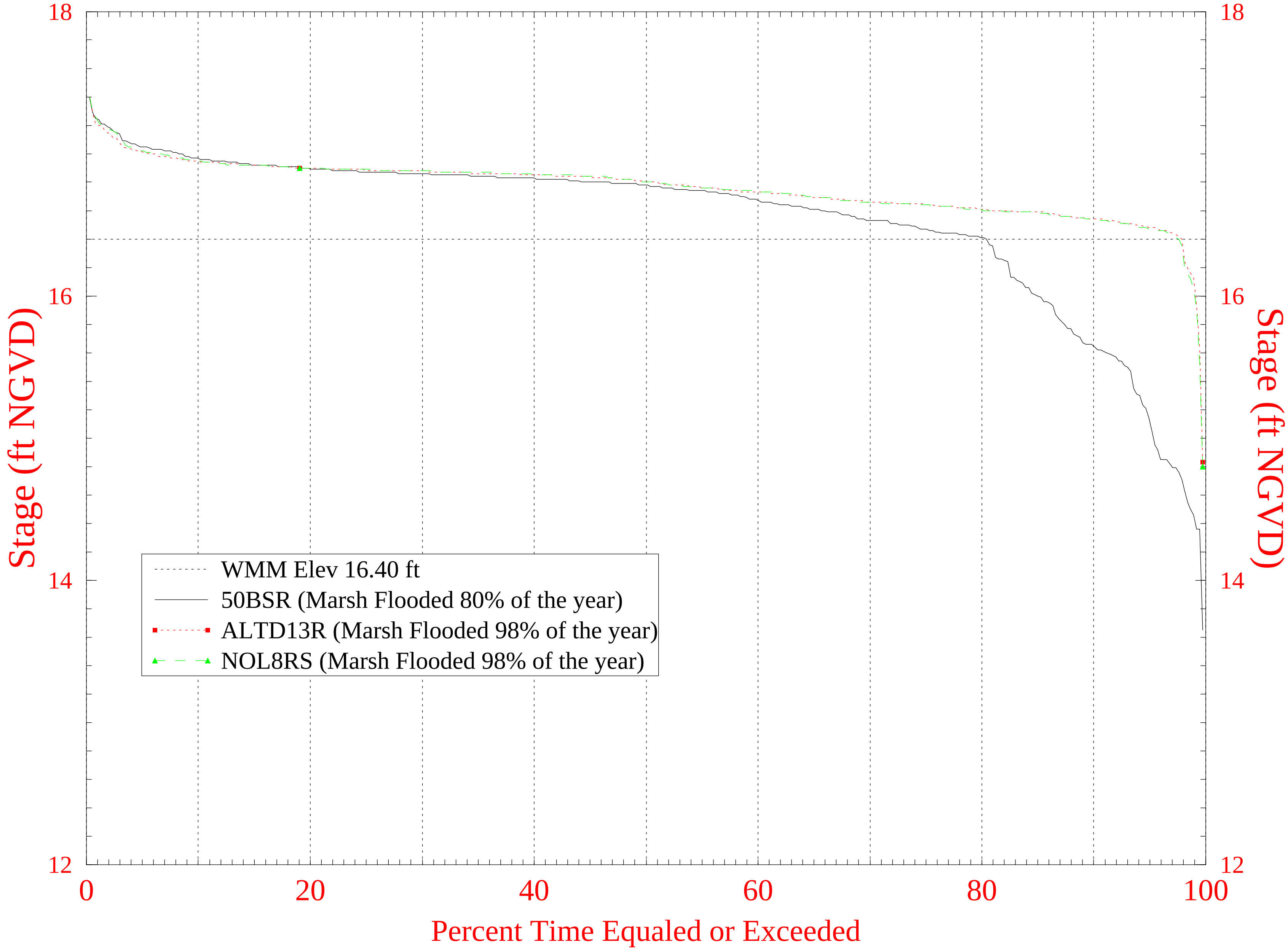
Figure B.3-49 Stage Duration Curves at Loxahatchee Slough

SFWMM Cell R59 C36



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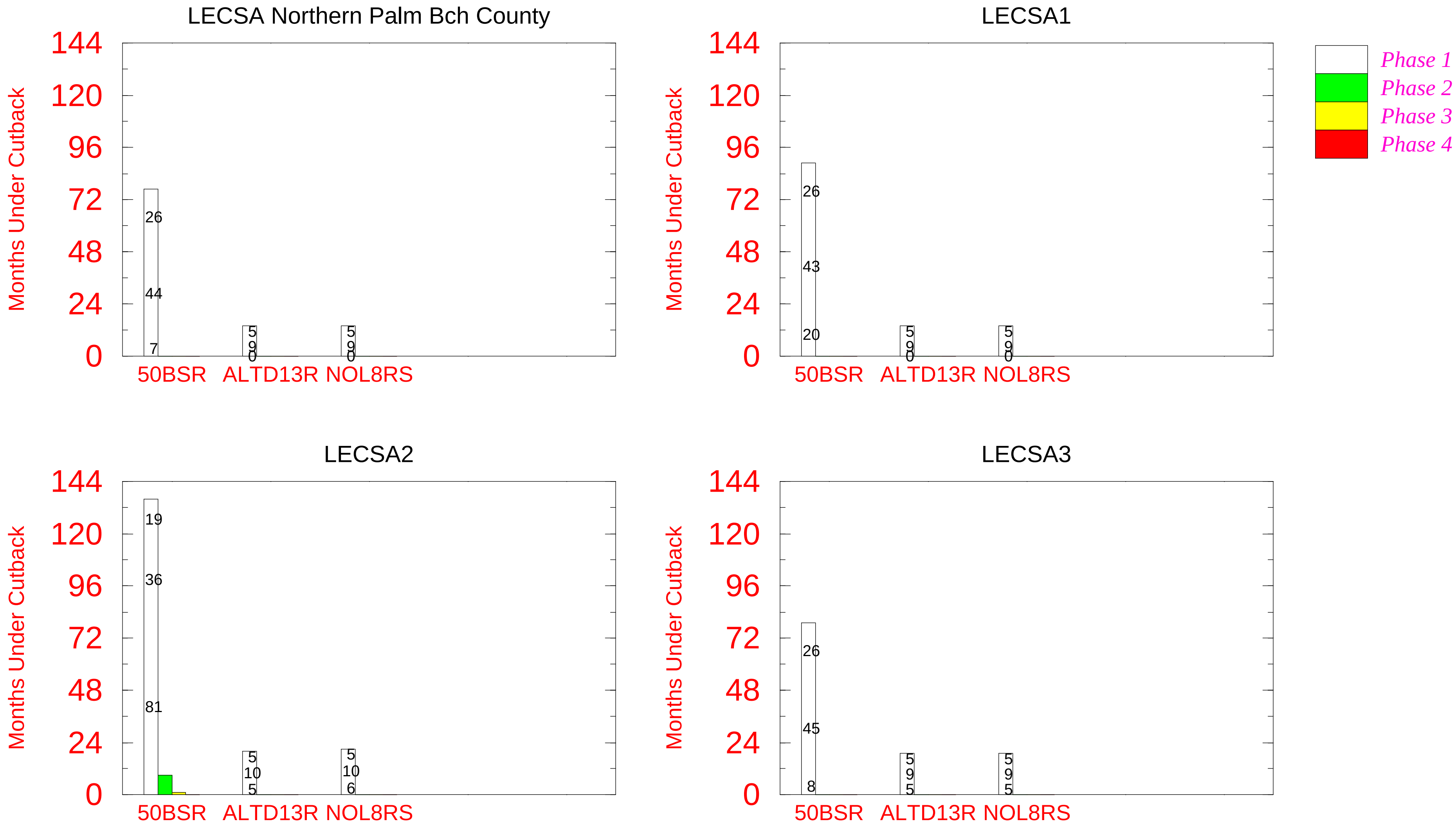
For Planning Purposes Only
SFWMM V3.5

Figure B.3-50 Number of Months of Simulated Water Supply Cutbacks for the 1965 - 1995 Simulation Period



Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).

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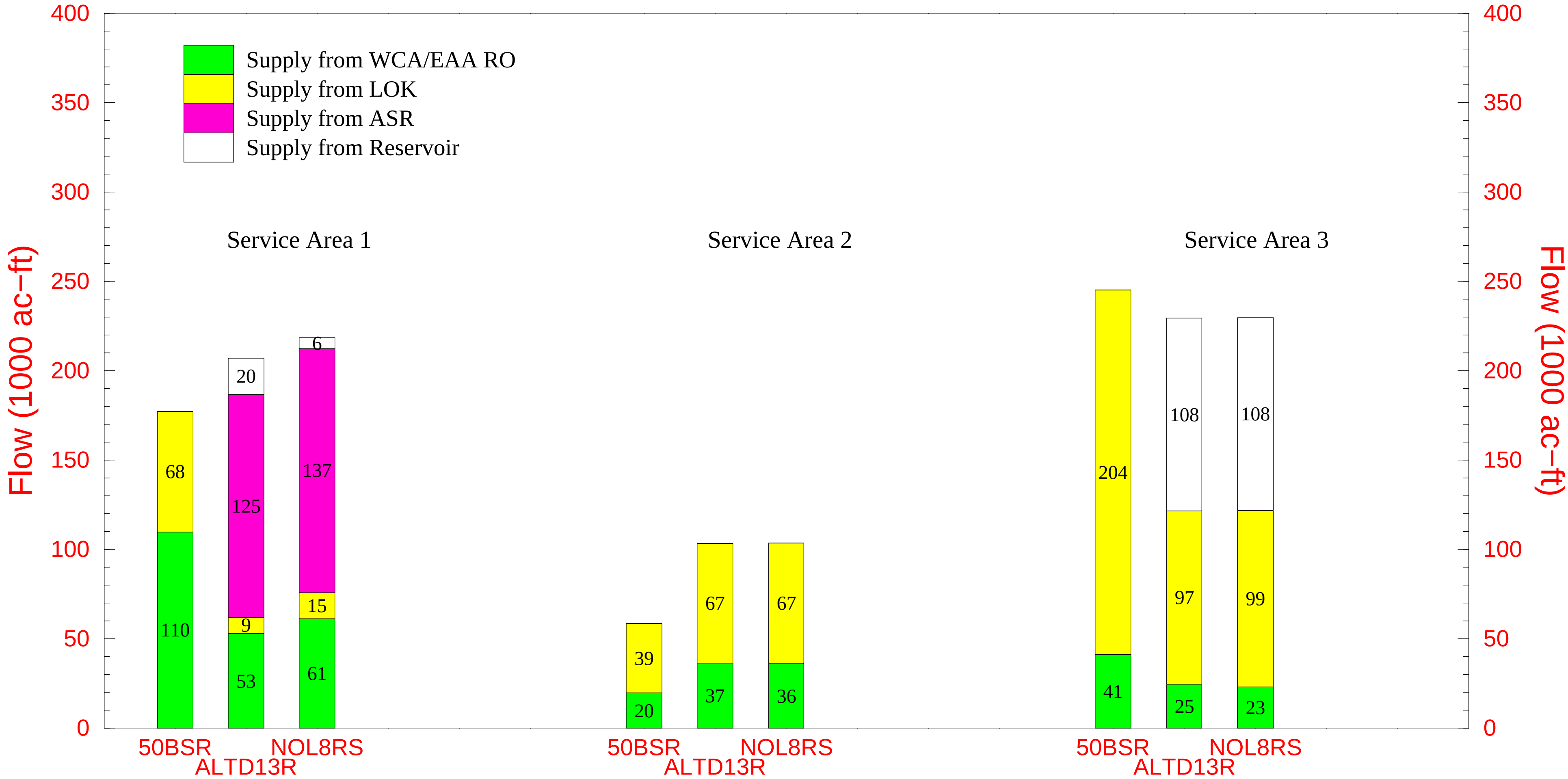
SFWMM V3.5

Figure B.3-51 Mean Annual Regional System Water Supply Deliveries to LEC Service Areas for the five Drought years (71,75,81,85,89)



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

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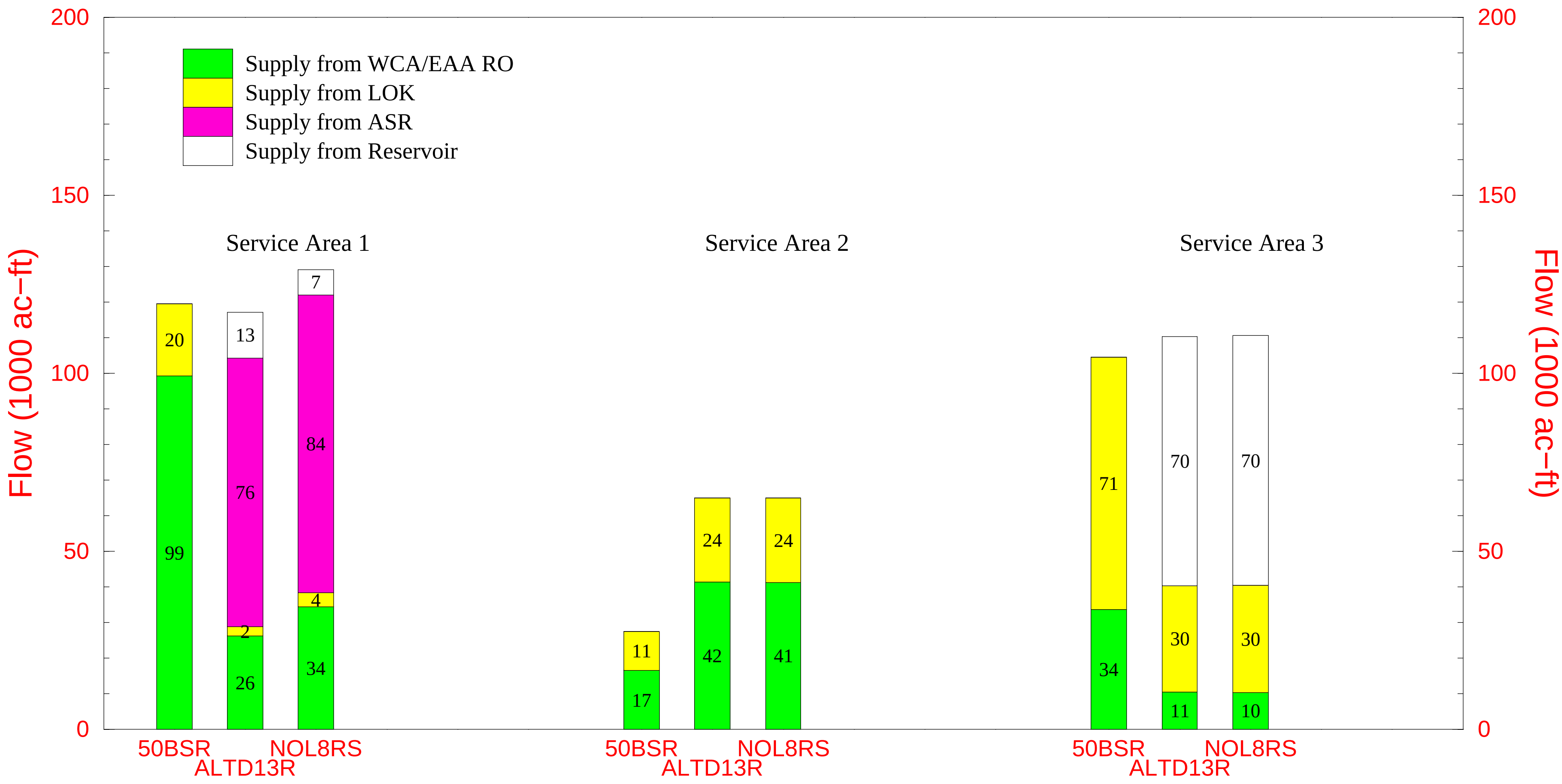
For Planning Purposes Only
SFWMM V3.5

Figure B.3-52 Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 - 1995 simulation



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

Run date: 07/17/98 17:24:25
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SFWMM V3.5

Figure B.3-53 Comparison of Simulated S-155 Discharge

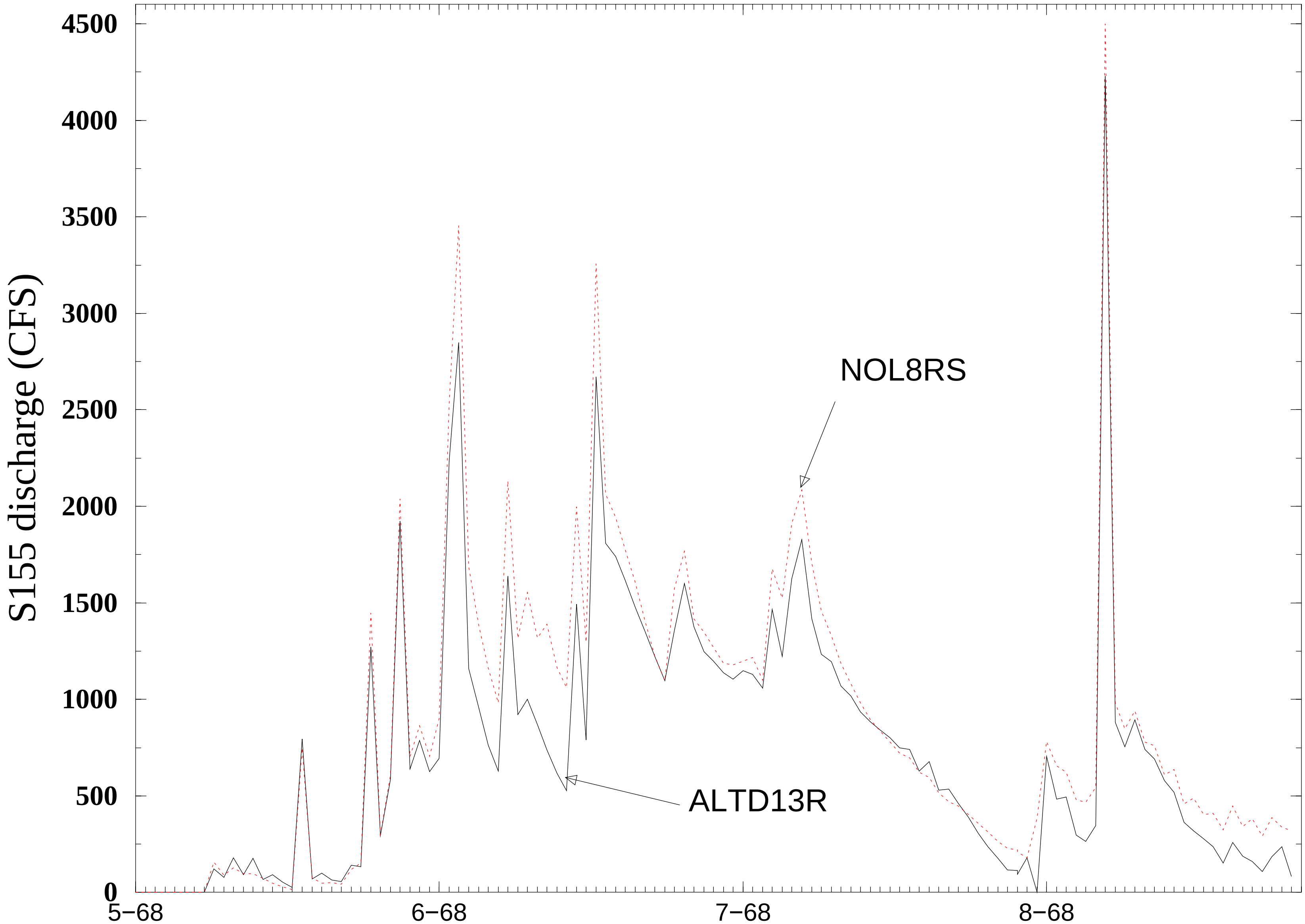
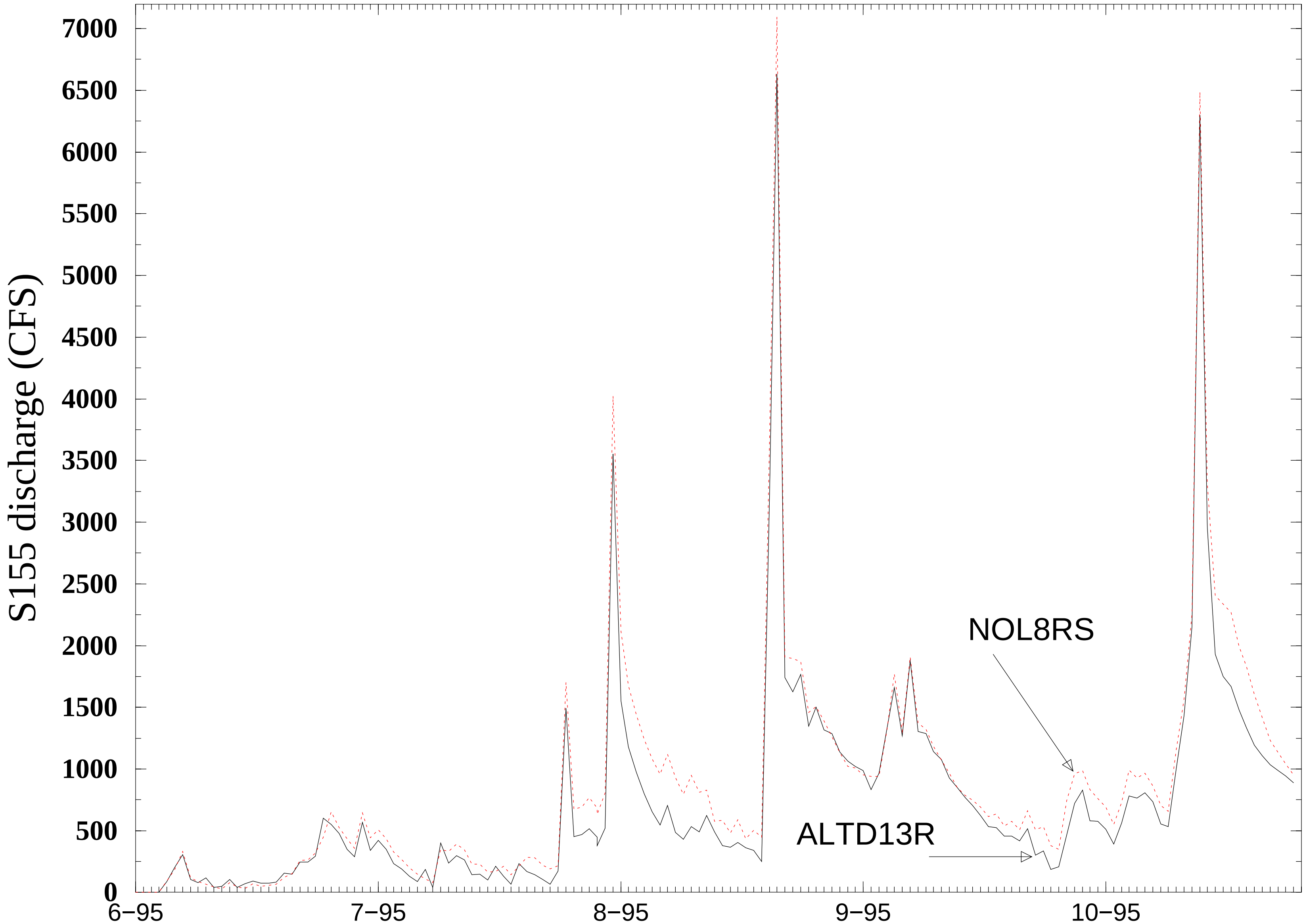


Figure B.3-54 Comparison of Simulated S-155 Discharge



B.3.5.5 Lower East Coast Aquifer Storage and Recovery

B.3.5.5.1 Description of Simulations

A sensitivity analysis of the proposed ASR systems in the LEC was completed utilizing the SFWMM. Outputs from three model simulations were compared.

The first or base model run corresponds to ALTD13R that was posted on the HPM Web page (June 19, 1998). This alternative proposes four major locations for ASR wells in the vicinity of West Palm Beach Catchment Area (WPBCAT), C-51 Canal (C51), proposed Central Palm Beach County agricultural reserve reservoir (CPBRES), and proposed Site 1 reservoir. These ASR systems are one of the many features described in components K6, LL6, VV6 and M6, respectively, of ALTD13R. A recovery efficiency of 70 percent is assumed for all ASR wells. Injection and retrieval capacities are identical in all ASR locations. All LEC ASRs are proposed to be built in LEC Service Area (LECSA) 1. Their magnitudes are shown as follows:

ASR designation*	WPBCAT	C51	CPBRES	SITE1
Size, MGD	50	170	75	150

*ASR designation refers to variable name used in SFWMM to identify the ASR.

The other two model runs are scenarios derived from the base run. Scenario 1 was simulated by having ASR injection and withdrawal capacities equal to zero MGD. The configuration and rules governing the operation of the ASRs as simulated in the base run was maintained in scenario 2--only the efficiency was changed from 70 to 35 percent. In the SFWMM, ASR efficiencies are applied upon injection so that the size of the ASR "bubble" at the end of each time step truly represents the available storage in the ASR well.

B.3.5.5.2 Assumptions

In both scenario runs, no operational adjustments or physical components were added or substituted to compensate for the reduction in efficiency or elimination of the LEC ASRs. The rest of the components incorporated in ALTD13R are identical to the ones utilized in both scenario runs. The modification by elimination or reduction in efficiency of LEC ASRs were done simultaneously in all locations.

B.3.5.5.3 Summary of Results

Performance measure (PM) graphics comparing selected model output summaries follow. The base run is designated as ALTD13R. Scenario 1 (without ASRs) and scenario 2 (ASRs with 35 percent efficiency) are designated as NOLASR and 35LASR, respectively. Unless otherwise noted, trends in either scenario run, e.g. increase in discharge or lowering of stages, are expressed relative to the base run. ALTD13R as the base run should be differentiated from the Restudy 1995 and

2050 base runs. Model output corresponding to the 1995 and 2050 base runs are plotted in all PM graphics for reference only. The major findings in this analysis are:

- For Lake Worth Lagoon, the number of high-flow violations significantly increased in the NOLASR scenario relative to the base run (from 96 to 144). For the same estuary, the 35LASR scenario showed a slight increase in the number of low-flow violations compared to the base run (from 24 to 27, Figure B.3-55).

- Mean annual surface flows to tide did not significantly change for the majority of service areas when ASR efficiencies were lowered from 70 to 35 percent. However, LECSA 1 exhibited an increase in the mean annual wet season and dry season flows to tide when the ASRs were completely removed ((+32 and +28 percent respectively, Figure B.3-56).

- The saltwater intrusion criteria as measured at S-155 (Figure B.3-57) and G-56 were not compromised with or without the proposed LEC ASRs (Figure B.3-58).

The CPBRES and SITE1 ASRs receive water from their respective reservoirs. The duration curves for Site 1 reservoir do not show a significant difference between the base run and 35LASR scenario (Figure B.3-59). The Central Palm Beach County reservoir dried up approximately 3 percent of the simulation period more often with a less efficient ASR (Figure B.3-60). The annual/wet season/dry season injection rates, in kac-ft/yr, for ALTD13R and 35LASR are 55.7 / 39.2 / 16.4 and 55.3 / 38.9 / 16.4, respectively.

- Water restrictions were not effected with or without ASRs in LECSA 1 in terms of the number of months in simulated water supply cutbacks (Figure B.3-61). Locally-triggered cutbacks in Service Area 1 did not exist even without ASRs.

- Figures B.62 and B.3-63 show the average annual regional system water supply deliveries to LEC Service Areas for the entire simulation and the five drought years (1971, 1975, 1981, 1985 and 1989), respectively. The mean annual water supply deliveries, in kac-ft/yr, by source to Service Area 1 during the five drought years are summarized in the table following. The values in parentheses represent the percent contribution of a given source to the total delivery for each model run.

SA-1 Water Supply Deliveries, (kac-ft/yr)

	Model Run		
Source	ALTD13R	35LASR	NOLASR
LEC ASR	125 (60%)	80 (41%)	0 (0%)
WCA/EAA runoff	53 (26%)	71 (37%)	91 (53%)
LEC Reservoir	20 (10%)	21 (11%)	42 (24%)
Lake Okeechobee	9 (4%)	21 (11%)	40 (23%)
Total	207	193	173

- Reducing the ASR efficiencies from 70 to 35 percent will do the following: (1) reduce the ASR contribution by 36 percent (from 125 to 80 kac-ft/yr); (2) increase WCA/EAA runoff contribution by 34 percent (from 53 to 71 kac-ft/yr); (3) approximately maintain the level of contribution from the reservoir; (4) increase Lake Okeechobee (LOK) contribution by 133 percent (from 9 to 21 kac-ft/yr); and (5) decrease the overall supply by 7 percent (from 207 to 193 kac-ft/yr). Additionally, totally the total elimination of ASRs in LEC Service Area 1 will do the following: (1) increase regional delivery (LOK + WCA/EAA runoff) by 111 percent (from 62 to 131 kac-ft/yr); (2) increase reservoir contribution by 110 percent (from 20 to 42 kac-ft/yr); and (3) decrease the overall supply by 16 percent (from 207 to 173 kac-ft/yr).

- Based on stage duration curves, slight lowering of water levels in WCA-1 can be noted as a trend from ALTD13R to 35LASR and from 35LASR to NOLASR for indicator regions 26 and 27 (Figures B.3-64a and B.3-64b). Relative to ALTD13R both scenario runs show that the southern indicator region exhibited greater interannual variation in mean weekly stage compared to the northern indicator region during the first half of the year (Figures B.3-65a and B.3-65b). Inundation duration summaries for indicator regions 26 and 27 in WCA-1 are given in the table following. Both scenario runs show an increase in number of continuous ponding events, a reduction in average flooding duration, and a reduction in average annual hydroperiod.

WCA-1 Inundation Durations (Region 26 and 27)

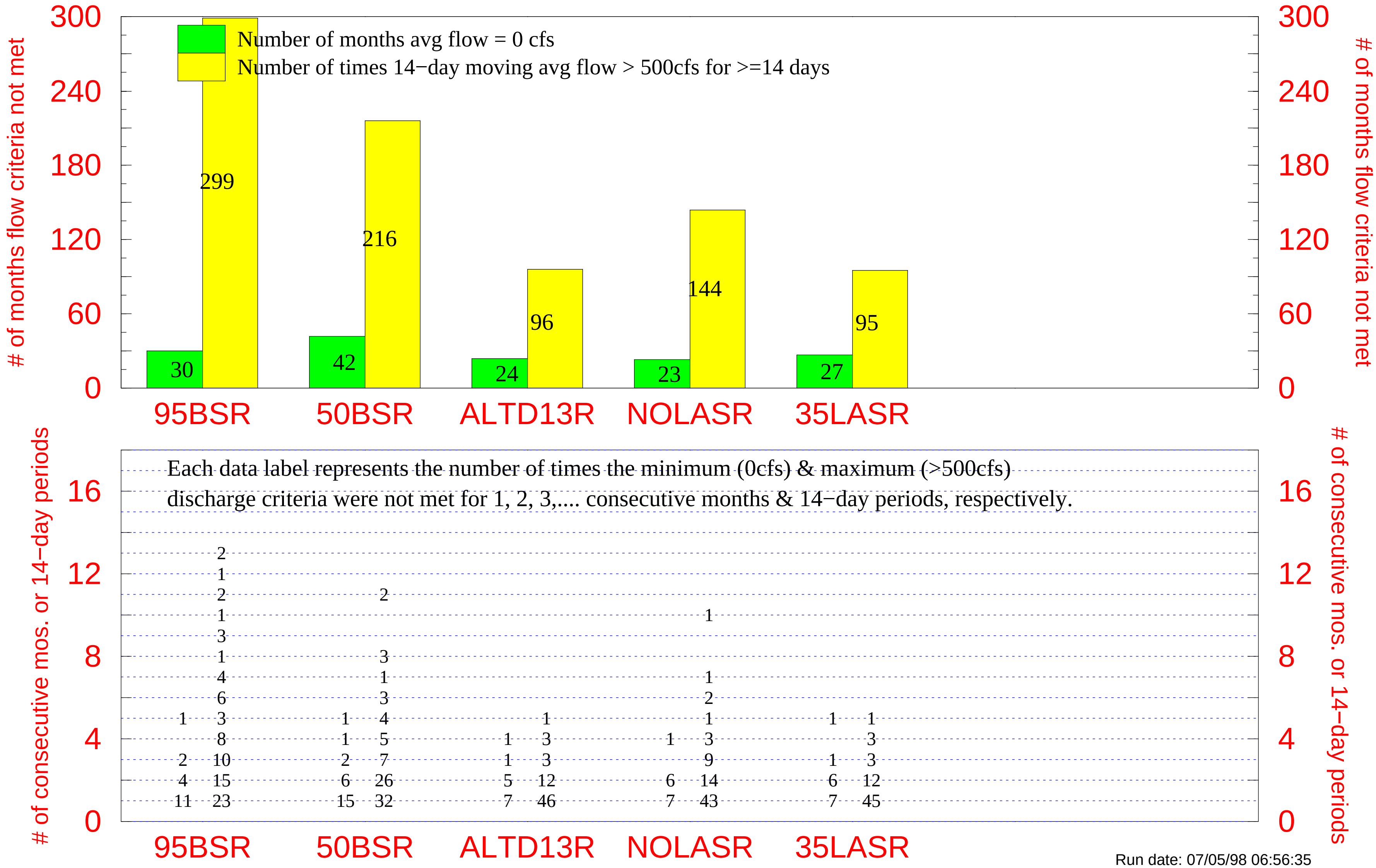
```
Indicator Region      #Events| Avg Flood Dur(Wks/Event)| Avg Ann Hydper(% of year)
Number  Name                 ALTD13R        35LASR          NOLASR
_______________________________________________________________________________
26    South LNWR           7| 228|  99    12| 132| 98    14| 112|  98
27    North LNWR          16|  96|  95    19|   80| 94    18|   84|  94
```

notes: #Events = number of continuous ponding events over the period of record
Average Flood Duration = [sum(days of ponding)/7]/#Events
Average Annual Hydroperiod = 100 x [sum(weeks of ponding per year)]/[52 x #years]

- The mean annual EAA/LOSA supplemental irrigation for both the entire simulation (Figure B.3-66a) and the five drought years did not change significantly (1971, 1975, 1981, 1985 and 1989, Figure B.3-66b).

- Both scenarios marginally lowered stages in Lake Okeechobee (Figure B.3-67). The NOLASR scenario showed an increase in both the percent (from 9 to 11 percent) and the number of times (from 10 to 13) of low stage or 12 ft, NGVD criteria exceedance. Likewise, the 35LASR scenario showed an increase in the percent (from 9 to 10 percent) but no change in the number of times (10) of low stage criteria exceedance (Figure B.3-68).

Figure B.3-55 Number of Times Salinity Envelope Criteria were NOT met for the Lake Worth Lagoon (mean monthly flows 1965 - 1995)



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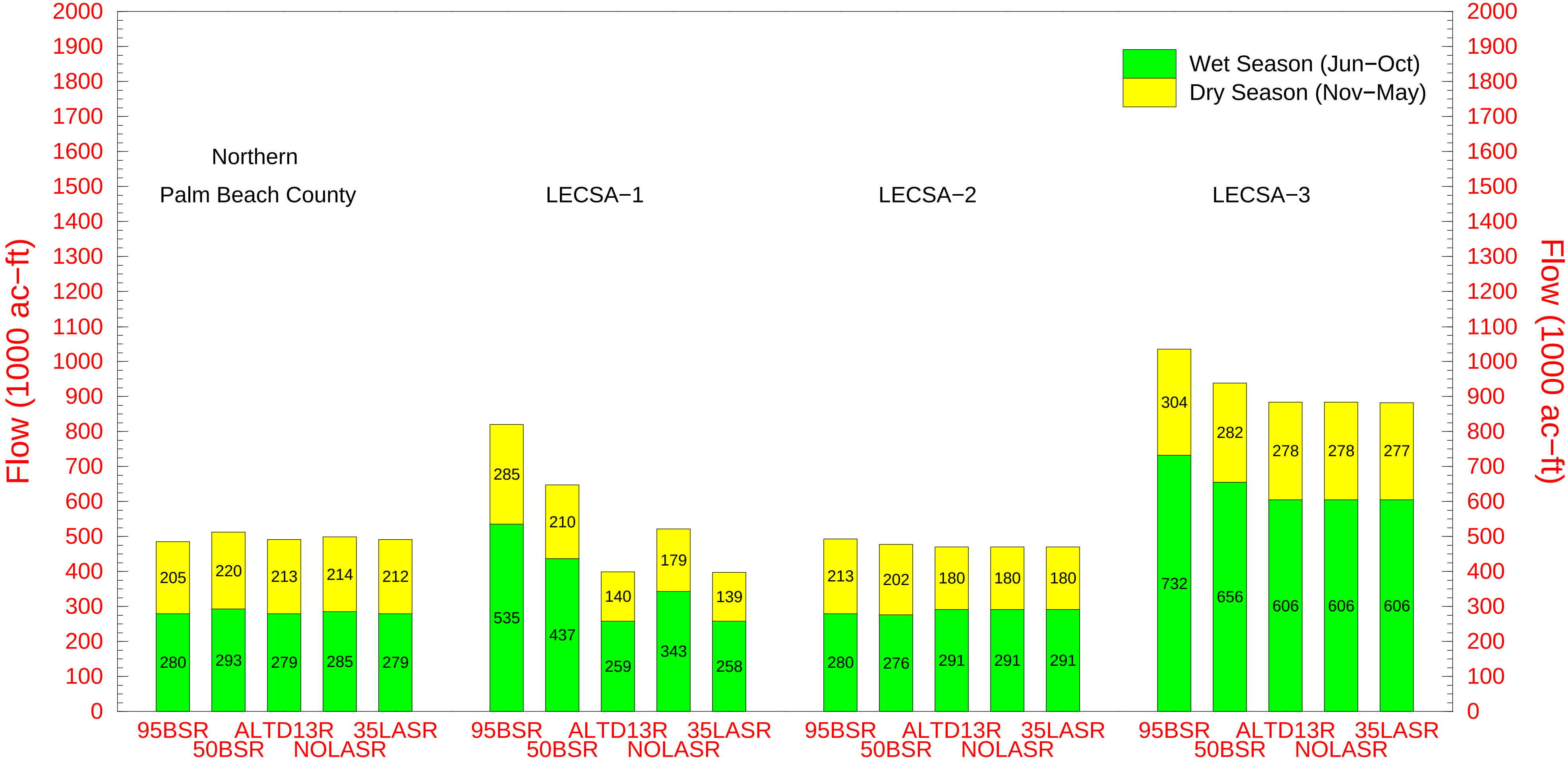
For Planning Purposes Only
SFWMM V3.5

Figure B.3-56 Mean Annual Surface Flows Discharged to Tide from the LECSA for the 1965 - 1995 Simulation Period



Service Area Canals Discharging to Tide:

Northern PB Co. = C−17
LECSA−1 = C−51, C−16, C−15 and the Hillsboro Canal
LECSA−2 = C−14, C−13, C−12, North New River Canal and C−10
LECSA−3 = C−9, Miami Canal, C−8, C−7, Coral Gables Canal, C−2,C−100A, C−100B, C−1, C−102, C−103, Military Canal and Model Land Canal

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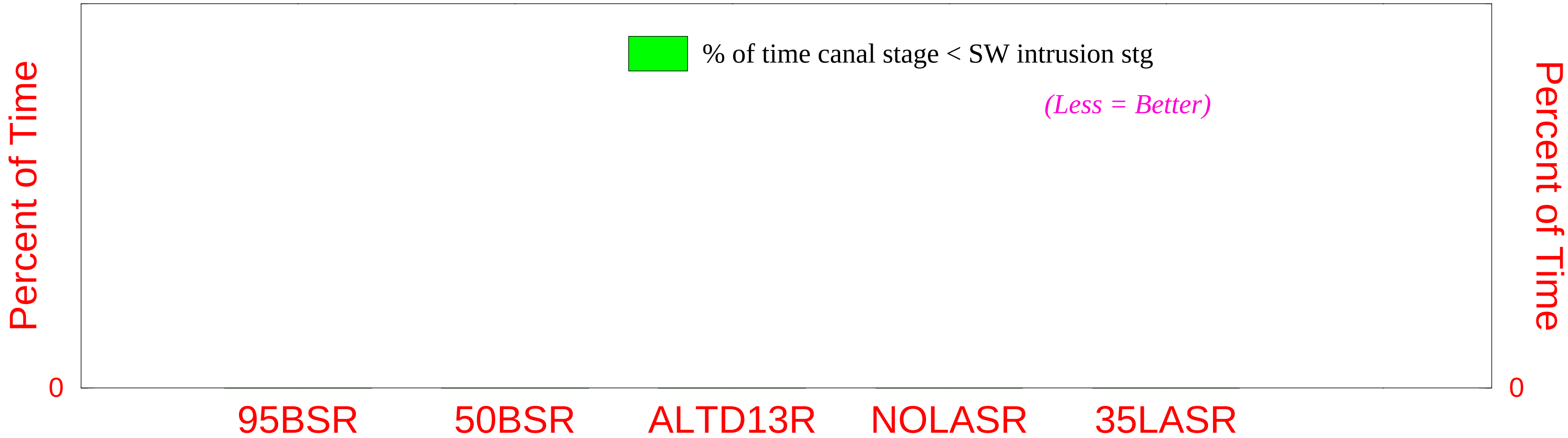
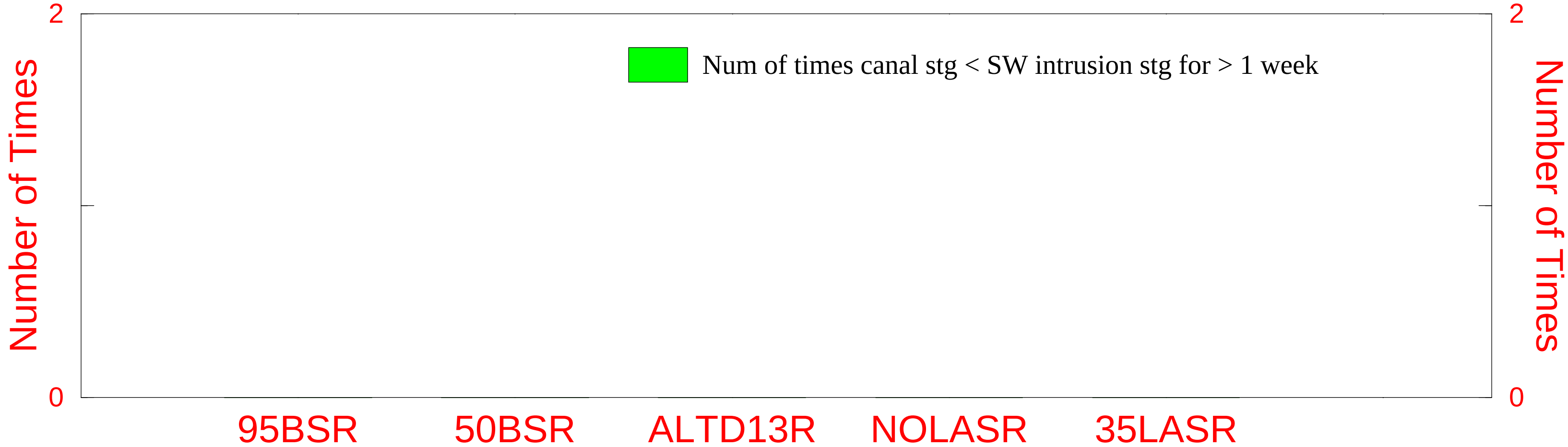
For Planning Purposes Only
SFWMM V3.5

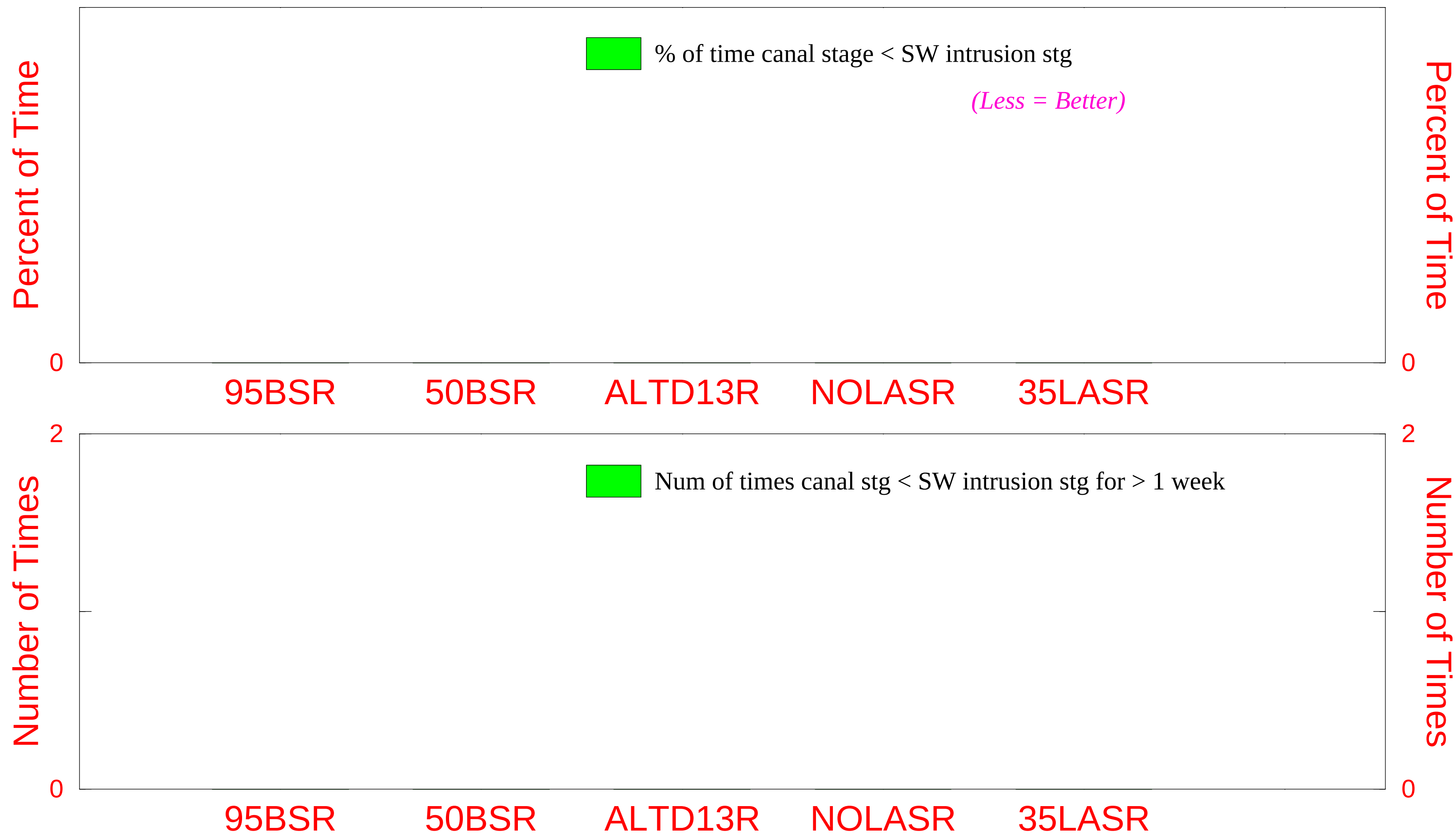
Figure B.3-57 Percent of Time Canal Stage < Salt-Water Intrusion Criteria & Occurences > 1 Week
Canal C-51 at S-155 (Salt-Water Intrusion Indicator Stg = 7.75 ft, NGVD)





Run date: 07/05/98 09:14:21
For Planning Purposes Only
SFWMM V3.5

Figure B.3-58 Percent of Time Canal Stage < Salt-Water Intrusion Criteria & Occurences > 1 Week
Canal Hillsboro at G-56 (Salt-Water Intrusion Indicator Stg = 6.75 ft, NGVD)



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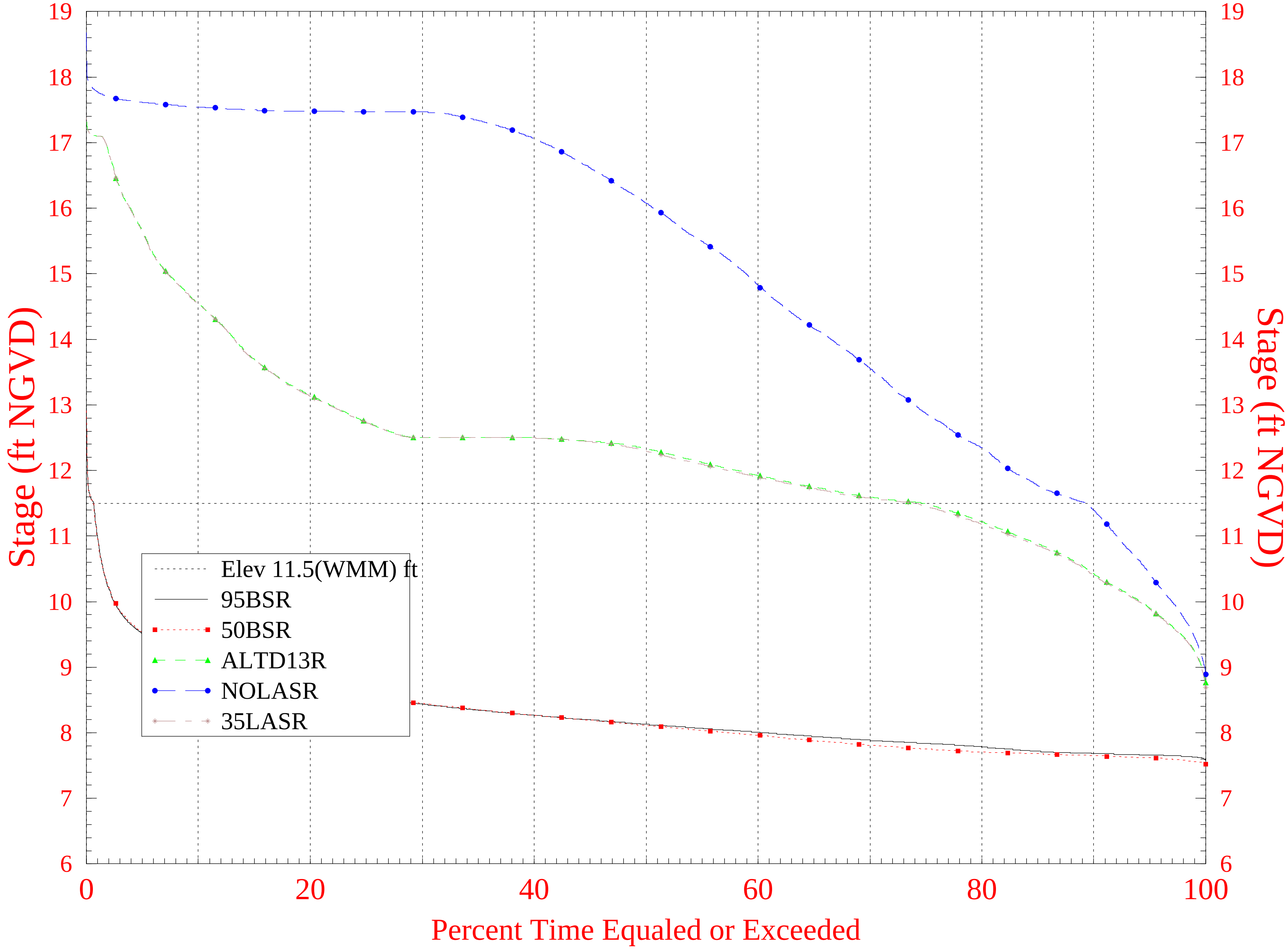
For Planning Purposes Only
SFWMM V3.5

Figure B.3-59 Stage Duration Curves at Site 1 Reservoir



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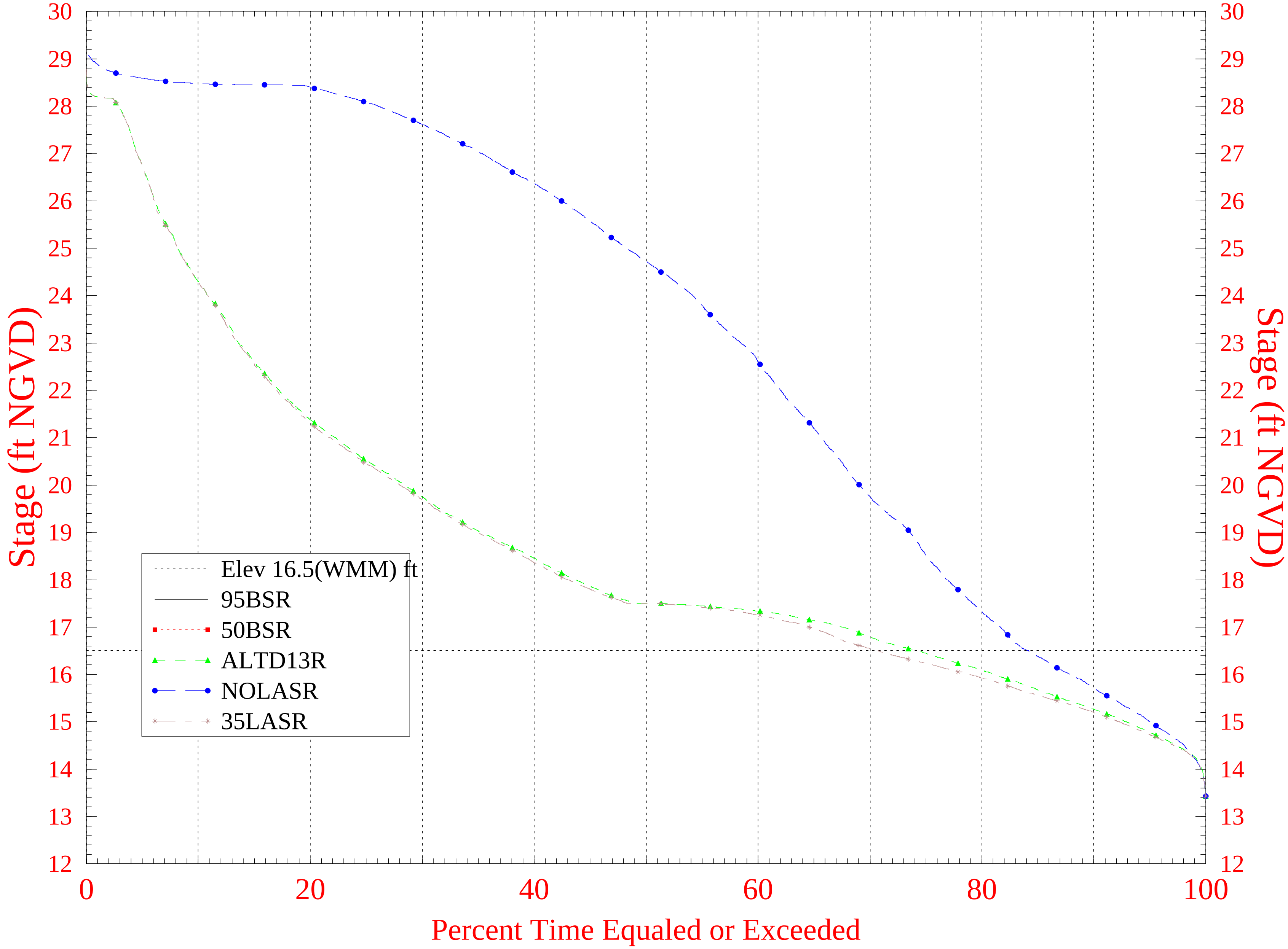
SFWMM V3.5

Figure B.3-60 Stage Duration Curves at Central PBC Reservoir



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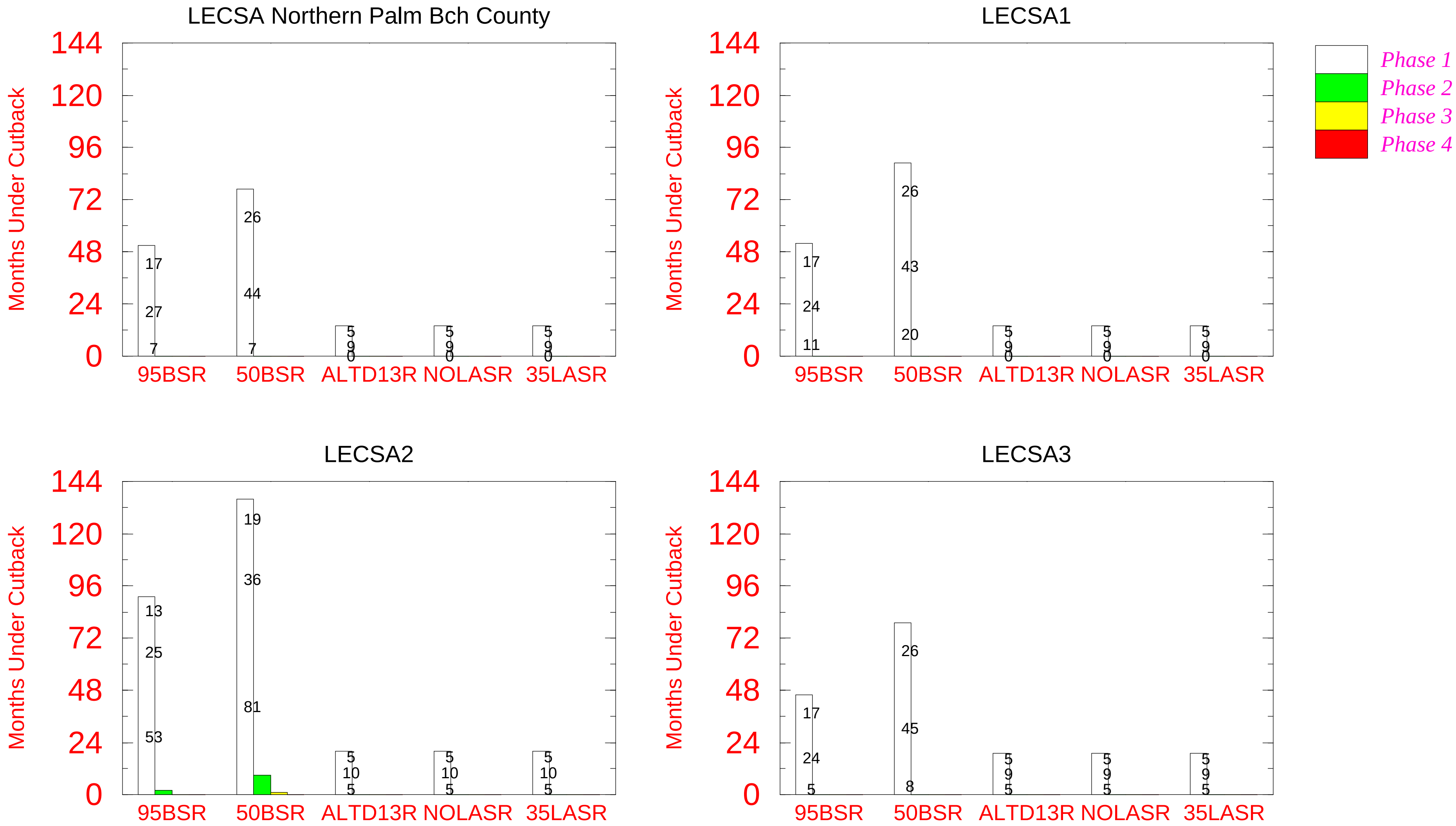
For Planning Purposes Only
SFWMM V3.5

Figure B.3-61 Number of Months of Simulated Water Supply Cutbacks for the 1965 - 1995 Simulation Period



Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).

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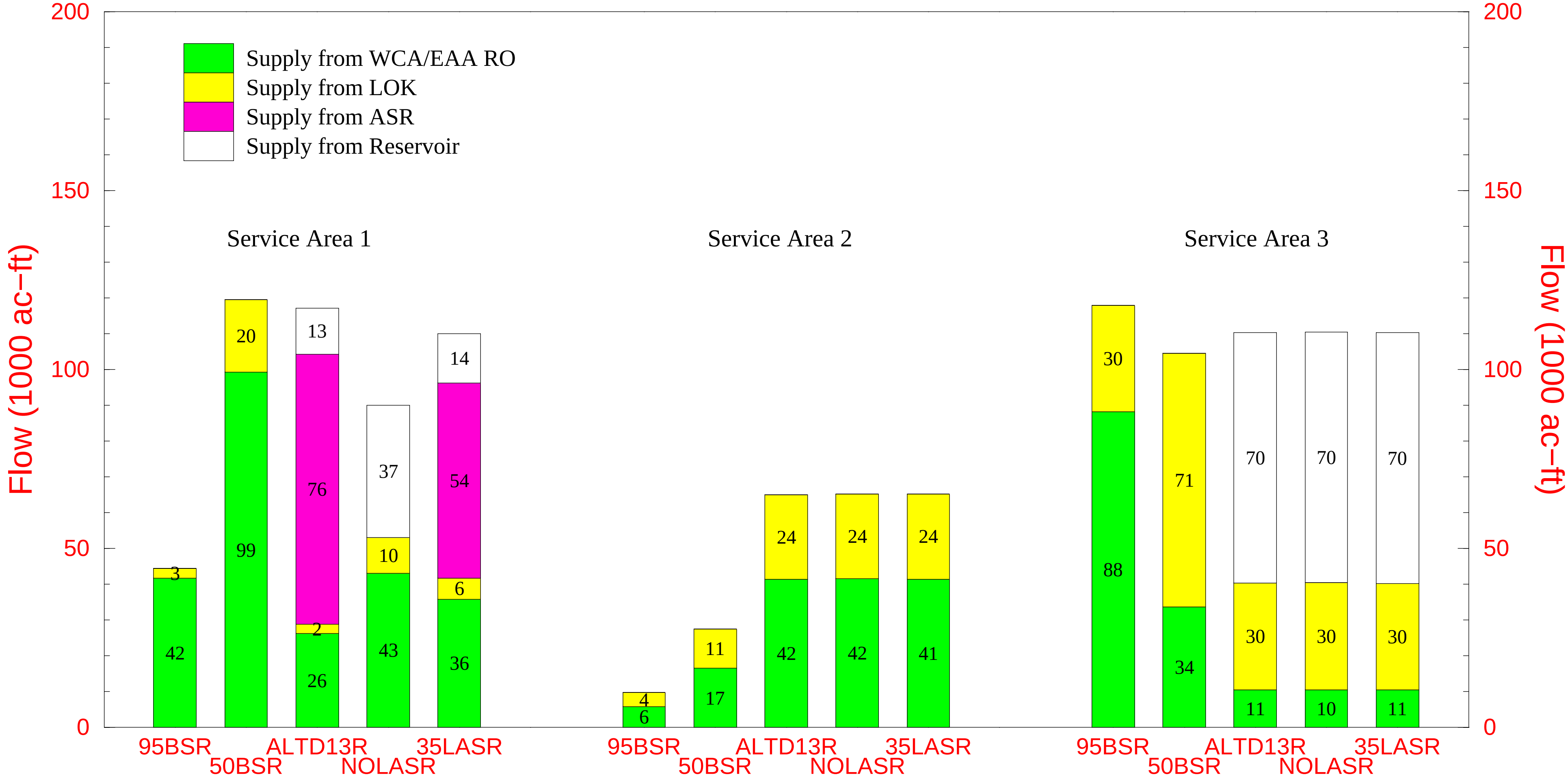
For Planning Purposes Only
SFWMM V3.5

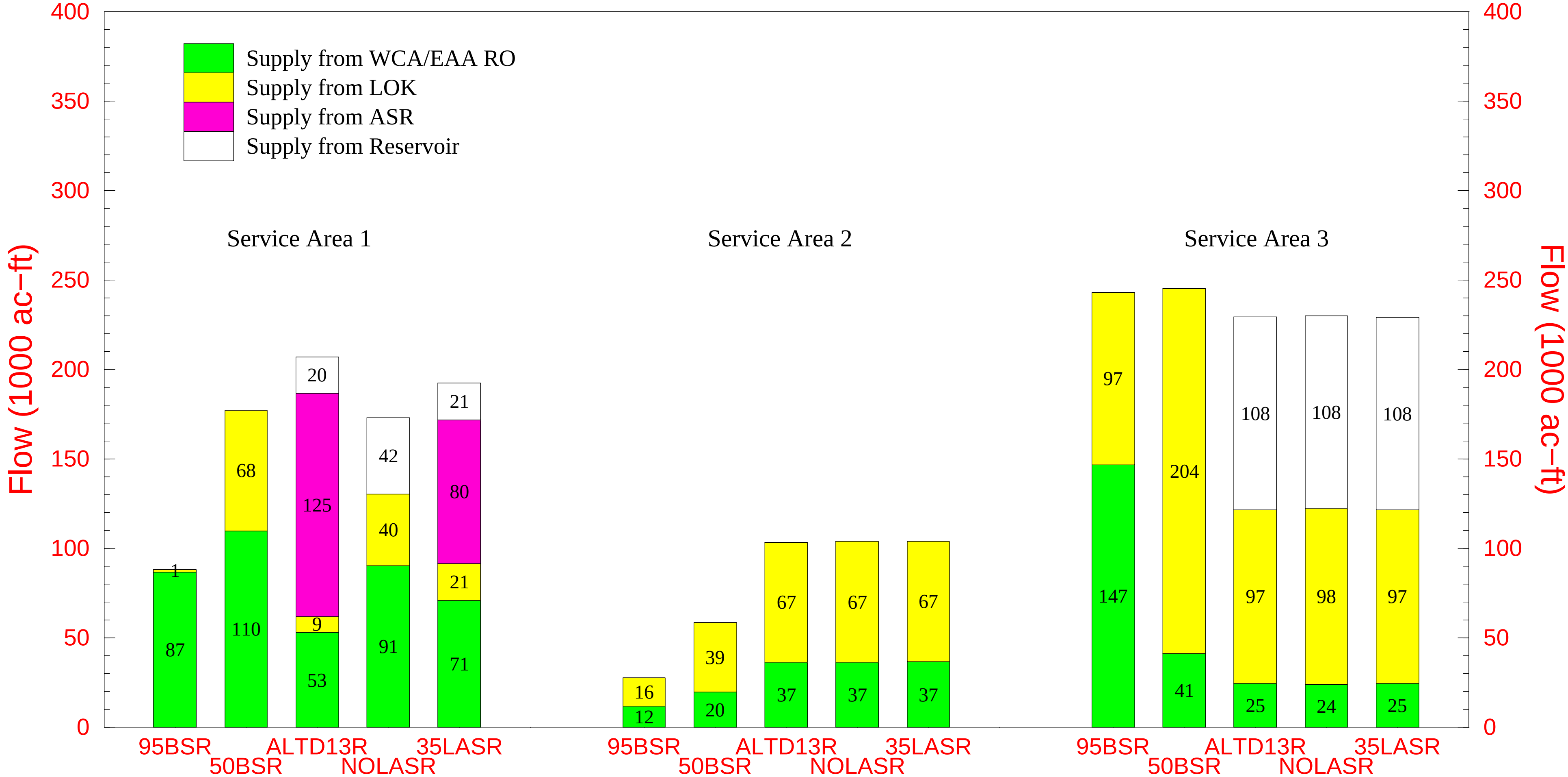
Figure B.3-62 Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 - 1995 simulation



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

Run date: 07/05/98 03:39:20
For Planning Purposes Only
SFWMM V3.5

Figure B.3-63 Mean Annual Regional System Water Supply Deliveries to LEC Service Areas for the five Drought years (71,75,81,85,89)

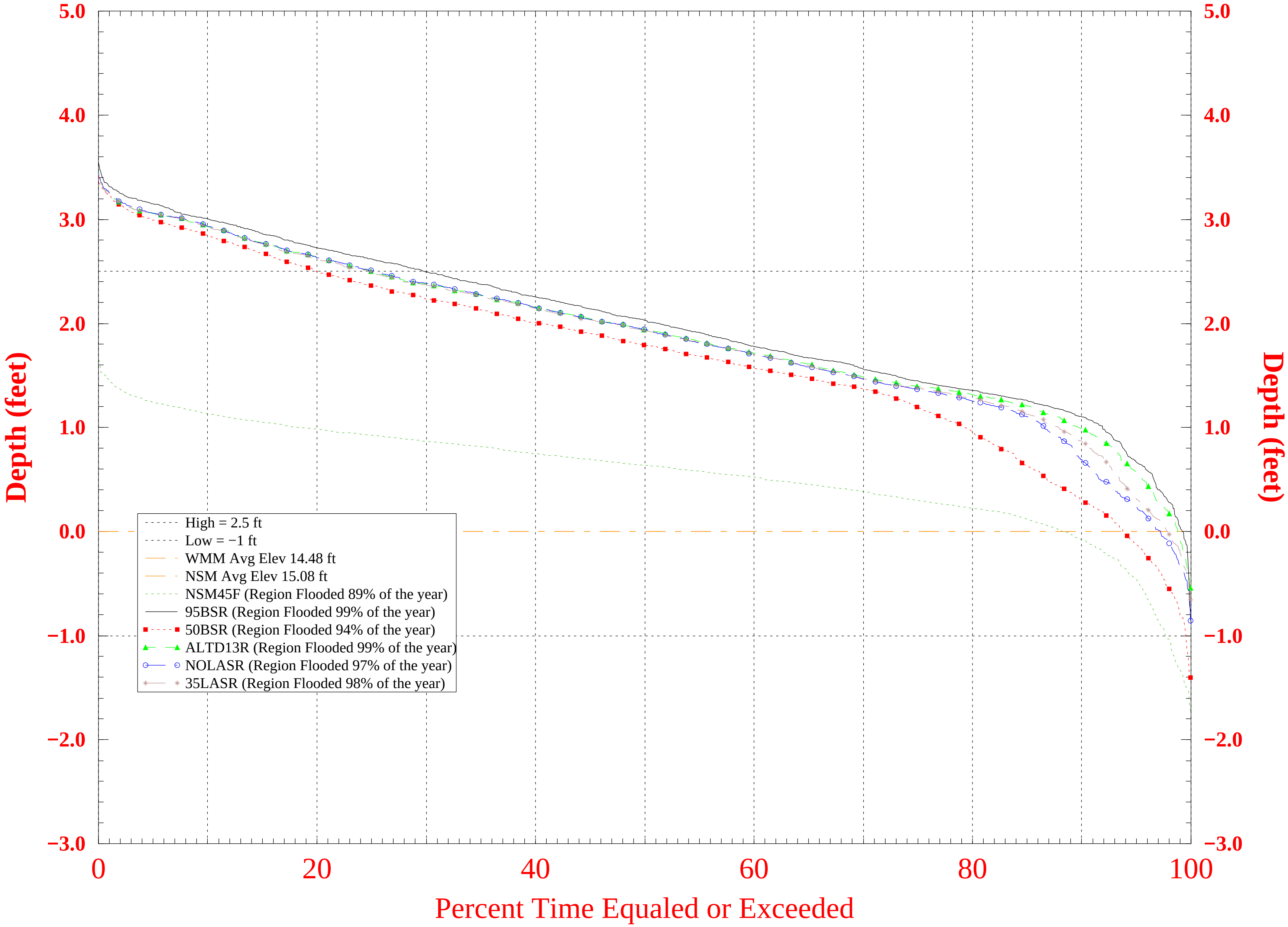


Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

Run date: 07/05/98 03:45:19
For Planning Purposes Only
SFWMM V3.5

Figure B.3-64a Normalized Weekly Stage Duration Curves for South LNWR (WCA-1)

Indicator Region 26 (R44C31-34 R45C30-34)

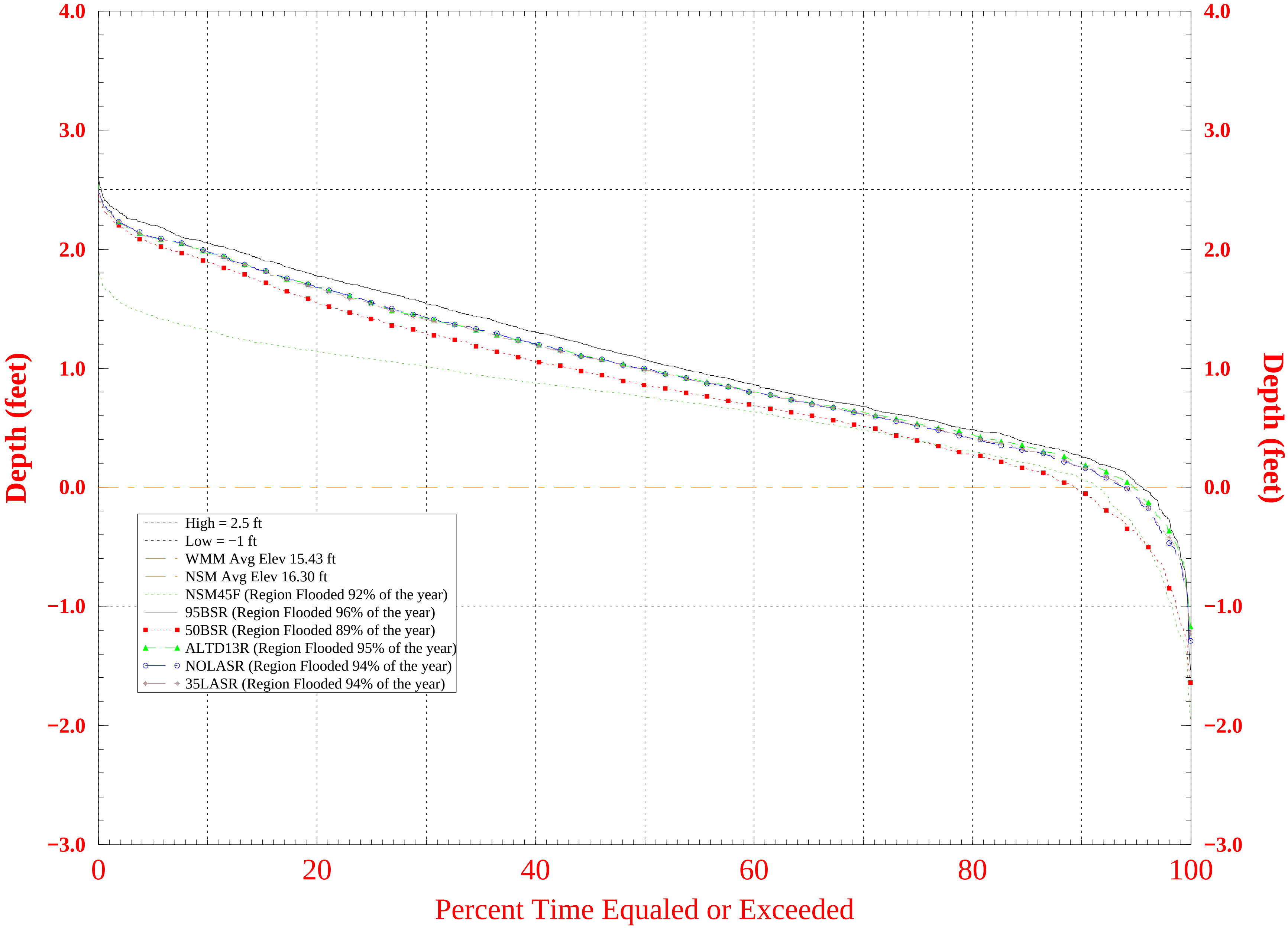


Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Sun Jul 5 10:49:01 EDT 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-64b Normalized Weekly Stage Duration Curves for North LNWR (WCA-1)

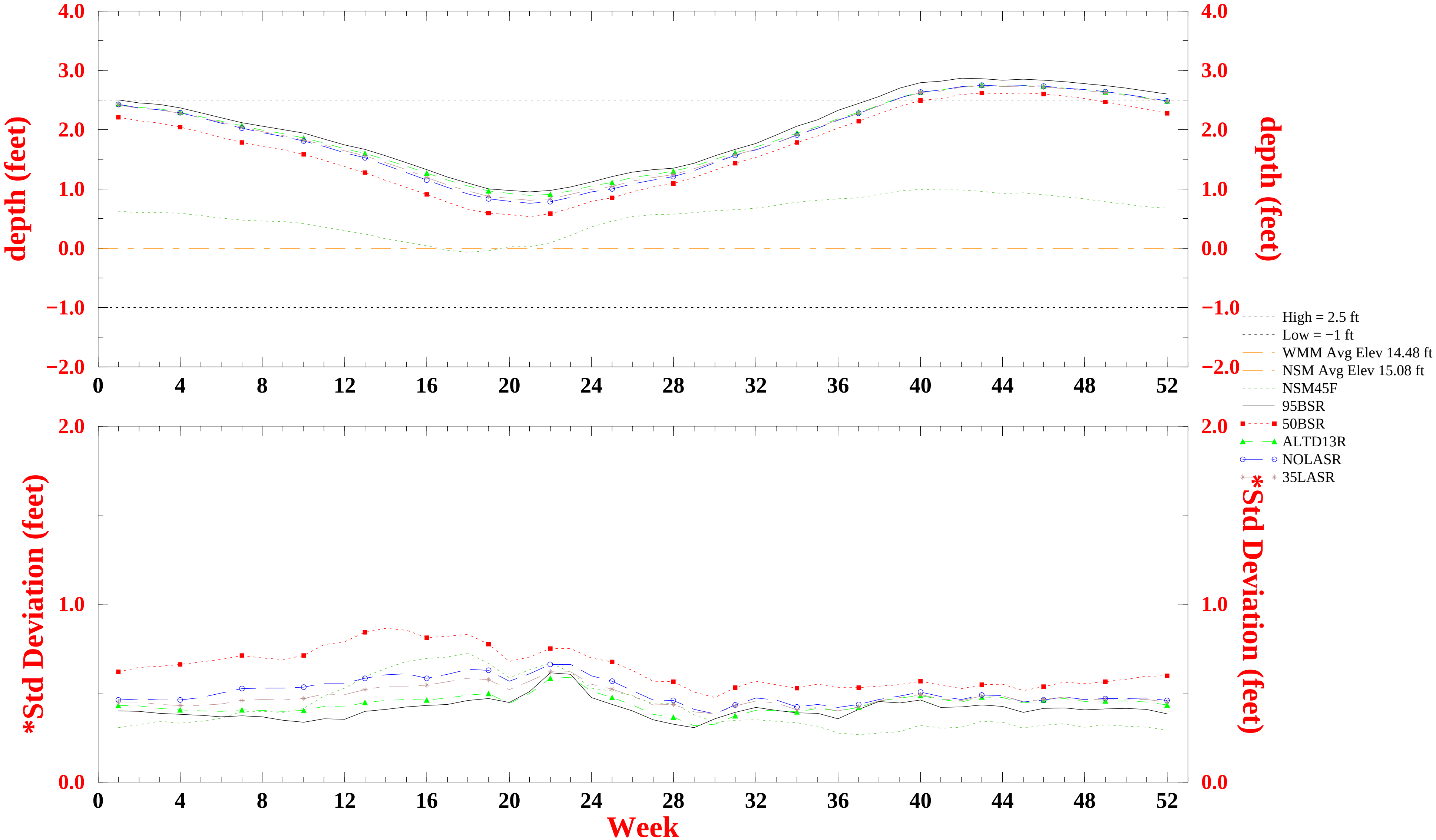
Indicator Region 27 (R47C30-34 R48C30-33 R49C30-33 R50C30-32 R51C30-31)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Sun Jul 5 10:49:33 EDT 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-65a Temporal Variation in Mean Weekly Stage for South LNWR (WCA-1)
Indicator Region 26 (R44C31-34 R45C30-34)



WEEK 1 STARTS JAN 1

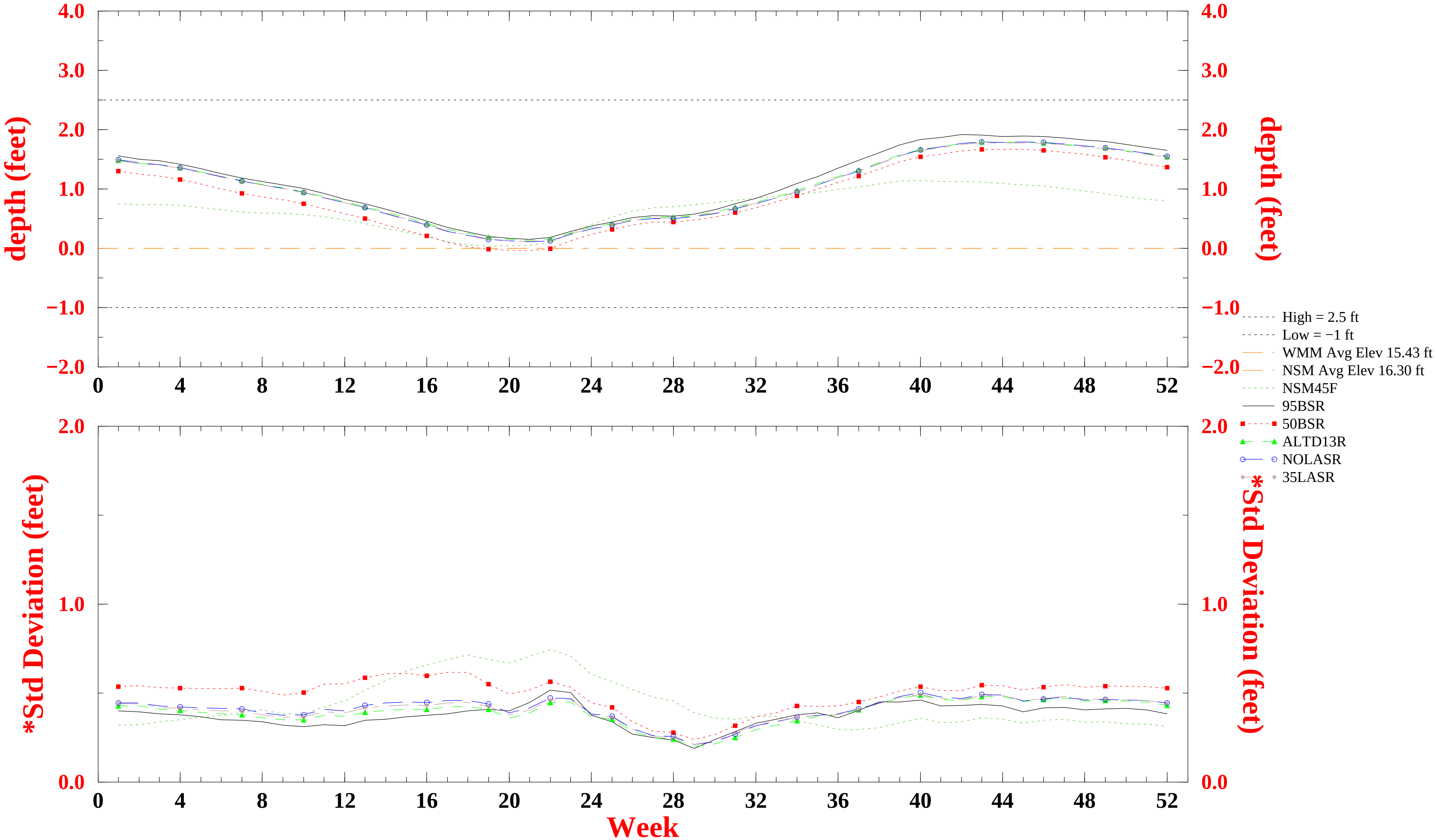
Depth and elev are weekly means for the indicator region for a 31 year simulation

High/Low = 0 indicates criteria undefined for region

* Standard Deviations are calculated among−year values;
* they illustrate interannual variation in mean weekly depth over the 31 year simulation period.

Run date: Sun Jul 5 10:49:01 EDT 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-65b Temporal Variation in Mean Weekly Stage for North LNWR (WCA-1)
Indicator Region 27 (R47C30-34 R48C30-33 R49C30-33 R50C30-32 R51C30-31)



WEEK 1 STARTS JAN 1

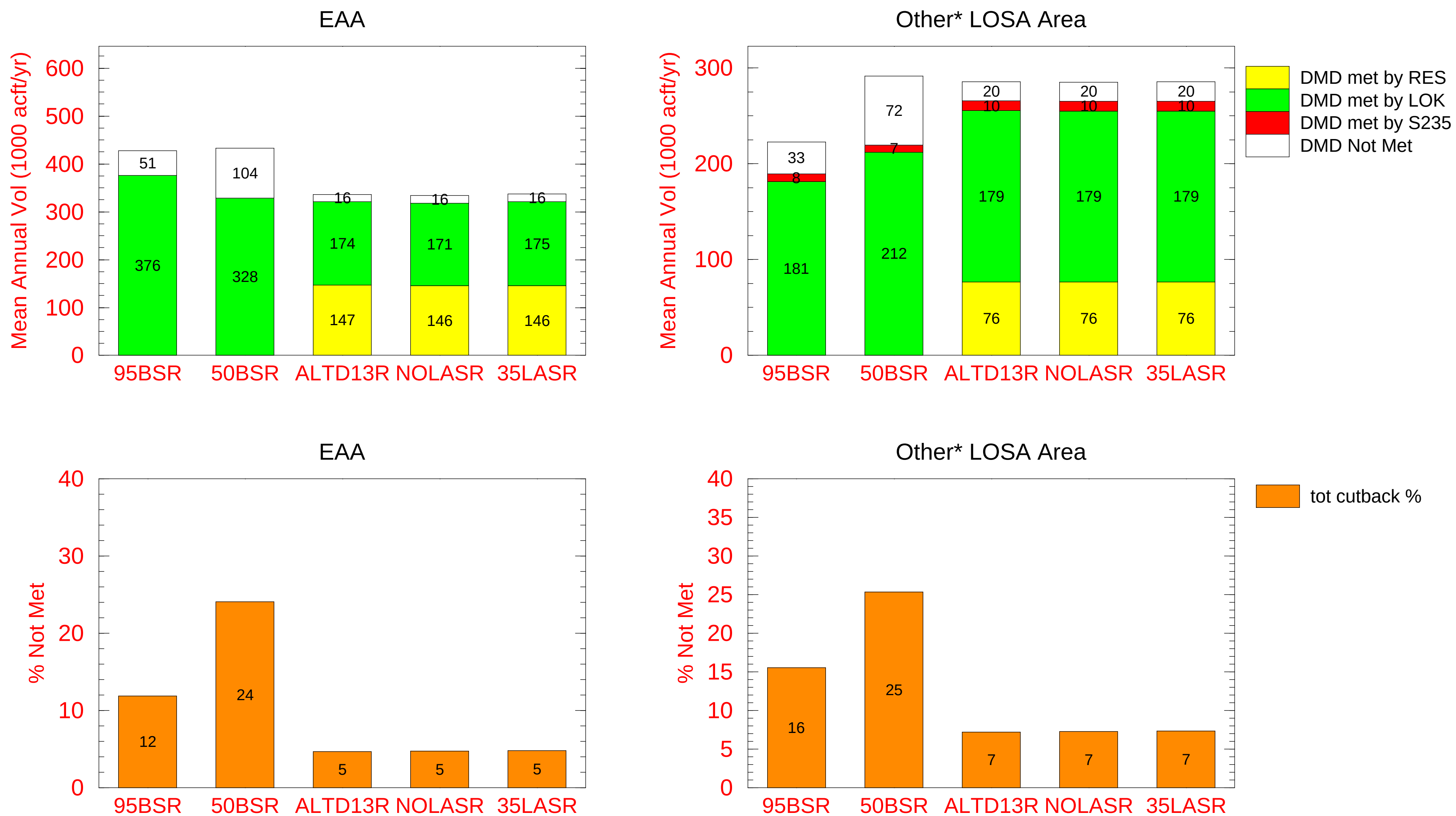
Depth and elev are weekly means for the indicator region for a 31 year simulation

High/Low = 0 indicates criteria undefined for region

* Standard Deviations are calculated among−year values;
* they illustrate interannual variation in mean weekly depth over the 31 year simulation period.

Run date: Sun Jul 5 10:49:33 EDT 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-66a Mean Annual EAA/LOSA Supplemental Irrigation: Demands and Demands Not Met for the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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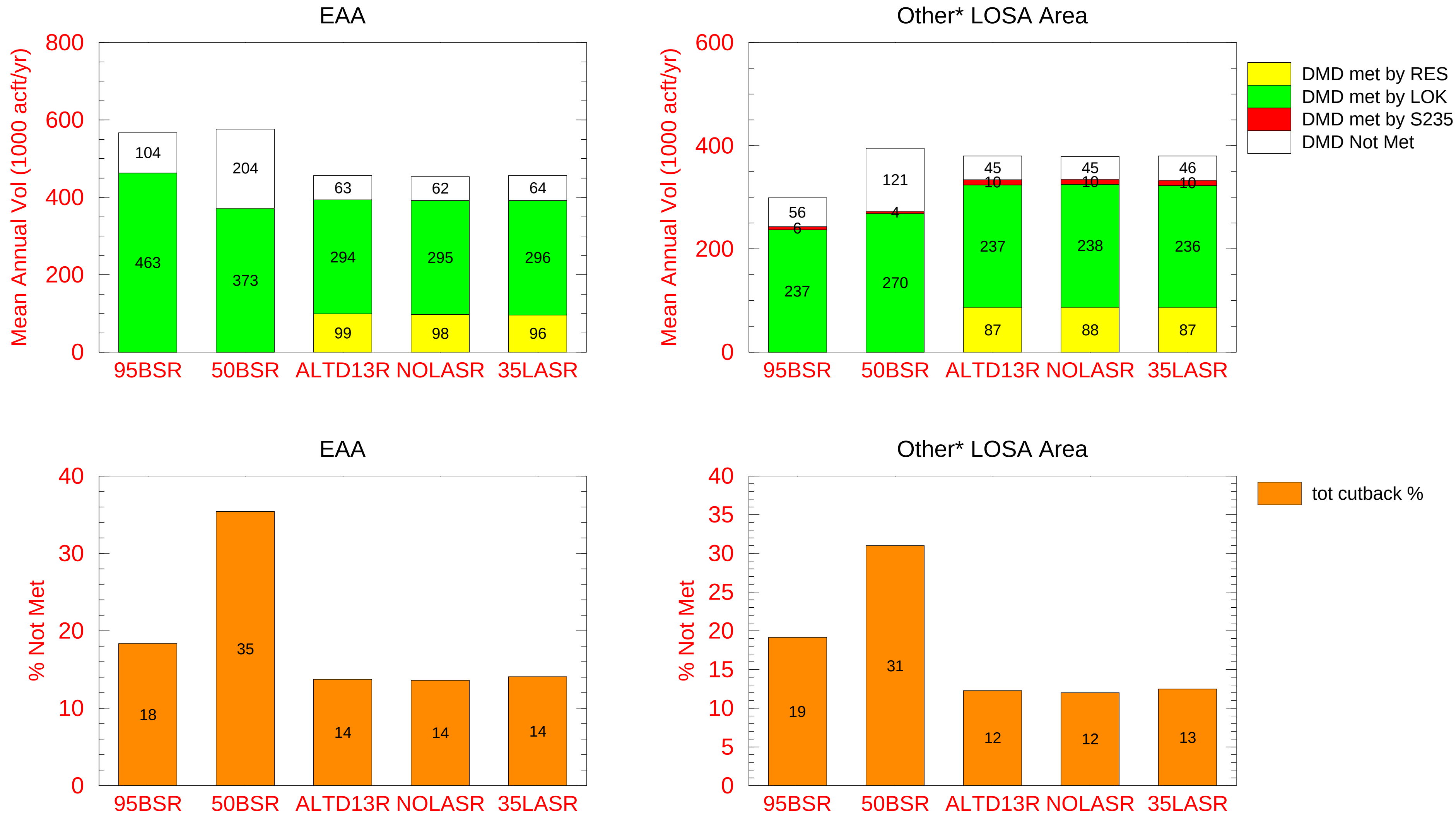
SFWMM V3.5

Figure B.3-66b Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met for the Drought Years:

1971, 1975, 1981, 1985, 1989 within the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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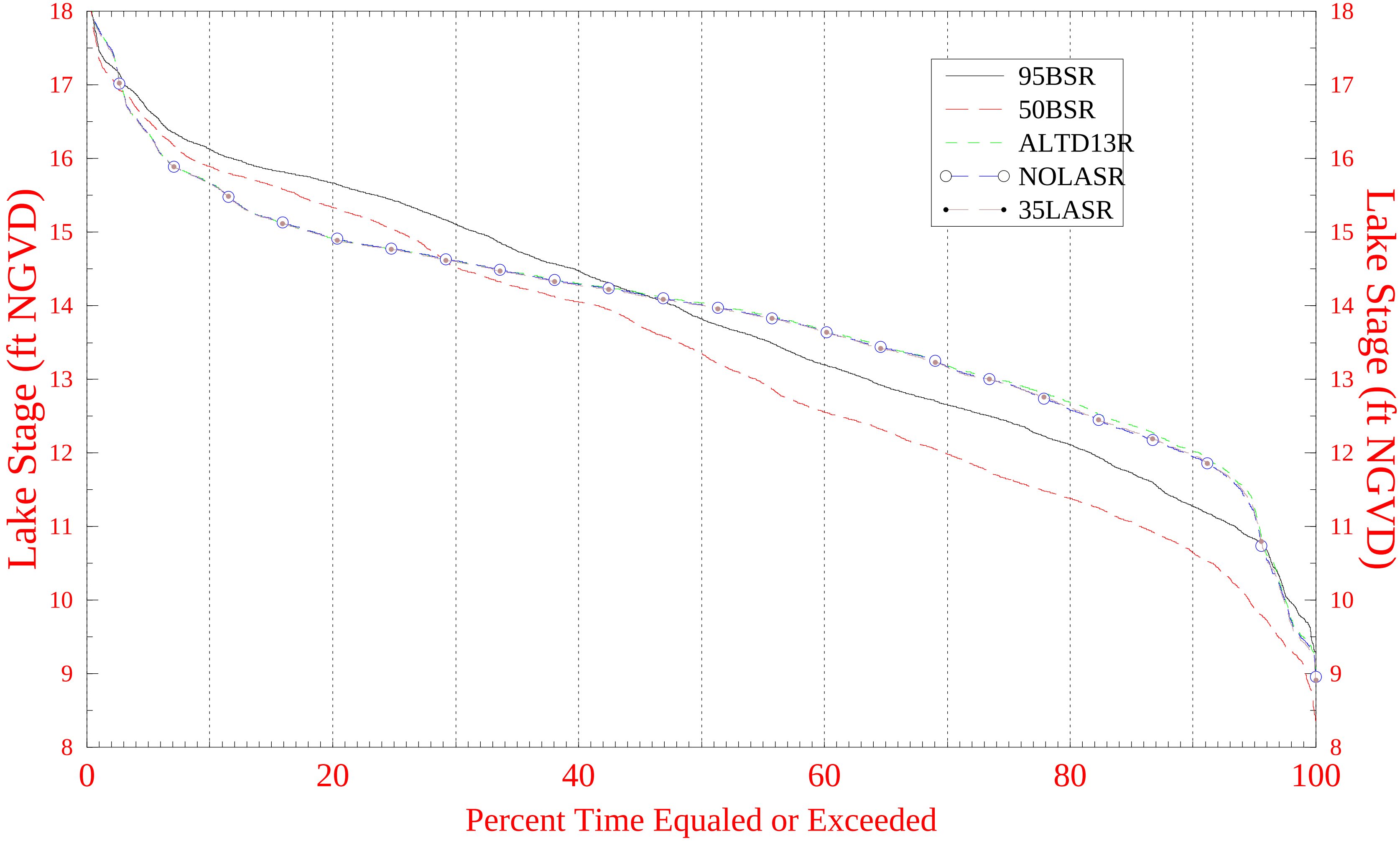
For Planning Purposes Only
SFWMM V3.5

Figure B.3-67 Lake Okeechobee Stage Duration Curves



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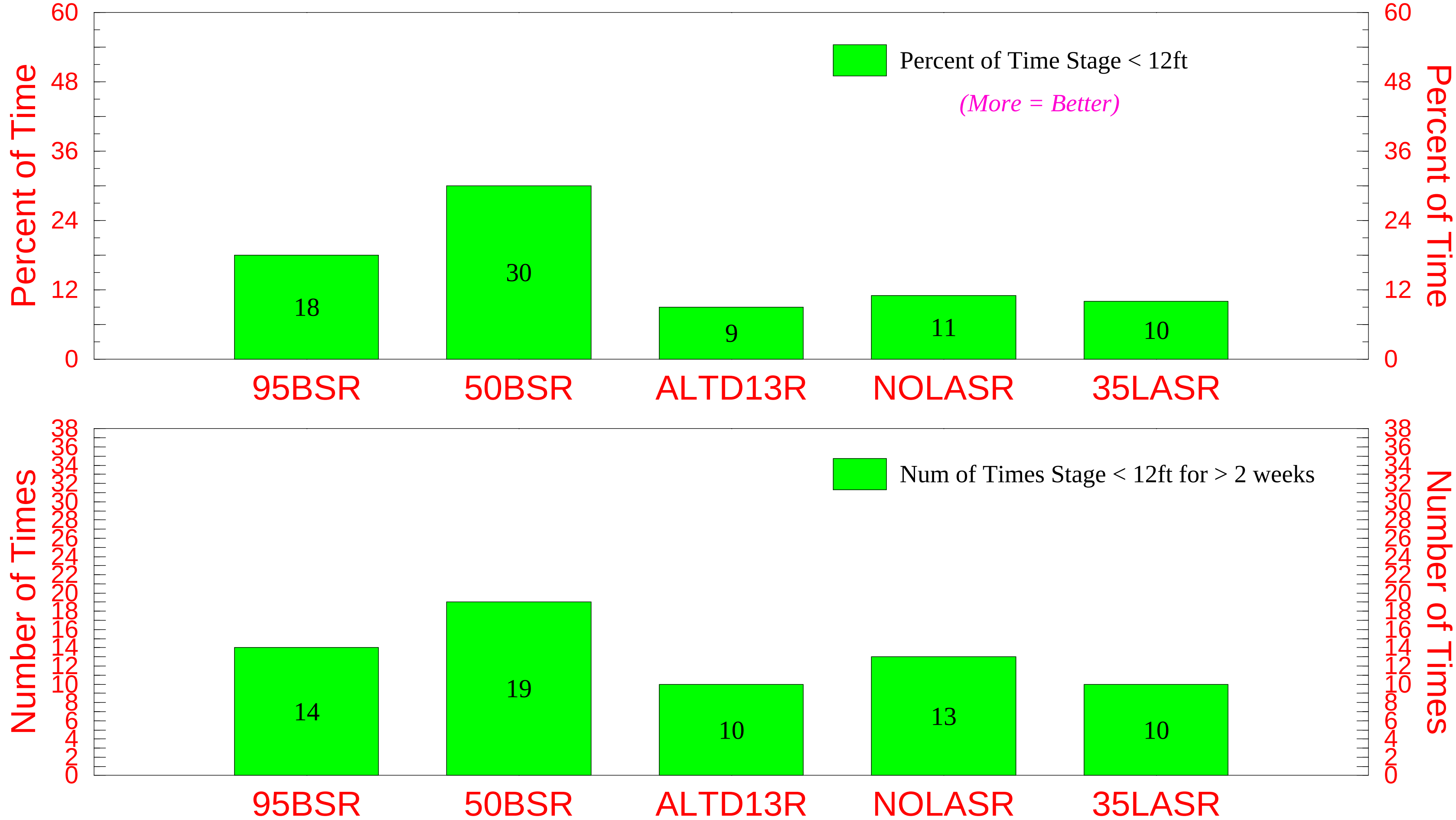
For Planning Purposes Only
SFWMM V3.5

Figure B.3-68 Percent of Time Lake Stage < 12ft NGVD and Number of Times Lake Stage < 12ft NGVD for > 2 weeks



* Short−term drying of the marsh allows for seed germination of beneficial plants, improves wading bird and snail kite habitat (eg. regrowth of willow) and helps to maintain the natural diversity and abundance of littoral zone biological communities.

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B.3.5.6 Removal of North Lake Belt Storage

B.3.5.6.1 Description of Simulation

Simulation is based on ALTD13R with North Lake Belt storage (Component XX) and its functions completely removed. This scenario run is denoted as NONLKB. In ALTD13R the North Lake Belt Storage area covers 4,500 acres with a maximum storage depth of 20 feet. The storage area is filled with excess water from western C-11, C-9 and C-6 Basins. In general, the North Lake Belt Storage provides water to maintain C-2, C-4, C-6 and C-9 and to increase canal discharges to Central Biscayne Bay.

B.3.5.6.2 Assumptions

- Perimeter seepage barrier is completely removed (Figure B.3-69).
- Excess water that is diverted into North Lake Belt storage from C-9 and C-6 in ALTD13R is allowed to go to tide.
- Excess water that is diverted into North Lake Belt storage in ALTD13R from Western C-11 Basin via proposed canal along US 27 (US27S canal in the model) is routed through S-9 into WCA-3A if US27S canal stage is sufficiently high. As in ALTD13R, the outflow from C-11 reservoir is routed directly into US27S canal.

B.3.5.6.3 Summary of Results

The removal of North Lake Belt storage results in the following:

- Significant increase in the dependence on Lake Okeechobee and WCA-3A, for water supply to LECSA3. Figure B.3-70 shows an increase from an average of 41 kac-ft/yr over the simulation period in ALTD13R to 95 kac-ft/yr with North Lake Belt removed. Note that from Figure B.3-70 the remaining 19 kac-ft/yr supplied to SA3 from a reservoir represents the supply from the Bird Drive Reservoir component. The increase in LOK releases is 24 kac-ft on an annual average basis. As a consequence, the stages in Lake Okeechobee decrease slightly during dry periods (up to 0.3 ft.) as shown in the stage duration curve of LOK stages (ALTD13R and NONLKB in Figure B.3-71). One additional undesirable Lake low stage event occurred (Figure B.3-72).
- Increase in total number of Phase 1 cutback months (from 20 to 39) in Service Area 2. Figure B.3-73 shows an increase of eight (from 5 to 13) locally-triggered cutback months and an increase of one (from 5 to 6) LOK stage induced cutback month in Service Area 2. The other LEC service areas experienced only an increase of one LOK stage induced cutback month.
- The increase in locally-triggered cutbacks is due to the inability to maintain canal stages. Minimum stages in C-9, C-6, and C-4, i.e. canals supplied by the North Lake Belt storage reservoir in ALTD13R, are maintained only 90

to 95 percent of the time as opposed to virtually 100 percent of the time in ALTD13R (See Figures B.3-74 through B.3-76).

- Slight increase in demand not met (<1 percent) in LOK Service Area due to the increased dependence on LOK for water supply to Service Area 3 (Figure B.3-77).
- A redistribution of surface water flows to Biscayne Bay. ***Table B.3-7***, which is a supplement to ***Figure B.3-78***, gives the seasonal breakdown of outflows to Biscayne Bay effected by the removal of North Lake Belt Storage. An average of 200 kac-ft/yr of surface water flowed into Central Biscayne Bay in ALTD13R, of which 103 kac-ft/yr was provided by North Lake Belt Storage. Note that North Lake Belt Storage contributed 90 percent of the surface water flow in the dry season (54 out of 61 kac-ft/yr). Thus, the seasonal distribution of flow into Central Biscayne Bay is less desirable without North Lake Belt Storage: 30 percent dry, 70 percent wet in ALTD13R; 25 percent dry, 75 percent wet without Lake Belt; target is 33 percent dry, 67 percent wet. The removal of Lake Belt Storage decreased the total surface water flow into Central Biscayne Bay from 200 to 138 kac-ft/yr. However, the removal increased the total surface water flow from the Miami River north (S-26) and Snake Creek Estuary (S-29) from 165 to 221 kac-ft/yr. This redistribution of outflow resulted in a 6 kac-ft/yr decrease in outflow to Biscayne Bay with North Lake Belt Storage removed. Seasonally the outflow decreased by 10 kac-ft/yr in the dry season and increased by 4 kac-ft/yr in the wet season as shown in ***Table B.3-7***.

Table B.3-7. Seasonal Breakdown of Outflows to Biscayne Bay Effected By Removal of North Lake Belt (1,000 acre-feet)

	Wet Season		**Dry Season**	
	ALTD13R	**NONLKBLT**	**ALTD13R**	**NONLKBLT**
Central Bay (Total/Contribution from NLKBLT)	139/49	104/0	61/54	34/0
Miami River (S-26)	42	52	18	23
Snake Creek (S-29)	79	108	26	38
TOTAL	260	264	105	95

Figure B.3-69 Sensitivity to Removal of North Lake Belt Storage Area from Alt D13R

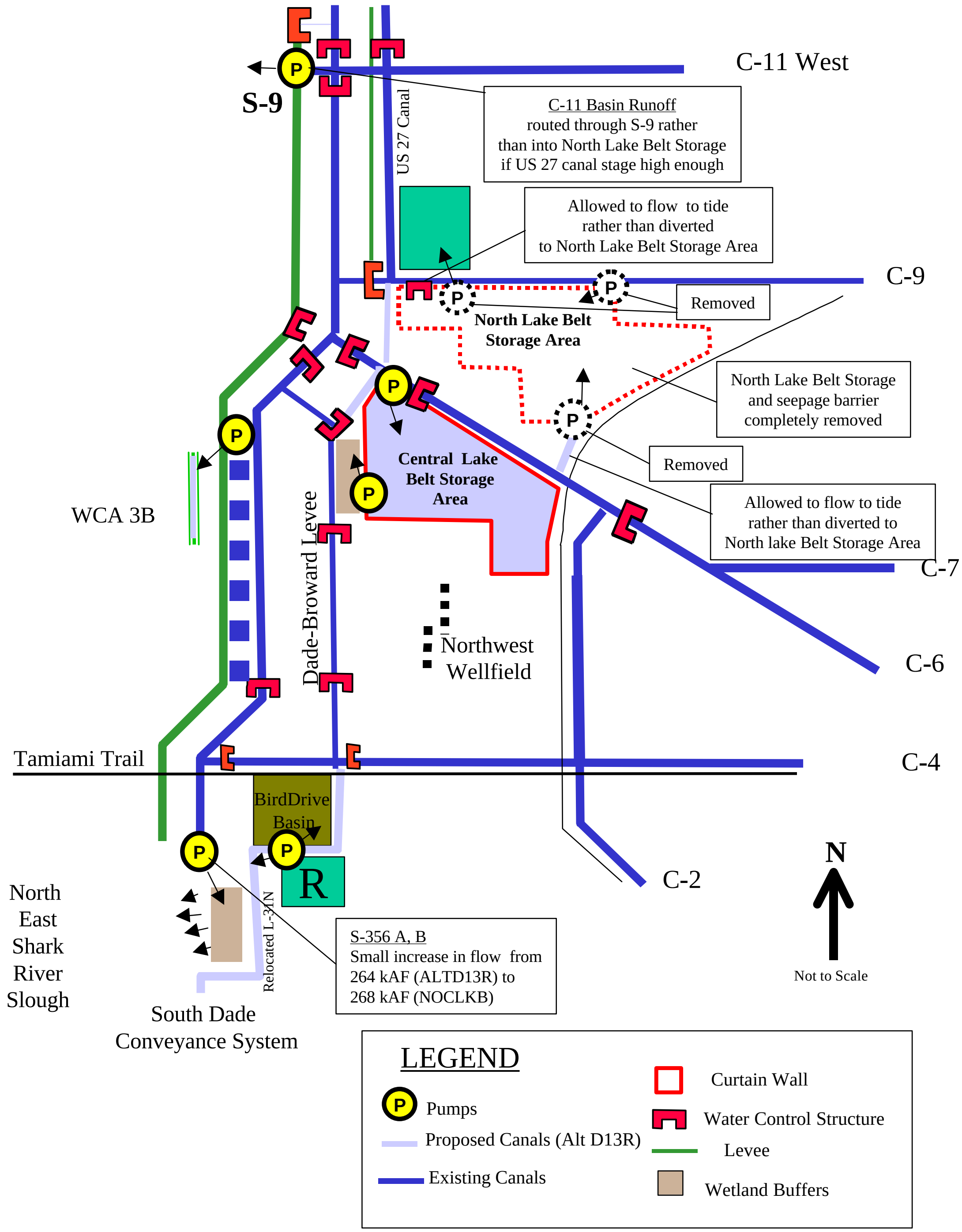
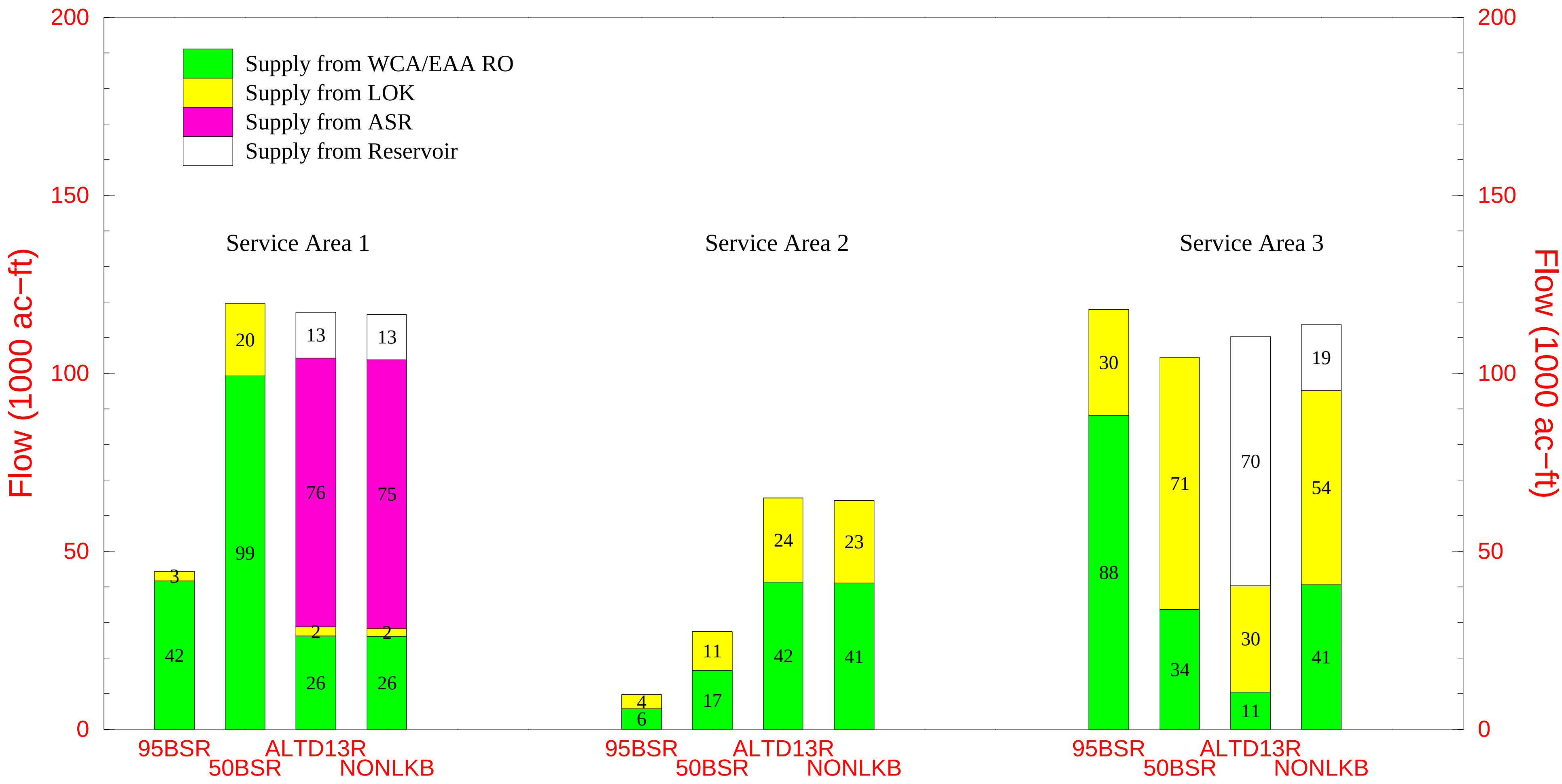


Figure B.3-70 Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 - 1995 simulation



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

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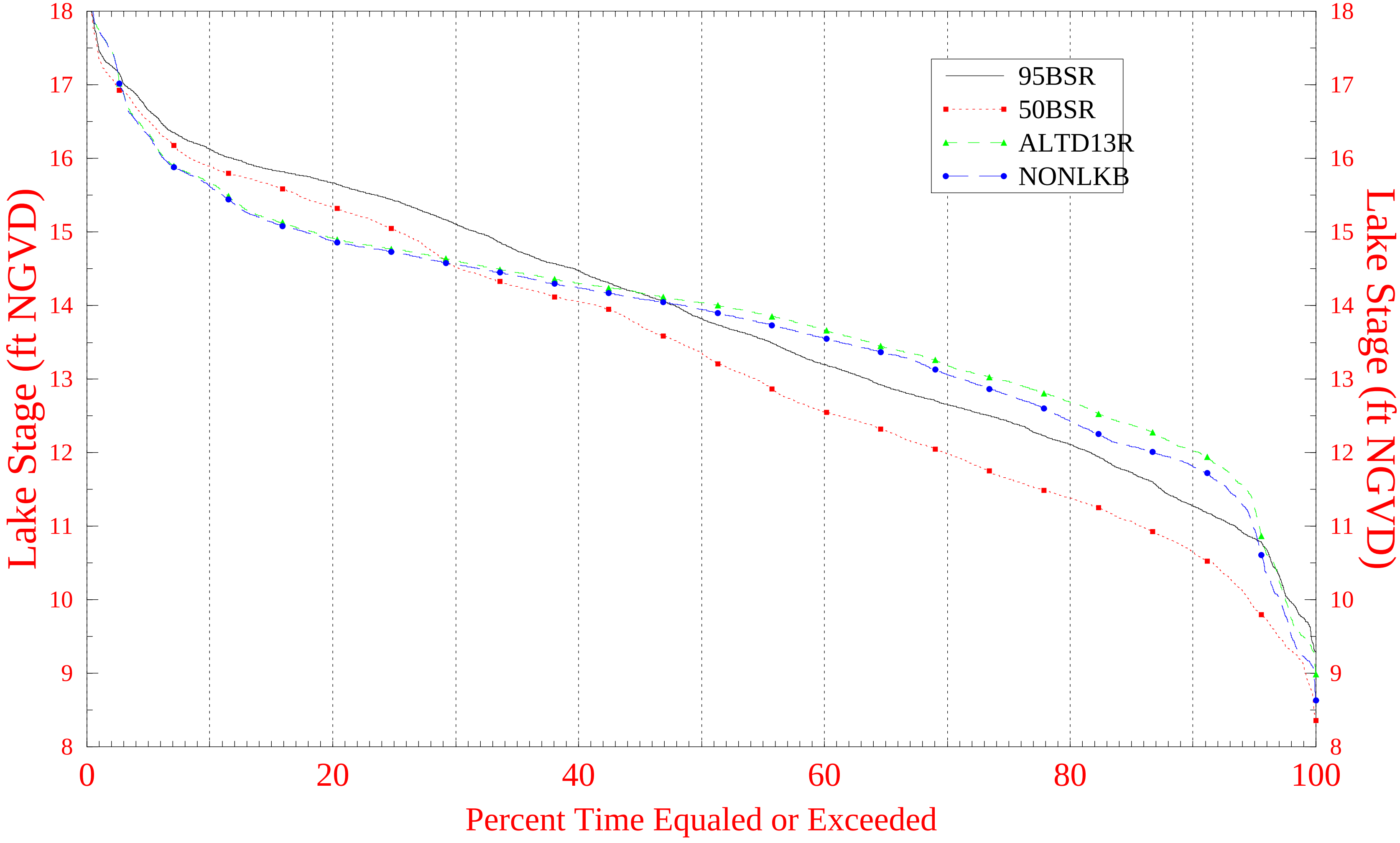
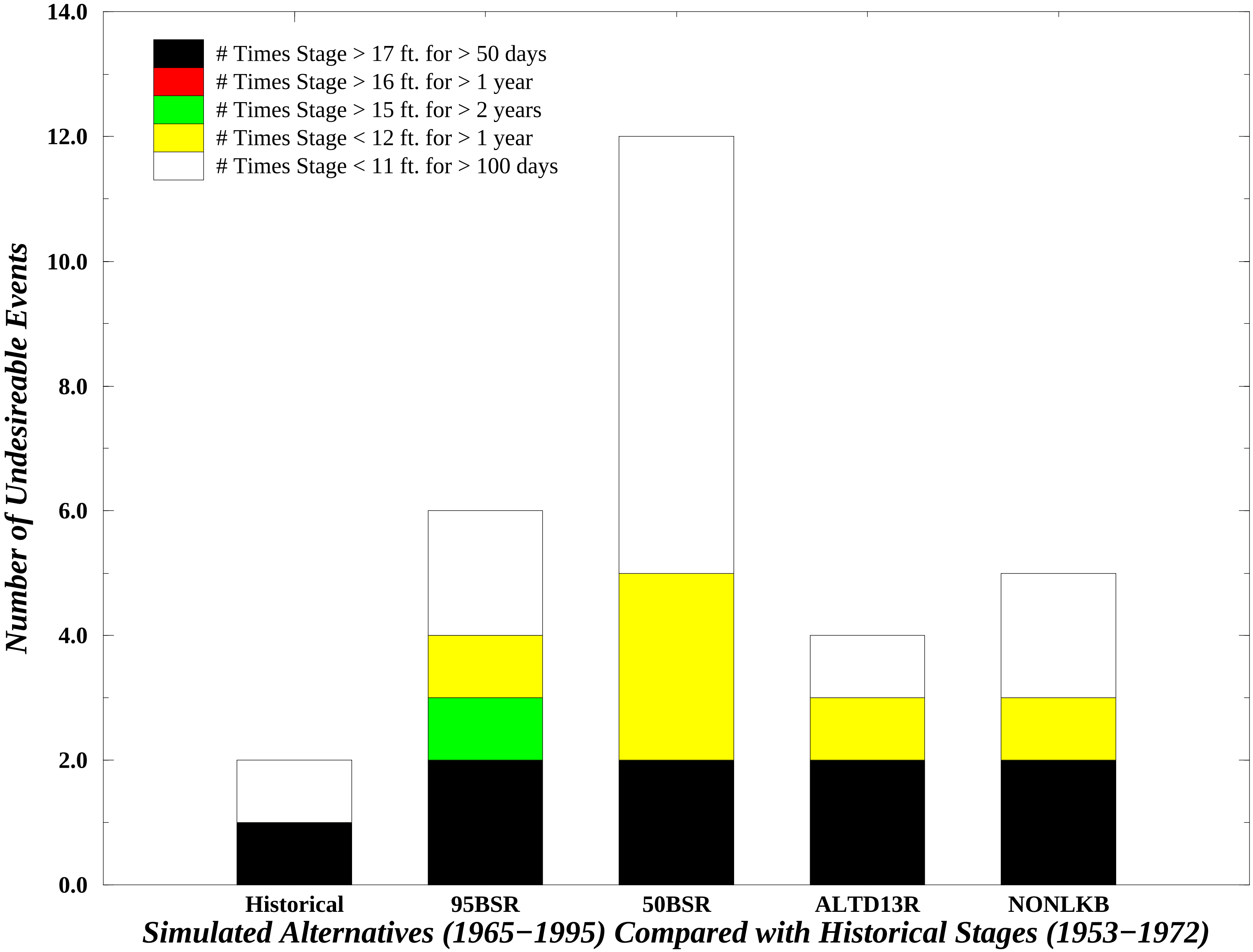
SFWMM V3.5

Figure B.3-71 Lake Okeechobee Stage Duration Curves



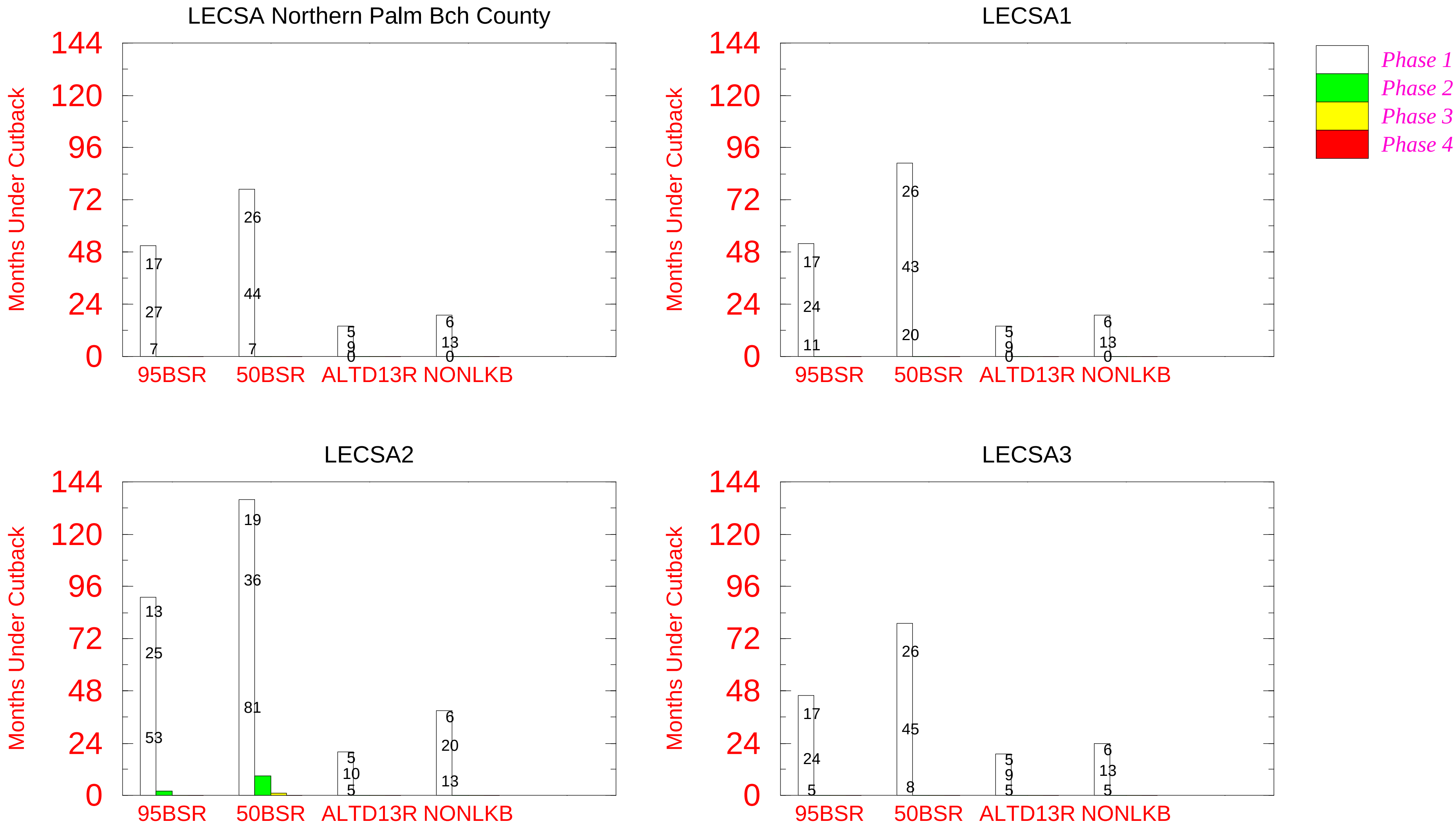
Run date: 06/30/98 16:42:17
For Planning Purposes Only
SFWMM V3.5

Figure B.3-72 Number of Undesireable Lake Okeechobee Stage Events



Run date: 06/30/98 22:08:02
For Planning Purposes Only
SFWMM V3.5

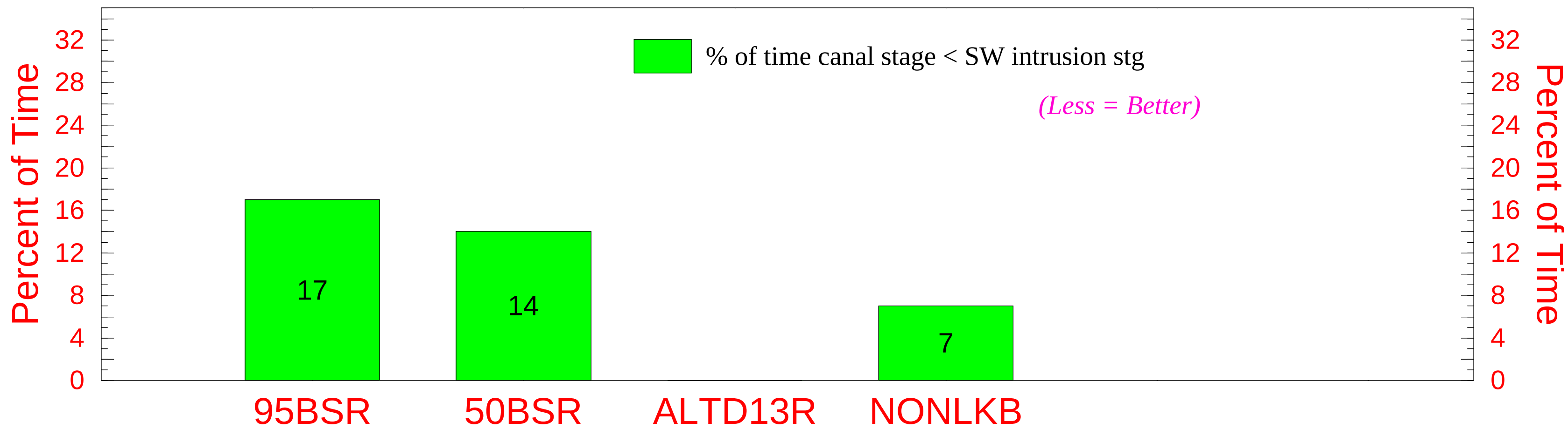
Figure B.3-73 Number of Months of Simulated Water Supply Cutbacks for the 1965 - 1995 Simulation Period

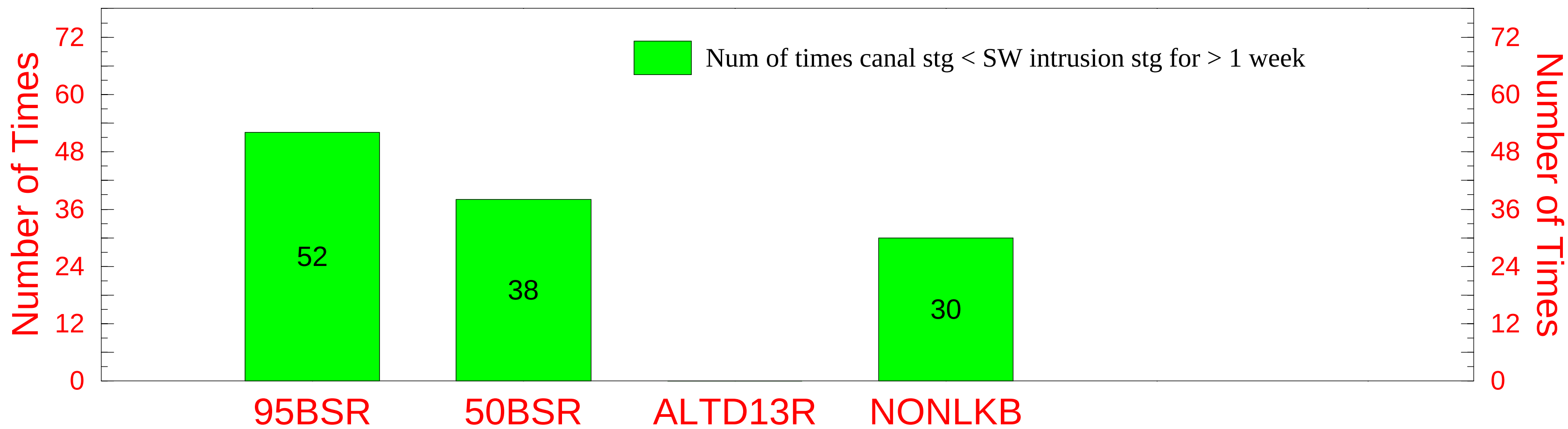


Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).

Run date: 06/30/98 17:00:43
For Planning Purposes Only
SFWMM V3.5

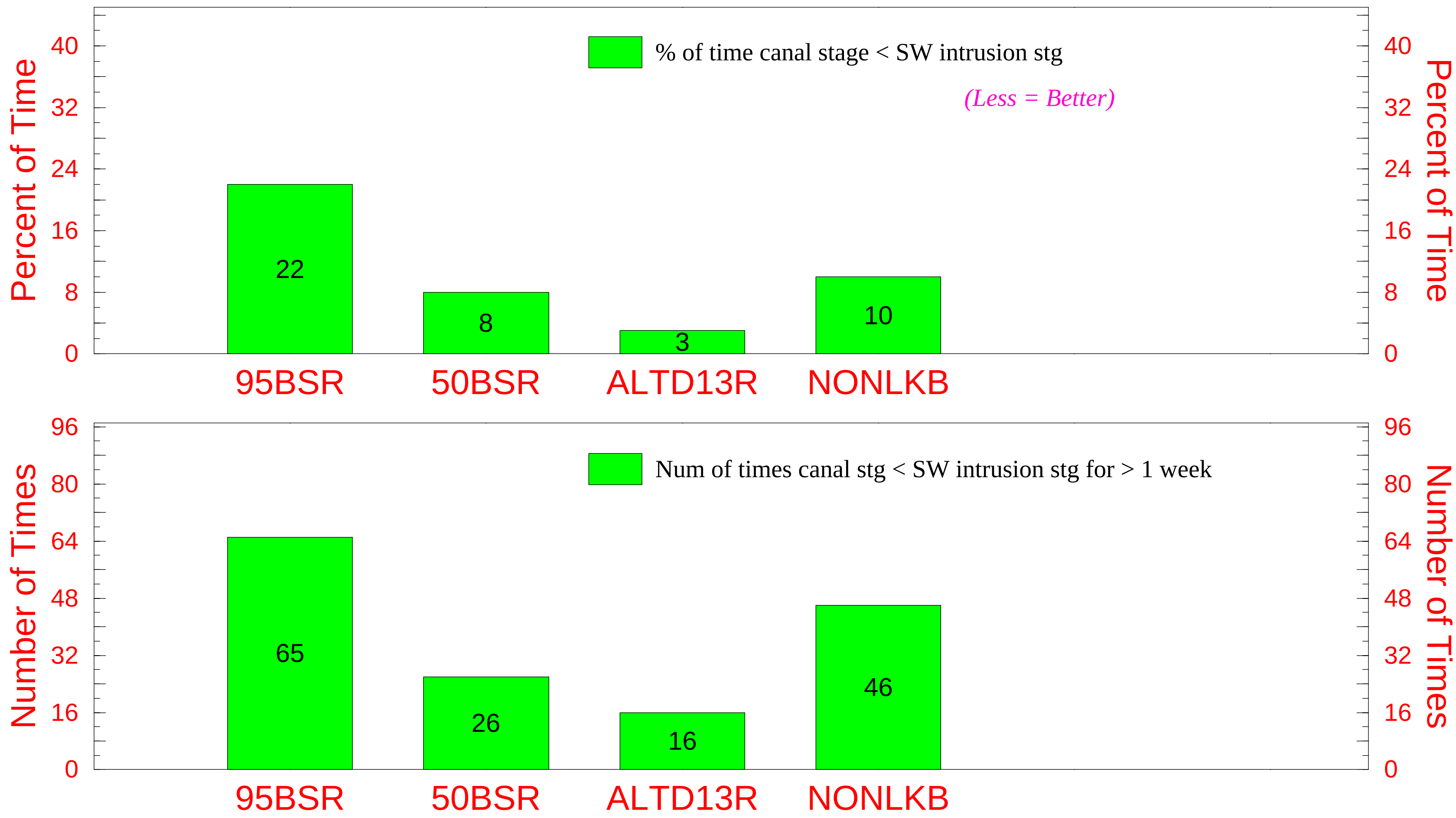
Figure B.3-74 Percent of Time Canal Stage < Salt-Water Intrusion Criteria and Occurences > 1 Week
Canal C-9 at S-29 (Salt-Water Intrusion Indicator Stg = 2.0 ft, NGVD)





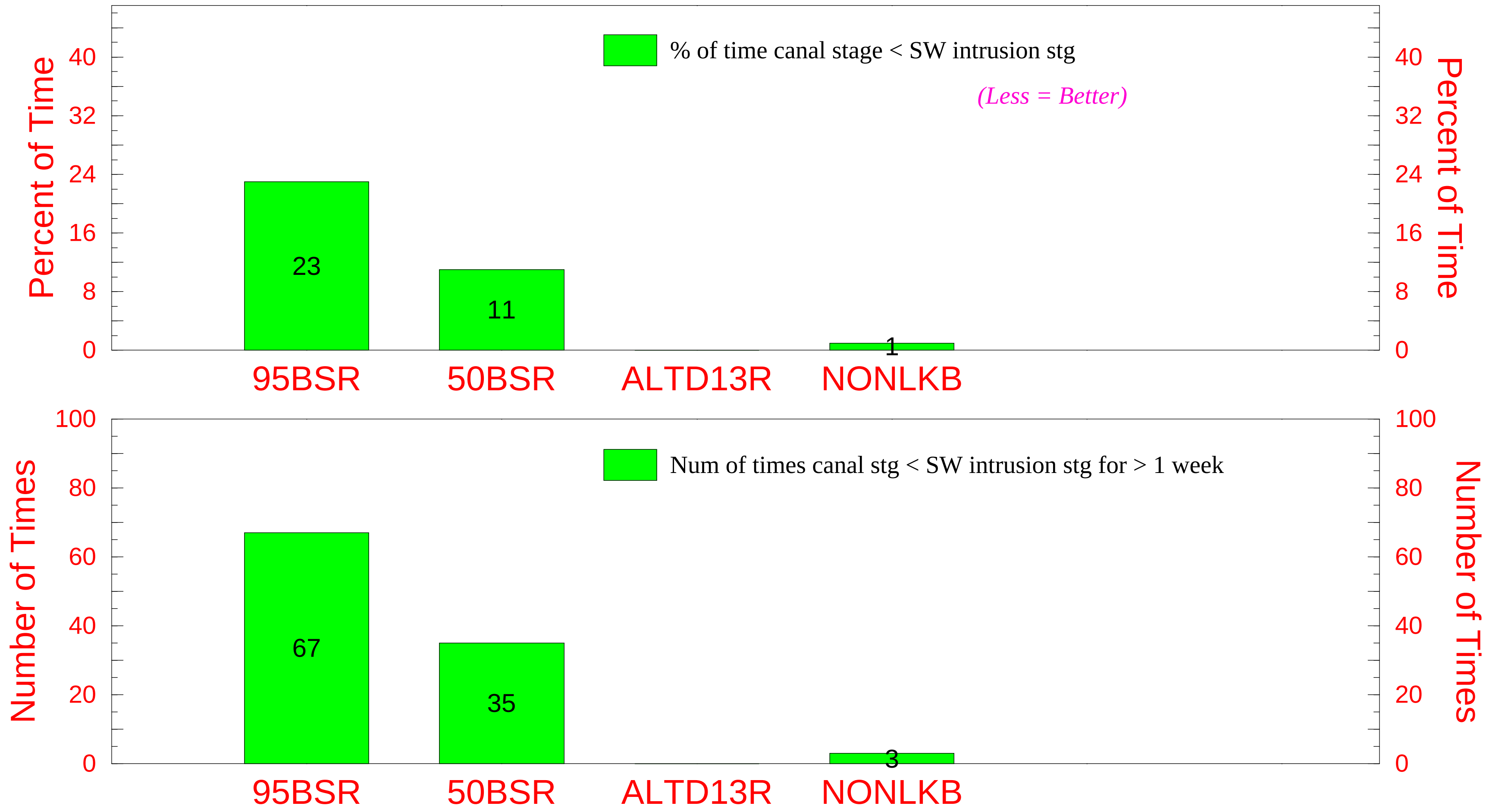
Run date: 06/30/98 21:04:37
For Planning Purposes Only
SFWMM V3.5

Figure B.3-75 Percent of Time Canal Stage < Salt-Water Intrusion Criteria and Occurences > 1 Week
Canal C-6 at S-26 (Salt-Water Intrusion Indicator Stg = 2.5 ft, NGVD)



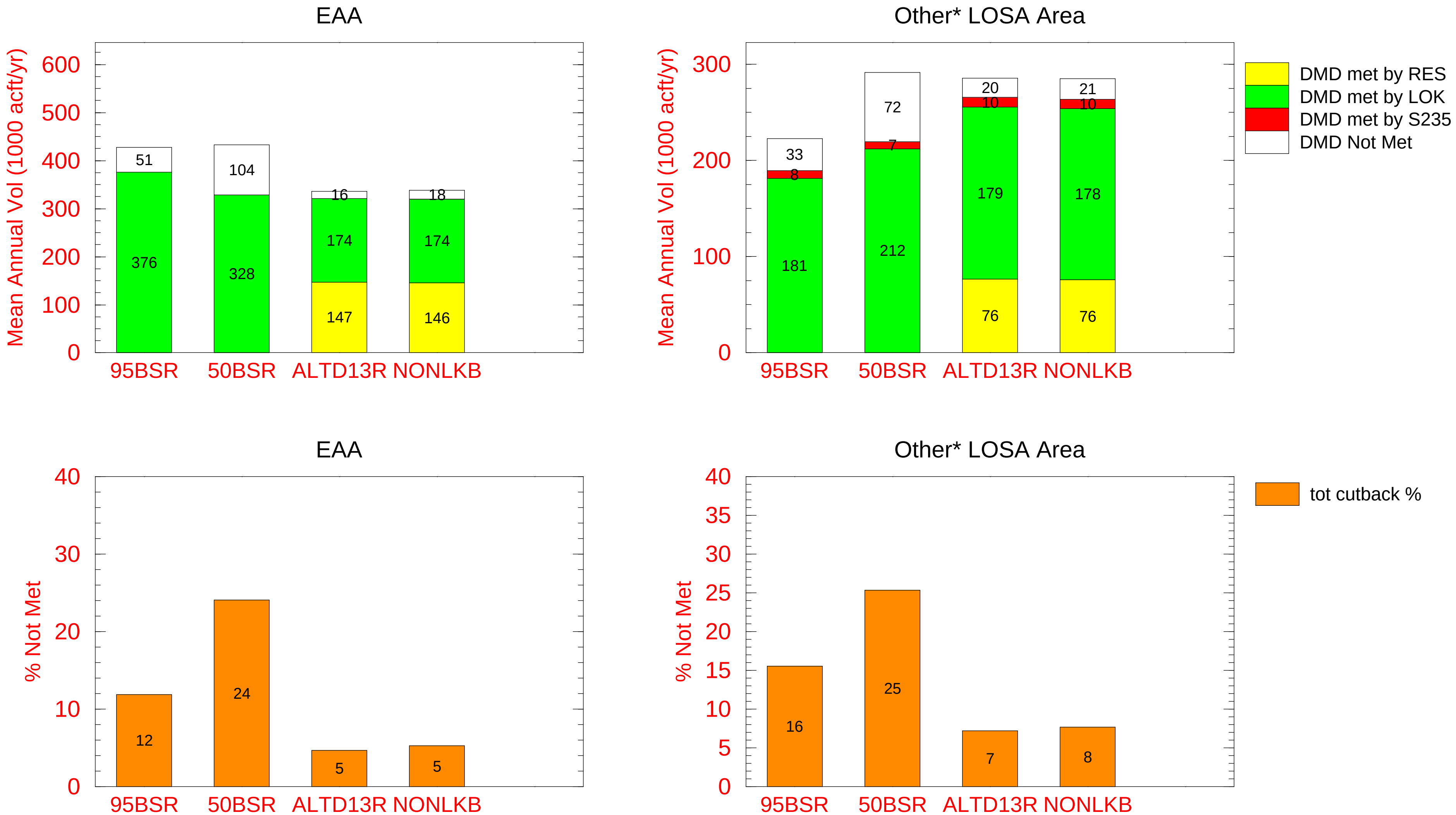
Run date: 06/30/98 21:05:28
For Planning Purposes Only
SFWMM V3.5

Figure B.3-76 Percent of Time Canal Stage < Salt-Water Intrusion Criteria and Occurences > 1 Week
Canal C-2 at S-22 (Salt-Water Intrusion Indicator Stg = 2.5 ft, NGVD)



Run date: 06/30/98 21:07:11
For Planning Purposes Only
SFWMM V3.5

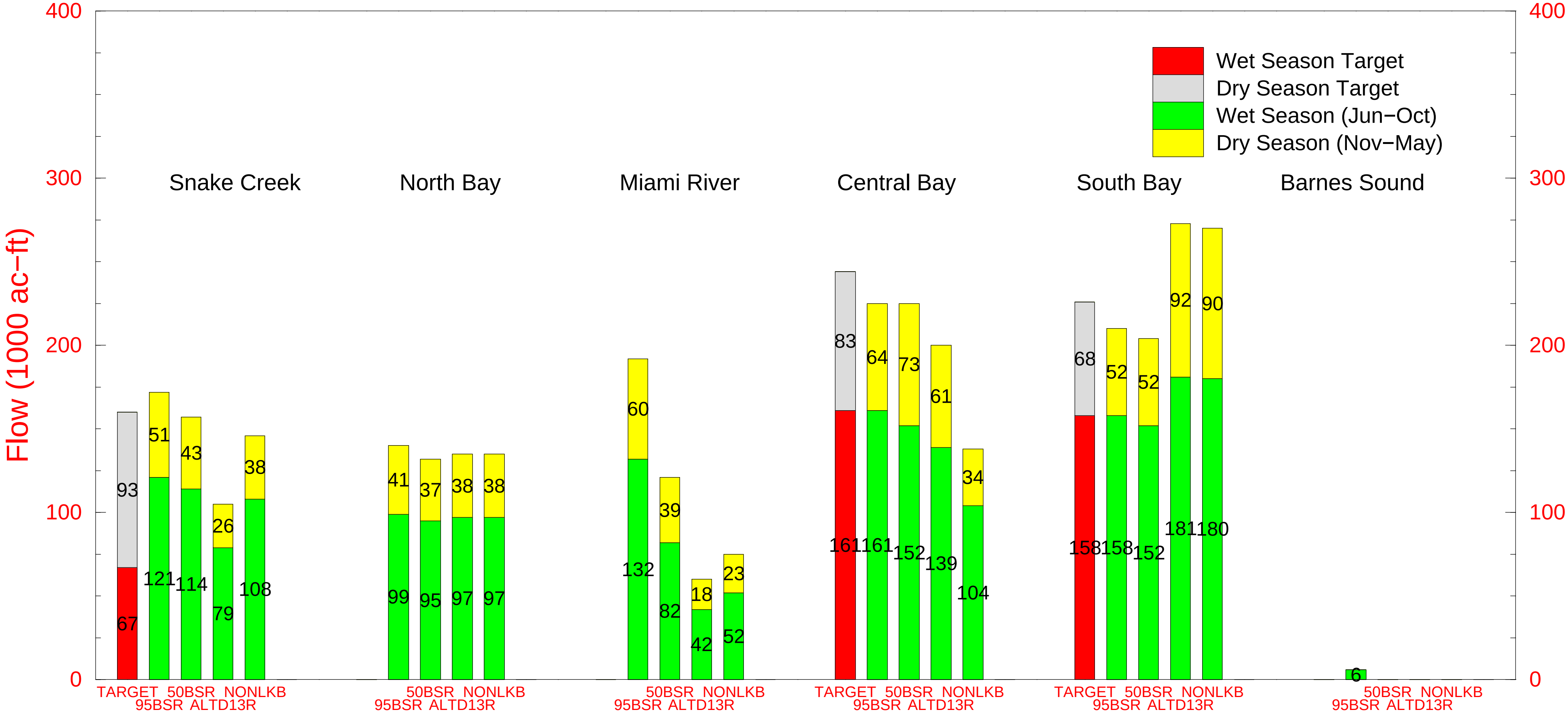
Figure B.3-77 Mean Annual EAA/LOSA Supplemental Irrigation: Demands and Demands Not Met for the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

Run date: 06/30/98 16:48:12
For Planning Purposes Only
SFWMM V3.5

Figure B.3-78 Simulated Mean Annual Surface Flows Discharged into Biscayne Bay for the 1965 - 1995 simulation period



Note: Snake Creek=S29; North Bay=G58+S28+S27; Miami River=S26+S25B+S25; Central=G97+S22+S123; South=S21+S21A+S20F+S20G; Barnes Sound=S197

Targets for Central and South Bay reflect a 30% increase in mean annual dry season flows over the 95 Base

Targets for Snake Creek reflect a minimum monthly flow volume of 13,300 ac−ft (x 5 months for wet season and x 7 months for dry season) to maintain salinity levels below 20 ppt.

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For Planning Purposes Only
SFWMM V3.5

B.3.5.7 Removal of Central Lake Belt Storage

B.3.5.7.1 Description of Simulation

Simulation is based on ALTD13R with Central Lake Belt Storage (component S) removed. The scenario run is denoted as NOCLKB. In ALTD13R the Central Lake Belt Storage covers 5,200 acres with a maximum storage depth of 36 feet. The storage area is filled with excess water from WCA-3A and WCA-3B. The area releases water to NESRS via S-356 A/B if the stage at G1502 falls below desired levels.

B.3.5.7.2 Assumptions

- Central Lake Belt Storage (CLBSA) and the perimeter seepage barrier are completely removed (Figure B.3-79).
- WCA-3A and WCA-3B excess water that flows into CLBSA, under ALTD13R, would be sent via borrow canals and the S-356's to ENP with no diversion.

B.3.5.7.3 Summary of Results

The removal of the Central Lake Belt storage results in the following:

- Significant increase in structural outflow from WCA-3A (WC3TLB ***in Table B.3-8***) and in seepage from WCA-3 to LEC, as shown in ***Table B.3-8***. The increased outflow lowered the stages in WCA-3B and eastern WCA-3A during high and low water conditions, as evident in ***Table B.3-10***. The increase in structural outflow from WCA-3A toward ENP is mainly a result of available storage in CLBSA no longer being a limiting factor. Consequently, approximately 10 percent less volume (508 to 450 kaf/yr) of overland flow occurred across Tamiami Trail to NESRS.

- A marked change in the seasonal distribution of flows through S-356 A/B, even though the average annual flow is similar as indicated in ***Table B.3-8***. In ALTD13R the seasonal split is 37 percent wet , 63 percent dry; without Central Lake Belt, the seasonal split is 58 percent wet , 42 percent dry . Reason being that in ALTD13R, 90 percent of the outflow from CLBSA occurs in the dry season when NESRS needs water. This seasonal redistribution of S-356 flows to NESRS from L31N has a direct impact on the seasonal distribution of overland flow westward into NESRS, as shown in Figure B.3-80.

- The preceding discussion translates to a significant reduction in stages in NESRS. Figure B.3-81 shows that the maximum decrease is about 0.5 feet, which occurs during April and May. The effect on durations of inundation and low water conditions in the Shark River Slough region is shown in ***Table B.3-9***. This illustrates the importance of timing in routing excess water to

ENP and the necessity of additional storage in achieving the desired result in ALTD13R.

- Increased surface water flows to Biscayne Bay, as shown in Figure B.3-82. The greatest increase (56kac-ft/yr) is to the central part of the Bay. This result is attributed to an increase in seepage from WCA-3B and groundwater flow eastward caused by the removal of the Central Lake Belt reservoir and its seepage barrier.

- Increased water depths in the Pensucco wetlands during the wettest times (more like NSM) and decreased during the drier times, as shown in Figure B.3-83. This is caused by the shift in timing of available water for NESRS as illustrated by the redistribution of S-356 flows.

- Removal of Central Lake Belt storage had no effect on frequency of water restrictions in LEC and minimal effect on Lake Okeechobee.

Table B.3-8. Average Annual Flow Comparisons at Selected Locations (units are in thousand acre-feet)

Location or Model Flow Variable Name*	ALTD13R	NOCLKB	Change
WC3TLB	37	103	+66
S-32	49	170	+121
Seepage from WCA-3A LEC	270	314	+44
LBTPK	93	0	-93
S31ENV	46	45	-1
NWSRS	429	412	-17
NESRS	508	450	-58
S-356's	264	268	+4
Central Biscayne Bay	200	256	+56

*Identified in Figure B.3-69.

Table B.3-9. Inundation and Low Water Summary for Impacted Indicator Regions in Shark River Slough

Indicator Region Number	Name	Depth (ft.) Criterion	#Events/Avg. Duration (wks per event)/ Avg. Annual Duration (% of yr)	
			ALTD13R	NOCLKB
8	Rockland Marl Marsh	Inundation <-1.5	36/26/59 22/10/14	39/24/58 27/10/17
11	NE Shark River Slough	Inundation <-1.0	7/226/98 3/2/0	15/102/95 4/3/1
12	New Shark River Slough	Inundation <-1.0	27/52/87 13/5/4	32/43/85 17/5/5
10	Mid Shark River Slough	Inundation <-1.0	4/398/99 2/2/0	13/119/96 4/3/1

Table B.3-10. High and Low Water Summary for Impacted Indicator Regions in WCA-3A and WCA-3B

Indicator Region Number	Name	Depth (ft) Criterion	#Events/Avg. Duration (wks per event)/ Avg. Annual Duration (% per yr)	
			ALTD13R	NOCLKB
15	West WCA-3B	>2.5 Inundation <-1.0	5/10/3 4/398/99 2/3/0	5/9/3 11/141/96 3/4/1
16	East WCA-3B	>2.5 Inundation <-1.0	13/7/5 6/262/98 4/3/1	13/6/5 18/84/94 7/4/2
18	North Central WCA-3A	>2.5 <-1.0	3/7/1 1/6/0	3/5/1 2/4/0

Figure B.3-79 Sensitivity to Removal of Central Lake Belt Storage from Alt D13R

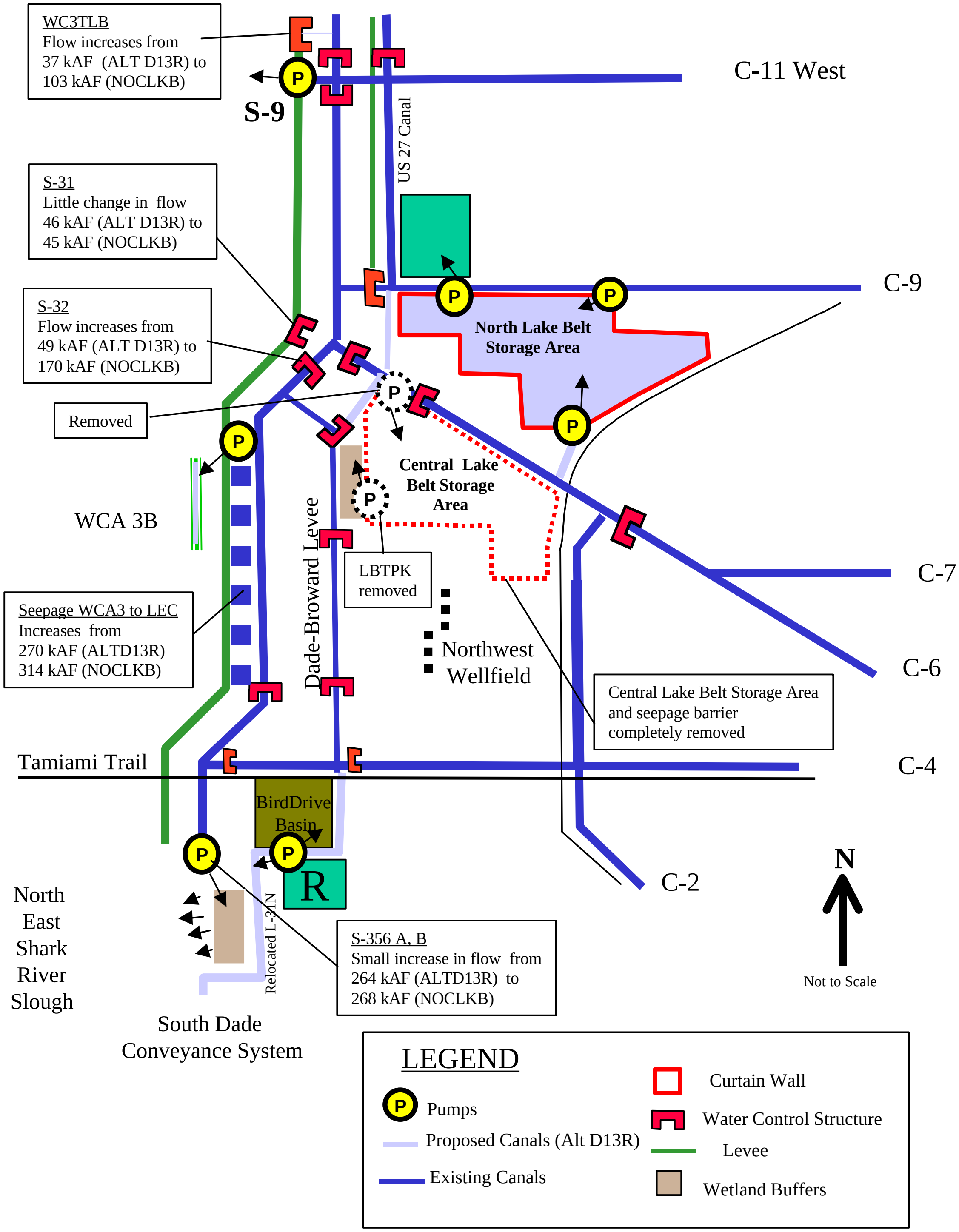
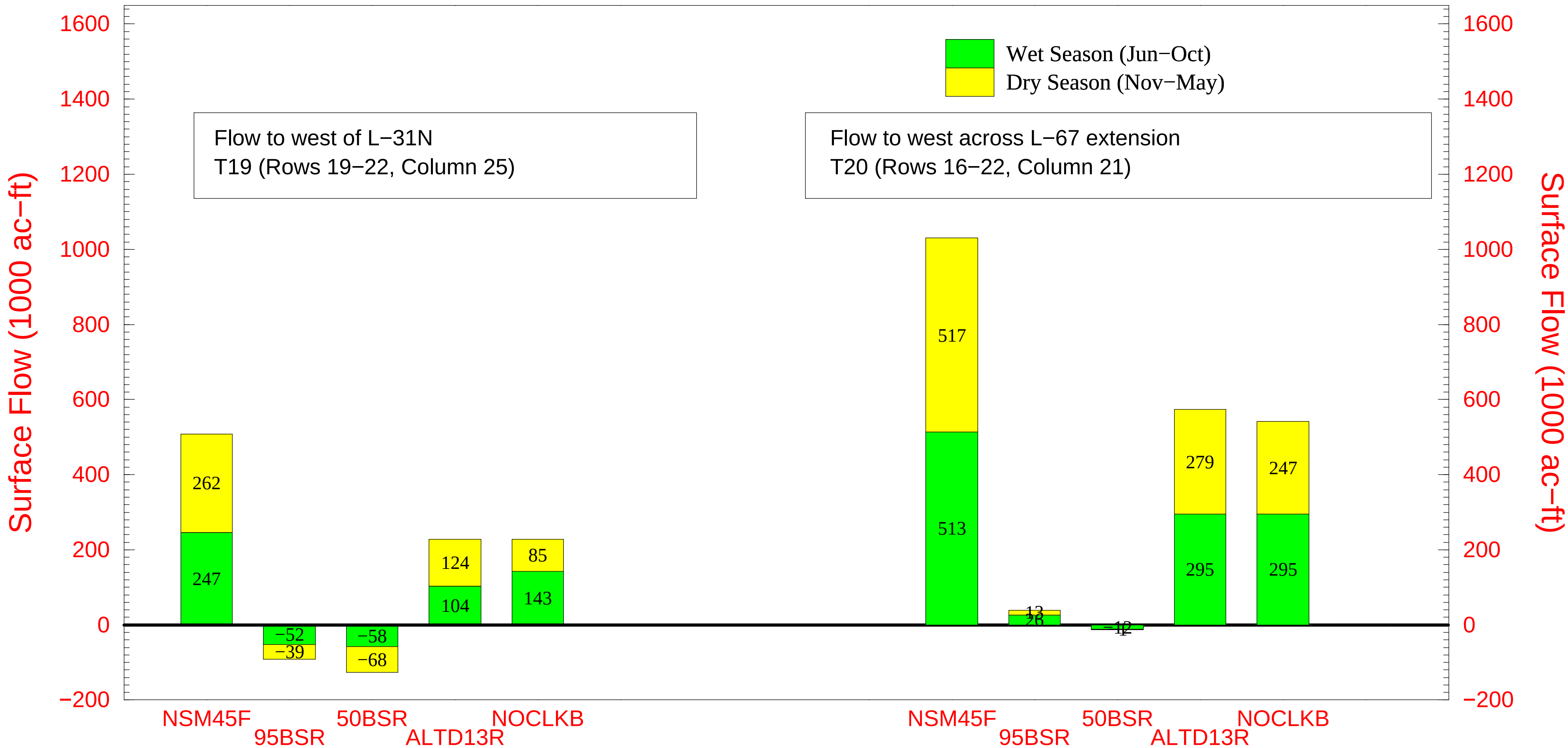


Figure B.3-80 Average Annual Overland Flow westward within the ENP

for the 31 year simulation period

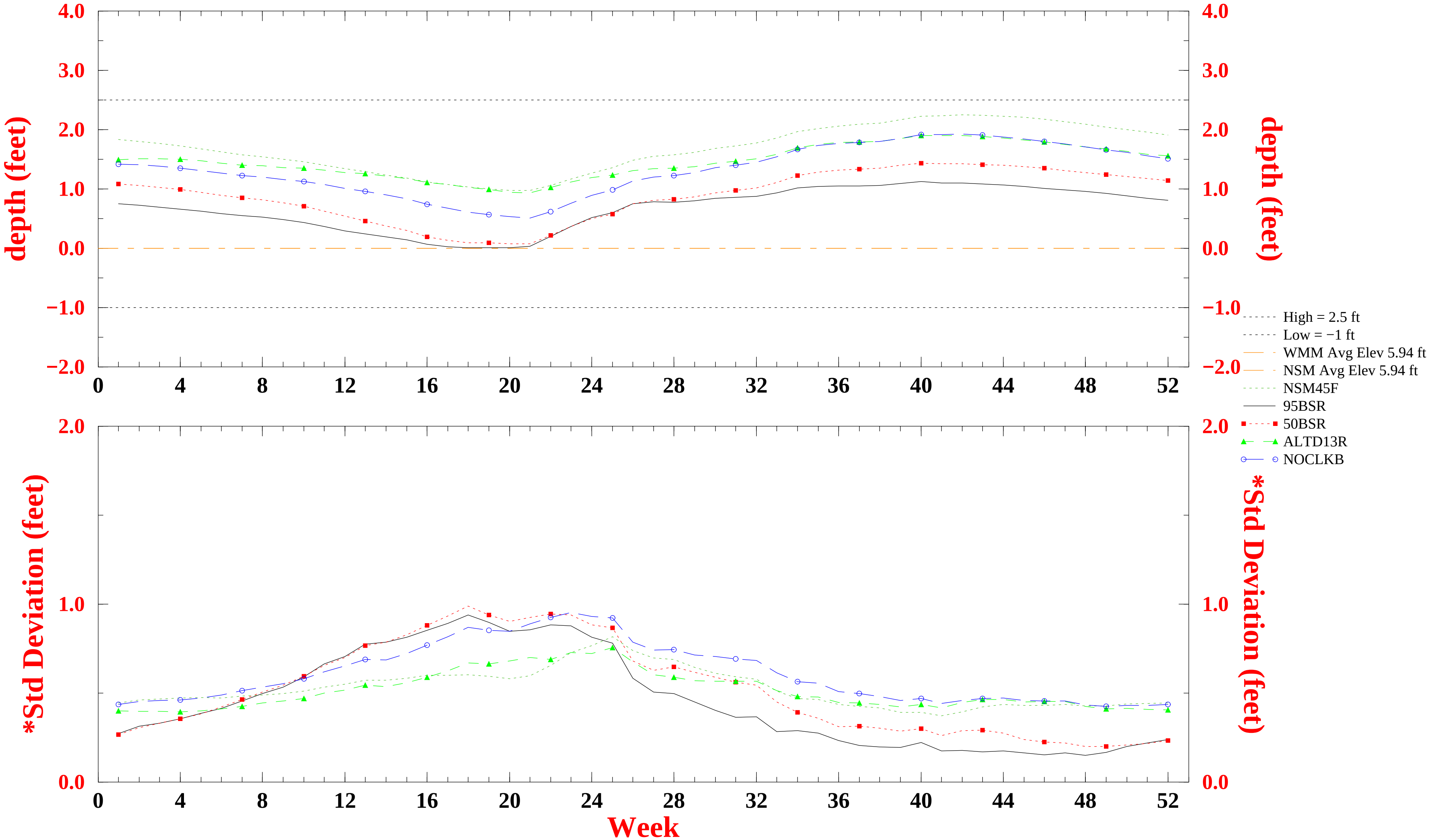


Note: NSM flows are NOT targets and are shown for comparative purposes only.
Negative values indicate flows from west to east.

Run date: 07/02/98 22:26:44
For Planning Purposes Only
SFWMM V3.5

Figure B.3-81 Temporal Variation in Mean Weekly Stage for NE Shark River Slough

Indicator Region 11 (R19C22-23 R20C22-26 R21C22-26)



WEEK 1 STARTS JAN 1

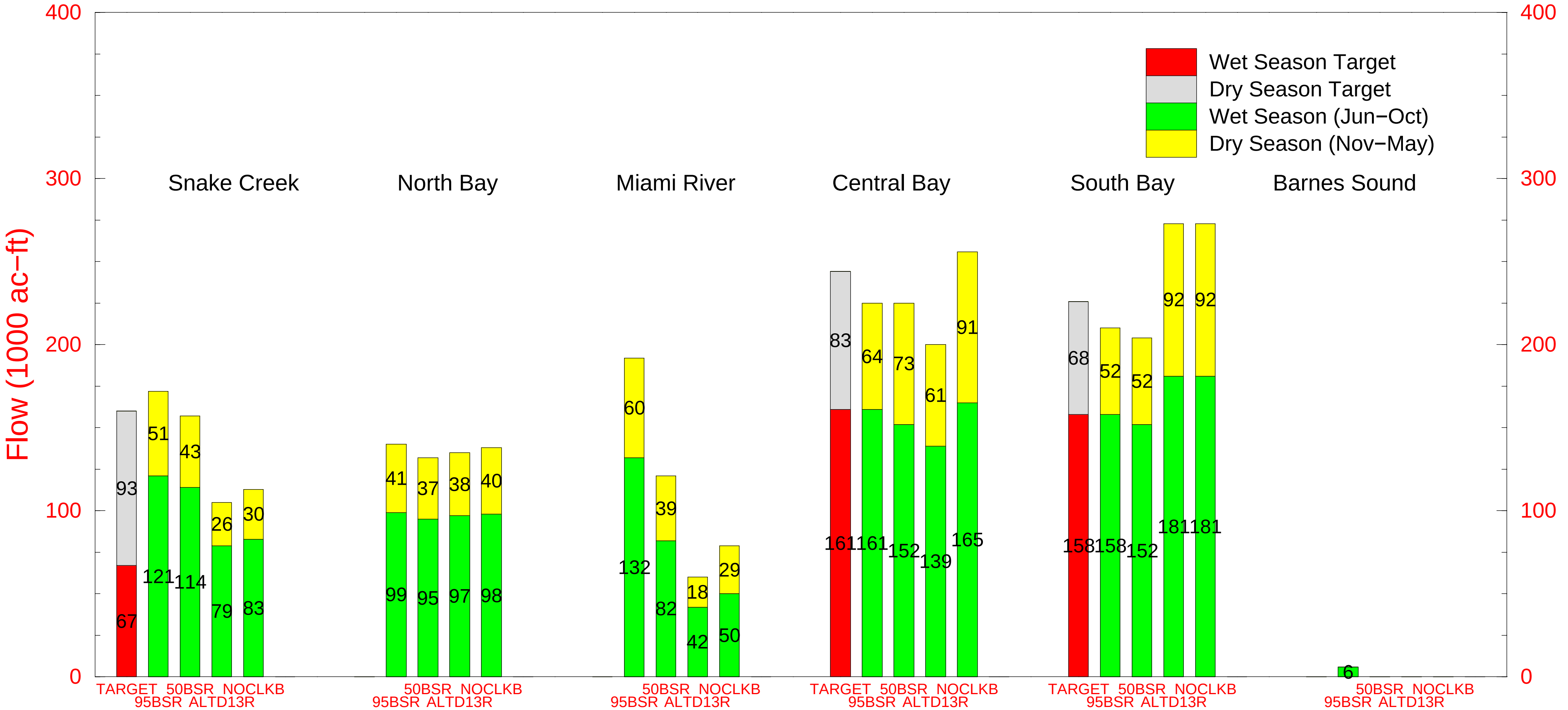
Depth and elev are weekly means for the indicator region for a 31 year simulation

High/Low = 0 indicates criteria undefined for region

* Standard Deviations are calculated among−year values;
* they illustrate interannual variation in mean weekly depth over the 31 year simulation period.

Run date: Mon Jul 6 12:04:37 EDT 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-82 Simulated Mean Annual Surface Flows Discharged into Biscayne Bay for the 1965 - 1995 simulation period



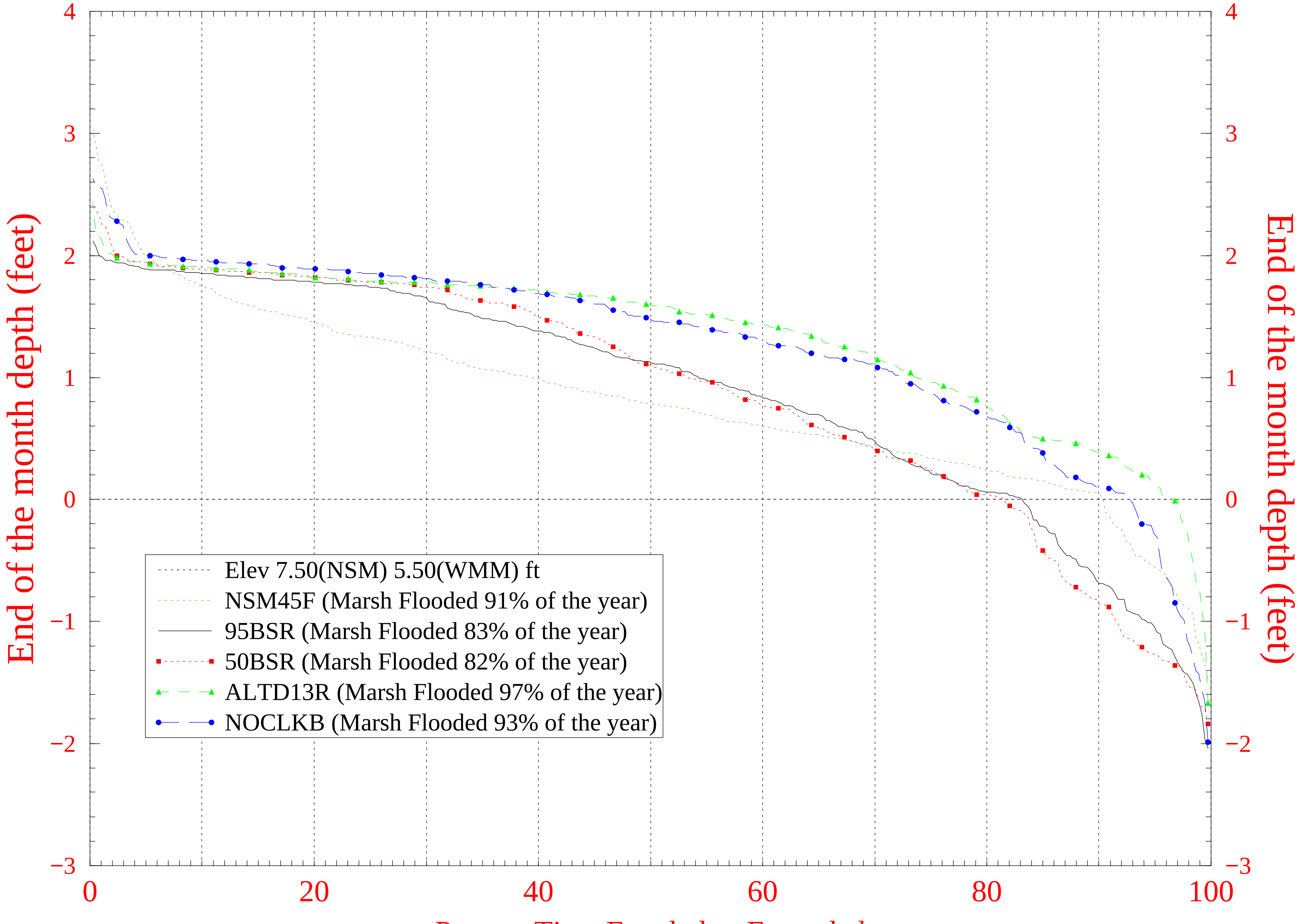
Note: Snake Creek=S29; North Bay=G58+S28+S27; Miami River=S26+S25B+S25; Central=G97+S22+S123; South=S21+S21A+S20F+S20G; Barnes Sound=S197

Targets for Central and South Bay reflect a 30% increase in mean annual dry season flows over the 95 Base

Targets for Snake Creek reflect a minimum monthly flow volume of 13,300 ac−ft (x 5 months for wet season and x 7 months for dry season) to maintain salinity levels below 20 ppt.

Run date: 07/02/98 18:42:14
For Planning Purposes Only
SFWMM V3.5

Figure B.3-83 Normalized Stage Duration Curves at Cell (R26 C27)
Pennsuco Wetlands



Run date: 07/02/98 21:25:03
For Planning Purposes Only
SFWMM V3.5

Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicates ponding while below zero indicates depth to the water table.

B.3.5.8 Miami-Dade County Wastewater Reuse

B.3.5.8.1 Description of Simulations

Both the No West and No South Miami-Dade Reuse simulations (NoWDR and NoSDR, respectively) were derived from ALTD13R by removing the reuse component. For NoWDR a 307.0 ac-ft/day reduction was modeled. For NoSDR a cumulative 402.0 (202.0 + 200.0) ac-ft/day reduction was modeled.

B.3.5.8.2 Assumptions

The reuse components BBB and HHH are physically removed in the proposed scenario runs.

The function of the inflow and outflow rules were not explicitly transformed or redirected elsewhere in the system; however, it is expected that other ALTD13R components will perform differently in an effort to meet system-wide objectives.

B.3.5.8.3 Summary of Results

- Removing the WDR component (NoWDR) lowered the stage in Bird Drive Reservoir two feet for approximately 70 percent of the simulation and between one to two feet for the remaining 30 percent of the simulation (Figure B.3-84). NoWDR also lowered the L-31N Canal stage at S-174 between 0.2 to 0.4 ft for approximately 20 percent of the time (Figure B.3-85).

- Simulated wet and dry season surface flows into Biscayne Bay from LECSA-3 decreased significantly for NoSDR and to a smaller extent for NoWDR. For NoSDR, decreases in mean annual dry and wet season flows were 60 and 62 kac-ft/yr, respectively, as compared to ALTD13R (Figure B.3-86). These decreases were most significant in Central and South Bay (Figure B.3-87)

- NoWDR simulated a five to six month (26-35 percent) increase in the number of water supply cutback months for each LECSA. The increase was primarily due to a Lake Okeechobee SSM trigger with a corresponding dry season trigger that occurred in 1991. NoSDR simulated an eight month (50+ percent) increase in the number of water supply cutback months for LECSA3. This increase was primarily due to an increase of local triggering in 1985, 1988 and 1989 (cutback volumes shown in Figure B.3-88).

- Mean annual water supply deliveries to the LECSA3 for the five drought years increased for both the NoSDR (18 kac-ft/yr) and the NoWDR (23 kac-ft/yr) compared to ALTD13R (Figure B.3-89). For NoWDR, there was also a significant decrease in Bird Drive Basin reservoir contributions (from 108 to 74 kac-ft/yr) to maintain canals in LECSA3 during drought years. This was attributed to the excessive lowering of stages in the reservoir (Figure B.3-84).

For the entire 31 year simulation, LECSA3 supply deliveries for NoSDR increased by 9 kac-ft/yr and for NoWDR by 14 kac-ft/yr compared to ALTD13R deliveries (Figure B.3-90). These supply delivery increases were satisfied by water flow from Lake Okeechobee. In general, NoWDR showed a more significant impact on the regional system's capacity to supply water to LECSA3.

- NoWDR simulated a four percent increase in the number of times Lake Okeechobee experienced minimum stages (Figure B.3-91), as well as an increase in undesirable stage events (Figures B.3-92 and B.3-93). Mean Annual LOSA irrigation demands not met increase by one percent (Figure B.3-94).

- NoWDR simulated a reduction in overland flow through Central Shark River Slough (40,000 ac-ft less, Figure B.3-95) and within the ENP (39,000 ac-ft less to west of L-31N and 37 thousand ac-ft less across L-67) as compared to ALTD13R (Figure B.3-96).

- Indicator region 11 in Northeast Shark River Slough showed the following:

  - One less inundation event (from 7 to 6 events) when the western reuse component is removed, but no change in the average annual percent of time the region was inundated.
  - Three fewer high water events (from 10 to 7 events) when the western reuse component is removed, and one less event (from 10 to 9) when the southern reuse component is removed. The average annual percent of time that the area exceeds the high water criteria (depth > 2.5 ft) does not change significantly (~4 percent of the time).
  - One less low water event (from 3 to 2 events) when the western reuse component is removed, and a slight increase (from 0 to 1 percent) in the percent of time that the area exceeds the low water criteria (depth < -1.0ft). No change resulted when the southern reuse component was removed.

TABLE B.3-11 Inundation Duration Summary for Indicator Regions

#Events|Avg Flood Dur(Wks/Event)|Avg Ann Hydper(Percent of Yr)

Indicator Region Number	Name	NSM45F			95BSR			50BSR			ALTD13R			NOSDR			NOWDR		
1	Taylor Slough	37	33	76	37	32	73	38	30	71	36	32	72	36	32	71	36	32	71
2	West Perrine Marl Marsh	68	9	39	70	9	39	70	9	38	67	9	39	67	9	39	68	9	39
3	Mid-Perrine Marl Marsh	43	23	60	41	24	61	51	17	53	50	17	54	50	17	53	51	17	53
4	C-111 Perrine Marl Marsh	47	21	62	73	12	55	71	13	59	45	27	76	42	29	75	44	28	75
5	Model Lands South	55	19	64	64	14	57	71	14	60	34	40	84	37	36	84	33	41	84
6	Model Lands North	43	27	72	97	6	37	87	7	36	109	7	45	102	7	43	110	7	45
7	Ochopee Marl Marsh	35	32	70	38	24	57	37	29	68	38	28	66	40	26	66	40	26	65
8	Rockland Marl Marsh	37	28	65	53	8	26	42	17	45	36	26	59	36	26	59	36	26	57
9	SW Shark River Slough	9	176	98	19	75	89	15	98	91	10	156	97	10	156	97	9	173	96
10	Mid Shark River Slough	5	321	100	16	93	92	14	108	94	4	398	99	6	265	99	6	265	99
11	NE Shark River Slough	4	402	100	21	67	88	21	68	89	7	226	98	7	227	98	6	262	98
12	New Shark River Slough	32	42	82	29	45	80	32	40	80	27	52	87	27	52	87	31	45	86
13	West Slough	38	28	66	36	30	67	38	31	74	34	32	67	34	32	67	34	32	67
14	South WCA-3A	17	88	92	6	267	99	15	101	94	11	139	95	11	139	95	12	127	95
15	West WCA-3B	20	74	92	11	141	96	19	79	93	4	398	99	4	398	99	5	318	99
16	East WCA-3B	15	102	95	18	81	90	28	50	86	6	262	98	6	262	98	8	195	97
17	South Central WCA-3A	24	59	87	14	109	95	24	59	88	14	110	95	15	102	95	14	110	95
18	North Central WCA-3A	24	59	89	18	82	91	21	69	89	11	142	97	10	155	96	10	155	96
19	East WCA-3A	25	55	86	7	227	99	15	100	93	13	115	93	14	108	93	14	107	93
20	NW WCA-3A	21	70	91	33	40	81	27	51	86	19	75	88	22	65	88	25	57	88
21	NE WCA-3A	28	49	85	40	30	74	20	73	91	31	44	84	30	45	84	32	42	84
22	NW Corner WCA-3A	20	73	91	34	36	77	19	77	91	19	81	95	18	85	95	18	85	95
23	WCA-2B	21	70	92	21	63	82	17	82	86	20	66	81	20	66	81	20	66	81
24	South WCA-2A	20	74	91	19	76	89	16	90	89	18	78	88	18	78	88	18	78	88
25	North WCA-2A	30	46	86	16	86	85	19	77	90	16	93	92	16	93	92	16	93	92
26	South LNWR (WCA-1)	25	57	89	7	229	100	16	95	94	7	228	99	7	228	99	7	228	99
27	North LNWR (WCA-1)	15	99	92	13	119	96	20	72	90	16	96	95	16	96	95	16	96	95
28	Rotenberger WMA	40	31	76	52	18	59	38	34	79	41	31	79	43	30	79	42	30	79
29	Holey Land WMA	28	50	88	14	108	94	12	128	95	28	50	88	31	45	87	29	49	88
30	Corbett WMA	61	13	50	64	3	13	55	4	13	56	3	10	55	3	10	55	3	10
31	Mullet Slough	64	14	56	56	13	46	57	13	46	59	14	50	59	14	50	58	14	50
32	Upland Pine	56	15	51	56	15	53	57	15	52	57	15	52	57	15	52	57	15	52
33	Upper Mullet Slough	64	8	33	64	8	33	64	8	33	65	8	33	65	8	33	65	8	33
34	Cypress Marsh	36	35	78	42	12	31	42	12	31	42	12	31	42	12	31	42	12	31
35	Wet Prairie	31	43	82	42	19	50	42	19	50	42	19	50	42	19	50	42	19	50
36	Wetter Prairie NE	59	18	65	59	16	60	68	14	57	64	15	59	64	15	59	64	15	59
37	Wetter Prairie SW	58	17	63	65	14	56	71	12	54	67	14	58	67	14	58	67	14	58
38	Drier Cypress NW	67	10	40	67	9	38	68	9	38	68	9	39	68	9	39	68	9	39
39	Drier Cypress NE	62	14	55	65	12	48	64	12	48	66	12	50	66	12	50	66	12	50
40	Cypress	48	23	67	49	21	65	53	20	64	48	22	65	48	22	65	48	22	65
41	NW Big Cypress	54	16	53	59	12	46	59	12	46	59	12	46	59	12	46	59	12	46
42	NE Big Cypress	44	22	61	56	12	43	56	12	43	55	16	53	55	16	53	55	16	53
43	NE Corner Big Cypress	39	31	75	37	4	10	38	4	9	44	14	38	45	14	38	45	14	38
44	SW Big Cypress	62	14	54	60	14	54	60	14	54	60	14	54	60	14	54	60	14	54
45	Racoon Point	61	11	42	67	10	40	65	10	39	64	10	40	64	10	40	64	10	40
47	North C-111	48	20	60	92	5	26	58	4	14	55	10	35	54	10	34	55	10	34
48	North Bisc. Bay Groundwater 1	14	7	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	North Bisc. Bay Groundwater 2	49	15	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	Central Bisc. Bay Groundwater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	South Bisc. Bay Groundwater	34	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

---edited---

Notes: #events = number of continuous ponding events over the period of record

Avg Flood Duration = [sum(days of ponding)/7]/#events

Avg Annual Hydroperiod = 100 x [sum(weeks of ponding per year)]/[52 x #years]

TABLE B.3–12. High Water Summary for Indicator Regions

#Events|Avg Duration (Wks/Event)|Avg Ann Duration(Percent of Yr)

Indicator Region Number	Name	Depth(ft) Criterion	NSM45F			95BSR			50BSR			ALTD13R			NOSDR			NOWDR		
			#Events	Avg Duration	Avg Ann Duration	#Events	Avg Duration	Avg Ann Duration	#Events	Avg Duration	Avg Ann Duration	#Events	Avg Duration	Avg Ann Duration	#Events	Avg Duration	Avg Ann Duration	#Events	Avg Duration	Avg Ann Duration
1	Taylor Slough	> 1.5	10	2	1	7	2	1	5	2	0	5	2	1	5	2	1	5	2	1
2	West Perrine Marl Marsh	> 2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Mid–Perrine Marl Marsh	> 2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	C–111 Perrine Marl Marsh	> 2.0	0	0	0	0	0	0	0	0	0	10	3	2	9	3	2	11	3	2
5	Model Lands South	> 2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Model Lands North	> 1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Ochopee Marl Marsh	> 2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Rockland Marl Marsh	> 2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	SW Shark River Slough	> 2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Mid Shark River Slough	> 2.5	5	11	4	1	1	0	1	1	0	5	6	2	6	5	2	5	6	2
11	NE Shark River Slough	> 2.5	15	10	9	0	0	0	0	0	0	10	6	4	9	6	4	7	7	3
14	South WCA–3A	> 2.5	0	0	0	33	18	36	10	9	6	2	9	1	2	9	1	2	8	1
15	West WCA–3B	> 2.5	6	6	2	2	10	1	6	12	5	5	10	3	5	10	3	5	10	3
16	East WCA–3B	> 2.5	7	9	4	6	8	3	15	9	8	13	7	5	12	7	5	11	7	5
17	South Central WCA–3A	> 2.5	0	0	0	6	10	4	4	9	2	2	9	1	2	9	1	2	9	1
18	North Central WCA–3A	> 2.5	0	0	0	5	5	2	2	10	1	3	7	1	3	7	1	3	6	1
19	East WCA–3A	> 2.5	0	0	0	37	23	53	23	8	11	27	12	19	25	12	19	27	11	19
20	NW WCA–3A	> 2.5	0	0	0	1	7	0	1	6	0	1	1	0	1	1	0	1	1	0
21	NE WCA–3A	> 2.0	2	2	0	2	8	1	2	9	1	6	7	3	6	7	3	6	7	3
22	NW Corner WCA–3A	> 2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	WCA–2B	> 2.5	4	5	1	20	13	17	15	60	56	25	7	10	25	7	10	25	7	10
24	South WCA–2A	> 2.5	0	0	0	3	1	0	5	2	1	4	4	1	4	4	1	4	4	1
25	North WCA–2A	> 2.5	0	0	0	0	0	0	1	1	0	3	1	0	3	1	0	2	1	0
26	South LNWR (WCA–1)	> 2.5	0	0	0	33	15	30	27	12	20	29	14	25	29	14	25	29	14	25
27	North LNWR (WCA–1)	> 2.5	0	0	0	4	1	0	1	1	0	1	1	0	1	1	0	1	1	0
28	Rotenberger WMA	> 1.5	17	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Holey Land WMA	> 1.5	22	8	12	34	16	34	32	21	41	30	4	7	30	4	7	30	4	7
47	North C–111	> 1.8	0	0	0	0	0	0	0	0	0	5	2	1	5	2	0	4	2	0
52	Pennsuco Wetlands North	> 2.0	16	8	8	5	2	0	5	6	2	6	4	1	7	4	2	6	4	1
53	Pennsuco Wetlands South	> 2.0	40	13	33	3	1	0	4	7	2	6	3	1	6	3	1	5	3	1

---edited---

Notes: #events = number of events with depths continuously greater than the criterion over the period of record
Avg Duration of High Water Events = [sum(days over criterion)/7]/#events
Avg Annual Duration of High Water(Percent) = 100 x [sum(weeks over criterion)]/[52 x #years]

TABLE B.3-13. Low Water Summary for Indicator Regions

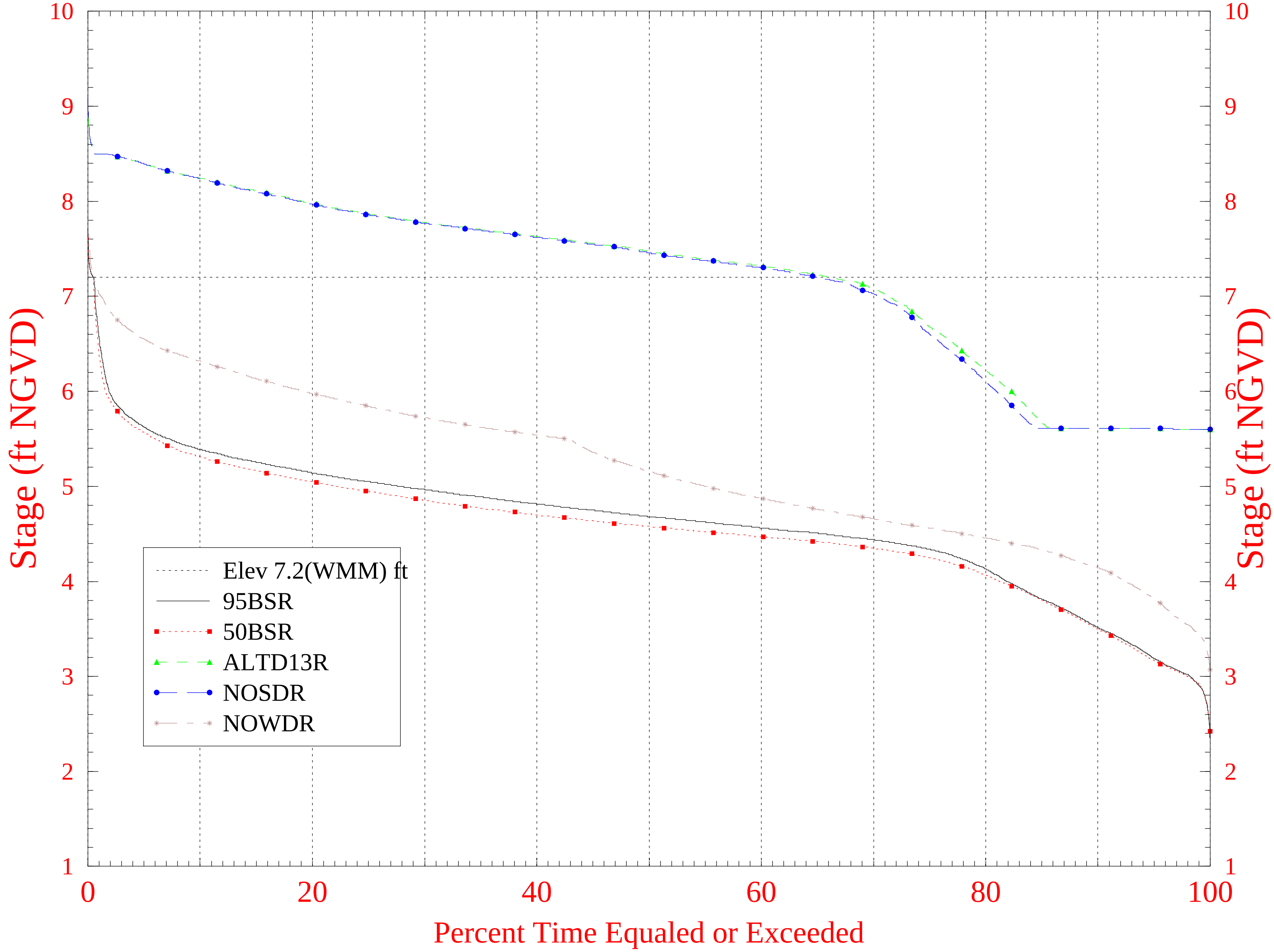
#Events|Avg Duration (Wks/Event)|Avg Ann Duration(Percent of Yr)

Indicator Region Number	Name	Depth(ft) Criterion	NSM45F			95BSR			50BSR			ALTD13R			NOSDR			NOWDR		
1	Taylor Slough	< -1.5	20	4	5	24	4	6	28	4	7	28	4	7	28	4	7	28	4	7
2	West Perrine Marl Marsh	< -1.5	36	7	16	36	8	18	38	7	17	35	8	16	35	8	16	36	7	17
3	Mid-Perrine Marl Marsh	< -1.5	28	8	13	23	3	5	30	4	8	34	4	9	34	4	9	35	4	9
4	C-111 Perrine Marl Marsh	< 0.5	54	24	80	51	27	86	34	40	84	53	17	55	49	18	56	49	19	56
5	Model Lands South	< 0.5	56	23	81	48	29	88	41	37	95	80	14	68	82	13	68	82	13	68
6	Model Lands North	< 0.2	54	14	46	45	34	95	44	35	95	51	29	93	51	30	94	51	30	93
7	Ochopee Marl Marsh	< -1.5	17	8	9	21	10	13	22	7	10	22	7	10	22	7	10	21	8	10
8	Rockland Marl Marsh	< -1.5	21	10	13	45	10	29	38	10	23	22	10	14	23	10	14	24	10	15
9	SW Shark River Slough	< -1.0	1	5	0	18	4	4	12	4	3	3	2	0	3	2	0	3	3	1
10	Mid Shark River Slough	< -1.0	1	1	0	7	6	3	7	5	2	2	2	0	2	2	0	2	3	0
11	NE Shark River Slough	< -1.0	1	1	0	10	6	4	9	6	3	3	2	0	3	2	0	2	5	1
12	New Shark River Slough	< -1.0	17	7	8	17	8	9	21	6	8	13	5	4	13	5	4	14	5	4
13	West Slough	< -1.5	22	7	10	18	9	10	17	7	7	20	8	10	20	8	10	20	8	10
14	South WCA-3A	< -1.0	8	4	2	0	0	0	4	4	1	4	4	1	4	4	1	4	4	1
15	West WCA-3B	< -1.0	3	2	0	2	2	0	7	2	1	2	3	0	2	3	0	2	5	1
16	East WCA-3B	< -1.0	1	1	0	10	4	3	15	5	5	4	3	1	4	3	1	3	5	1
17	South Central WCA-3A	< -1.0	8	7	3	6	3	1	10	6	4	5	2	1	5	3	1	5	2	1
18	North Central WCA-3A	< -1.0	9	5	3	10	5	3	10	6	3	1	6	0	2	4	0	2	4	0
19	East WCA-3A	< -1.0	10	6	4	1	1	0	9	3	2	8	3	1	8	3	1	7	3	1
20	NW WCA-3A	< -1.0	6	6	2	16	7	7	11	7	5	9	5	3	9	5	3	8	6	3
21	NE WCA-3A	< -1.0	15	7	7	21	9	12	10	7	4	15	4	4	14	5	4	13	5	4
22	NW Corner WCA-3A	< -1.0	7	5	2	25	7	11	11	6	4	5	3	1	5	3	1	4	5	1
23	WCA-2B	< -1.0	5	5	1	14	7	6	11	7	5	14	7	6	14	7	6	14	7	6
24	South WCA-2A	< -1.0	6	8	3	12	5	4	8	8	4	12	7	5	12	7	5	12	7	5
25	North WCA-2A	< -1.0	8	8	4	10	9	5	8	7	3	4	9	2	4	9	2	4	9	2
26	South LNWR (WCA-1)	< -1.0	10	4	2	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0
27	North LNWR (WCA-1)	< -1.0	8	4	2	1	4	0	5	5	1	1	3	0	1	3	0	1	3	0
28	Rotenberger WMA	< -1.0	18	8	9	33	9	19	20	4	6	18	3	4	18	3	4	18	3	4
29	Holey Land WMA	< -1.0	14	6	5	9	2	1	5	2	1	11	4	3	11	4	3	11	4	3
32	Upland Pine	< -7.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Cypress Marsh	< -6.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	Wet Prairie	< -6.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	Wetter Prairie NE	< -6.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	Wetter Prairie SW	< -6.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	Drier Cypress NW	< -5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	Drier Cypress NE	< -5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	Cypress	< -4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	NW Big Cypress	< -3.0	13	5	4	13	5	4	13	5	4	13	5	4	13	5	4	13	5	4
42	NE Big Cypress	< -3.0	6	5	2	10	6	4	10	6	4	9	5	3	9	5	3	9	5	3
43	NE Corner Big Cypress	< -3.0	0	0	0	21	6	7	22	6	8	22	6	9	22	6	9	22	6	9
44	SW Big Cypress	< -3.0	9	6	3	10	7	4	10	7	4	10	7	4	10	7	4	10	7	4
47	North C-111	< 0.0	47	14	41	88	14	76	58	24	87	55	19	66	53	20	67	55	20	67
48	North Bisc. Bay Groundwater 1	< -5.1	18	4	5	1	1612	100	1	1612	100	1	1612	100	1	1612	100	1	1612	100
49	North Bisc. Bay Groundwater 2	< -5.0	0	0	0	21	75	98	11	145	99	11	146	100	11	146	100	10	161	100
50	Central Bisc. Bay Groundwater	< -7.5	3	3	1	76	12	56	105	10	66	130	7	59	114	9	64	125	8	62
51	South Bisc. Bay Groundwater	< -3.0	30	9	17	79	12	61	87	12	66	92	11	65	95	12	69	92	11	65
52	Pennsuco Wetlands North	< -1.0	3	2	0	22	5	7	29	5	9	4	4	1	3	5	1	5	4	1
53	Pennsuco Wetlands South	< -1.0	1	1	0	22	7	10	31	7	13	5	6	2	4	6	1	7	6	2

---edited---

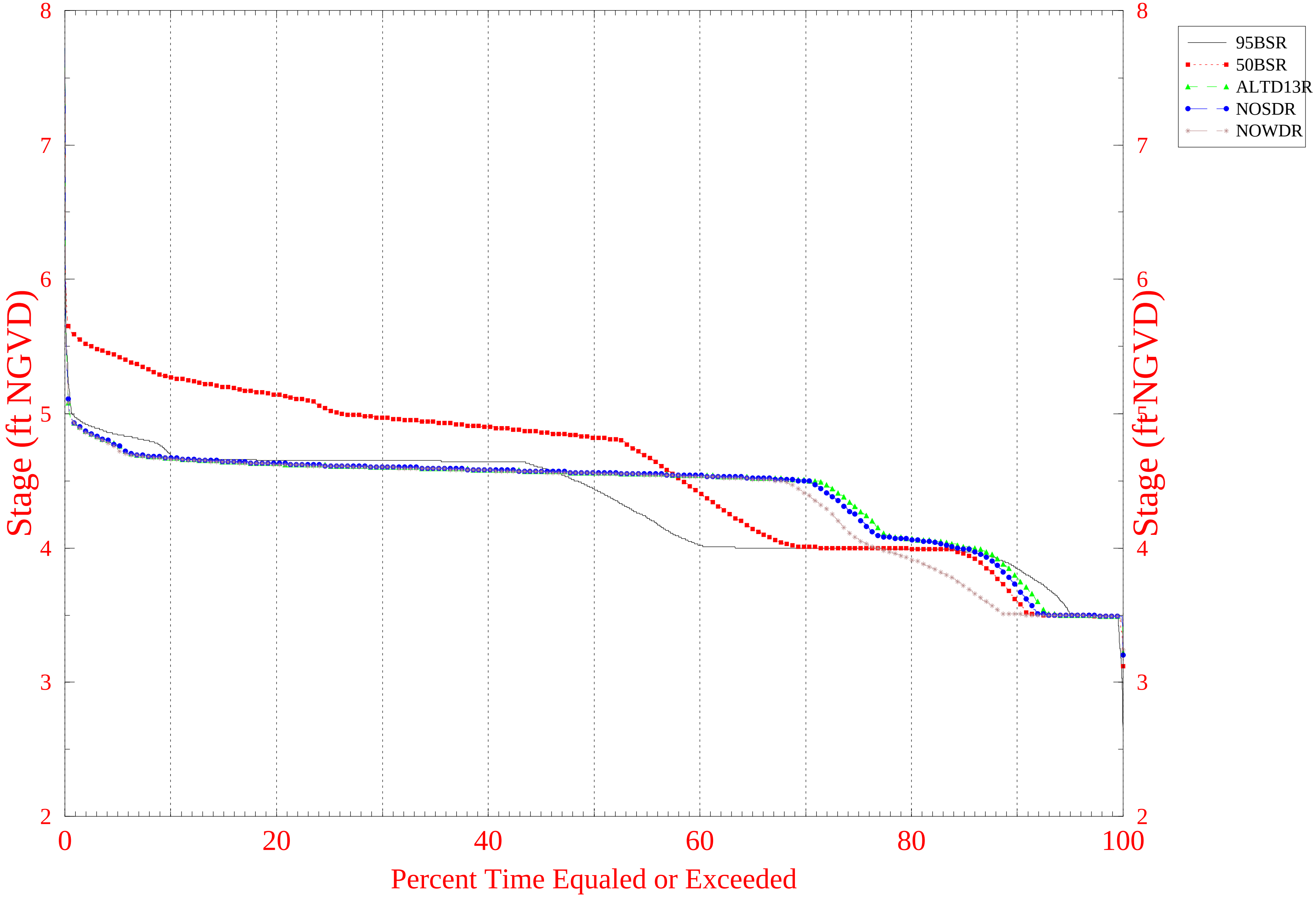
Notes: #events = number of events with depths continuously less than the criterion over the period of record
Avg Duration of Low Water Events = [sum(days below criterion)/7]/#events
Avg Annual Duration of Low Water(Percent) = 100 x [sum(weeks below criterion)]/[52 x #years]

Figure B.3-84 Stage Duration Curves at Bird Drive Reservoir



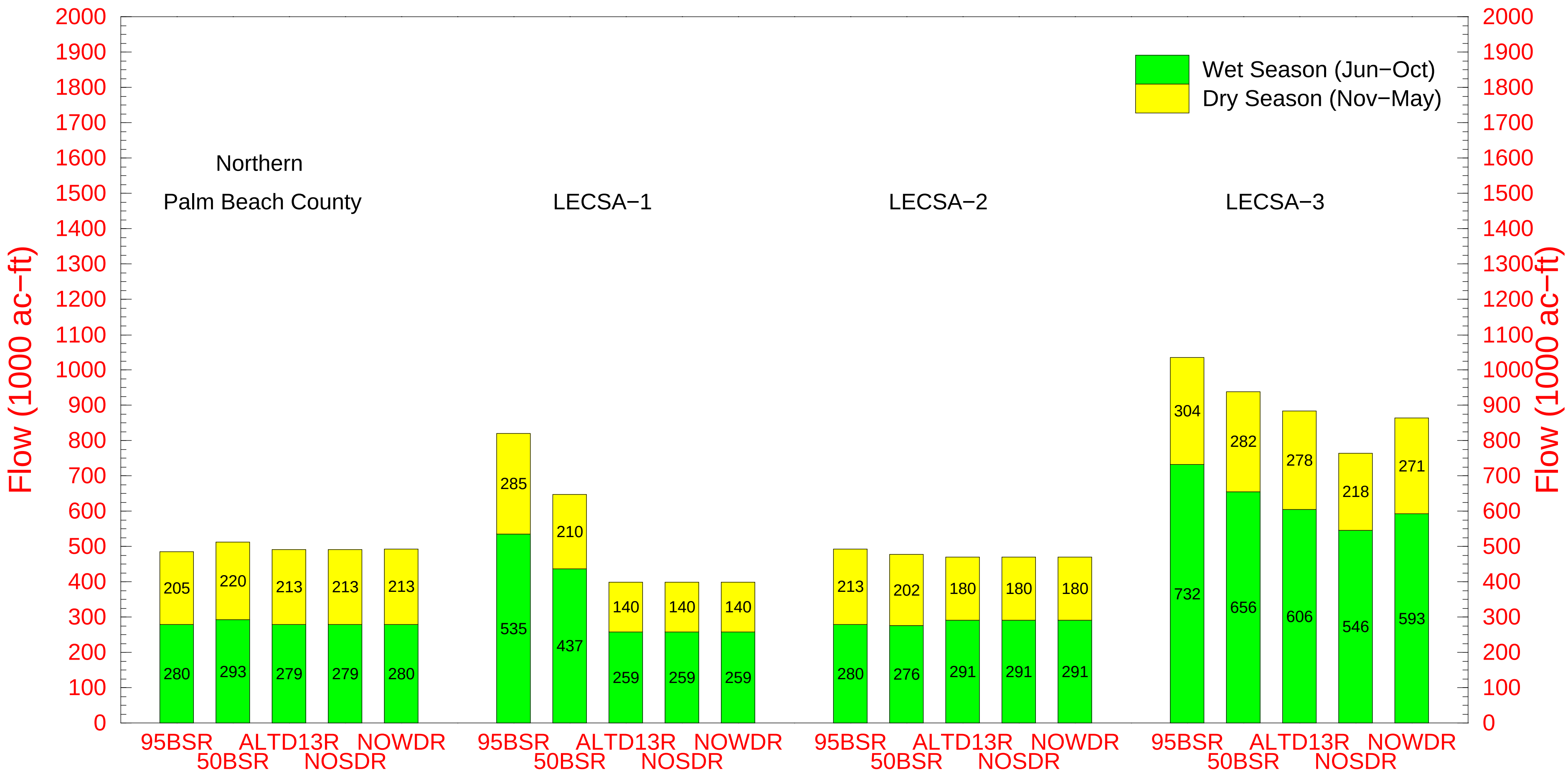
Run date: 07/21/98 22:38:09
For Planning Purposes Only
SFWMM V3.5

Figure B.3-85 Stage Duration Curves for L-31N Canal at S-174
(Salt-Water Intrusion Indicator Stage = 2.1 ft, NGVD)



Run date: 07/22/98 01:23:37
For Planning Purposes Only
SFWMM V3.5

Figure B.3-86 Mean Annual Surface Flows Discharged to Tide from the LECSA for the 1965 - 1995 simulation period

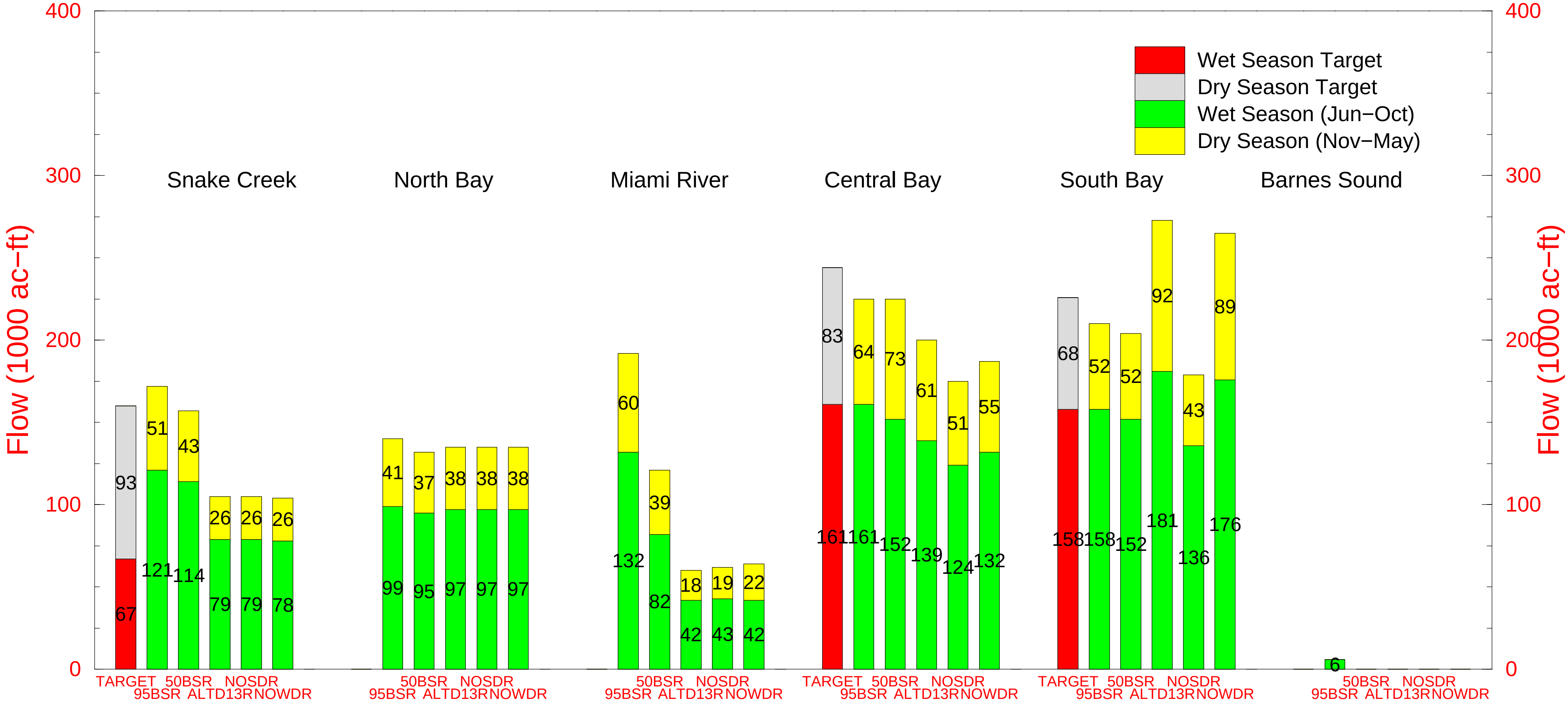


Service Area Canals Discharging to Tide:

Northern PB Co. = C−17
LECSA−1 = C−51, C−16, C−15 and the Hillsboro Canal
LECSA−2 = C−14, C−13, C−12, North New River Canal and C−10
LECSA−3 = C−9, Miami Canal, C−8, C−7, Coral Gables Canal, C−2,C−100A, C−100B, C−1, C−102, C−103, Military Canal and Model Land Canal

Run date: 07/21/98 17:22:58
For Planning Purposes Only
SFWMM V3.5

Figure B.3-87 Simulated Mean Annual Surface Flows Discharged into Biscayne Bay for the 1965 - 1995 simulation period

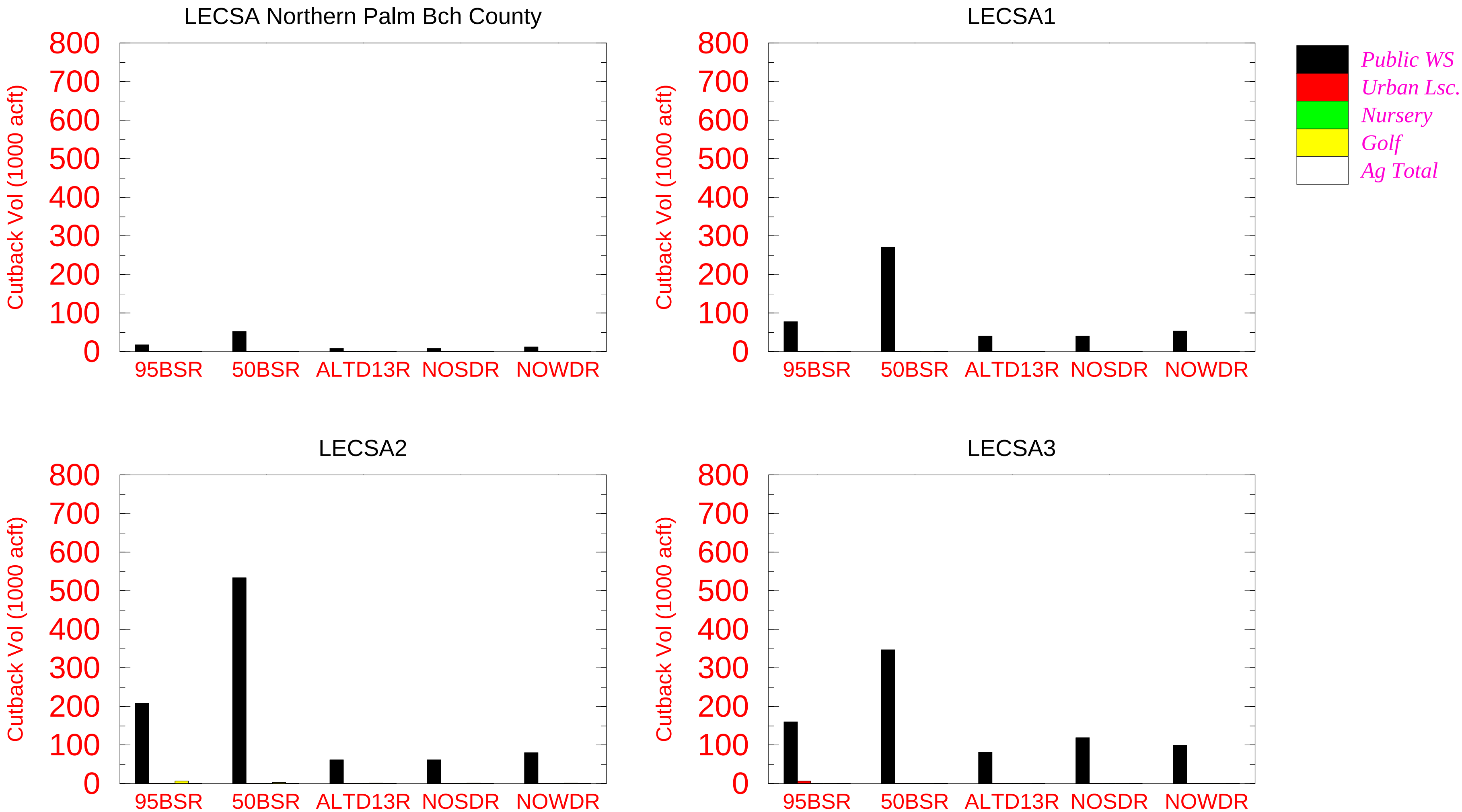


Note: Snake Creek=S29; North Bay=G58+S28+S27; Miami River=S26+S25B+S25; Central=G97+S22+S123; South=S21+S21A+S20F+S20G; Barnes Sound=S197

Targets for Central and South Bay reflect a 30% increase in mean annual dry season flows over the 95 Base
Targets for Snake Creek reflect a minimum monthly flow volume of 13,300 ac−ft (x 5 months for wet season and x 7 months for dry season) to maintain salinity levels below 20 ppt.

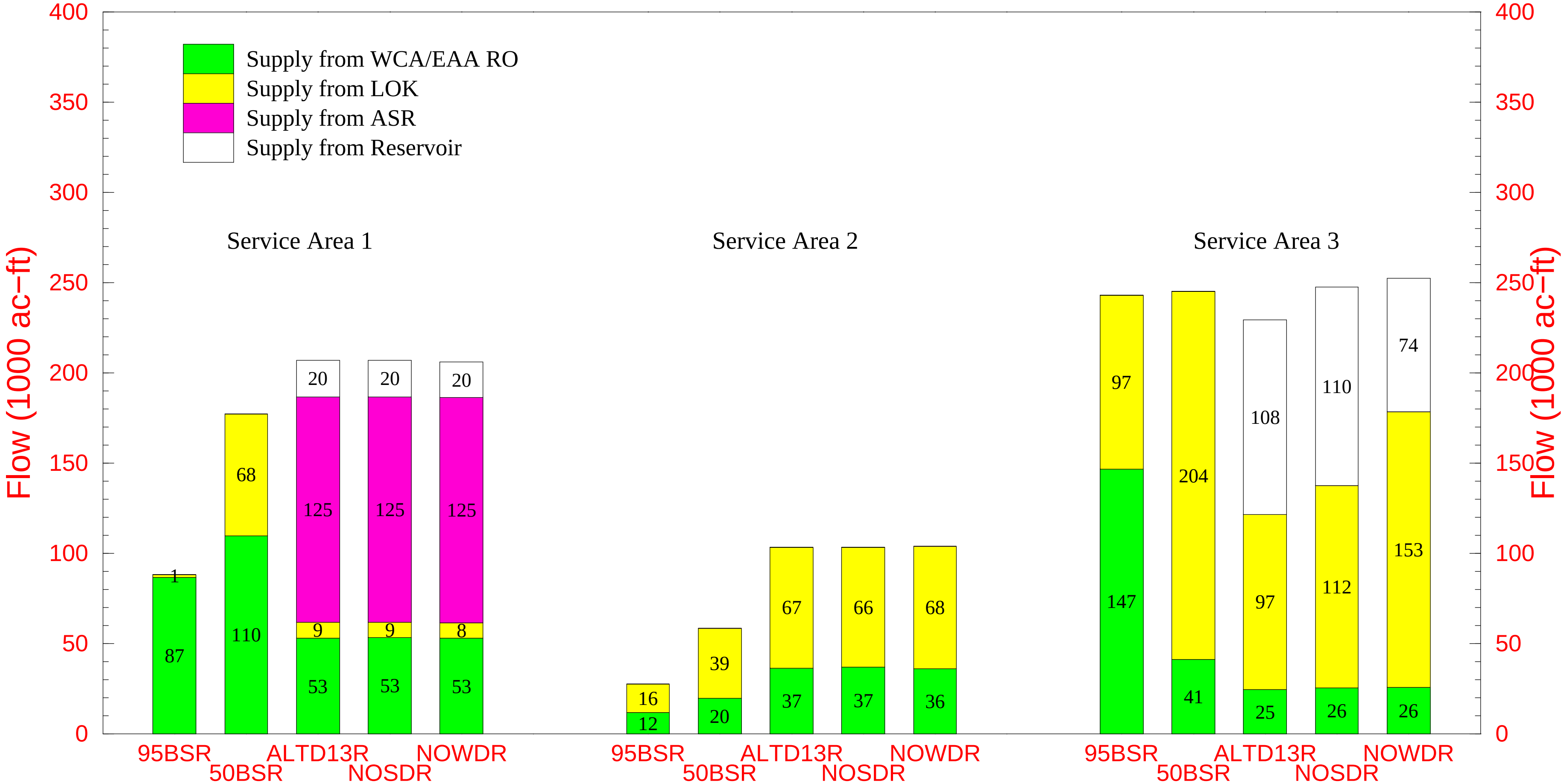
Run date: 07/21/98 17:10:30
For Planning Purposes Only
SFWMM V3.5

Figure B.3-88 Volume of Simulated Water Supply Cutbacks by Use-Type for the 1965 - 1995 Simulation Period



Run date: 07/21/98 16:56:53
For Planning Purposes Only
SFWMM V3.5

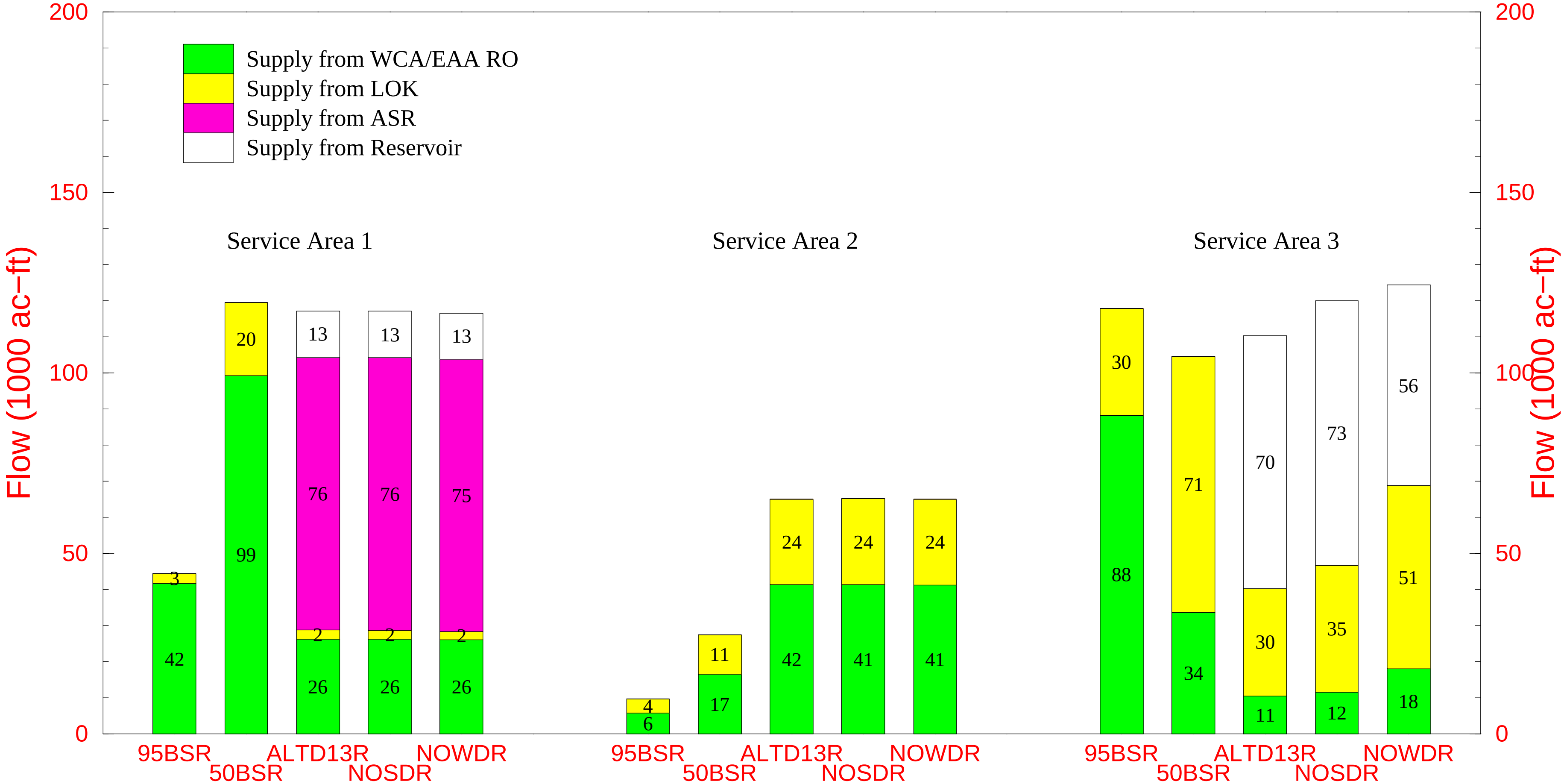
Figure B.3-89 Mean Annual Regional System Water Supply Deliveries to LEC Service Areas for the five Drought years (71,75,81,85,89)



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

Run date: 07/21/98 16:53:46
For Planning Purposes Only
SFWMM V3.5

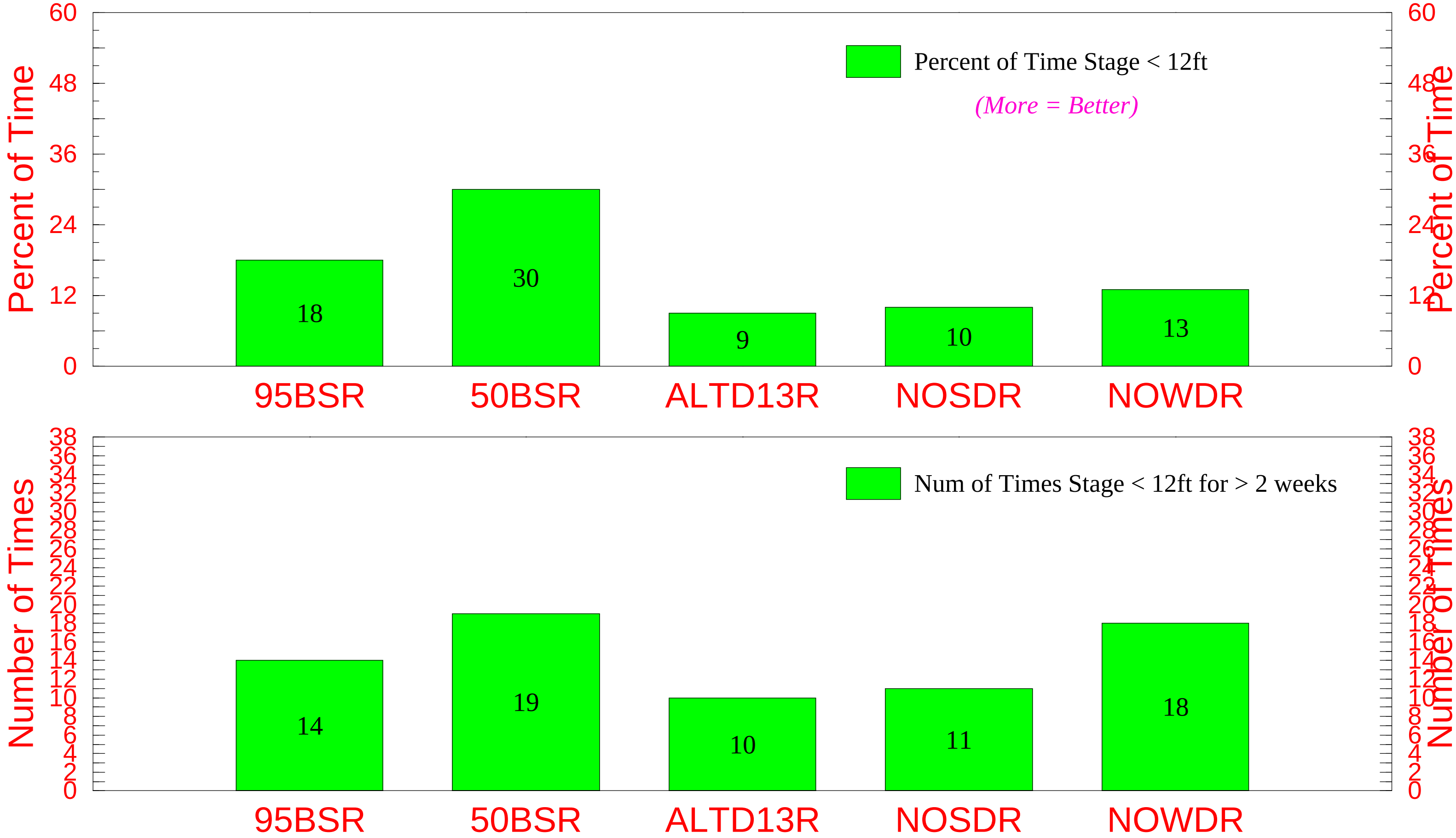
Figure B.3-90 Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 - 1995 simulation



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

Run date: 07/21/98 16:48:14
For Planning Purposes Only
SFWMM V3.5

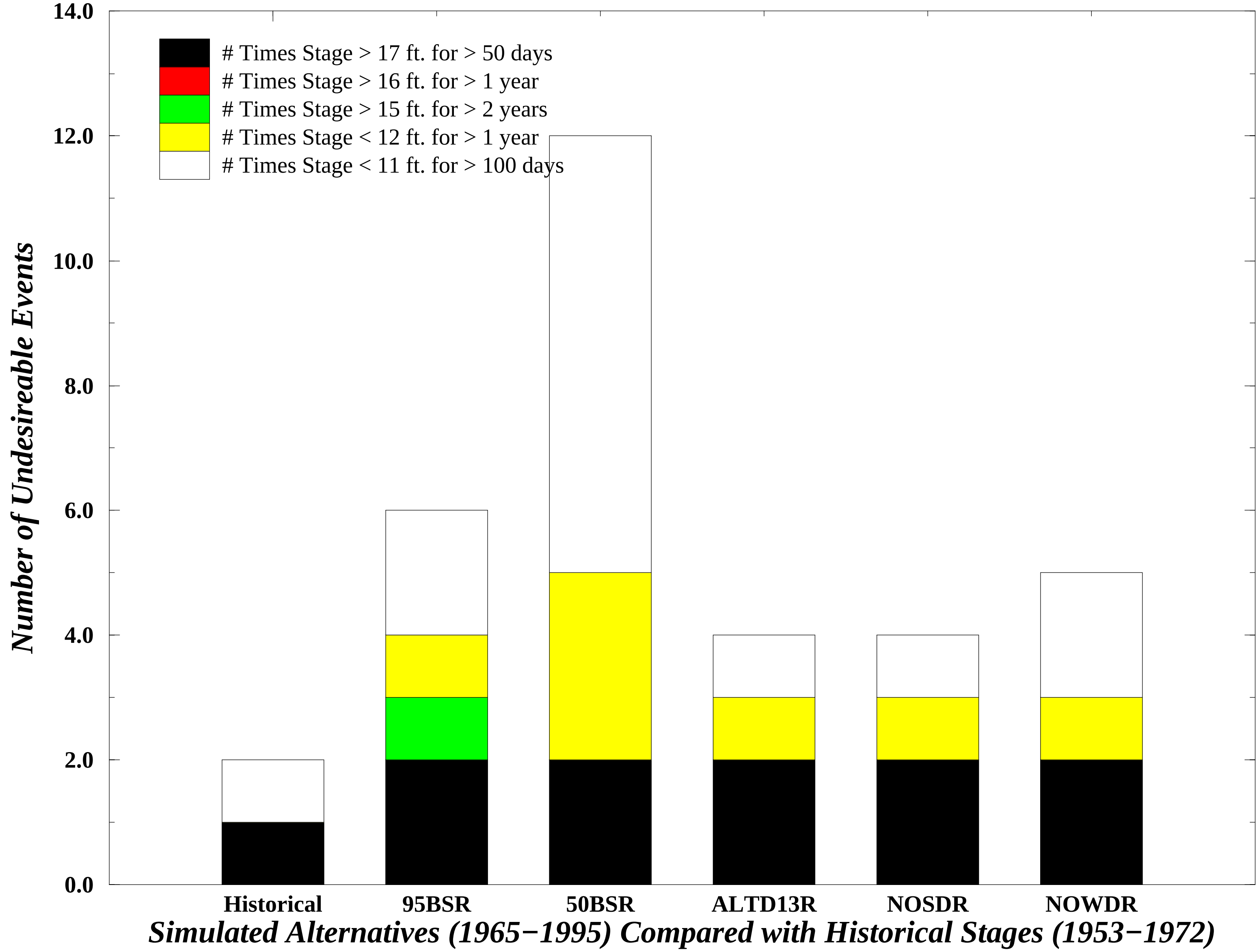
Figure B.3-91 A) Percent of Time Lake Stages Fell < 12ft NGVD
B) Num of Times Lake < 12ft NGVD for > 2 weeks



* Short−term drying of the marsh allows for seed germination of beneficial plants, improves wading bird and snail kite habitat (eg. regrowth of willow) and helps to maintain the natural diversity and abundance of littoral zone biological communities.

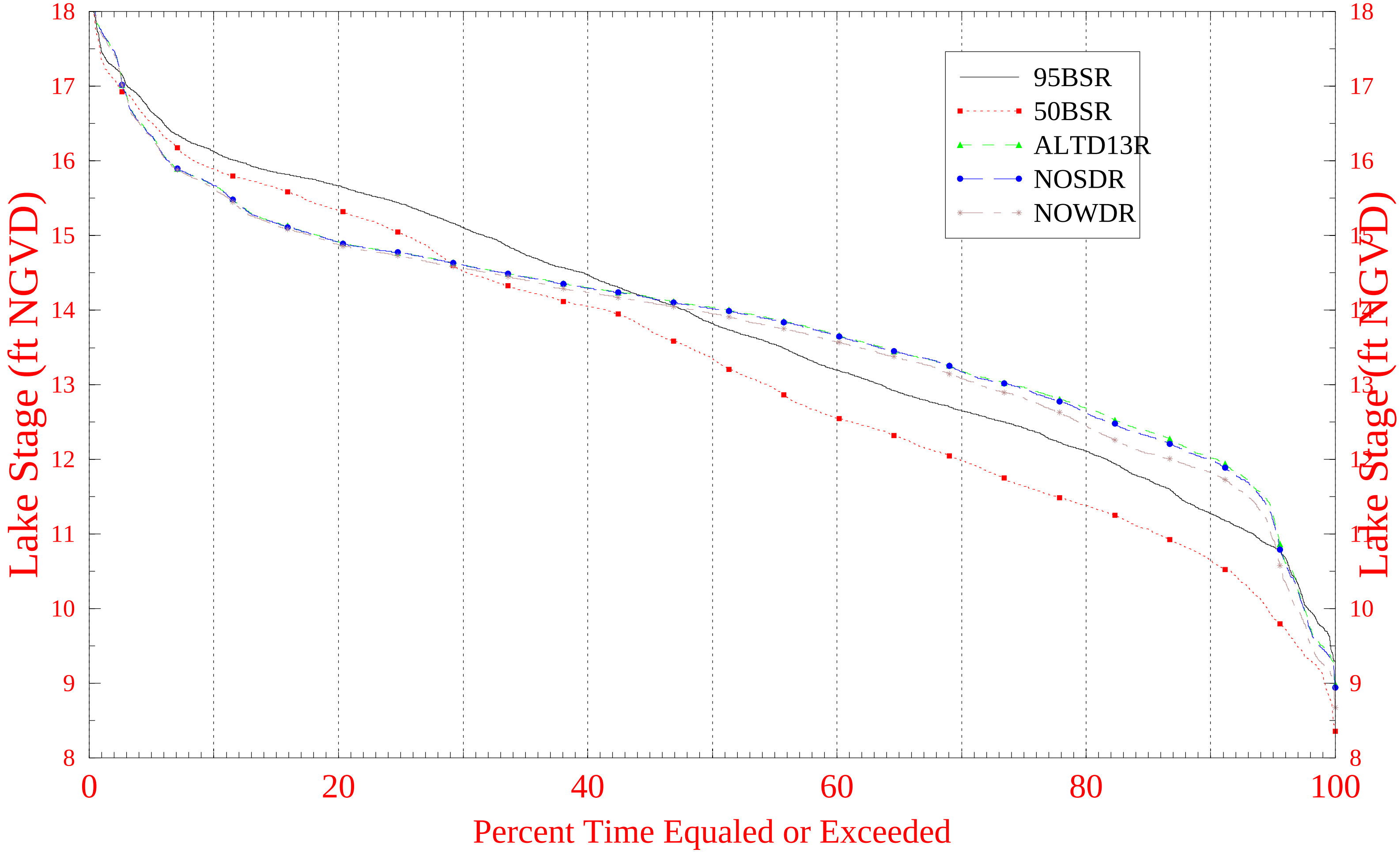
Run date: 07/21/98 22:52:41
For Planning Purposes Only
SFWMM V3.5

Figure B.3-92 Number of Undesireable Lake Okeechobee Stage Events



Run date: 07/22/98 02:23:29
For Planning Purposes Only
SFWMM V3.5

Figure B.3-93 Lake Okeechobee Stage Duration Curves

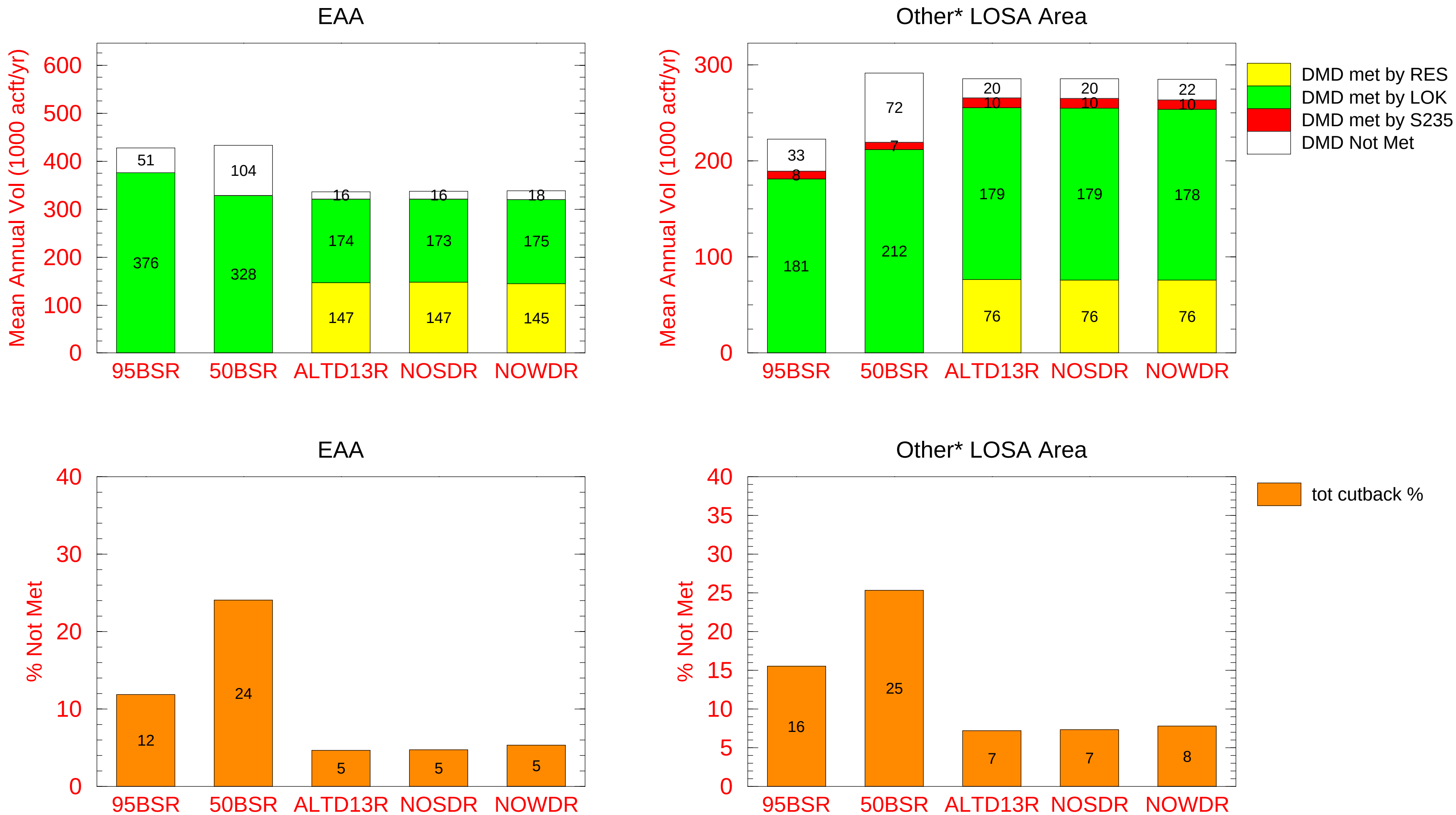


Run date: 07/21/98 16:10:48
For Planning Purposes Only
SFWMM V3.5

Figure B.3-94 Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met

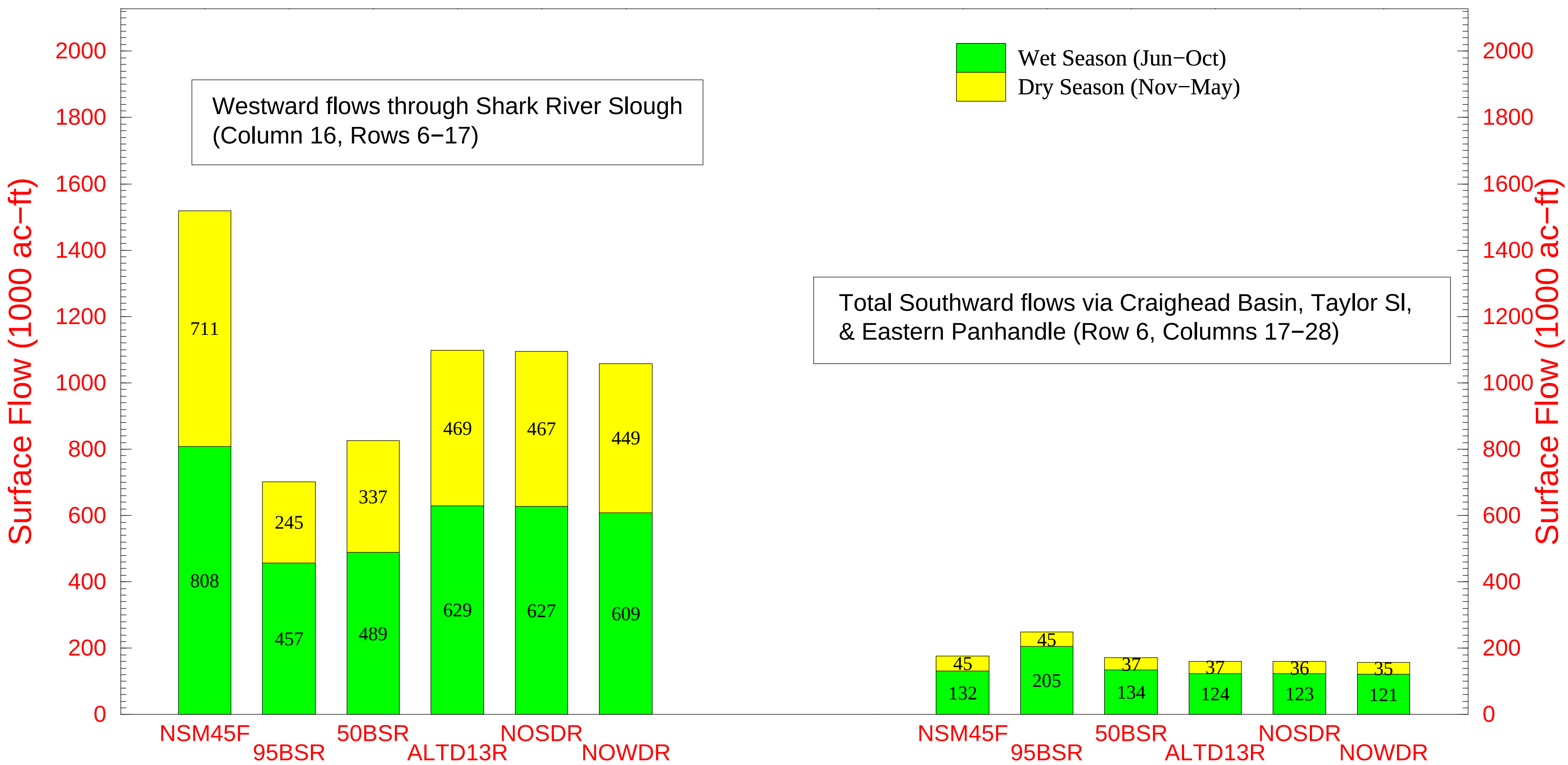
for the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

Run date: 07/21/98 16:25:04
For Planning Purposes Only
SFWMM V3.5

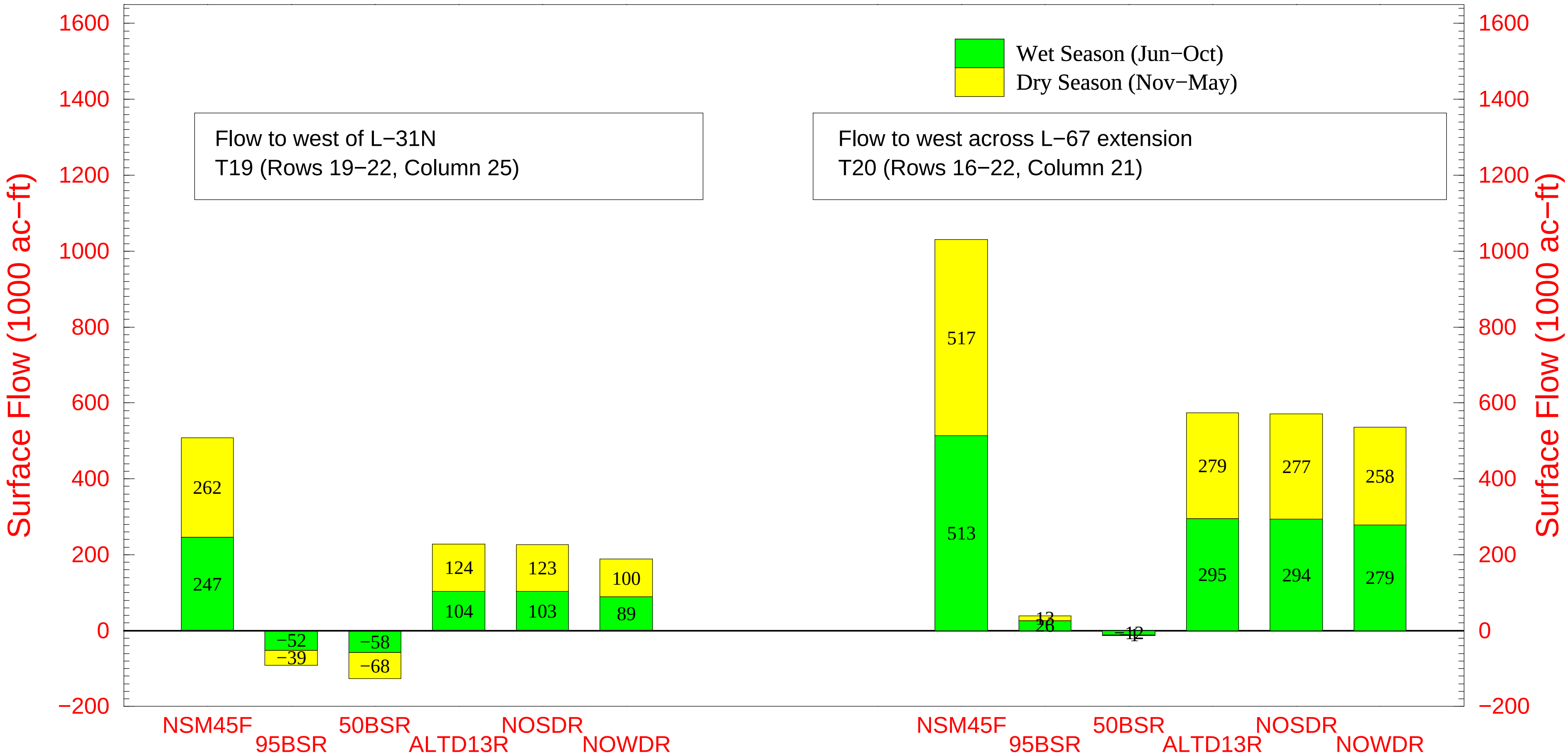
Figure B.3-95 Average Annual Overland Flows toward Whitewater Bay and Florida Bay for the 31 year simulation period



Note: NSM water depths at key ENP gage locations are used as operational targets for most alternatives.
NSM flows are NOT targets and are shown for comparative purposes only.

Run date: 07/21/98 17:51:20
For Planning Purposes Only
SFWMM V3.5

Figure B.3-96 Average Annual Overland Flow westward within the ENP for the 31 year simulation period



Note: NSM flows are NOT targets and are shown for comparative purposes only.
Negative values indicate flows from west to east.

Run date: 07/21/98 21:58:19
For Planning Purposes Only
SFWMM V3.5

B.3.5.9 Partitioning Lake Okeechobee Scenario

B.3.5.9.1 Description of Simulation

An initial investigation of the effect caused by partitioning Lake Okeechobee into two compartments (split-lake concept) was completed using the 2050 Base Run as a reference. Various system responses simulated with the split-lake concept were compared to 2050 Base . Performance measure graphics presented for this scenario do not show comparisons with any of the other Restudy alternatives.

B.3.5.9.2 Assumptions

Background information regarding the nature of the simulation of the split-lake concept is listed as the following:

- The simulations essentially reflect the Restudy 2050 Base Run with Lake Okeechobee divided into two compartments (littoral on the west and reservoir on the east) by an interior levee. This levee was assumed to be impervious and runs along the 2-foot contour line of the lake bathymetry. It joins the north and southeastern portions of the exterior Lake levee (Hoover Dike) as shown in Figure B.3-97. The littoral and reservoir compartments occupy 60 percent and 40 percent, respectively, of the total Lake Okeechobee surface area.

- A single-line regulation schedule was assumed for the littoral compartment. If the littoral compartment stage exceeds the lower limit of Zone D (proposed WSE operational schedule, Figure B.3-98), then excess water, i.e. the amount beyond what is required from this compartment to meet downstream needs, is routed south to WCA-3A via STA 3/4, subject to conveyance limitations. A 4,000 cfs capacity pump was utilized to lift water from the littoral to the reservoir compartment. Pumping occurred if the regulatory discharge to south was insufficient to bring water levels in the littoral compartment below the regulation schedule.

- No flood control or regulatory release rule was implemented for the reservoir compartment. Its primary function was to meet downstream needs (i.e. environmental, agricultural and LEC water supply) when the littoral compartment stage is below regulation schedule, subject to conveyance limitations. A dead storage concept was applied to the reservoir compartment if the stage decreased below 2 ft, NGVD., When the application was operating, downstream needs could then be met from the littoral compartment, subject to conveyance limitations.

- Supply-side management (SSM) can be implemented for the littoral compartment during times when it is used to meet downstream needs because the reservoir compartment is unable to provide water to meet those needs (stages below 2 ft NGVD). Note that dead-storage can be defined to correspond to zero storage in future split-lake scenarios.

B.3.5.9.3 Significant Findings

Results from two model runs are presented (split-lake with no SSM or SLNSSM and split-lake with SSM or SLWSSM). A standard set of performance measure graphics were generated to evaluate the performance of the two split-lake scenarios relative to the 2050 Base Run or 50BSR. A limited assessment of the feasibility of the split-lake concept can be summarized as follows:

- Significant reductions in the percentage demands-not-met on an annual average basis occurred in the EAA (50BSR, 24; SLNSSM, 1; SLWSSM, 6) and other Lake Okeechobee Service Areas (50BSR, 25; SLNSSM, 7; SLWSSM, 11). The simulation without SSM indicated that conveyance limitations alone contributed to demands-not-met (Figure B.3-99).

- The stages in the reservoir ranged from less than 2 ft NGVD in 1977, 1978, 1981-82, and 1989-91 to more than 25 ft NGVD for over a year starting in 1970 and towards the end of 1995. The carryover storage from the peak event in 1970 lasted over five years (Figure B.3-100).

- Generally, the stages in the littoral zone were much more favorable relative to the 2050 Base Run. Figure B.3-101 illustrates the number of undesirable LOK stage events reduced from a total of 12 in 50BSR to 5 in either split-lake scenarios. Figure B.3-102 illustrates that the percent of time LOK stages exceeded 15.0 ft NGVD decreased from 25 to 16; and the number of times the littoral zone was flooded over 182 consecutive days decrease from 8 to 1. Additionally, the time series of water levels crossed through the desired spring recession window approximately 10 more years (over 31 years of simulation) for either split-lake scenario compared to the 2050 Base Run (Figure B.3-103).

- Minimum stages in the littoral compartment during the simulation period for SLNSSM was about 7 ft, NGVD in 1981-1982 and 1990, and for SLWSSM about 8 ft, NGVD (Figure B.3-100). Both were lower than the 50BSR case. However, the duration of time that the stages in the littoral compartment were below 10 to 12 ft was significantly reduced in both as well. Thus, the long-term range and timing of stages in the littoral zone markedly improved with the split-lake concept. Also, supply-side management policy for the littoral compartment minimizes the number of occurrences of excessively low stage events.

- Short-term dry-outs were less frequent, thus less desirable, in the split-lake runs compared to the 2050 Base Run, as shown in Figure B.3-104. A more logical operation of the littoral compartment should be proposed to circumvent this drawback.

- The cumulative storage over the 31-year simulation for either scenario run was about 2 million ac-ft greater than the total cumulative storage for 2050 Base Run.

- Flood control discharges from the littoral compartment to the Caloosahatchee and St. Lucie estuaries were eliminated, although the discharges south to the WCAs more than doubled (Figure B.3-105). The increase was primarily due to the difference in the regulation schedules utilized in the 2050 Base Run (RUN25 schedule) and the split-lake scenarios (WSE schedule). The WSE schedule commences flood control releases south at levels (range 13.50 to 15.50 ft, NGVD) lower than the RUN25 schedule (range 15.65 to 16.75 ft, NGVD).

- A positive consequence of the increased lake discharges to the south was some improvement in NSM hydroperiod matching for the WCAs and the ENP as a whole, and most of the individual WCAs (Figure B.3-106, B.3-107).

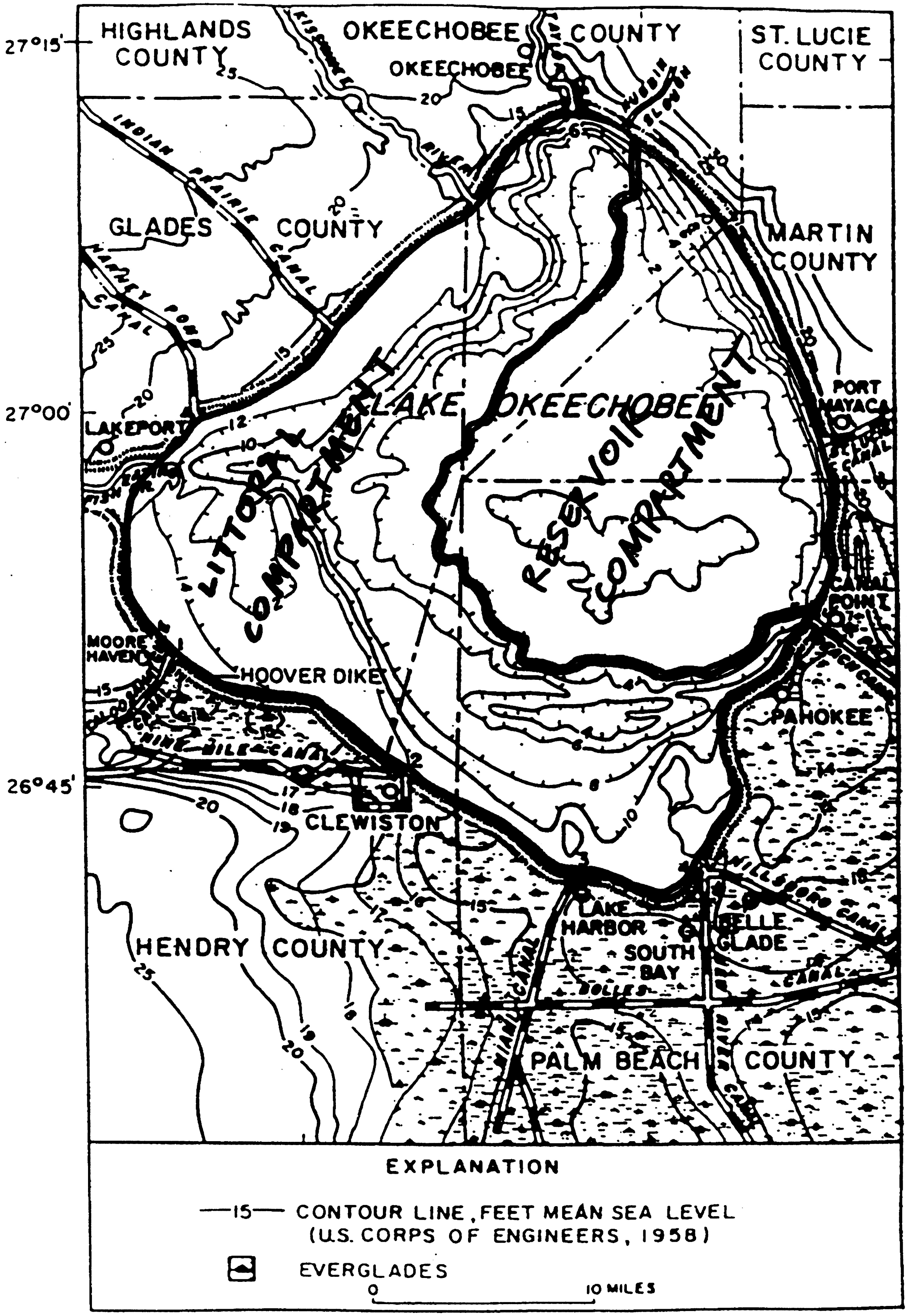
- There was a significant decrease in the number of SSM and dry-season-triggered public water supply cutback months for all LEC Service Areas. Locally-triggered cutbacks for all three runs were essentially equal (Figure B.3-108).

- The average annual LOK water supply deliveries to LEC Service Areas 1 and 2 for the three runs are similar. At the same time surface water delivery to Service Area 3 decreased (Figure B.3-109). This was likely the result of increased LOK releases to the Everglades. This result could be caused by: (1) greater storage in WCA3B and ENP; (2) more seepage across the protective levees into LECSA3, thus effectively recharging the underlying aquifer in the service area; and (3) reduction of water required from LOK and WCAs to maintain LECSA3 canals that provide groundwater recharge to the same aquifer (Figure B.3-110).

- For the Caloosahatchee Estuary, significant reductions in the number of high flow violations were due to the elimination of LOK regulatory releases in the split-lake scenarios . Low-flow violations did not significantly change from 50BSR to either SLWSSM or SLNSSM (Figure B.3-111).

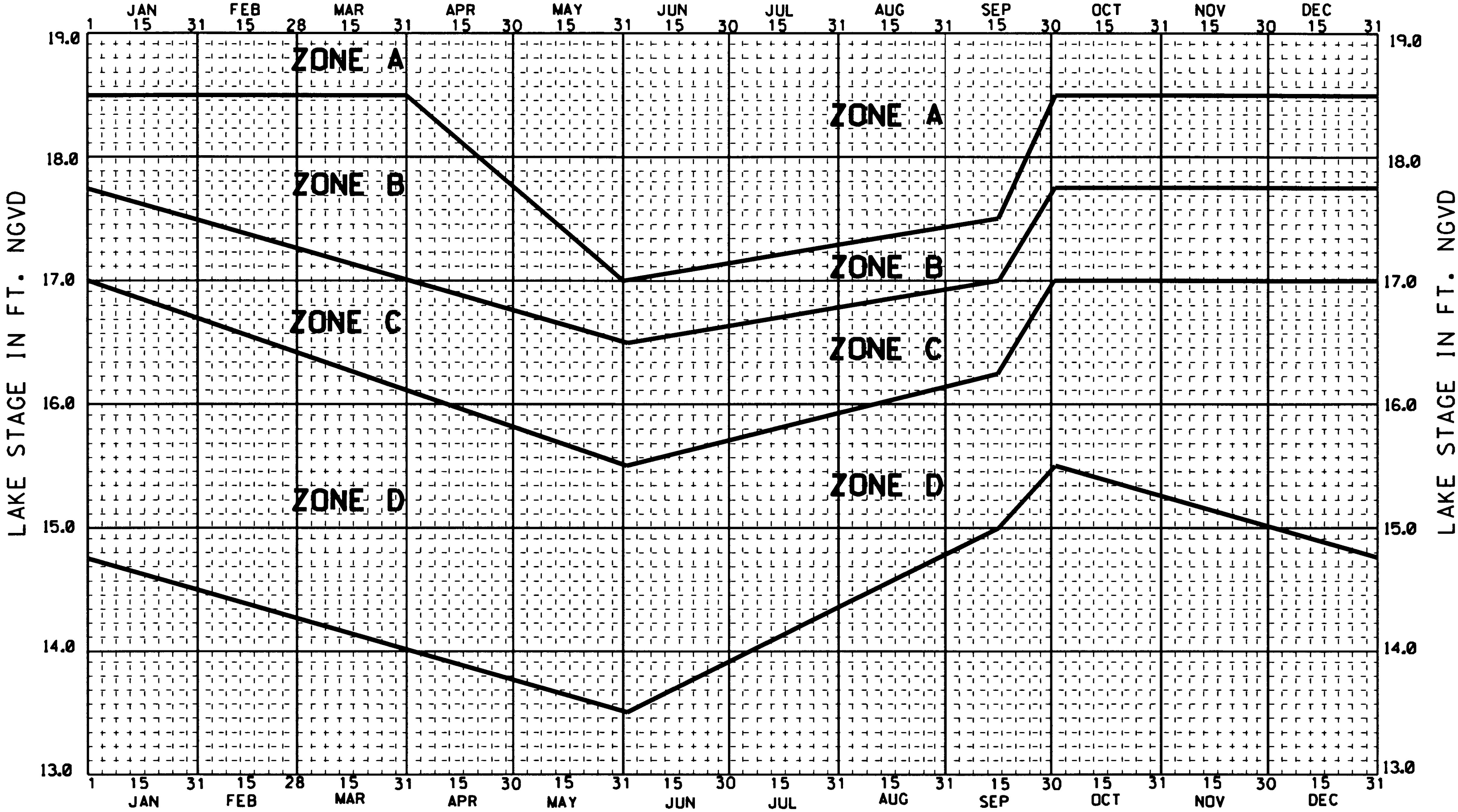
- For the St. Lucie Estuary, the same reductions in high-flow violations were obtained (Figure B.3-112). The number of low-flow violations (monthly average flow <350 cfs) increased from the 2050 Base Run. In all three runs, St. Lucie Basin (C44) runoff was assumed to flow naturally to the west (of S-

308), instead of to the east (of S-80), into the estuary when stages in the Lake (or reservoir for the split-lake scenario) were less than 14.5 ft, NGVD. Most of the increased violations of low-flow criteria were thought to have occurred during the 1970's. This was when the reservoir compartment stage was consistently below 14.5 ft, NGVD. Imposing an explicit minimum estuarine flow requirement that can be met by C-44 Basin runoff can offset this drawback. Note that no minimum estuarine flow requirement is imposed in the 2050 Base Run.



Map of Lake Okeechobee area showing topography and principal drainage.

Figure B.3-97



RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS To WCAs (1)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	NORMAL TO WET: UP TO 6500 CFS DRY: UP TO MAXIMUM PULSE RELEASE	NORMAL TO WET: UP TO 3500 CFS DRY: UP TO MAXIMUM PULSE RELEASE
C (3)	MAXIMUM PRACTICABLE RELEASES	WET: UP TO 4500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE	WET: UP TO 2500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE
D (3)	AS NEEDED TO ENHANCE NATURAL HYDROPERIODS IN THE EVERGLADES	VERY WET: PULSE RELEASE OTHERWISE: NONE	VERY WET: PULSE RELEASE OTHERWISE: NONE

NOTES:
(1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS. RELEASES SHOULD BE PUMPED WHEN NECESSARY FOR THE ENHANCEMENT OF THE EVERGLADES NATURAL HYDROPERIOD
(4) PULSE RELEASES ARE MADE TO MINIMZE ADVERSE IMPACTS TO THE ESTUARIES

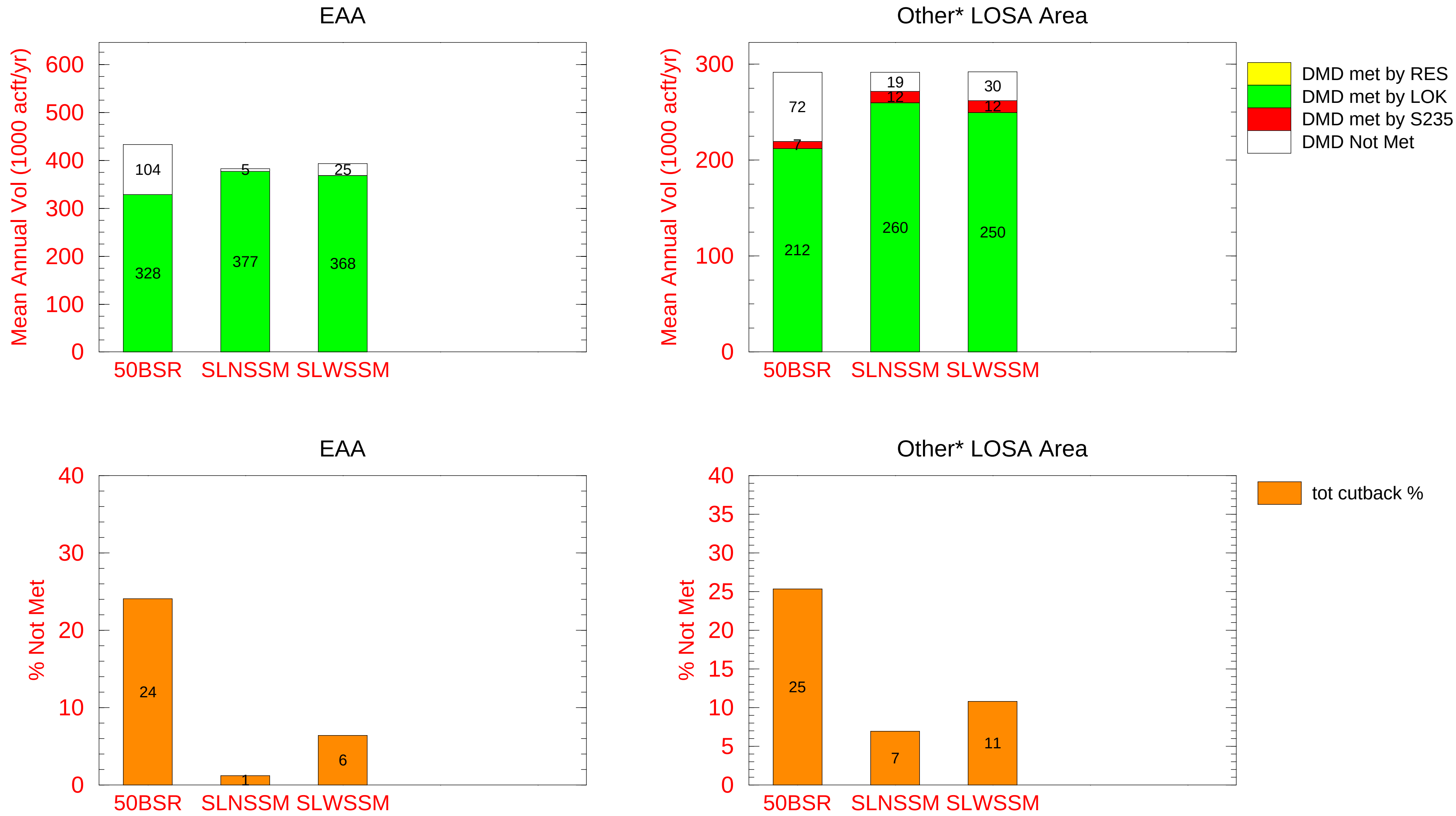
DRAFT PROPOSED REGULATION SCHEDULE
LAKE OKEECHOBEE
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA
DATED: 15 APRIL 1998
WSE

Figure B.3-98 Alternative Operational Schedule

Figure B.3-99 Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met

for the 1965 - 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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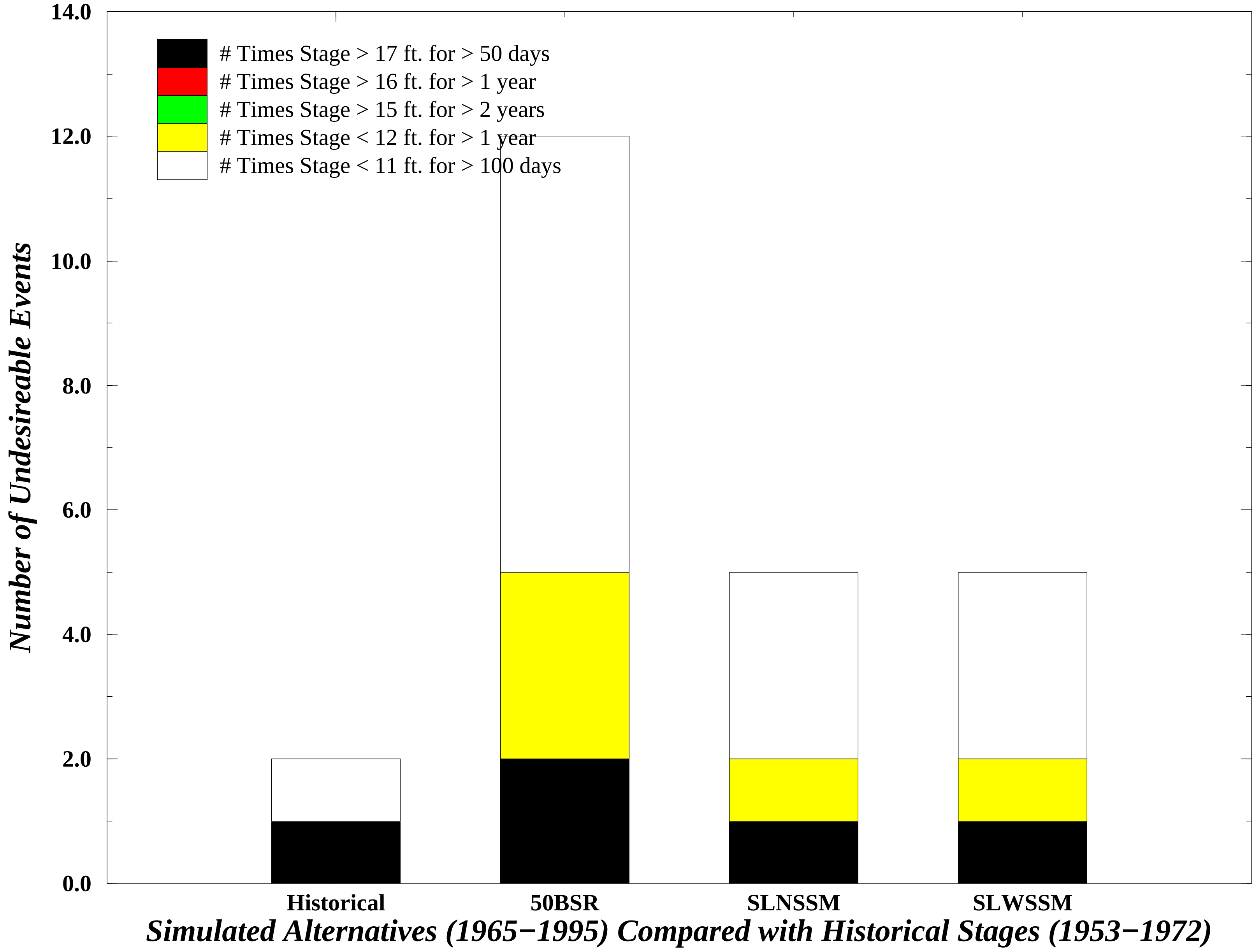
For Planning Purposes Only
SFWMM V3.5

Figure B.3-100 Daily Stage Hydrographs for Lake Okeechobee

Run date: 06/19/98 10:06:20
For Planning Purposes Only
SFWMM V3.5

Figure B.3-101 Number of Undesireable Lake Okeechobee Stage Events



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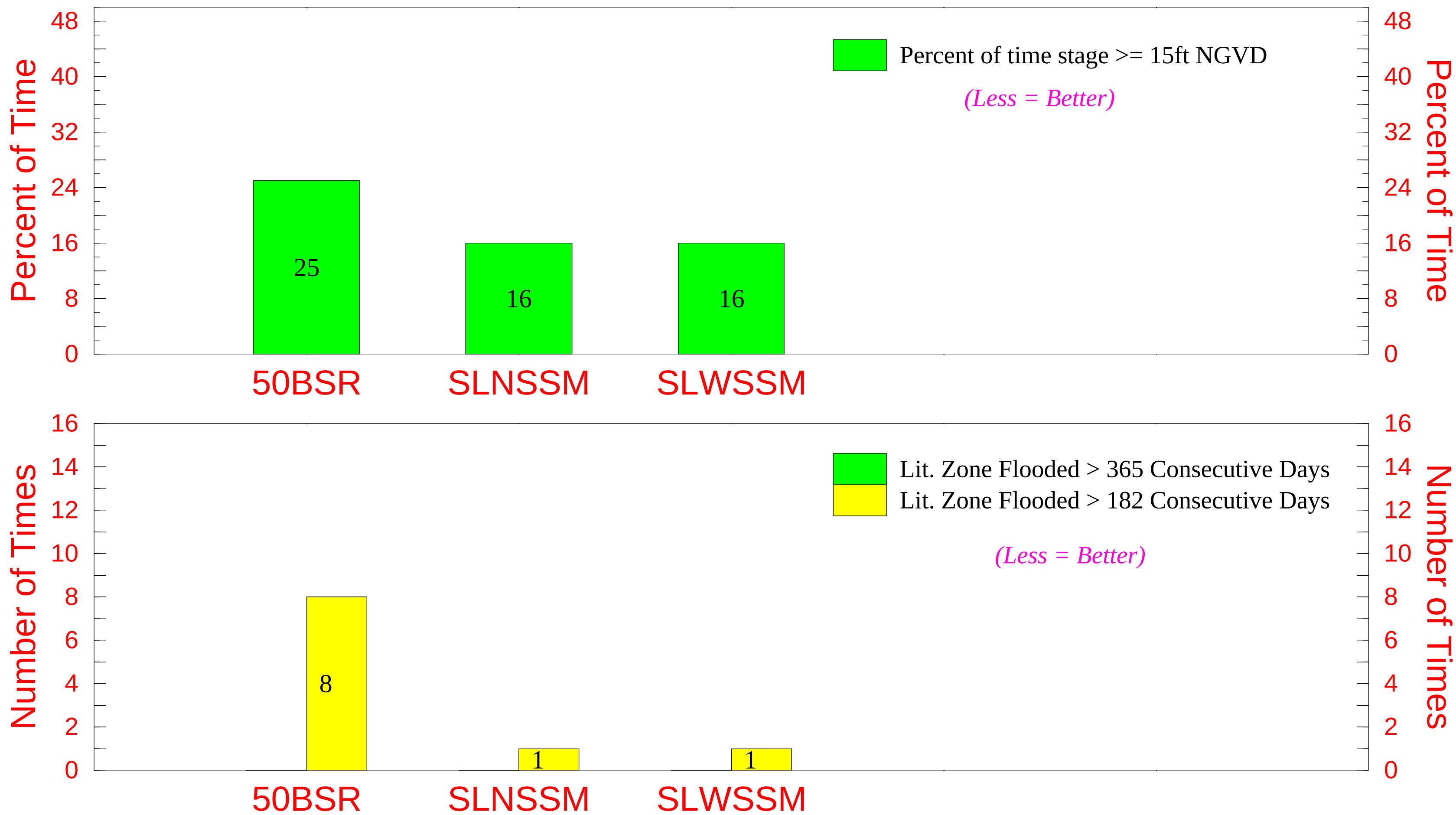
For Planning Purposes Only
SFWMM V3.5

Figure B.3-102 Percent of Time Lake Stages Equaled or Exceeded 15ft NGVD AND Number of Times Littoral Zone Flooded > 365/182 Consecutive Days



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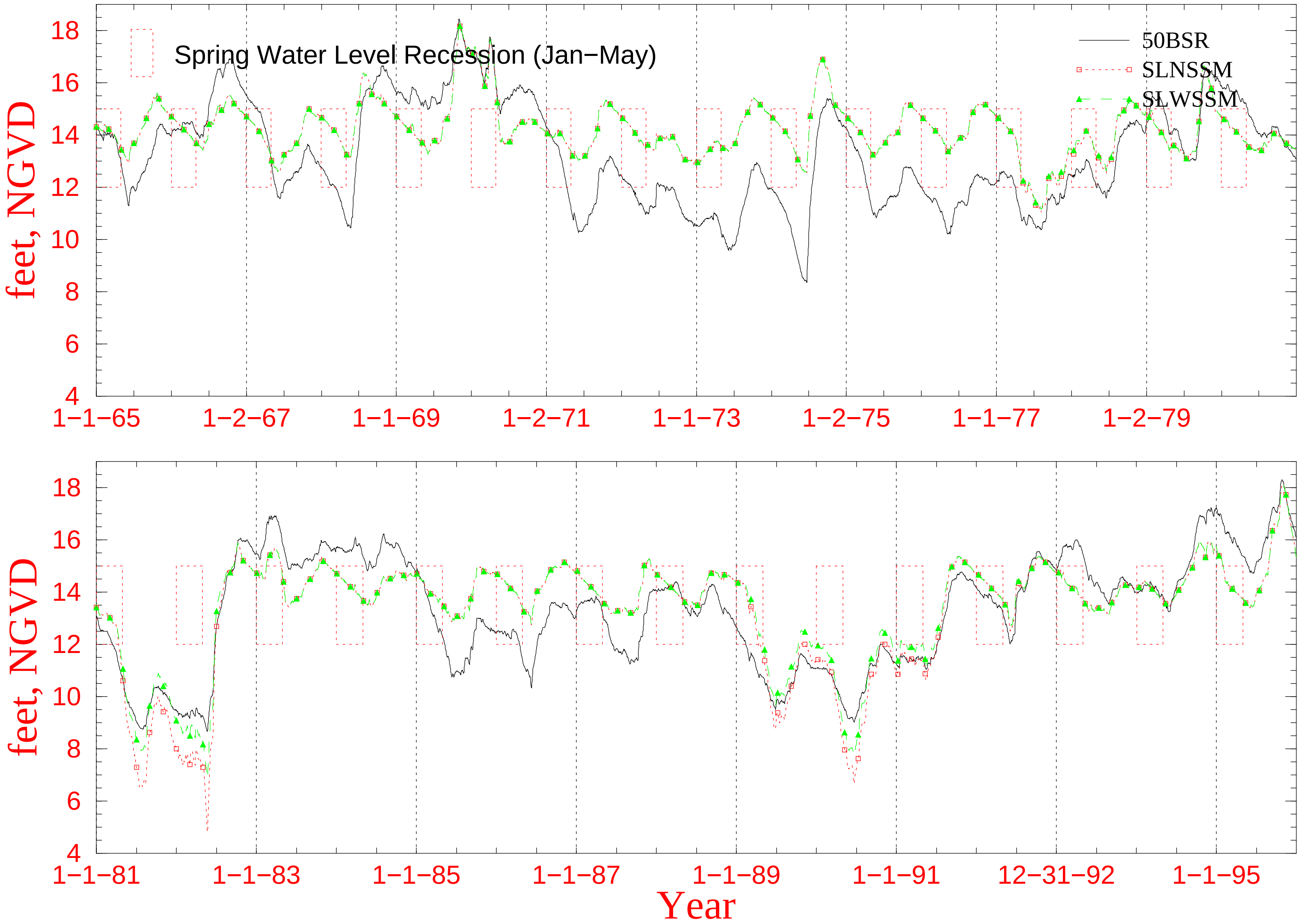
For Planning Purposes Only
SFWMM V3.5

Figure B.3-103 Daily Stage Hydrographs for Lake Okeechobee
Spring Water Level Recession Windows



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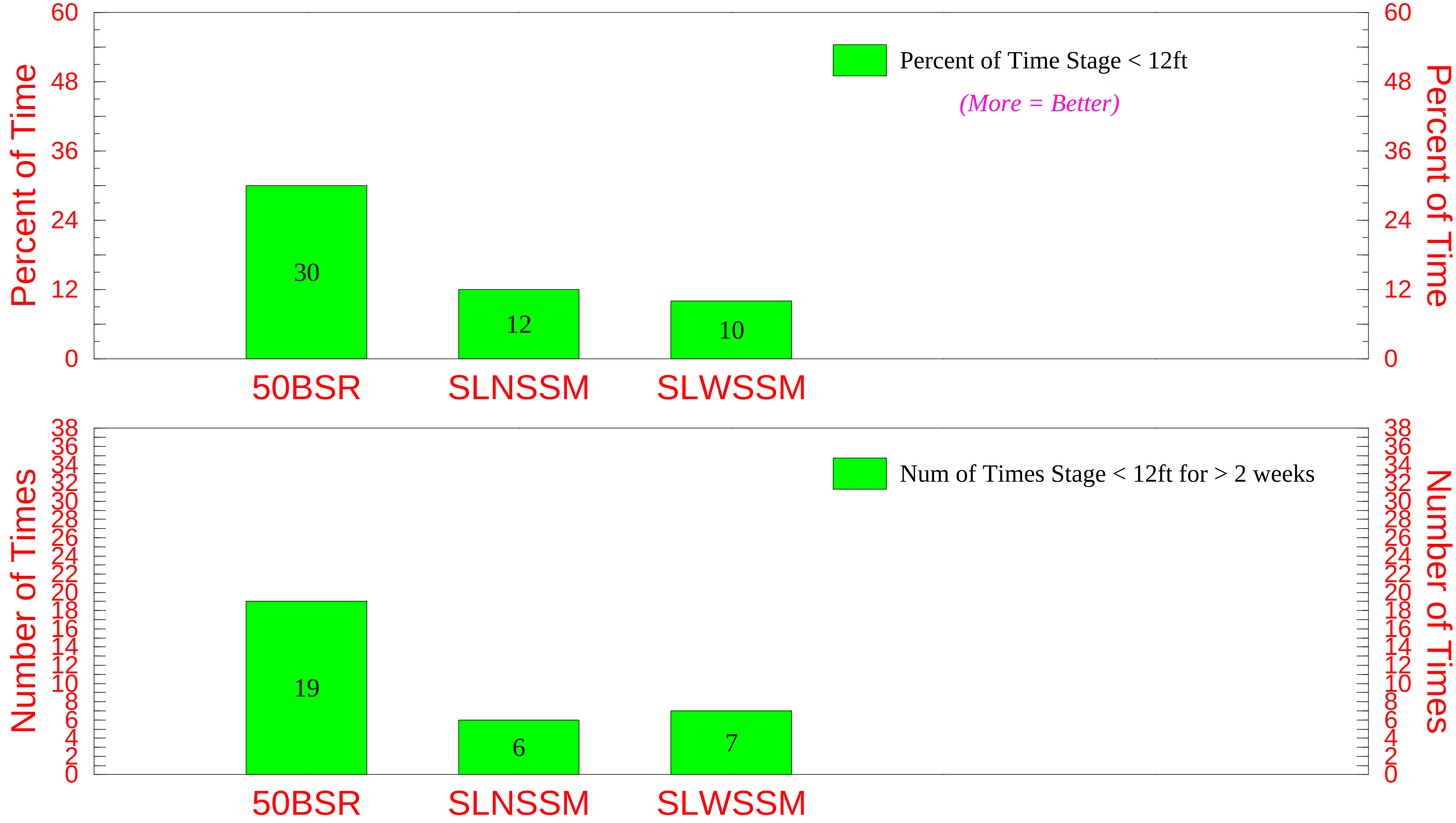
For Planning Purposes Only
SFWMM V3.5

Figure B.3-104 Percent of Time Lake Stages Fell < 12ft NGVD AND Num of Times Lake < 12ft NGVD for > 2 weeks



* Short−term drying of the marsh allows for seed germination of beneficial plants, improves wading bird and snail kite habitat (eg. regrowth of willow) and helps to maintain the natural diversity and abundance of littoral zone biological communities.

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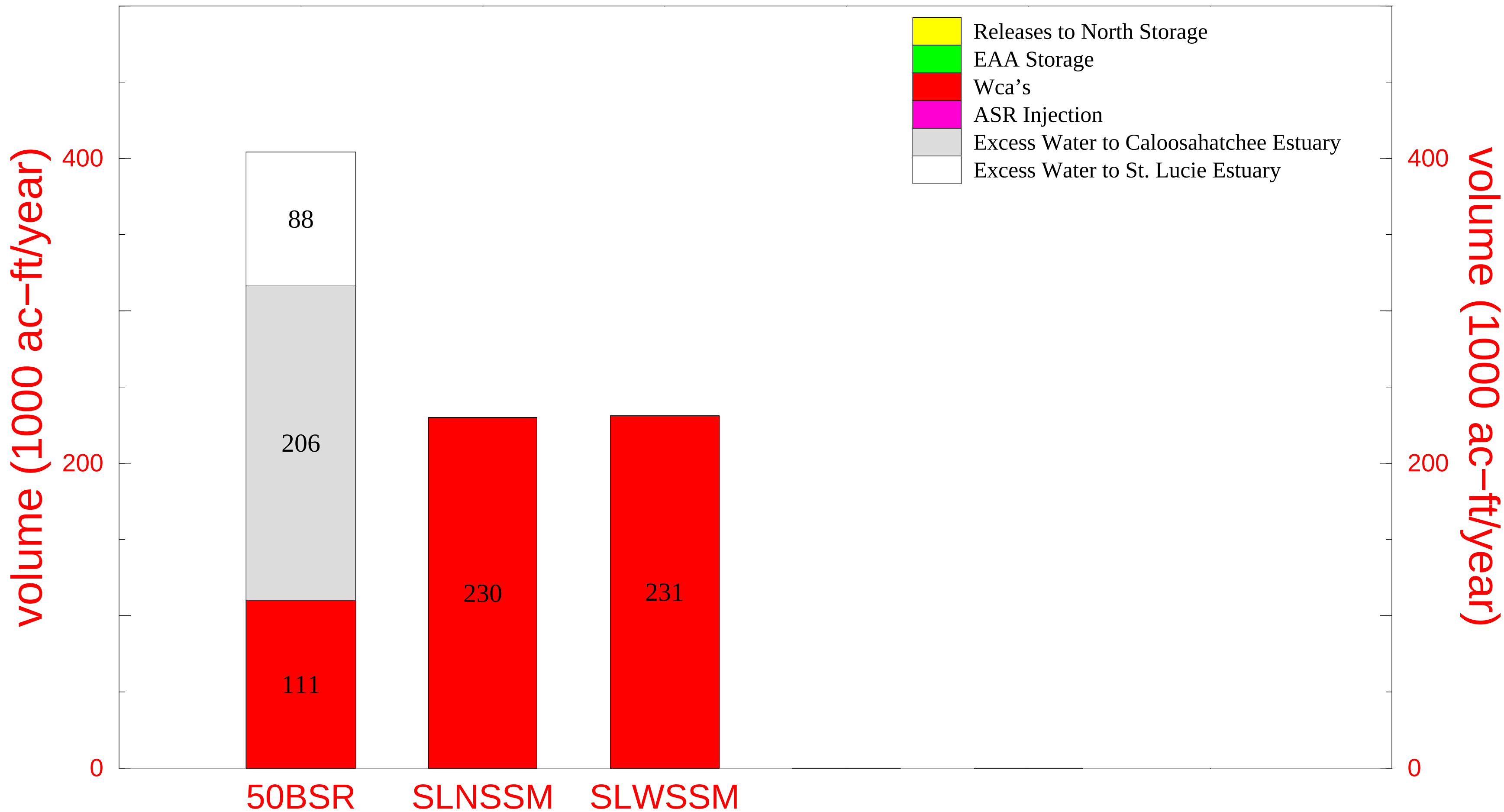
For Planning Purposes Only
SFWMM V3.5

Figure B.3-105 Mean Annual Flood Control Releases from Lake Okeechobee for the 31-yr. (1965 - 1995) Simulation



Note: Although regulatory (flood control) discharges are summarized here in mean annual values, they do not occur every year. Typically they occur in 2−4 consecutive years and may not occur for up to 7 consecutive years.

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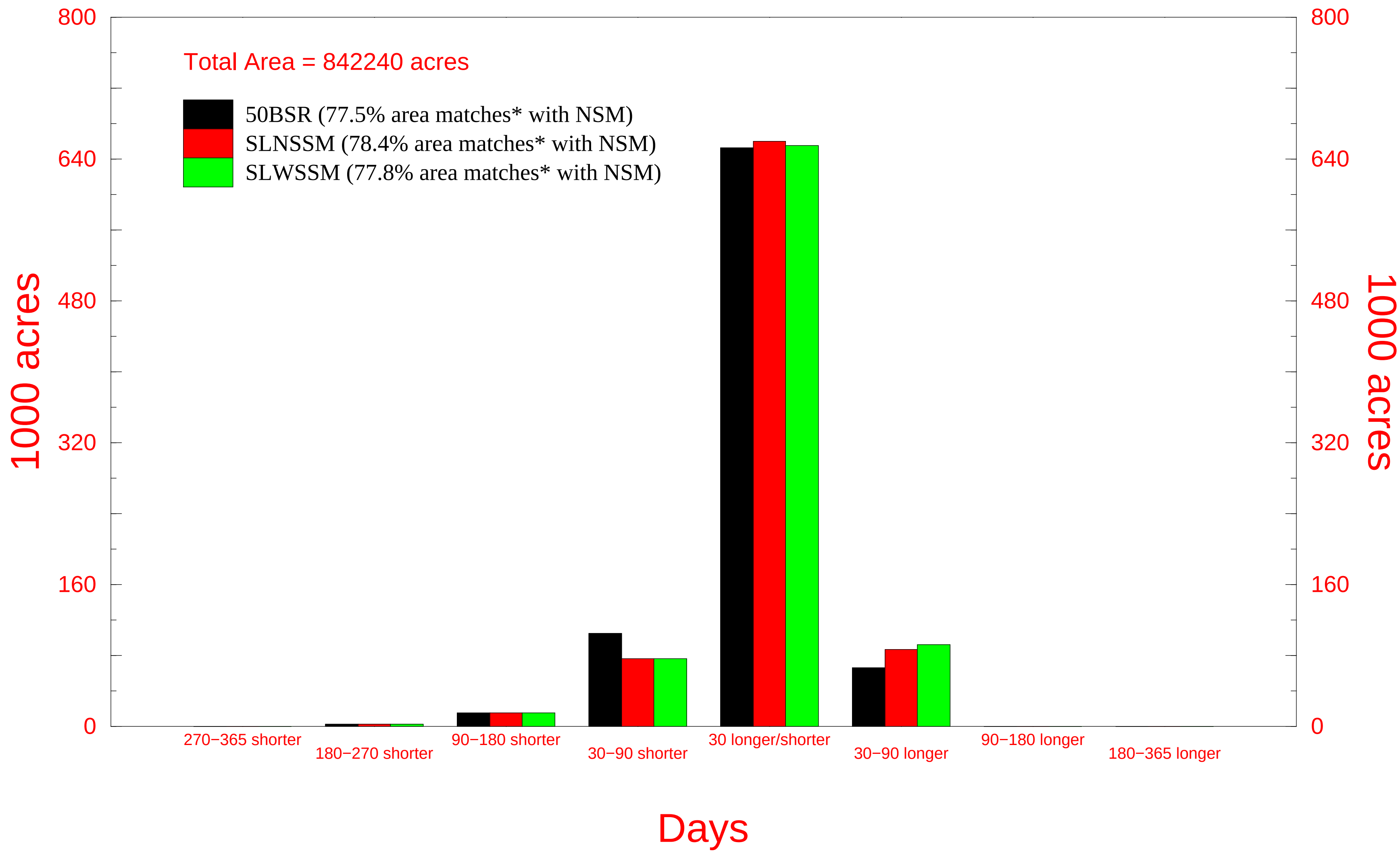
For Planning Purposes Only
SFWMM V3.5

Figure B.3-106 Mean NSM Hydroperiod Matches for the WCA SYSTEM for the 31-yr. Simulation



Note: xaxis represents hydroperiod days shorter or longer as compared to NSM
*Match corresponds to 30 hydroperiod days shorter or longer than NSM.

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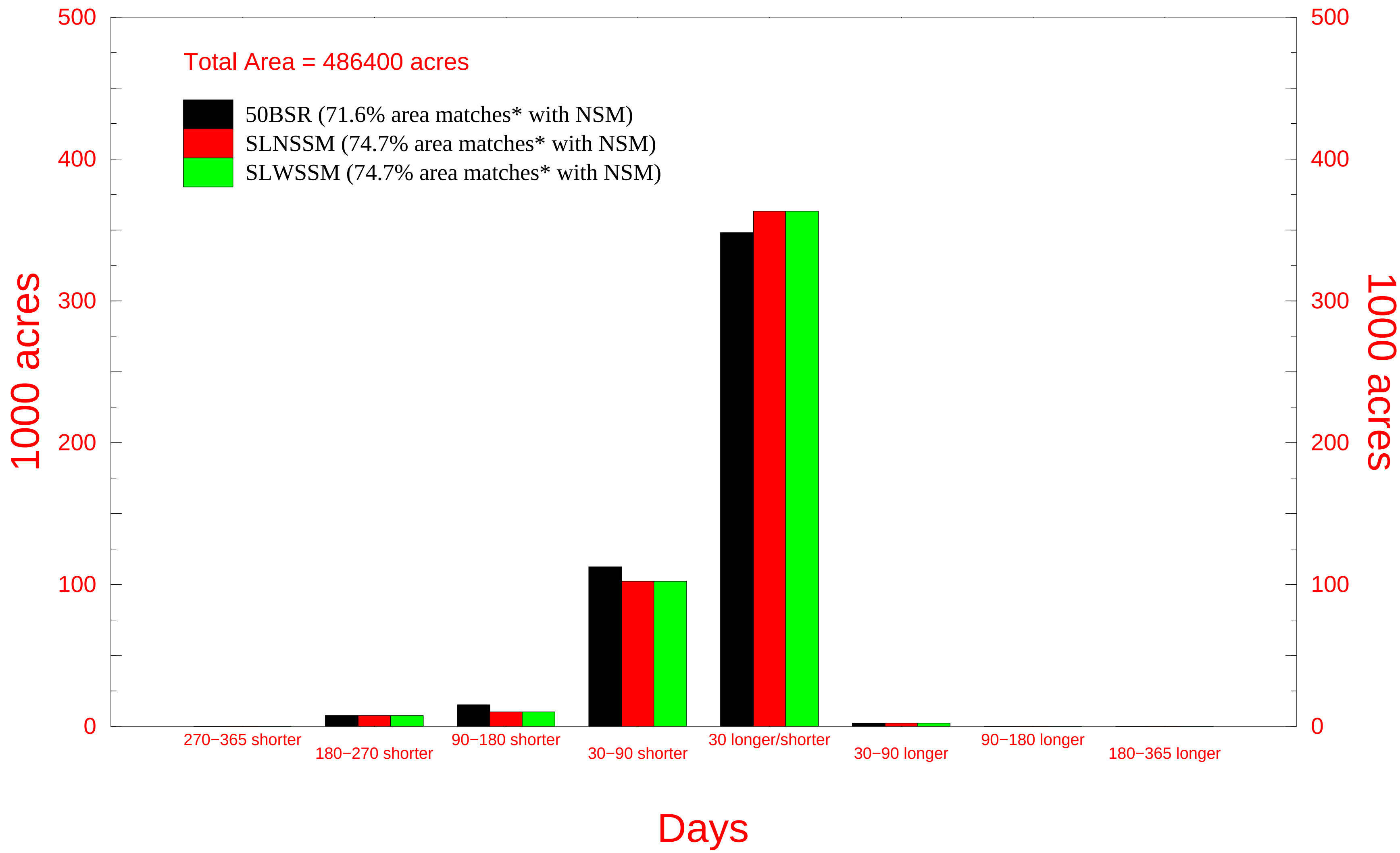
For Planning Purposes Only
SFWMM V3.5

Figure B.3-107 Mean NSM Hydroperiod Matches for the Everglades National Park for the 31-yr. Simulation



Note: xaxis represents hydroperiod days shorter or longer as compared to NSM
*Match corresponds to 30 hydroperiod days shorter or longer than NSM.

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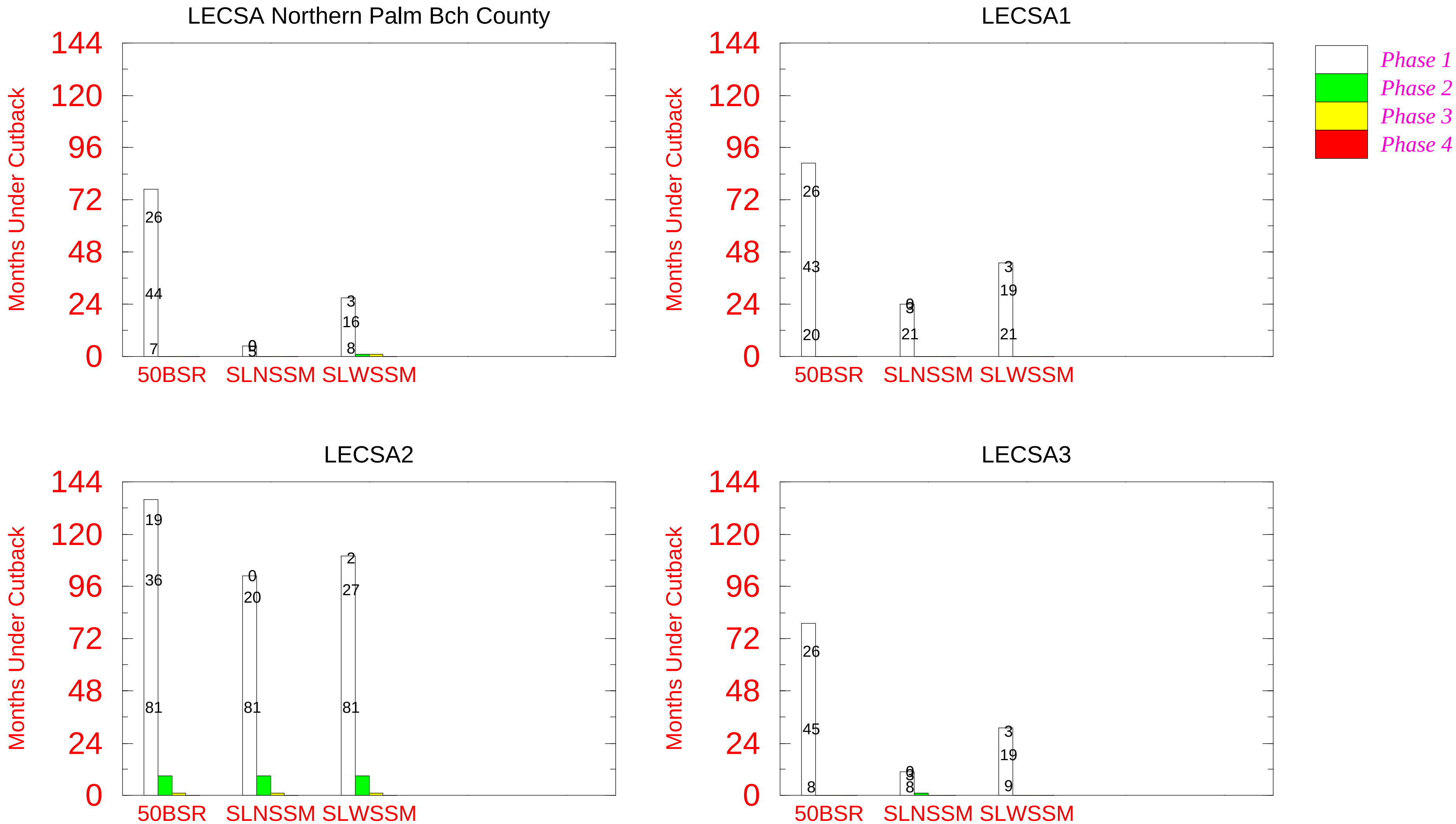
For Planning Purposes Only
SFWMM V3.5

Figure B.3-108 Number of Months of Simulated Water Supply Cutbacks for the 1965 - 1995 Simulation Period



Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).

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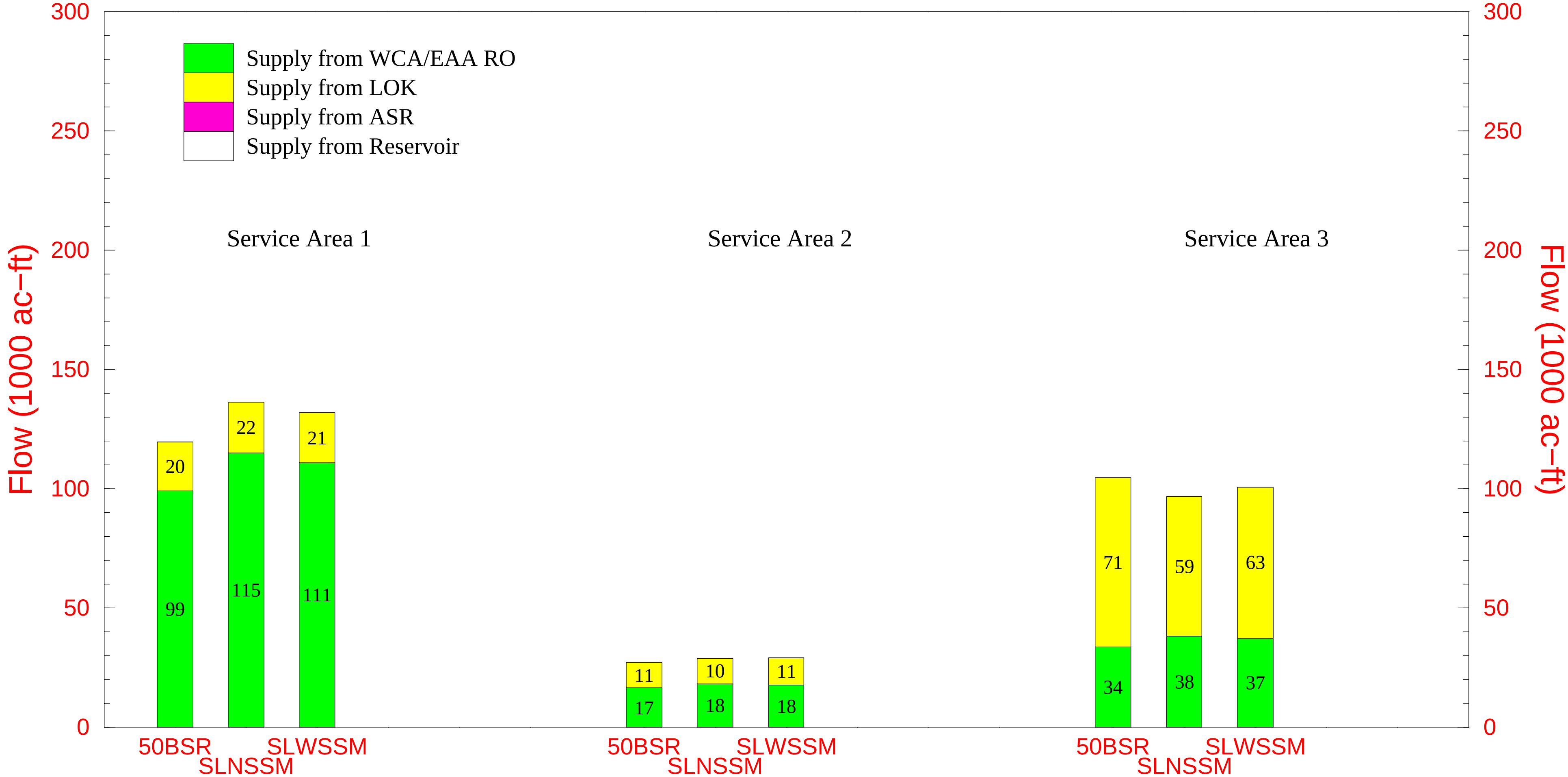
For Planning Purposes Only
SFWMM V3.5

Figure B.3-109 Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 - 1995 simulation



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

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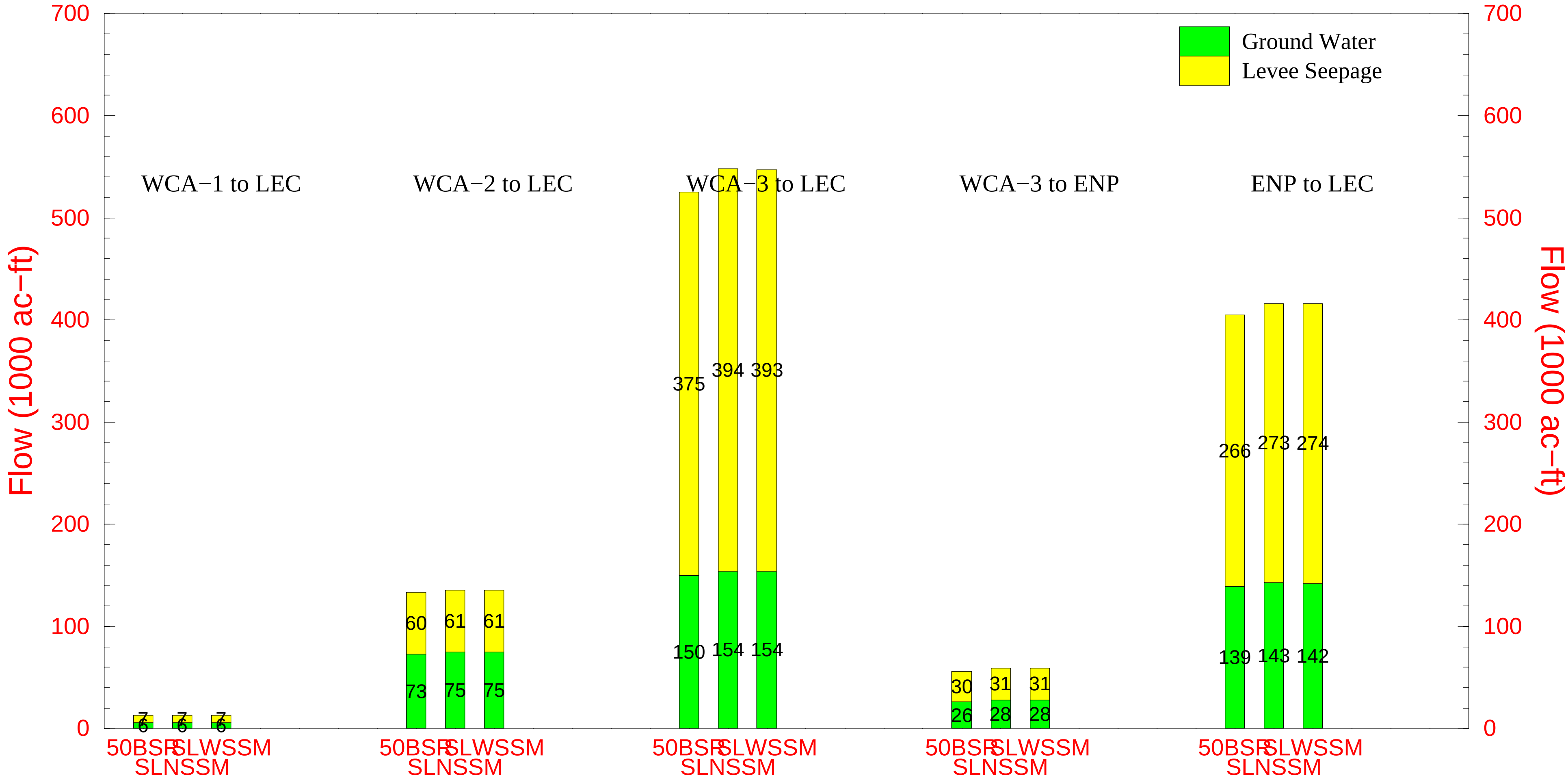
For Planning Purposes Only
SFWMM V3.5

Figure B.3-110 Average Annual Ground Water & Levee Seepage Flows from WCA's & ENP to LEC for 1965 - 1995 Simulation Period



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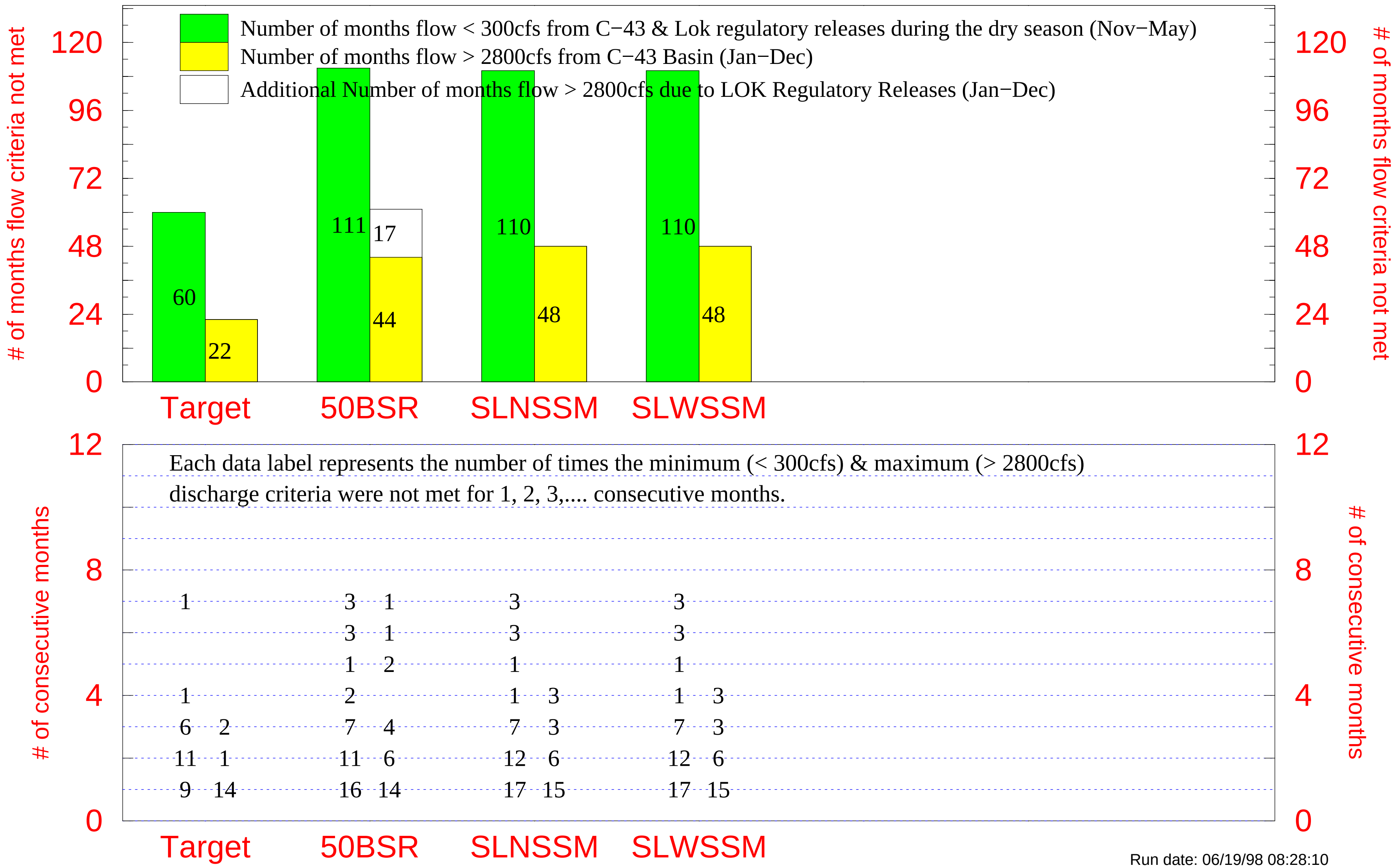
For Planning Purposes Only
SFWMM V3.5

Figure B.3-111 Number of Times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary (mean monthly flows 1965 - 1995)



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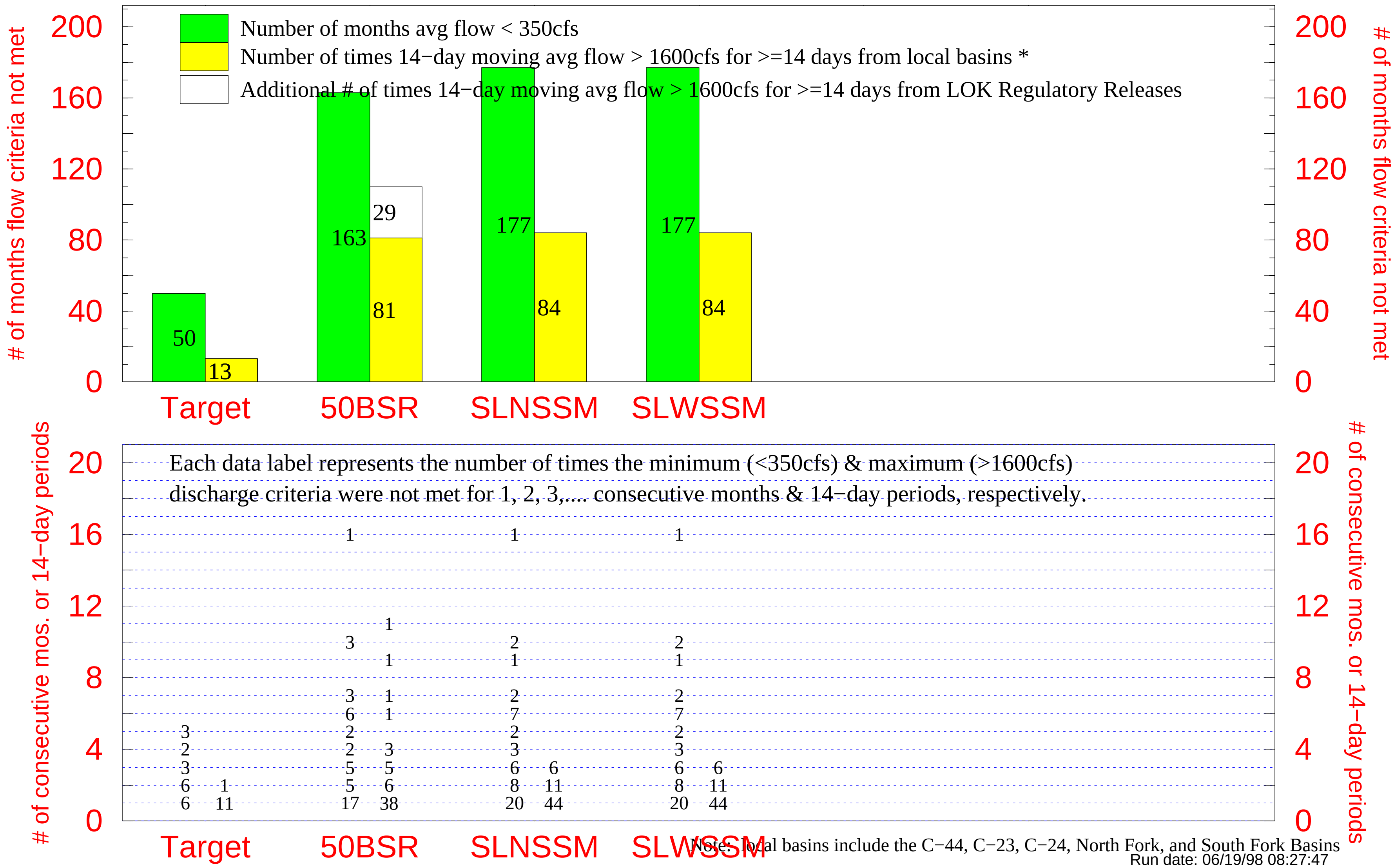
For Planning Purposes Only
SFWMM V3.5

Figure B.3-112 Number of Times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary



Note: local basins include the C−44, C−23, C−24, North Fork, and South Fork Basins

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For Planning Purposes Only

SFWMM V3.5

B.3.5.10 Lower East Coast Public Water Supply Scenarios

B.3.5.10.1 Definition of the Simulations

All the SFWMM simulations included in the Public Water Supply (PWS) sensitivity analysis were built from the Alternative 5 run (ALT5). For each run the LEC PWS demands were modified from the levels specified in Alternative 5 as follows:

ALT5NOPWS: Demands in Alternative 5 were reduced to zero.
ALT595BSPWS: Demands from the 95 BASE case were used.
ALT52XPWS: Demands in Alternative 5 were multiplied by a factor of two.

The first two runs represent a decrease in PWS demands compared to Alternative 5, while the last run is an increase in PWS. The Performance measure graphics compare four runs: ALT5, ALT5NOPWS, ALT595BSPWS and ALT52XPWS.

B.3.5.10.2 Assumptions

The runs were implemented taking into account the following considerations and assumptions:

- Location of PWS wells remained the same for all runs as in ALT5, except for ALT595BSPWS where the PWS wells were located as in the 95BASE.

- LEC irrigation demands remained at the same level for all runs as in ALT5. The PWS demands used in ALT5 included water conservation for the LEC Service Areas listed as follows:
  SA-1: 16 percent SA-2: 18 percent
  SA-3: 18 percent SA-4 (North Palm Beach County): 17 percent

- For all the runs, the same fraction of the urban landscape irrigation demand resulting in a volume of 254.7 kac-ft/yr is supplied from PWS, even though NOPWS turns off public water demands completely. If the volume of the urban landscape irrigation demand supplied from PWS is zeroed, the unsaturated zone will impose an extra load on the groundwater resource to satisfy the landscape irrigation demands. The end result could be to increase groundwater withdrawals when PWS is reduced.

B.3.5.10.3 Summary of Results

The general results are summarized in the following points. In the summary, comparisons are mainly against the ALT 5 run unless otherwise specified.

B.3.5.10.3.1 General

- The results from decreasing PWS were marginal in most of the modeling domain areas. In contrast to the PWS reduction case, an increase in PWS generates more significant effects on several components of the system (e.g. Lake Okeechobee, WCAs, ENP, and LEC Service Areas). The system does not appear to behave linearly under changes to the PWS demands.

- In general, the west portions of the system (e.g. Rotenberger WMA, Holey Land, BCNP, western WCA-3A, and western ENP), were not effected by either change in PWS. The closer a system element was to the Service Areas the more sensitive that element was to changes in PWS.

B.3.5.10.3.2 Lake Okeechobee and Lake Okeechobee Service Area:

- Lake Okeechobee stages marginally increase with a decrease in PWS. An increase in PWS causes a large decrease in stages. Lake Okeechobee is largely effected by an increase in PWS. For example, the percent of the time the stage is at or below 14 ft rises from 14 to 34 percent for ALT5 and 2XPWS, respectively. At some points, the stage drops 1.5 or 2.0 ft. For the same run, regulatory releases from the Lake also decrease by 183 kaf/yr (24 percent) with respect to ALT5. Also, the number of undesirable low stage events increases.

- The percent of demands not met for the Lake Okeechobee Service Areas behaves in a non-linear manner. A decrease in PWS generates a slight decrease in the percent of demands not met, while major increases are observed in the indicator when PWS is doubled. This results from impacts on Lake Okeechobee stages that influence the water use cutbacks in the Lake Service Area.

B.3.5.10.3.3 Remaining Everglades and Big Cypress National Preserve

- Most of the Indicator Regions in the Big Cypress Preserve and the western portion of WCA-3A show no changes in stages when PWS is increased or decreased.

- Most of the Indicator Regions for WCA-1, WCA-2A and eastern WCA-3A show a moderate decrease in stages when PWS is increased, with virtually no variation under PWS reductions. An increase in PWS causes large decreases in stage for south WCA-1, WCA-2B and WCA-3B. Generally, the closer a particular region is to the East Coast Protective Levee, the more effected it is by an increase in PWS demands.

- Indicator Regions for Shark River Slough in the ENP show marginal changes in stages when PWS is decreased. Increased PWS translates into a reduction in stages for Shark River Slough. The stage reductions caused by increased PWS were larger than the stage increases generated by decreased PWS.

- ***Table B.3-14*** shows how flows related to major sections in the ENP behave in different runs. Again, major changes are associated with an increase in PWS. NOPWS generates an increase in magnitude of the flows entering and leaving the ENP. This is caused mainly by an increase in the discharges from the LEC to ENP via the S-332 and S-356 structures.

Table B.3-14 Mean Annual Flows (kac-ft/yr) for Major Sections in the ENP

Run	Overland flow south of Tamiami Trail		Overland flow west Shark River Slough		Overland flow south Florida Bay		Structure flows from LEC	
	Flow	% (*)	Flow	% (*)	Flow	% (*)	Flow	% (*)
ALT5	890		1083		169		598	
NOPWS	933	5	1206	12	182	8	759	27
95BSPWS	906	2	1138	5	175	4	675	13
2XPWS	741	-17	841	-22	149	-12	359	-40

(*) % change with respect to ALT5

- In terms of hydroperiod improvement and matches, no run was identified that would produce a definite improvement for the Remaining Everglades when compared to ALT5. For ponding matches with the NSM, 2XPWS results in an improvement for the WCA system. The ENP is worse in terms of ponding matches when comparing 2XPWS to ALT5. This behavior is the result of less water available in the remaining Everglades, which causes a reduction in ponding depths, or a shift towards smaller depths for the ponding depth distribution. Coincidentally, this results in an improvement for most of the WCAs. Reduction in PWS produces virtually no changes in hydroperiod matches, yielding another example of non-linear behavior of the system.

- An increase in PWS tends to decrease hydroperiods in the WCA system, especially for cells close to the East Coast Protective Levee. Shorter hydroperiods are also experienced in northern WCA-3A and the ENP, especially around NE Shark River Slough and the regions close to the SDCS. A decrease in PWS slightly increases hydroperiods in the northern portion of WCA-1 and around NE Shark River Slough.

- Hydroperiod matches change to shorter durations around Shark River Slough and North WCA-1 when PWS was increased. The changes in the indicators for hydroperiod improvement and matches generated by an increase in PWS tend to be larger than the changes induced by the reductions in PWS.

- An increase in public water demands causes shallower ponding depths in Shark River Slough, WCA-3B and Eastern WCA-3A. A decrease in PWS generates slightly higher ponding depths at the south-western tip of Shark River Slough.

B.3.5.10.3.4 Lower East Coast Service Areas

- The amount of water discharged to tide from the Service Areas increases when PWS is decreased and decreases when PWS is doubled, as shown in ***Table B.3-15*** and ***Figure B.3-113***. Volumes discharged to tide is the only indicator for which decreasing PWS has a larger or similar response when compared to the simulation increasing PWS. The large volumes discharged to tide when PWS is turned off indicates that ALT5 makes large use of local runoff and local storage to recharge the aquifer and supply the public demand. Notwithstanding the good use of local sources noted previously, reductions observed in 2XPWS were still substantial. Note how the effects tend to be more drastic as the analysis moves south from Service Area 4 or North Palm Beach County Service Area to Service Area 3. The slope values in Figure B.3-113 indicate that SA-3 and SA-4 will yield the largest decrease in flows to tide per unit increase in PWS. This is a direct result of the lower subsurface storage capability (lower land elevation and smaller depth to the water table) in Service Areas 3 and 4.

- Duration curves for the indicator regions and individual cells in the LEC illustrate that stages in the Service Areas tend to be <u>equally</u> effected by either reduction or increase in PWS. For LEC individual cells, changes in stage ranged from a small magnitude (up to 0.2 ft) to as high as 2.0 to 3.0 ft (40 percent of cells) in either direction. This was the only indicator that appears to behave linearly with PWS demand changes for most cases. Also, of particular interest for this indicator is the fact that changes for several cells are substantial in both directions. Because of the averaging operation incorporated in the indicator region performance measure, the changes observed in stage duration in the indicator regions are smaller than the ones for the individual cells.

- For some cells in the LEC, ALT595BSPWS will generate stages similar to or lower than those found in ALT5. This is due to the 95 BASE location of the PWS wells. The 95 BASE has more wells located closer to the coast.

- Regional water supply deliveries are directly, but not proportionally related to PWS, as shown in ***Table B.3-16***. When PWS was increased, the amounts required from Lake Okeechobee and the WCA system quadrupled and the dependency on reservoirs increased by a factor of three when compared to ALT5. Note how deliveries from ASR are effected in a different manner when compared to the other sources. The volume of regional water supply deliveries was another indicator, which exemplifies the non-linear behavior of the system. When PWS demands decrease, the dependence on the regional system decreases, but to a much lesser degree than the increase in PWS increases the dependency.

Table B.3-15. Mean Annual Flows (kac-ft/yr) to Tide for each Service Area

SA	SA-1		SA-2		SA-3		SA-4		Totals	
Run	**Flow**	**% (*)**	**Flow**	**% (*)**	**Flow**	**% (*)**	**Flow**	**% (*)**	**Flow**	**% (*)**
ALT5	416		455		895		465		2231	
NOPWS	576	39	645	42	1404	57	511	10	3136	41
95BSPWS	478	15	476	5	1054	12	485	4	2493	12
2XPWS	296	-29	365	-20	639	-29	415	-11	1715	-23

(*) % change with respect to ALT 5

Figure B.3-113

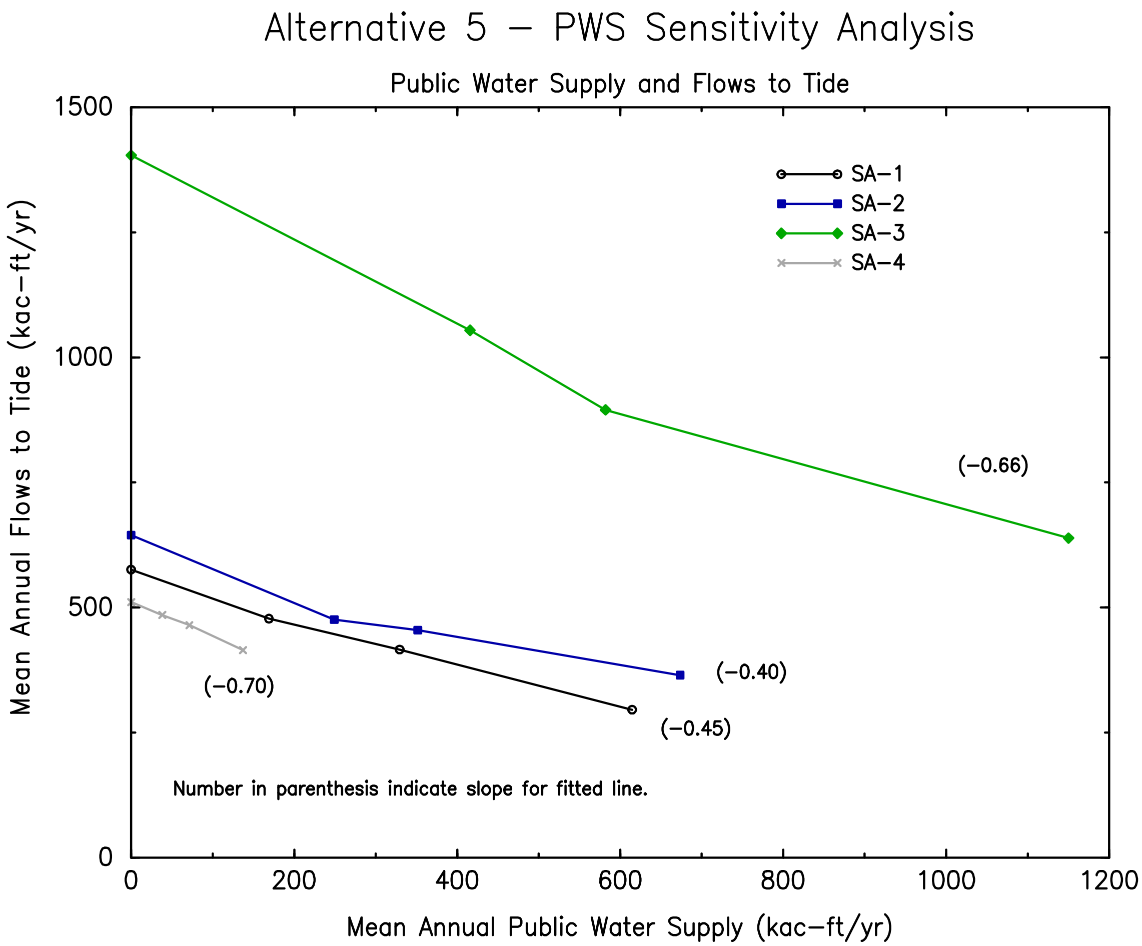


Table B.3-16 Summary of Average Annual Regional Water Supply Deliveries (kac-ft/yr) to SA-1, SA-2 and SA-3.

Run	Source of Deliveries			
	WCA System	Lake Okeechobee	ASR	Reservoirs
ALT5	88	56	103	67
NOPWS	18	41	40	1
95BSPWS	62	45	62	37
2XPWS	338	222	94	179

- An increase in PWS generates substantial increases in the frequency, level and severity of PWS cutbacks for most of the LEC Service Areas (***Table B.3-17***). In some cases, 95BSPWS appeared to increase the frequency of water restrictions. However, this is attributed to well locations in 95BASE that are typically closer to the coast where salt water intrusion trigger wells are more effected. Also, in 2XPWS public water demands are not redistributed in space.

- Even though NOPWS imposes no PWS demands on the system, certain long water restriction periods remain in the simulation. These periods and their duration are identified as follows:
  - LOSA: 16 months, March 1981 to June 1982
  - SA-1: 14 months, November 1977 to May 1978 and November 1981 to May 1982
  - SA-2: 18 months, November 1977 to May 1978, November 1981 to May 1982 and February 1990 to May 1990
  - SA-3:14 months, November 1977 to May 1978 and November 1981 to May 1982
  - SA-4:14 months, November 1977 to May 1978 and November 1981 to May 1982

With NOPWS, other demands, such as LEC irrigation and LOSA demands remain in the system. Also, the model still attempted to maintain the LEC canals at specified minimum elevations so that saltwater intrusion was minimized.

Table B.3-17 summarizes supply and cutback volumes for the LEC Service Areas for the different demand types. It can be easily verified that demands for 2XPWS and ALT5 runs are in a 2:1 ratio. Irrigation demands for the LEC remained constant across the different model runs. As expected, major cutbacks for all type of demands appeared with the 2XPWS run.

Table B.3-17 Supply and Cutback Volumes in (1,000 ac-ft) for different demand types and for each Service Area, for the 1965 to 1995 Simulation Period.

Serv. Area and Type	ALT5		ALT5NOPWS		ALT595BSPWS		ALT52XPWS	
	Supply	Cutback	Supply	Cutback	Supply	Cutback	Supply	Cutback
SA-1								
PWS	10216.54	57.97	0.00	0.00	5241.96	33.12	19058.08	1490.93
ULSC	4553.82	0.00	4553.82	0.00	4553.82	0.00	4542.23	11.58
NURSERY	596.58	0.00	596.58	0.00	596.58	0.00	591.93	4.64
GOLF	1093.69	1.31	1094.11	0.89	1091.49	3.50	1013.14	81.85
AGLVOL	147.11	0.00	147.11	0.00	147.11	0.00	147.11	0.00
AGOVH	505.42	0.00	505.42	0.00	505.42	0.00	503.86	1.56
AGOTHR	86.28	0.00	86.28	0.00	86.28	0.00	85.74	0.53
SA-2								
PWS	10906.07	158.73	0.00	0.00	7723.17	124.66	20880.39	1249.20
ULSC	6049.77	0.00	6049.77	0.00	6049.77	0.00	6046.94	2.82
NURSERY	267.24	0.00	267.24	0.00	267.24	0.00	265.54	1.71
GOLF	767.84	10.37	769.57	8.65	766.30	11.92	723.71	54.50
AGLVOL	0.47	0.00	0.47	0.00	0.47	0.00	0.47	0.00
AGOVH	1.13	0.00	1.13	0.00	1.13	0.00	1.12	0.00
AGOTHR	142.29	0.00	142.29	0.00	142.29	0.00	141.53	0.76

SA-3								
PWS	18042.67	103.94	0.00	0.00	12892.01	66.92	35653.61	639.61
ULSC	7007.75	0.00	7007.75	0.00	7007.75	0.00	7007.75	0.00
NURSERY	952.44	0.00	952.44	0.00	952.44	0.00	952.44	0.00
GOLF	310.92	0.47	310.60	0.79	310.96	0.43	309.18	2.21
AGLVOL	653.18	0.00	653.18	0.00	653.18	0.00	653.18	0.00
AGOVH	1428.06	0.00	1428.06	0.00	1428.06	0.00	1428.06	0.00
AGOTHR	222.24	0.00	222.24	0.00	222.24	0.00	222.24	0.00
SA-4								
PWS	2214.55	13.27	0.00	0.00	1182.87	5.80	4253.87	201.74
ULSC	1248.66	0.00	1248.66	0.00	1248.66	0.00	1244.13	4.54
NURSERY	55.66	0.00	55.66	0.00	55.66	0.00	55.02	0.64
GOLF	569.75	0.56	569.98	0.33	569.57	0.74	539.01	31.30
AGLVOL	57.15	0.00	57.15	0.00	57.15	0.00	57.15	0.00
AGOVH	37.68	0.00	37.68	0.00	37.68	0.00	37.61	0.08
AGOTHR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PWS: Public Water Supply
ULSC: Urban Landscape Irrigation
NURSERY: Nursery Irrigation
GOLF: Golf Course Irrigation
AGLVOL: Agricultural Low Volume Irrigation
AGOVH: Agricultural Overhead Irrigation
AGOTHR: Agricultural Other Irrigation

B.3.5.11 Modification of L-31N and C-111 Canal Stage Operations

B.3.5.11.1 Description of Simulation

Simulation or run was based on the ALT3 with modifications to the operational criteria of structures to the south of G-211 on the L-31N and C-111 Canals to lower their stages. The intent of the simulation was to determine the affect on the ENP and the potential reduction in flood risk to the LEC Service Areas resulting from lower canal operational criteria.

B.3.5.11.2 Assumptions

Operational criteria for structures on the L-31N and C-111 Canals were changed for this run (denoted as L31FC for flood control) according to ***Table B.3-18***. Only structures for which the operational criteria are different from those of ALT3 are shown in ***Table B.3-18***. Note that the structure operational criteria depicted in ***Table B.3-18*** changed when the base simulations were revised and ALT3 became Alt. A.

B.3.5.11.3 Summary of Results

- Hydroperiod matches with NSM within the ENP improved from 84 to 90 percent. As a result of the increased pumping through the S-332 structures, several model cells to the west of the C-111 Canal were ponded to within 30 days of NSM in L31FC (Figure B.3-115, compared to hydroperiods 30 to 90 days shorter than NSM in ALT3 (Figure B.3-114).,).

- Groundwater and levee seepage from the ENP to LECSA increased by 31 percent from 292 to 383 kac-ft (***Table B.3-19***). The increase in seepage was more in the wet season (+57 percent) than in the dry season (+14 percent). Increased seepage was due to a larger difference between stages in the ENP and LECSA as a result of L-31N and C-111 Canal stages being operated lower.

- Increased seepage resulted in slightly wetter (closer to NSM) Indicator Regions (IR, refer to Figure B.3-116) to the east of C-111, namely in the C-111 Perrine Marl Marsh (IR 4, Figure B.3-117), and in the North C-111 (IR 47, Figure B.3-118). Similarly, marsh areas to the west of L-31N in the Rockland Marl Marsh (IR 8, Figure B.3-119) and to the west and southwest of C-111 in the Mid-Perrine Marl Marsh (IR-3, Figure B.3-120) and Taylor Slough (IR-1, Figure B.3-121) were also slightly wetter. The North C-111 area was inundated for 407 weeks in L31FC compared with 340 weeks in ALT3 (NSM45P was inundated for 973 weeks).

- Overland flow across the western portion of Tamiami Trail into the ENP decreased slightly (by two percent, ***Table B.3-19***) while structural flow into the ENP increased by five percent (79 kac-ft, ***Table B.3-19***). Increased flow through the S-355 structures (+ 6 percent) was reflected in the relatively small increase (+ 3 percent) in overland flow through the eastern portion of Tamiami Trail. Increased flow at the S-332 structures was as a result of back pumping of the increased seepage. Surface water flows to Biscayne Bay remained unchanged.

- The mean annual water table elevation was higher to the west of the C-111 Canal and lower to the east of the C-111 Canal with L31FC (Figure B.3-123) than with ALT3 (Figure B.3-122).

- Canal stages in the L-31N Canal at S-174 were approximately 0.5 ft lower in L31FC than in ALT3 (Figure B.3-124) for 70 percent of the time.

- Peak stages were higher with L31FC to the west of the C-111 Canal (Figure B.3-125) and in the marsh areas to the east of the C-111 Canal than in ALT3 (Figure B.3-126). In the agricultural areas to the east of L-31N and C-111, peak stages were lower in L31FC than in ALT3.

- Flow down the L-31N Canal through S-331 was almost doubled (+56 kac-ft, ***Table B.3-19***) when the S-331 was no longer closed in the wet season in L31FC. Flows down C-111 through S176 were increased by 40 percent for the same reason. Much of this water apparently recharged the C-111 marsh areas on either side of the C-111 Canal, as there was only a small increase (+3 kac-ft, ***Table B.3-19***) in flow to the C-111 E spreader canal.

- The potential for reducing the risk of flooding to the east of the L-31N and C-111 Canal, with lower canal operational stages is shown in Figures. B.3-127 through B.3-131 that illustrate the stage exceedance frequency curves for selected model cells. Stages were lower at each cell in L31FC than in ALT3. At cell R10 C25 water table elevations were within 1 ft of the surface 2 percent of the time in L31FC compared to 15 percent of the time in ALT3 (Figure. B.3-127). In both cases the water table was within 2 ft of the surface approximately 50 percent of the time. At R13 C25 the water table was within 2 ft of the surface approximately 50 percent of the time in L31FC compared with 65 percent of the time in ALT3 (Figure B.3-128). At R15 C26 the water table was within 2 ft of the surface 15 percent of the time in L31FC compared with 23 percent of the time in ALT3 (Figure B.3-129). At R17 C27 high water table elevations were 2 to 4 ft below the surface with the water table in L31FC, up to 1 ft lower than ALT3 (Figure B.3-130). At R19 C27 differences between L31FC and ALT3 water table elevations were small, with L31FC up to 0.1 ft lower than ALT3 (Figure B.3-131).

B.3.5.11.4 Conclusions and Recommendations

Lower L-31N and C-111 Canal operational criteria have the potential to improve hydroperiods in Everglades National Park due to increased overland flow to the ENP. However, for the most part, increased flow is due to the return of increased seepage. The increase in seepage from the ENP to the LEC improves hydroperiods in the C-111 marsh areas. Lower canal stages decrease the flood potential to the agricultural areas to the east of the canals. It was recommended that lower operational criteria be used for the L-31N and C-111 Canals in ALT4 and subsequent Restudy alternatives.

Table B.3-18. Modifications to C-111 operational criteria. Stages in feet.

C-111 Operational Criteria				As modeled for the C&SF Restudy using SFWMMv3.4			
Canal	Reach	Structure	Operation	95 Base	50Base, Alt1, Alt2	Alt 3	L31FC
L-31N	S-355 to G-211	G-211	open	6.0	6.0 (6.2)[1]	6.5 (cl.)	6.0 (6.0)
			close	5.5	5.7	6.0	5.5
		S-338	on	5.8	6.0	6.5 (7.5)	5.8
			off	5.5	5.8	6.2 (7.0)	5.5
L-31N	G-211 to S-331	S-331 and S-173	on	4.8	4.8	4.8 (cl.)	4.8
			off	4.3	4.3	4.3 (cl.)	4.3
L-31N	S-331 to S-176	S-194	open	5.3	6.0	6.0	5.3
			close	4.8	5.5	5.5	4.8
		S-196	open	5.5	6.0	6.0	5.5
			close	4.8	5.5	5.5	4.8
		S-176	open	5.0	6.6	6.6	5.0
			close	4.75	6.0	6.0	4.75
		S-332A	on	non-existent	5.5	5.5	4.85
			off		5.1	5.1	4.65
		S-332C	on	non-existent	5.5	5.5	4.85
			off		5.1	5.1	4.65
		S-332D	on	non-existent	5.5	5.5	4.85
			off		5.1	5.1	4.65
C-111	S-176 to S-177	S-177	open	4.2	5.1	5.1	4.2
			close	3.6	4.5	4.5	3.6
	S-177 to S-18C	S-18C	open	2.6	3.5	3.5	2.6
			close	2.3	2	2	2.3

Note: 1. Values in ( ) indicate wet season values where they differ from dry season values. (cl.) means structure closed during wet season. Structures with values in ( ) can be used for flood control and water supply in the dry season but only for water supply in the wet season.

Table B.3-19. Flows at selected locations. Units are in thousand acre-feet (kac-ft).

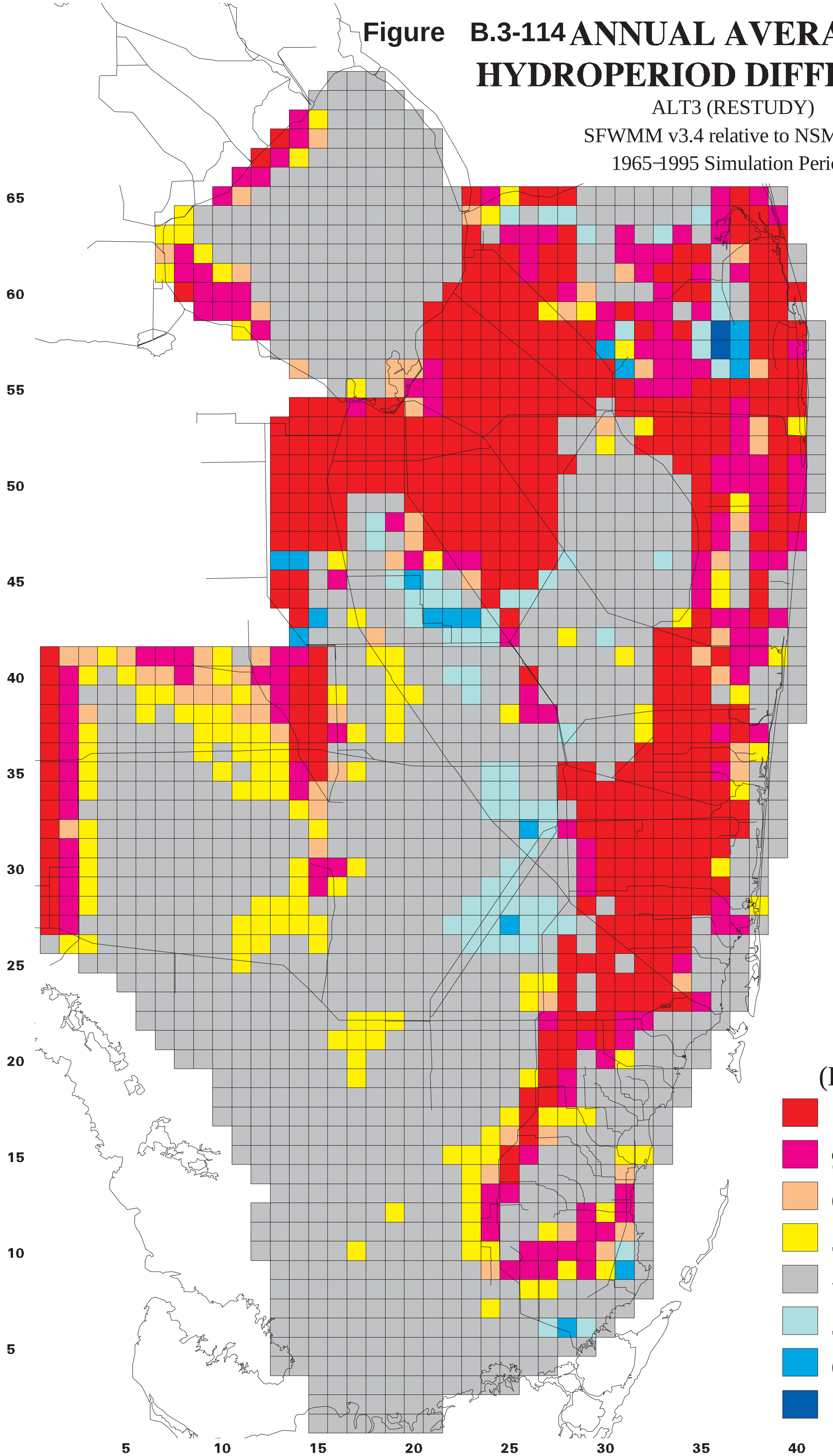
Location	ALT3	L31FC	ALT3-L31FC
Structural Flows into ENP			
S12's	451	439	-12
S-333	468	470	+2
S-355	364	386	+22
S-356A+B	52	14	-38
S-332A	41	70	+29
S-332C	55	89	+34
S-332D	69	111	+42
Total structural flow into ENP	**1500**	**1579**	**+79**
Overland flow into ENP			
Tamiami Trail West	435	425	-10
Tamiami Trail East (includes S-355 flow)	826	847	+21
Flow down L31N and C-111			
S-331	59	115	+56
S176	46	64	+18
S-332E	3	5	+2
Groundwater seepage from ENP to LEC			
Dry season	177	202	+25
Wet season	115	181	+66
Total seepage from ENP to LEC	**292**	**383**	**+91**

Figure B.3-114 **ANNUAL AVERAGE HYDROPERIOD DIFFERENCES**

ALT3 (RESTUDY)

SFWMM v3.4 relative to NSM v4.5

1965–1995 Simulation Period



Hydroperiod

Difference Class

(Days relative to NSM)

- 180–365 days shorter
- 90–180 days shorter
- 60–90 days shorter
- 30–60 days shorter
- +/−30 days
- 30–60 days longer
- 60–120 days longer
- 120–365 days longer

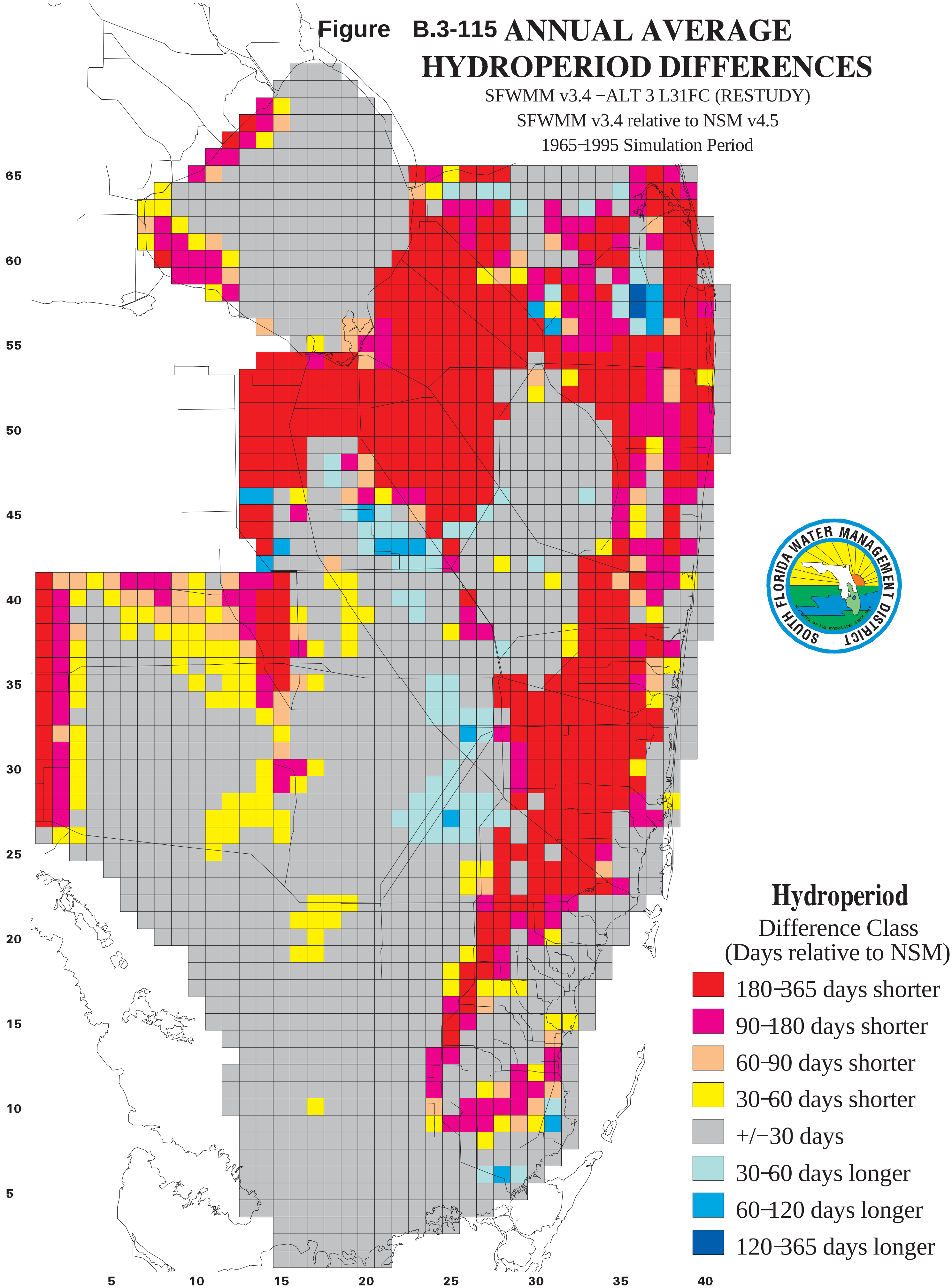
23 Jan 98 08:43:44 Friday

Figure B.3-115 ANNUAL AVERAGE HYDROPERIOD DIFFERENCES

SFWMM v3.4 −ALT 3 L31FC (RESTUDY)

SFWMM v3.4 relative to NSM v4.5

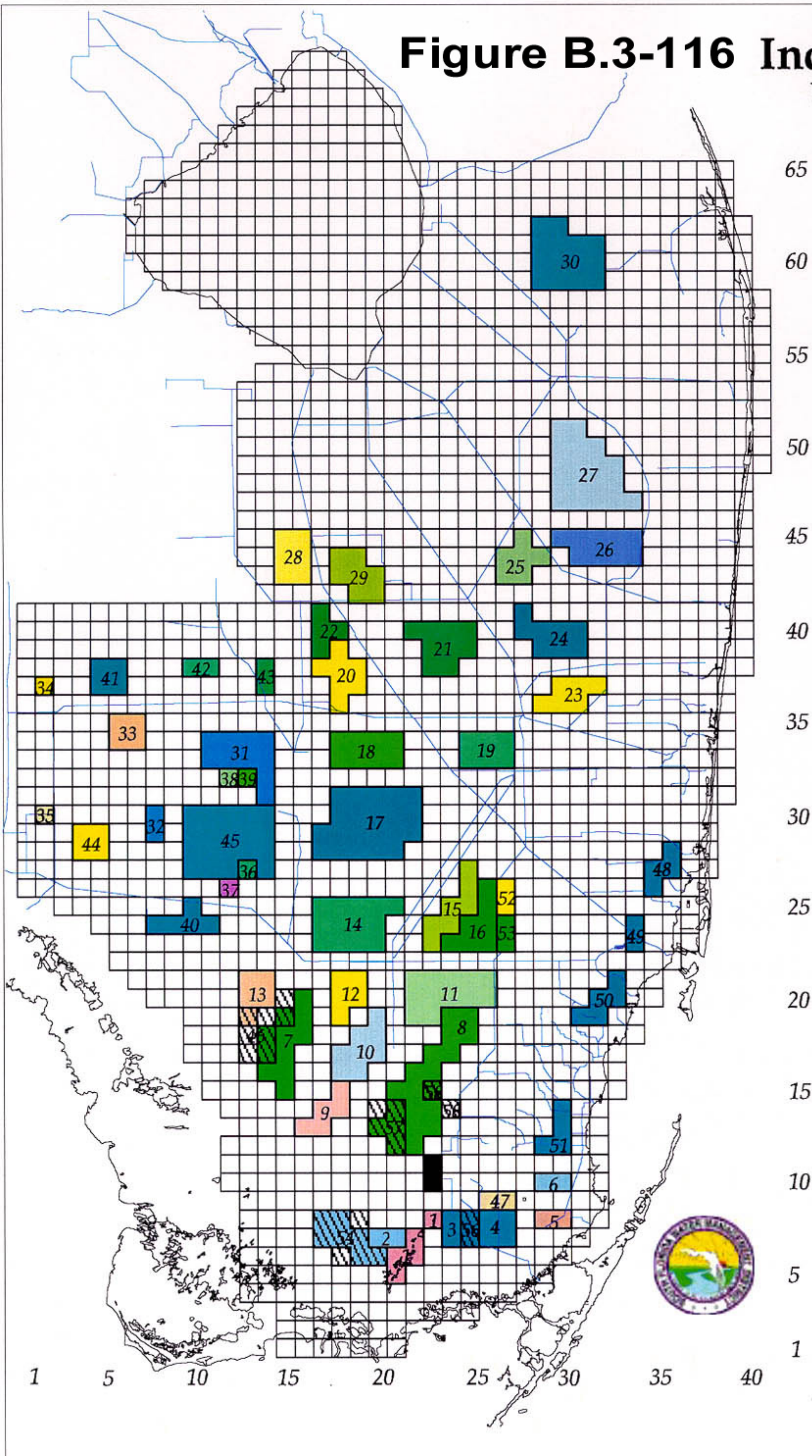
1965−1995 Simulation Period



11 Feb 98 16:03:57 Wednesday

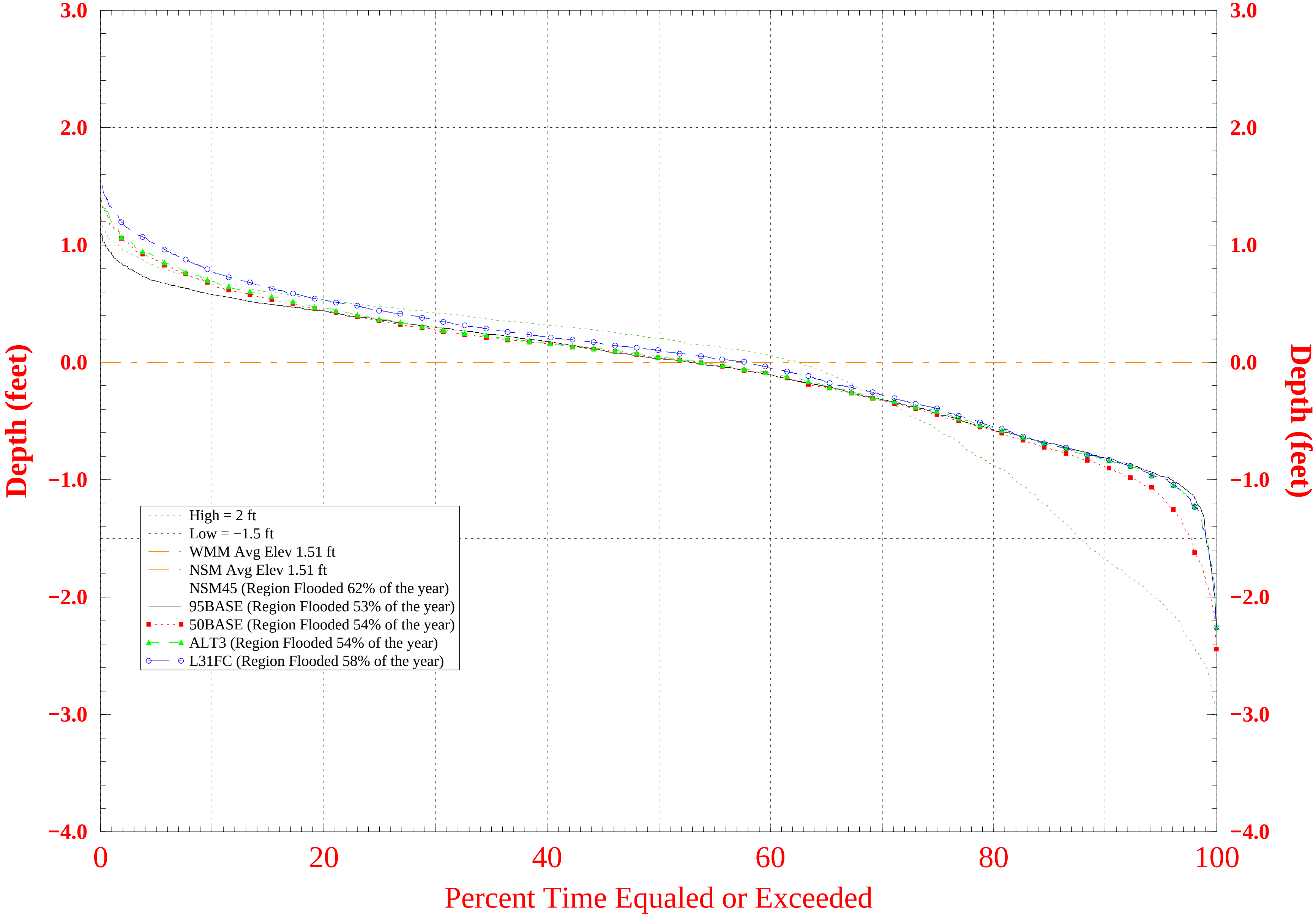
Figure B.3-116 Indicator Regions

Updated April 13, 1998



1=Taylor Slough
2=West Perrine Marl Marsh
3=Mid-Perrine Marl Marsh
4=C-111 Perrine Marl Marsh
5=Model Lands South
6=Model Lands North
7=Ochopee Marl Marsh
8=Rockland Marl Marsh
9=SW Shark River Slough
10=Mid-Shark River Slough
11=NE Shark River Slough
12=New Shark River Slough
13=West Slough
14=South WCA-3A
15=West WCA-3B
16=East WCA-3B
17=South Central WCA-3A
18=North Central WCA-3A
19=East WCA-3A
20=NW WCA-3A
21=NE WCA-3A
22=NW Corner WCA-3A
23=WCA-2B
24=South WCA-2A
25=North WCA-2A
26=South WCA-1 (LNWR)
27=North WCA-1 (LNWR)
28=Rotenberger WMA
29=Holey Land WMA
30=Corbett WMA
31=Mullet Slough
32=Upland Pine
33=Upper Mullet Slough
34=Cypress Marsh
35=Wet Prairie
36=Wetter Prairie NE
37=Wetter Prairie SW
38=Drier Cypress NW
39=Drier Cypress NE
40=Cypress
41=NW Big Cypress
42=NE Big Cypress
43=NE Corner Big Cypress
44=SW Big Cypress
45=Racoon Point
47=North C-111
48=N. Biscayne Bay Groundwater 1
49=N. Biscayne Bay Groundwater 2
50=Central Biscayne Bay Groundwater
51=S. Biscayne Bay Groundwater
52=Pennsuco Wetlands North
53=Pennsuco Wetlands South
46=Cape Sable Sparrow A
54=Cape Sable Sparrow B
55=Cape Sable Sparrow C
56=Cape Sable Sparrow D
57=Cape Sable Sparrow E
58=Cape Sable Sparrow F

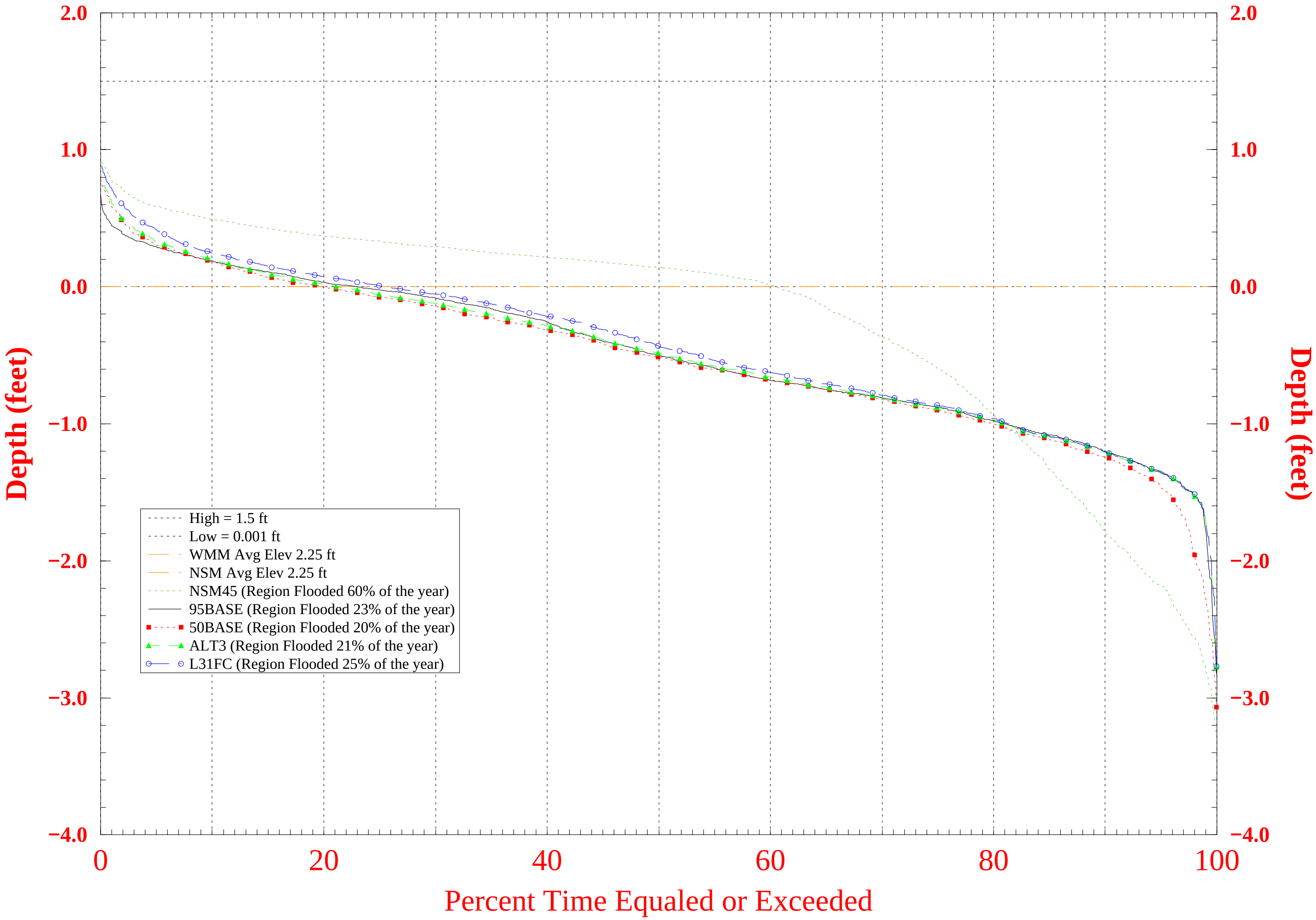
Figure B.3-117 Normalized Weekly Stage Duration Curves for C-111 Perrine Marl Marsh Indicator Region 4 (R7C26-27 R8C26-27)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Wed Feb 11 19:28:40 EST 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-118 Normalized Weekly Stage Duration Curves for North C-111
Indicator Region 47 (R9C26-27)

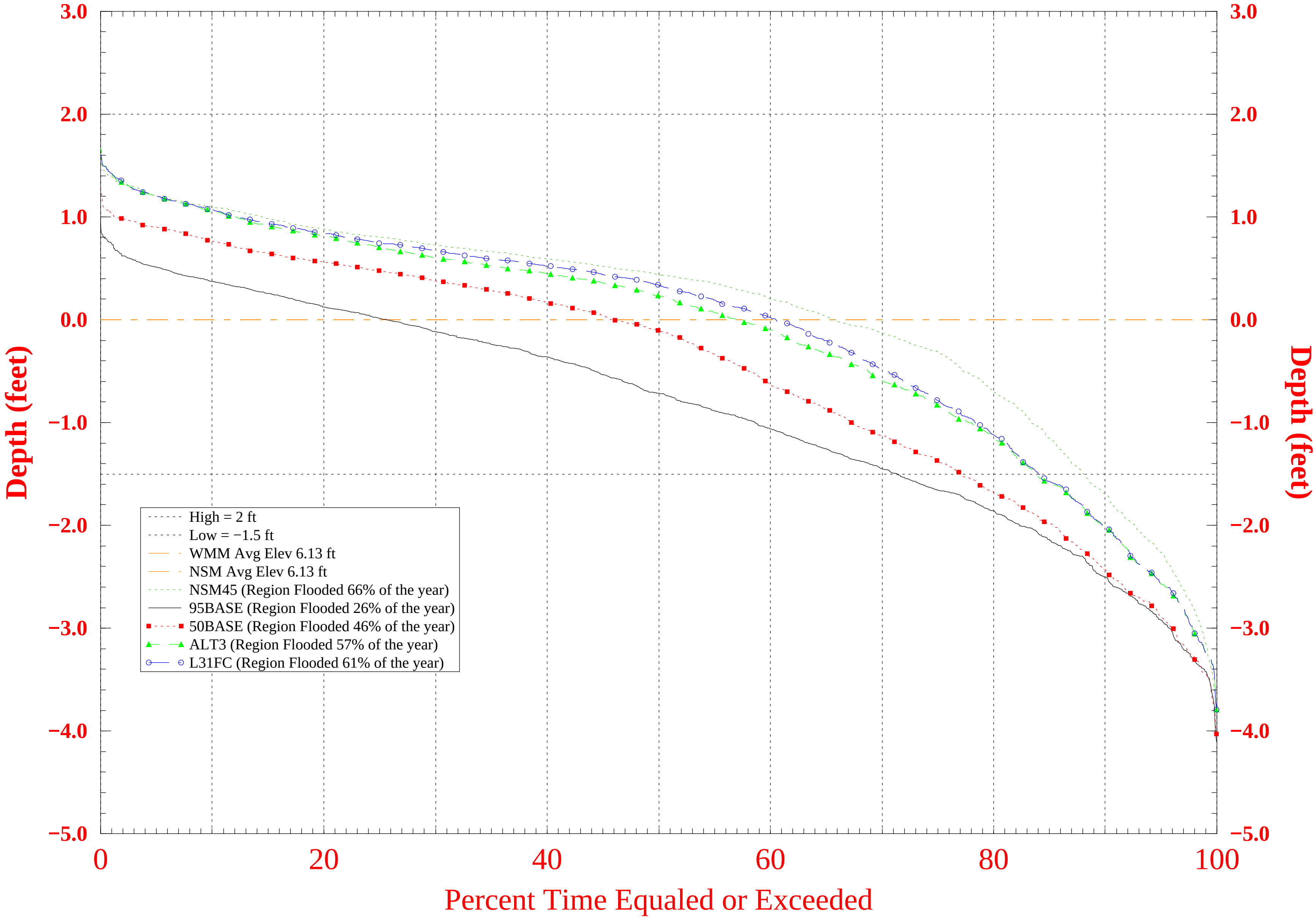


Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Thu Feb 12 04:28:16 EST 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-119 Normalized Weekly Stage Duration Curves for Rockland Marl Marsh

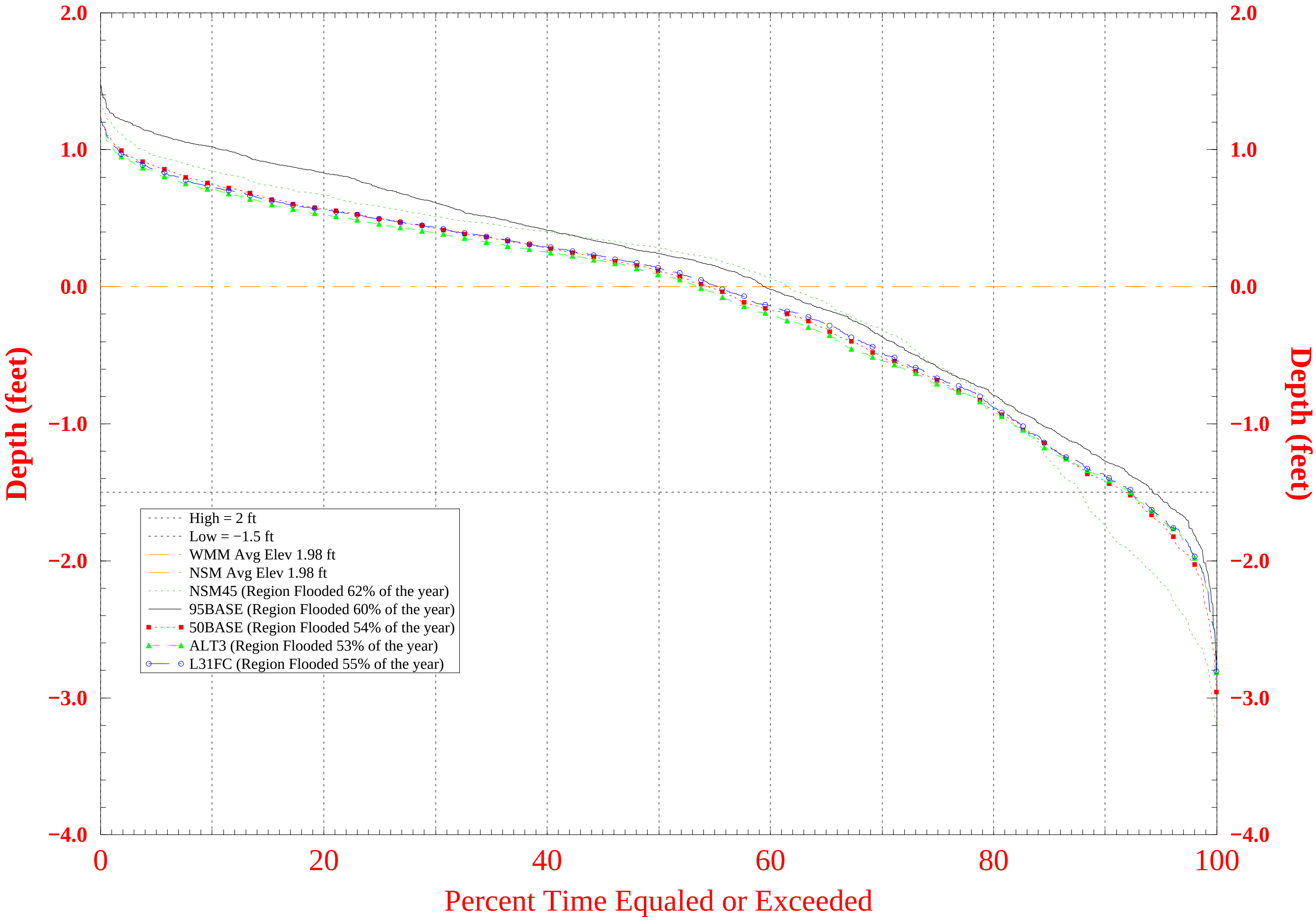
Indicator Region 8 (R12C21-22 R13C20-23 R14C21-23 R15C21-23 R16C22-23 R17C23-24 R18C24-25 R19C25-25)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Wed Feb 11 20:24:29 EST 1998
For Planning Purposes Only
SFWMM V3.4

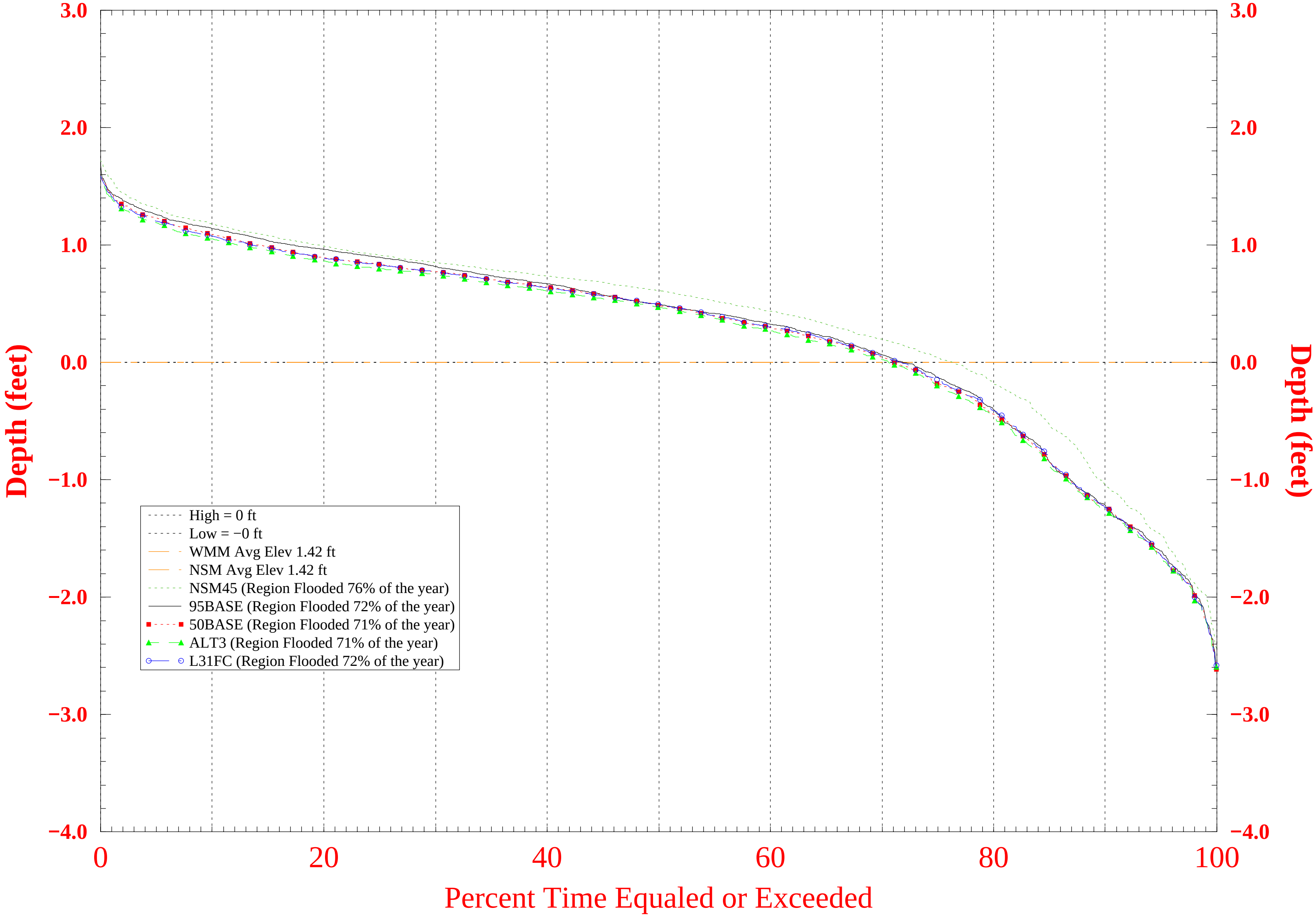
Figure B.3-120 Normalized Weekly Stage Duration Curves for Mid-Perrine Marl Marsh Indicator Region 3 (R7C24-25 R8C24-25)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Wed Feb 11 19:15:47 EST 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-121 Normalized Weekly Stage Duration Curves for Taylor Slough
Indicator Region 1 (R5C21-21 R6C21-22 R7C22-22 R8C23-23)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

Run date: Wed Feb 11 18:40:55 EST 1998
For Planning Purposes Only
SFWMM V3.4

Figure B.3-122

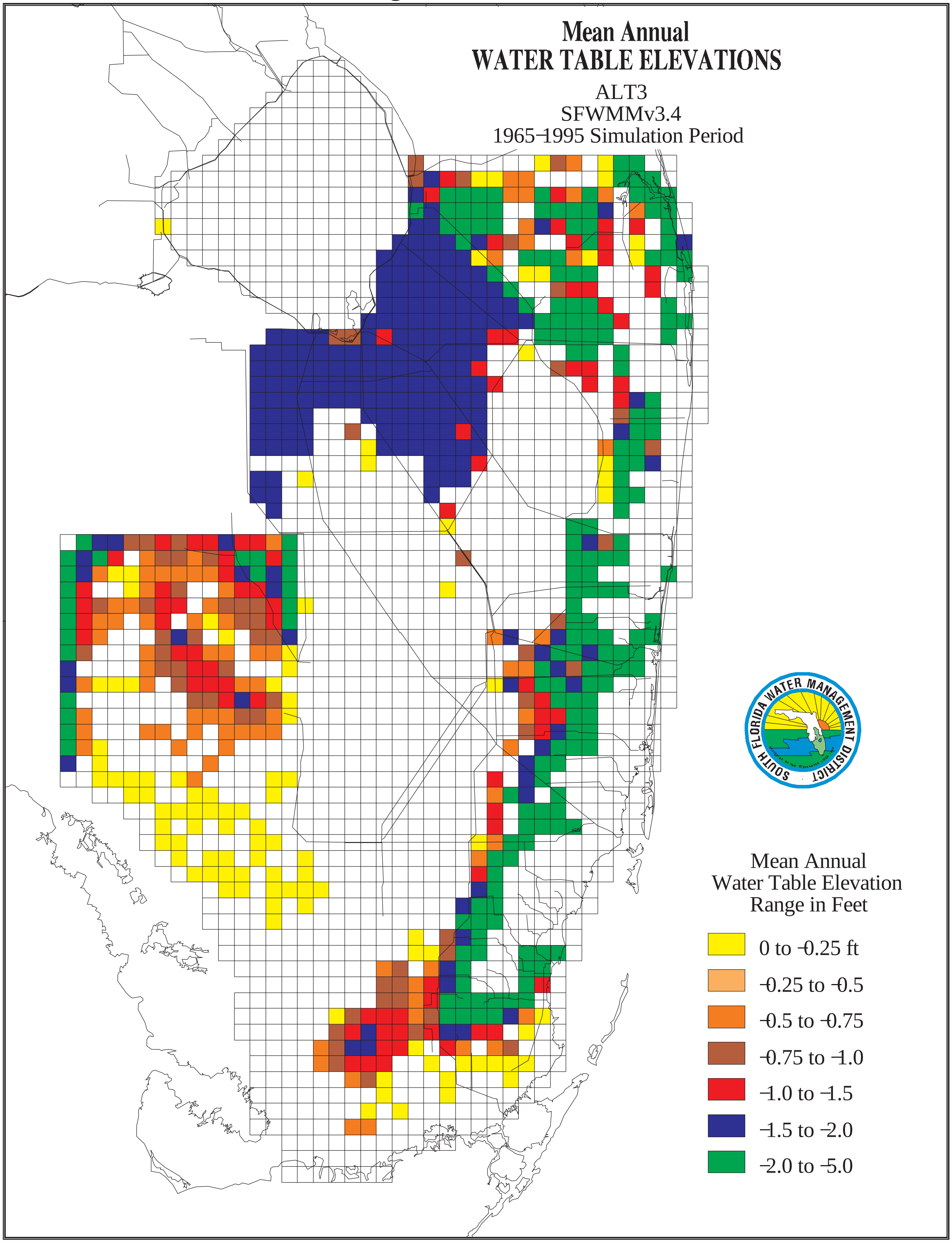


Figure B.3-123

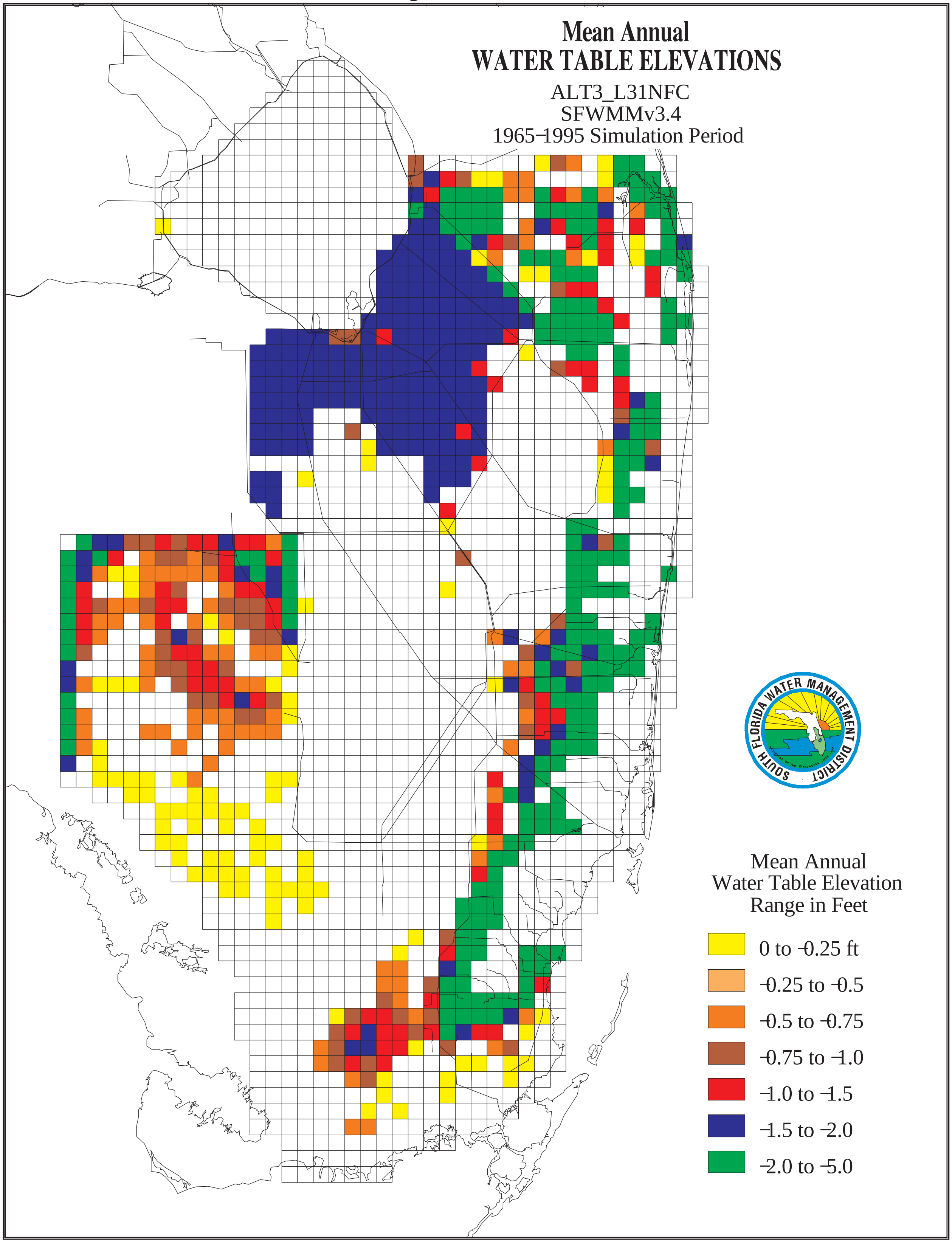
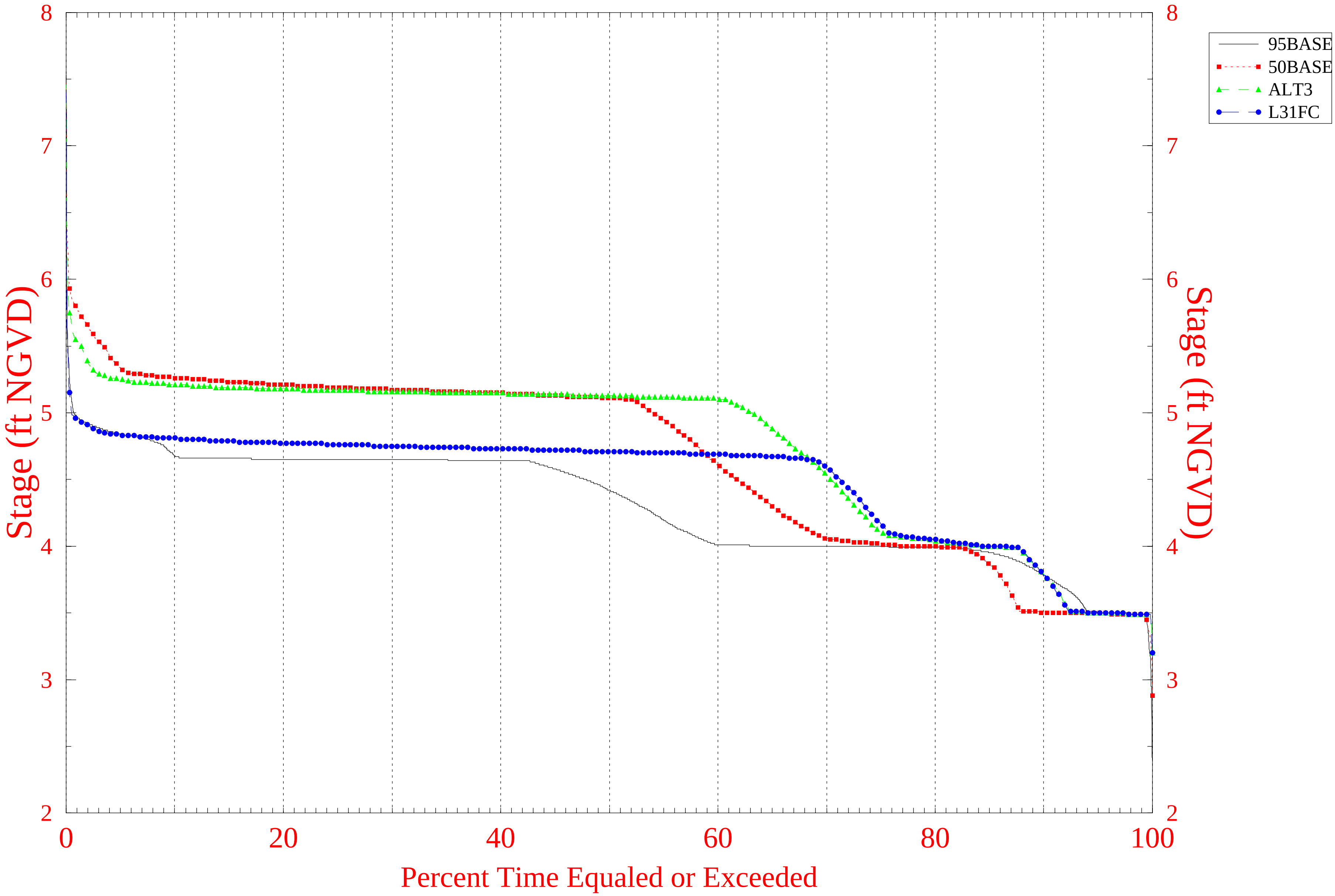
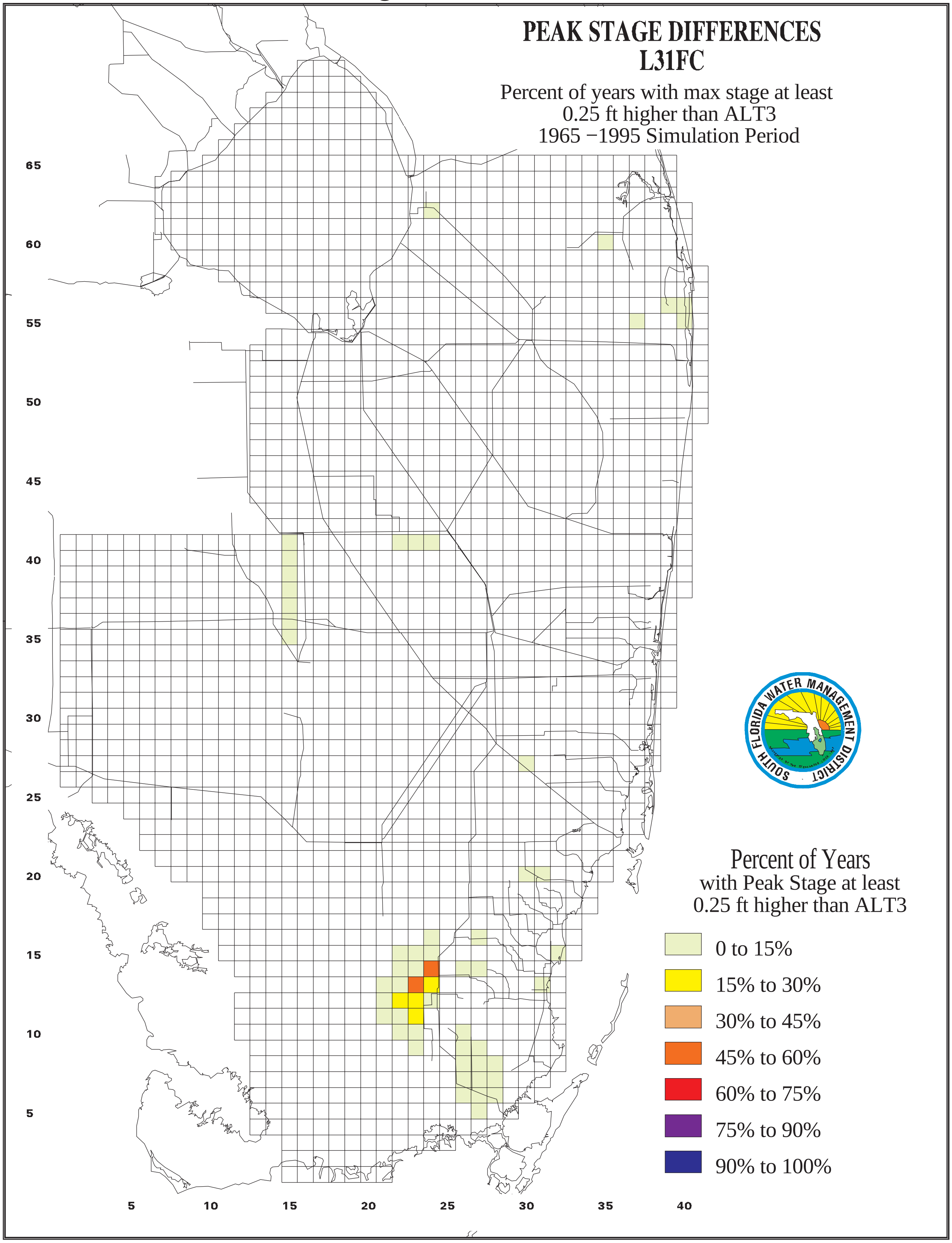


Figure B.3-124 Stage Duration Curves for L-31N Canal at S-174
(Salt-Water Intrusion Indicator Stage = 2.1 ft, NGVD)



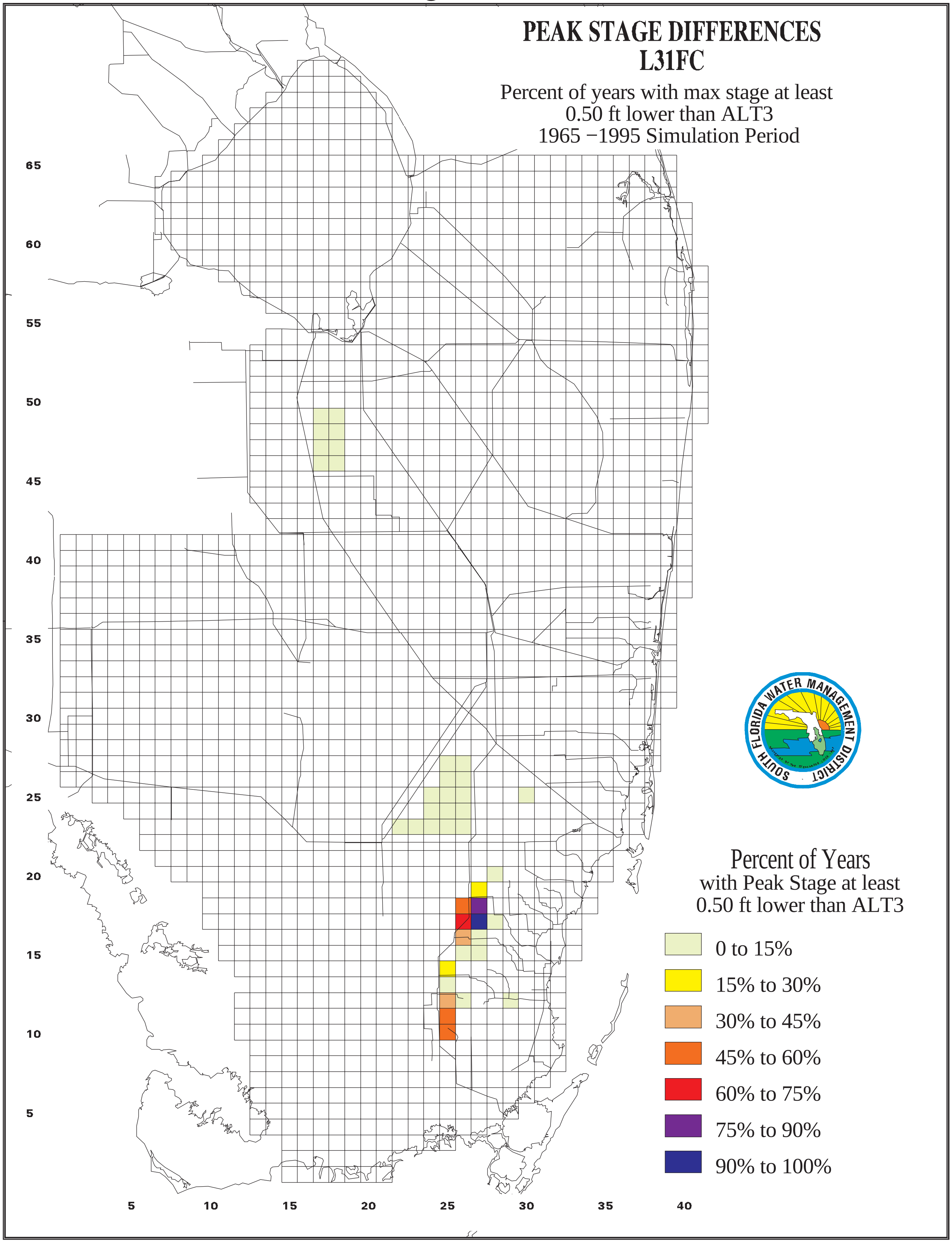
Run date: 02/11/98 21:36:11
For Planning Purposes Only
SFWMM V3.4

Figure B.3-125



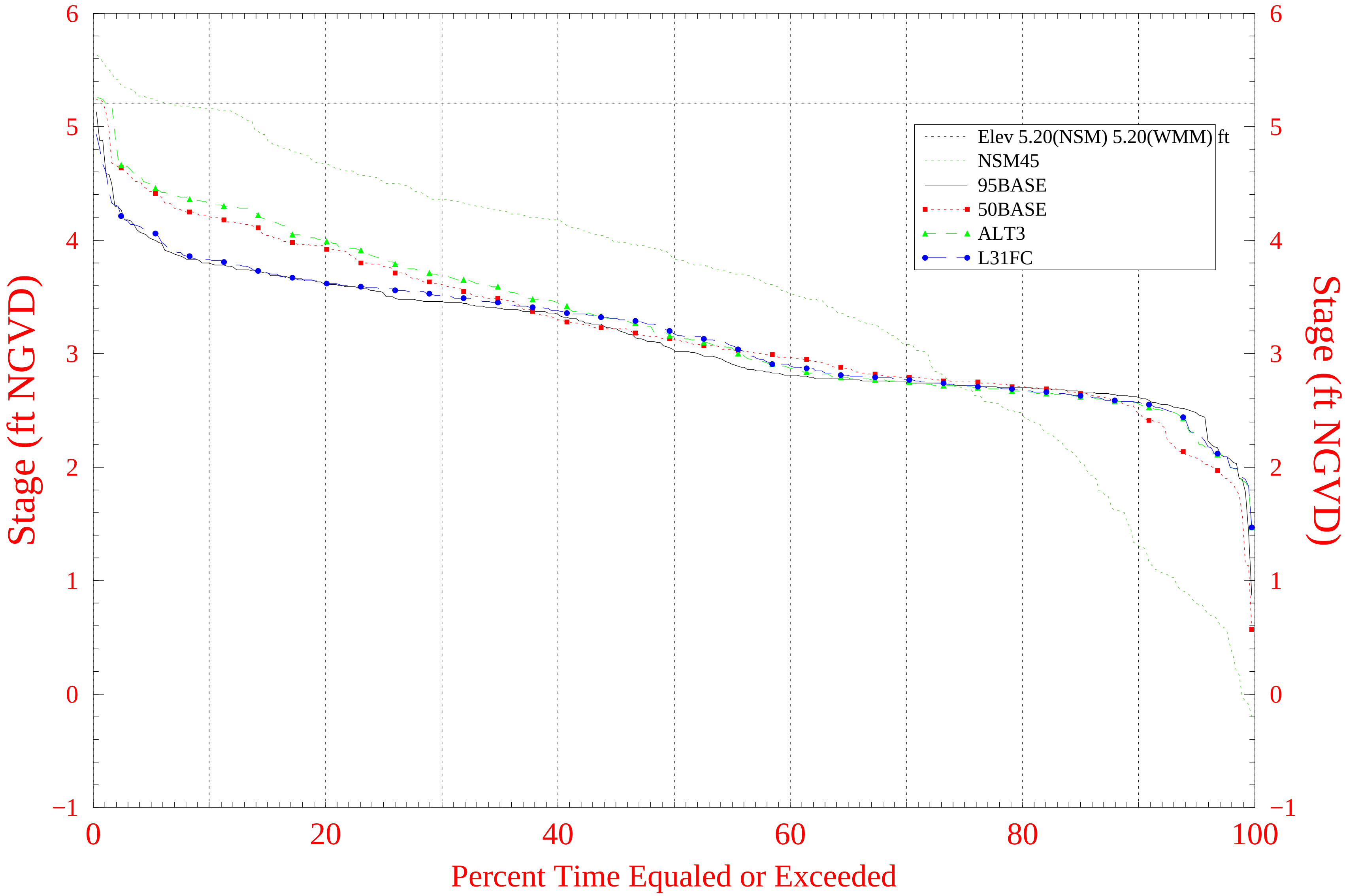
Note: Map values do not distinguish between groundwater and surface water and should only be used as a general indicator of subregions that may have a change in peak stages. Those subregions require more detailed investigation and analysis before site-specific inferences about changes in flooding risk can be made.

Figure B.3-126



Note: Map values do not distinguish between groundwater and surface water and should only be used as a general indicator of subregions that may have a change in peak stages. Those subregions require more detailed investigation and analysis before site-specific inferences about changes in flooding risk can be made.

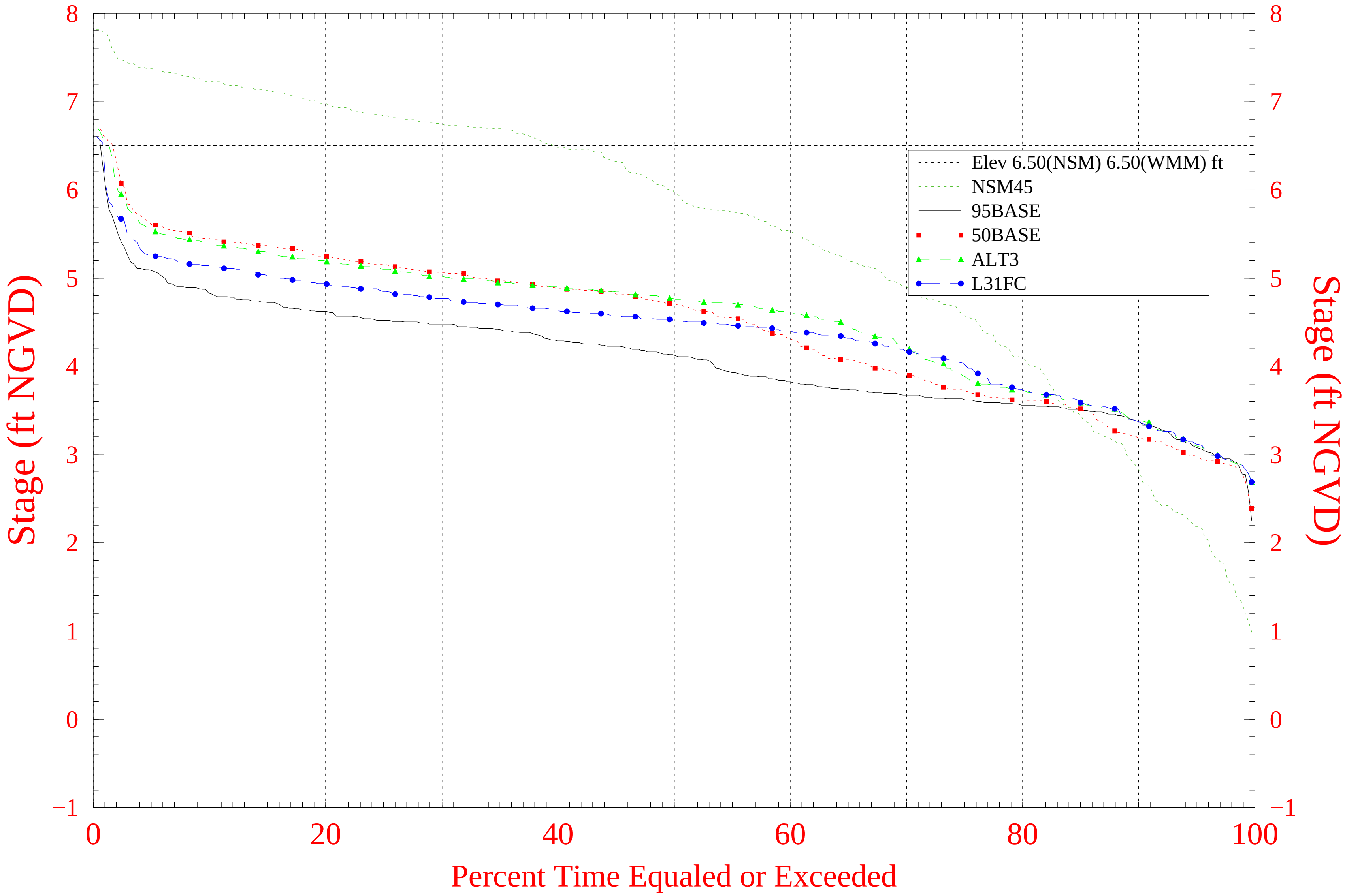
Figure B.3-127 End of the Month Stage Duration Curves at Cell R10 C25 in the LEC



Note: The simulated groundwater and surface water stages represent areally AVERAGED values over a 2mile−by−2mile region; the values DO NOT represent specific stages, or surface water depths and durations, for specific locations within the 4−square−mile grid cell. Land elevation values also represent areally AVERAGED values over the 4−square−mile grid cell.

Run date: 02/11/98 20:21:05
For Planning Purposes Only
SFWMM V3.4

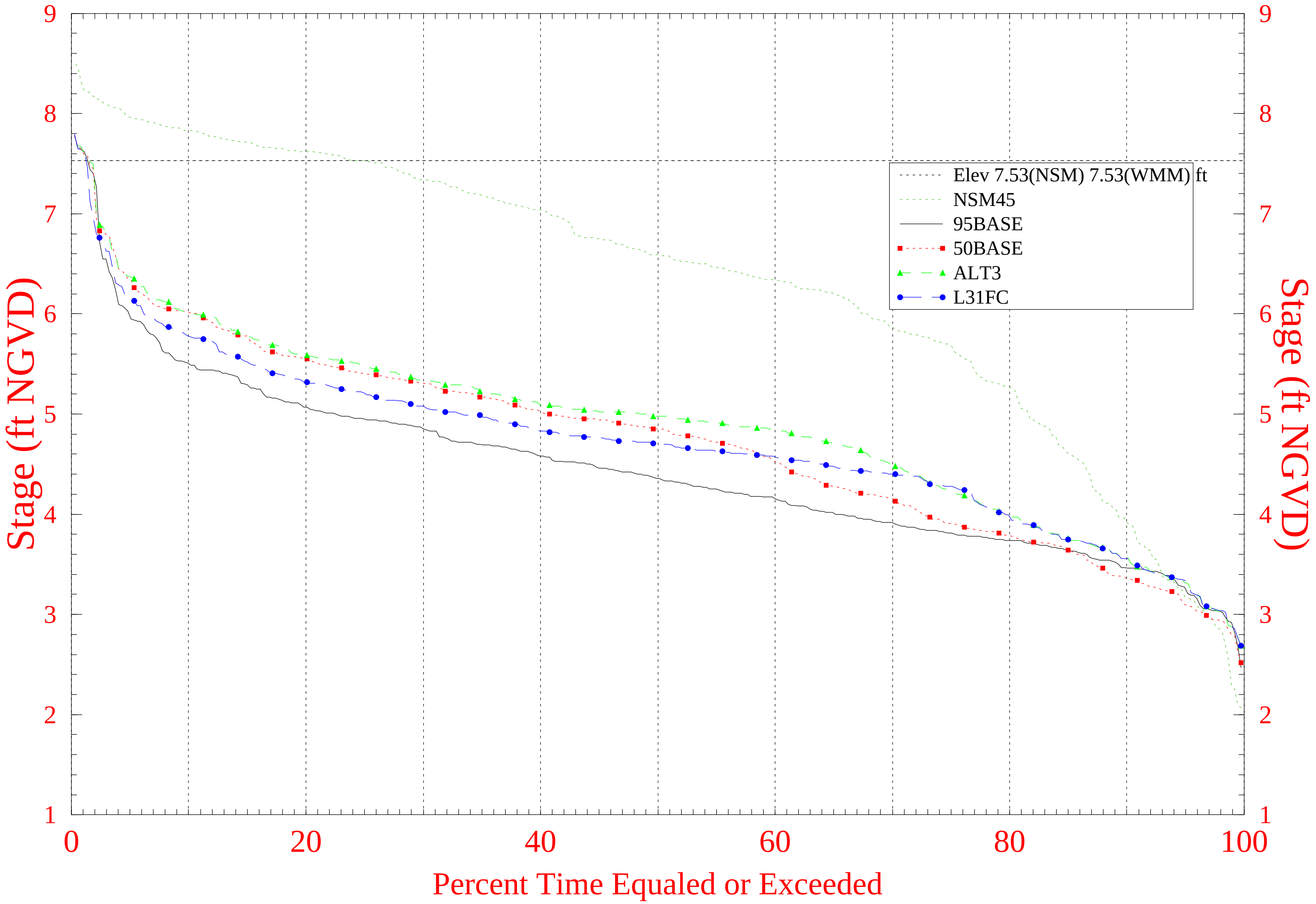
Figure B.3-128 End of the Month Stage Duration Curves at Cell R13 C25 in the LEC



Note: The simulated groundwater and surface water stages represent areally AVERAGED values over a 2mile−by−2mile region; the values DO NOT represent specific stages, or surface water depths and durations, for specific locations within the 4−square−mile grid cell. Land elevation values also represent areally AVERAGED values over the 4−square−mile grid cell.

Run date: 02/11/98 20:20:35
For Planning Purposes Only
SFWMM V3.4

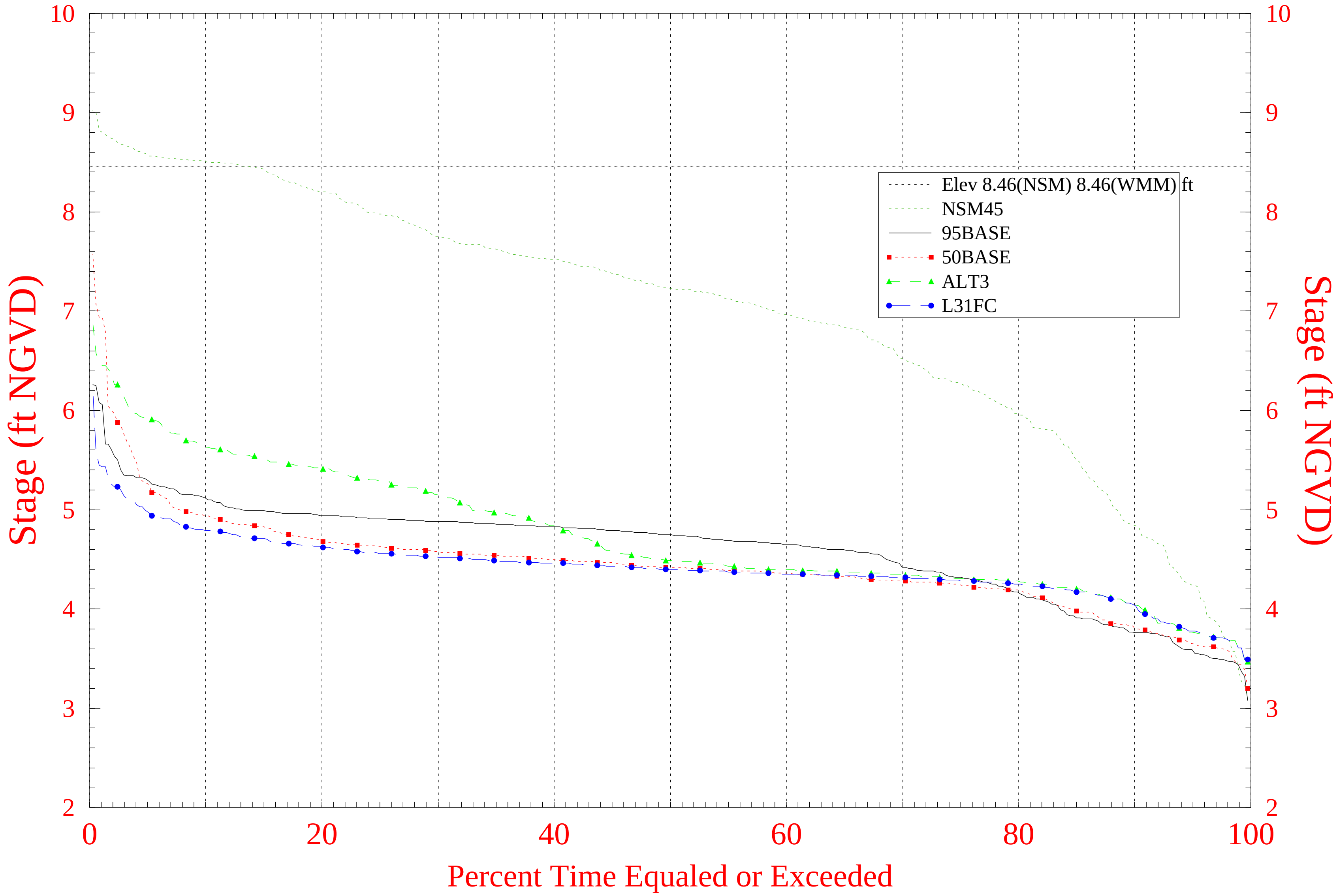
Figure B.3-129 End of the Month Stage Duration Curves at Cell R15 C26 in the LEC



Note: The simulated groundwater and surface water stages represent areally AVERAGED values over a 2mile−by−2mile region; the values DO NOT represent specific stages, or surface water depths and durations, for specific locations within the 4−square−mile grid cell. Land elevation values also represent areally AVERAGED values over the 4−square−mile grid cell.

Run date: 02/11/98 20:20:08
For Planning Purposes Only
SFWMM V3.4

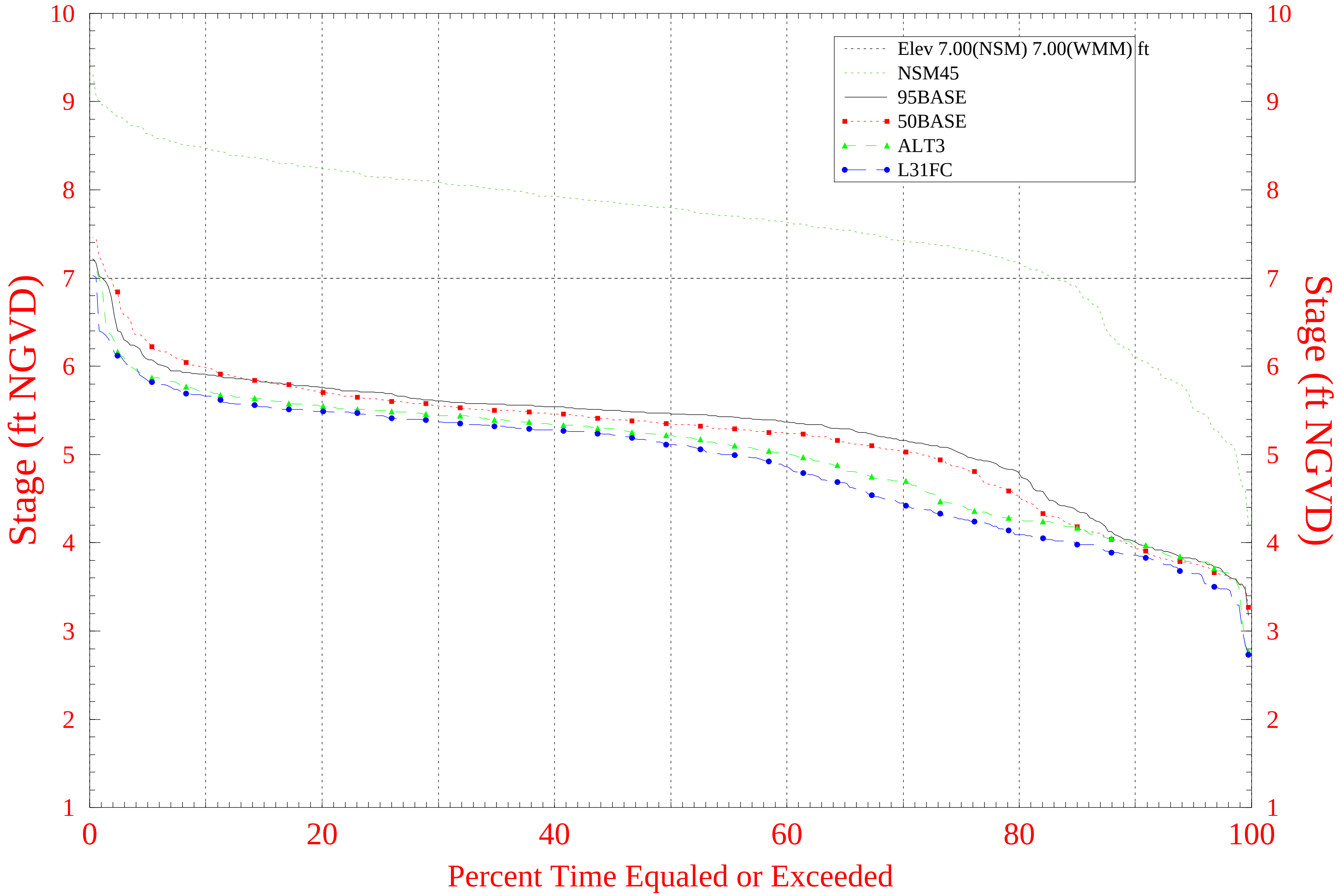
Figure B.3-130 End of the Month Stage Duration Curves at Cell R17 C27 in the LEC



Note: The simulated groundwater and surface water stages represent areally AVERAGED values over a 2mile−by−2mile region; the values DO NOT represent specific stages, or surface water depths and durations, for specific locations within the 4−square−mile grid cell. Land elevation values also represent areally AVERAGED values over the 4−square−mile grid cell.

Run date: 02/11/98 20:19:53
For Planning Purposes Only
SFWMM V3.4

Figure B.3-131 End of the Month Stage Duration Curves at Cell R19 C27 in the LEC



Note: The simulated groundwater and surface water stages represent areally AVERAGED values over a 2mile−by−2mile region; the values DO NOT represent specific stages, or surface water depths and durations, for specific locations within the 4−square−mile grid cell. Land elevation values also represent areally AVERAGED values over the 4−square−mile grid cell.

Run date: 02/11/98 20:19:30
For Planning Purposes Only
SFWMM V3.4

B.3.5.12 Sea Level Rise Scenario

B.3.5.12.1 Overview

The University of Miami Rosenstiel School of Marine and Atmospheric Sciences geologist Harold Wanless (1989) has estimated that sea level rise along Florida's shoreline has accelerated to a rate of 8 to 16 inches per hundred years since 1932. This is more than six times the rate recorded by earlier tide-gauge record and that estimated from geological history for the past three thousand years. However, the recent accelerated rate of sea rise is not unprecedented. Global sea level rise has been occurring at varying rates since the end of the last major ice age fifteen thousand years ago. Average sea level rates as large as 3 to 6 feet per century have lasted for periods of thousands years at a time. It is generally accepted that sea level rise is associated with global warming through several processes including the melting of mountain glaciers and thermal expansion of the ocean waters. Past global warming was likely attributed to such factors as long-term increases in solar energy output and variations of the earth's orbit around the sun. Scientific evidence suggests that in the future anthropogenic activities may also contribute in a significant matter to global warming. Regardless of the cause for the warming, the effect of sea level rise poses a formidable challenge for water resources planning for the future.

The Environmental Protection Agency (EPA) is the lead federal agency for guiding coastal states on planning for sea level rise (Edgerton, 1991). This role is particularly difficult because of the scale and complexity of the interaction of processes on several different scales that are involved. However, the EPA has consulted with a large group of leading experts in the fields of climate variability, oceanography and glaciology to estimate the most probable sea level rise that will likely occur in the future (Titus and Naranyan, 1995). The scientists that contributed to the EPA estimates were generally experts from the National Academy of Sciences and the Intergovernmental Panel on Climate Change. The most probable global sea level rise for the year 2050 was estimated to be 0.5 feet higher than the 1995 level. This EPA estimate does not include the effects of local subsidence, erosion, compression and other tectonic instabilities that may occur at varying rates along the Florida coastlines. These additional factors may cause the relative rate of sea level rise at a particular location to be substantially different and most often at a larger rate than the global rate of sea level rise.

In this regional hydrologic analysis, only the effects of the global sea level rise are being considered. The lower east coast of Florida is generally a stable coastline. In an effort to estimate the effects of expected sea level rise on south Florida's regional water management objectives of the future, the SFWMM was modified to re-simulate the 2050 Base run with the sea level boundary condition adjusted to be 0.5 feet higher than the base condition. One of the major concerns associated with sea level rise is the potential for saltwater encroachment into the coastal freshwater aquifers. The SFWMM is not designed to address the full spectrum of issues that may arise related to the potential for salt water encroachment with a sea level rise scenario. However, by making some rudimentary assumptions an estimate of the potential impacts that sea level rise may have on regional water management issues such as the Everglades hydroperiod restoration and impacts to regional water supply can be realized. It was with this rationale that water levels maintained within key coastal canals during dry conditions were increased by 0.5 feet. This perfunctory increase in canal maintenance levels was considered the minimal adjustment that would be required to offset the saltwater encroachment that may otherwise occur. Notwithstanding, preliminary analysis with density-dependent groundwater models suggest that the canals may need to be maintained at even higher levels to adequately offset the projected 0.5 feet rise in sea level. It should also be recognized that significant infrastructure changes may also be required.

B.3.5.12.2 Evidence of Past Sea Level Fluctuation

Globally sea level rise has been observed during the last century to be at a rate between 0.3 to 0.8 feet per 100 years. Historical global tide gage records supporting this fact exist at the Permanent Service For Mean Sea Level[1].

It is an observed fact that sea level rise relative to most coastal regions in the world is occurring and causing major problems just at the time when rapid coastal development is taking place (Douglas, 1995, 1996).

The Intra-Americas Sea has experienced sea level rise at similar rates as the global average based on 62 tidal gages located in the region of the Caribbean Sea, Gulf of Mexico, Bahamas, and Bermuda (Maul, 1993)

Sea level rise relative to coastlines is often larger than the eustatic (global) sea level rise due to land subsidence and geological instabilities. Sea level rise observed at Key West from 1913 through 1987 was estimated to be about 0.07 feet per decade (Maul and Martin, 1993). This site is particularly noteworthy because it is geologically stable.

In summary, if the sea level along the southeast coast of Florida continues to rise at the same rate that has occurred in the past 100 years, then the projected sea level rise between 1995 and 2050 will be between 0.3 and 0.4 feet. This rate of sea level rise does not include the increase in the sea level rise rate that is expected to occur due to anthropogenic effects.

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[1] http://www.nbi.ac.uk/psmsl/pmsl.infol.html). As of August 1997, this data base included over 43,000 station-years of record including annual means received from over 1,750 tidal gages around the world. This agency is served by an Advisory Group of leading experts around the world.

Table B.3-20 Relative Rate of Sea Level Rise along the Coastline of Florida (Maul and Martin, 1993)

Location	Rate (inches per century)
Key West	9.8
Miami Beach	9.4
Cedar Key	5.5
Fernandina Beach	8.7
Mayport	7.5
St. Petersburg	11.8
Pensacola	9.5

B.3.5.12.3 Projections of Sea Level Rise For The Future

In 1987 Congress directed the Environmental Protection Agency (EPA) to be the lead Federal Agency for dealing with the effects of global climate change (Edgerton, 1991). Recent research findings by the EPA reports on a probability-based projection for eustatic sea level change that can be adjusted to local tide-gauge trends to estimate the future sea level at particular locations. The projections are based on subjective probability distributions supplied by a cross section of climatologists, oceanographers, and glaciologists. The experts who assisted this effort were mostly authors of previous assessments by the National Academy of Sciences and the Intergovernmental Panel on Climate Change (IPCC).

A summary of the EPA's key findings is listed as follows (all increases in water levels are relative to those at the time the EPA report was published in 1995):

1. Global warming is most likely to raise the sea level 0.5 feet by the year 2050 and 1.1 feet by the year 2100. There is an estimated 10 percent chance that climate change will contribute 1.0 foot by the year 2050, 2.1 feet by 2100, and 3.5 feet by 2200. These estimates do not include sea level rise caused by factors other than greenhouse warming.

2. There is an estimated one percent chance that global warming will raise the sea level by 3.3 feet in the next 100 years and 13 feet in the next 200 years. Large rises in sea level given could occur either if Antarctic ocean temperatures warm by 5°C and Antarctic ice streams respond more rapidly than most glaciologists expect, or if Greenland temperatures warm by more than 10°C. Neither of these scenarios are likely.

3. Along most coasts, factors other than anthropogenic climate change will cause the sea to rise more than the rise resulting from climate change alone. These factors include compaction and subsidence of land, groundwater depletion, and

natural climate variations. If these factors do not change, global sea level is likely to rise 1.5 feet by the year 2100, with a 1 percent chance of a 3.7 feet rise.

B.3.5.12.4 SFWMM Simulation Assumptions

The specific coastal canal water levels maintained higher for the sea level rise scenario compared to the 2050 Base Run are illustrated in ***Table B.3-21***. In certain cases the initiation of flood control releases were also delayed to allow for a higher maintenance level when necessary. However, the water level at which maximum releases were made was not altered. Trigger levels for cutbacks were also raised by 0.5 feet, except for one interior trigger in Palm Beach County.

Table B.3-21 Special Operations for Coastal Canals for sea level rise (ft, NGVD)

Canal Reach	Flood Control[2]		Maintenance Levels	
	2050 Base	Sea Rise	2050 Base	Sea Rise
C-14 (S-37B)	6.7 - 7.5	7.2 - 7.5	6.5	7.0
C-14 (G-65)	6.6 - 7.5	7.1 - 7.5	6.5	7.0
C-14E (S-37A)	3.5	4.0	3.5	4.0
G-57	4.5	4.5	3.0	3.5
C-13 (S-36)	4.5 - 5.3	4.7 - 5.3	4.0	4.5
G-54	3.6 - 4.5	4.1 - 4.5	3.5	4.0
C-12 (S-33)	3.5 - 4.0	3.5 - 4.0	2.7	3.2
C-9 (S-29)	2.0 - 2.8	2.5 - 2.8	2.0	2.5
C-6 (S-26)	2.5 - 2.8	3.1- 3.2	2.5	3.0
C-7 (S-27)	1.8 - 2.0	2.1 - 2.2	1.5	2.0
C-4 (S-22)	2.85	3.1	2.5	3.0
S-197	2.5	2.5	1.2	1.7
S-18C	2.3 - 3.5	2.3 - 3.5	1.8	2.0
S-165	4.0 - 4.6	4.0 - 4.6	2.8	3.3
S-167	4.0 - 4.6	4.0 - 4.6	2.8	3.3
S-148	4.6 - 5.2	4.6 - 5.2	3.0	3.5
Snapper Creek	4.3	4.3	3.0	3.5

B.3.5.12.5 Summary of SFWMM Simulation Results

- **Lower East Coast Service Areas water supply**

Lower East Coast Water Supply Cutbacks are simulated to increase significantly. This was especially true for LECSA1 and LECSA2, where the number

[2] When a range of water levels are listed, the modeling assumption is that the gate of the downstream structure will be gradually opened wider as the water level in the canal increases.

of months of cutbacks more than doubled. Phase two cutbacks occurred more often in LECSA2. The additional number of phase 1 and phase 2 cutbacks are due to the higher groundwater levels where water use cutbacks are triggered. Deliveries to LEC Service Area 2 and 3 increased significantly from the 2050 Base condition to the 2050 Base condition with sea level rise. Water supply deliveries for LECSA2 and LECSA3 also increased. This is due to the higher canal maintenance levels during dry periods in these two service areas.

- **Lower East Coast Flood Protection**

The peak stage difference map illustrates a significant increase in the number of years that peak stages were greater than 0.25 feet the base case along certain major canals in northern Miami-Dade and Broward counties. This indicates a potential increase in flood risk in these areas. Mean water levels were simulated to be higher throughout the same area.

- **Interior Hydrology**

The interior of south Florida does not appear to be significantly effected by a sea level rise of 0.5 feet.. The Lake Okeechobee, northern ENP, and WCAs performance measures illustrate this.

- **Coastal Ecosystems**

Certain coastal ecosystems (for example mangroves along coastal boundary in Miami-Dade County) may be impacted by the intrusion of high saline water. In the ENP for instance, if sea level rise occurs at a slow enough rate it is believed that the mangrove ecosystem would be able to migrate inward (Wanless, 1989). However, in the more developed areas of the LEC Service Areas the opportunity for migration may be limited. Estuaries throughout the District may need additional fresh water deliveries to balance increased high saline water entering these valuable habitats. This additional volume if required, is not known at this time. Therefore, it is not included in these sea level rise scenarios.

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APPENDIX C

ENGINEERING CONSIDERATIONS AND COSTS

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APPENDIX C
ENGINEERING CONSIDERATIONS AND COSTS

The purpose of this engineering appendix is to evaluate the major project features of each alternative presented in the Central and Southern Florida Project Comprehensive Review Study Feasibility Report (known as the "Restudy"). It is intended that this information will serve as the basis for preparation of future design memorandums and construction plans and specifications relative to the selected alternative.

C.1 SCOPE

The scope of this evaluation includes an investigation of hydrologic, hydraulic, geotechnical, and structural aspects of the major project features and associated components. This assessment considers their technical viability and associated costs related to engineering and construction principles and practices.

C.2 DESCRIPTION OF MAJOR PROJECT FEATURES

Each alternative presented in the main report consists of a combination of major project features and associated components described below. While the quantity, size, and location of each vary between different alternatives, their basic intended function remains the same.

C.2.1 Water Preservation Areas

Water preservation areas (WPA) are above ground storage reservoirs. They consist of relatively flat landmasses surrounded by impoundment levees to retain water and prevent un-regulated flows into and out of the area. They can serve a variety of purposes including potable water supply, environmental water supply, flood control, aquifer recharge, and recreation.

C.2.2 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) is a water management technology whereby underground aquifers are used as a reservoir to store excess water which later is withdrawn for use. In areas such as central and southern Florida where water availability is limited on a seasonal basis, excess water can be stored in the subsurface during wet periods and later withdrawn during dry periods to meet demands.

Current Environmental Protection Agency (EPA) standards require that pre-injection water quality meet primary drinking water standards. Unless an exemption to this requirement is allowed, the use of treatment facilities in conjunction with ASR for injecting collected stormwater will be needed.

C.2.3 In-Ground Reservoirs

In-ground reservoirs are essentially man-made lakes that store excess water for later use. They can serve a variety of purposes including potable water supply, environmental water supply, flood control, aquifer recharge, and recreation. Most areas in the central and southern Florida area have highly transmissive soils. Therefore, in order to store large volumes of water or drawdown the reservoir during dry periods, perimeter seepage barriers are needed.

C.2.4 Stormwater Treatment Areas

Stormwater treatment areas (STA) are synthetic wetlands. These areas rely on the concept of using plant material and microbes to naturally extract excess nutrients and pollutants from incoming water. The water is retained in the STA for a sufficient amount of time to achieve a desired chemical composition before discharging.

C.2.5 Advanced Wastewater Treatment Facilities

Advanced wastewater treatment facilities provide treatment of reclaimed water for direct release into natural areas. The superior treatment technology removes phosphorous, nitrogen, and other nutrients left by normal wastewater treatment processes to provide acceptable water quality.

C.2.6 Associated Components

With all the major features listed above there are associated components that enable them to perform their intended function. These components include:

- <u>conveyance canals</u> - for moving water to and from different locations
- <u>levees</u> - earth barriers to impound water
- <u>pump stations</u> - to regulate water flow from lower to higher elevations
- <u>gravity control structures</u> - spillways and culverts to regulate water flow
- <u>injection wells</u> - wells and pumps with treatment facilities to provide ASR
- <u>cutoff walls</u> - to prevent groundwater movement

C.3 ENGINEERING CONSIDERATIONS

C.3.1 HYDROLOGY

To support the development of alternatives for the Restudy, hydrologic modeling has been conducted using the South Florida Water Management Model (SFWMM). The SFWMM calculates the flow pattern of water across a region beginning with Lake Okeechobee and ending at Florida Bay. The eastern boundary is essentially the coastline while the western boundary ends in Big Cypress National Preserve.

The region is divided into a 2-mile by 2-mile grid pattern in order to determine average overland and groundwater flows and stages for each grid. Daily average depth and flow values are calculated for overland areas including existing Water Conservation Areas and flood control structures. Associated components of the major project features (levees, canals, ASR, structures, etc.) are also included. The predictions of stage and flow are considered adequate for developing estimates of new facilities needed; however, they are not consistent with investigations for detailed design work. It is anticipated that additional modeling will be required for future design efforts.

C.3.2 HYDRAULIC CRITERIA AND DESIGN

The hydraulic design for components in each alternative plan is based on accepted engineering practice and applicable provisions of US Army Corps of Engineers publications. Documents referenced include engineering regulations, circulars, manuals, and the Waterways Experiment Station report “Hydraulic Design Criteria,” relative to the design and construction of civil works projects. Engineering designs and analyses are formulated by utilizing sound engineering judgement, experience gained from past projects and studies, and criteria successfully used for the design of flood control works throughout peninsular Florida. Hydraulic design and analysis assumptions for this study are made to provide a systematic and simplified approach for designing each component. Allotted time and funding limitations restricted the ability to compile the level of information normally required for feasibility reports.

C.3.2.1. Conveyance Canals

Reservoirs and STAs were sited at locations determined by the planning group. Project canals were designed to link reservoirs and STAs with existing canals to minimize the need for lengthy new runs. Topography in most project areas has very small changes in elevation over large distances. Design water surface profiles for canals in south Florida have very small head losses over very large distances. Soils in the project area are subject to erosion when velocities exceed 2.5 ft/sec. Subsequently, slope and velocity are the controlling criteria for channel designs in south Florida. Canals for the project features outlined in this report are sized to carry the design discharge with an average velocity of approximately 1.0 ft/sec. This is based on previous experience with existing canals in the Restudy area. Short canal segments and approach canals to spillways or pump stations are designed to provide velocities of up to 2.0 ft/sec so that real estate requirements can be minimize.

Canal excavation quantities are primarily based on the assumption that the surrounding over-bank areas are completely flat. If topography at the exact site location is unknown, then elevations shown on United States Geological Service quadrant maps are used to determine design stages. It is assumed that excavated material will be used to construct adjacent levees. These assumptions may have to be revised when feature locations are accurately established and topographic surveys are available.

C.3.2.2. Levees

Levees are sized with a top width of 10 ft. Side slopes are assumed at 1 vertical : 3 horizontal. This is a typical average side slope used on many of the existing levees in the study area. The top elevation is set 3 ft above the design water surface elevation. This allows for wave run up, erosion, and a margin of safety from overtopping. Overtopping sections will be chosen at locations that cause the least amount of damage. In some cases the levee dimensions are set to match specific dimensions given in the alternative description. It is assumed that material for the levees can be excavated from adjacent canal construction.

Reservoir containment levees are aligned to conform to topographic features or according to real estate considerations. Levee volumes and depths of storage are determined based on the objective of the project element. If no restrictions are imposed by real estate or topography, the assumption is made that the reservoir or STA area is rectangular in shape with a length twice as long as its width. Levee lengths for designated areas are scaled from current maps. Reservoir depths for components varied from 4 to 10 feet.

C.3.2.3. Pump Stations

Design and operation of pump stations is based on the assumption that new structures will be operated in the same manner as existing pump stations constructed by the Jacksonville District. Main pumping station capacities are sized in one of three ways:

1. To fill water storage areas or reservoirs within a specified amount of time.
2. To match existing permitted flood control pump stations.
3. Based on a specific removal rate from a given drainage area.

4. To return seepage water from a reservoir or STA levee back to the reservoir or STA.

Pumps are designed for up to 10 feet of lift. Total pump capacities are computed by taking average seepage rates through levees and adding them to pump discharges required for flood control and other purposes.

Seepage through levees is based on very general seepage rates ranging from 2.5×10^{-10} to 2.9×10^{-10} cubic feet per second (cfs)/ft/ft for the restudy area. Actual rates could vary considerably depending on site conditions. Seepage pumps are sized to pump one-half of the estimated seepage. Reservoir stages would fluctuate such that the amount of seepage for a "full condition" would rarely need to be pumped. Loss of seepage during high stage times is deemed not to be a critical concern.

C.3.2.4. Gravity Control Structures

Spillways, culverts and other gravity control are assumed to be constructed and operated in the same manner as existing spillways and culverts built by the Jacksonville District. Structures are designed to provide a full range of releases required to meet flood control, environmental management, and water supply goals of the project. Spillways and gated culverts are sized to address one or all of the following criteria:

1. To pass peak discharges and prevent overtopping of project containment levees.
2. To provide discharge capacity required for emptying the component reservoir within a specified amount of time.
3. To provide greater control of water now lost to tide.

C.3.3 SOILS AND GEOLOGY

C.3.3.1. Surface Features

Generally, the topography of central and southern Florida is relatively flat. However, there is a narrow coastal ridge that rises to elevations of 50 feet NGVD, beginning just north of Jupiter Inlet and extending south all the way to Homestead. From this ridge, the ground slopes gently downward in the direction of the Everglades to the west.

The Everglades are "*a flat plane with negligible relief that slopes gently to the south-southwest, from an elevation of about 15 feet south of Lake Okeechobee, to sea level about 75 miles away*" (Randazzo and Jones, 1997). To the west of the Everglades are areas of slightly higher ground known as the Immokalee Rise and the Big Cypress Spur. Further to the west is the Southwestern Slope and then, finally, the Coastal Swamps along the Gulf of Mexico.

C.3.3.2. Aquifers

There are three principal aquifers in the region of the Restudy: the Biscayne Aquifer, the Undifferentiated Surficial Aquifer, and the Upper Floridan Aquifer. The Biscayne Aquifer is a surficial aquifer that extends from the lower quarter of Palm Beach County southward through Broward and Dade County. The Undifferentiated Surficial Aquifer is a shallow aquifer, like the Biscayne, and is present in most of Palm Beach County. The other principle aquifer in the region of this study is the Floridan Aquifer, which is much deeper than the other two aquifers.

C.3.3.2.1. Undifferentiated Surficial Aquifer

The Undifferentiated Surficial Aquifer is a non-artesian fresh-water aquifer that covers much of peninsular Florida. Over most of this area, this aquifer is made up of unconsolidated sand, shelly sand and shell. However, in Palm Beach County this aquifer has many areas that are made up of limestone beds that are similar to the make-up of the Biscayne Aquifer. This aquifer is up to 250 feet thick in parts of Palm Beach County. Transmissivity values as great as 50,000 feet squared per day have been reported in places where this aquifer is thick and permeable (Randazzo and Jones, 1997).

C.3.3.2.2. Biscayne Aquifer

The Biscayne Aquifer is a non-artesian, highly permeable fresh-water aquifer. It is made up mostly of limestone and sandy limestone, and yields large volumes of water. The Biscayne Aquifer is 100 to 400 feet thick in coastal Dade and Broward counties but thins to a few feet near the westward boundary of the counties (Hyde, 1965, R 1975). Transmissivity values greater than 1,000,000 square feet per day were calculated from aquifer tests in Brevard County (Fish, 1988). A thick, clayey confining layer, which in places is up to 1,000 feet thick, underlies the Biscayne Aquifer and separates it from the underlying Floridan Aquifer (Randazzo and Jones, 1997).

C.3.3.2.3. Floridan Aquifer

The Floridan Aquifer not only underlies the Undifferentiated Surficial Aquifer of Palm Beach County and the Biscayne Aquifer of Broward and Dade Counties, but also the entire state of Florida. In north Florida the Floridan Aquifer contains fresh water and is generally continuous from top to bottom. However, in south Florida the Floridan Aquifer contains brackish water, and is a system that is subdivided by a series of confining layers known as the Upper Floridan and the Lower Floridan Aquifers.

The thickness of the Floridan Aquifer and the depth to its upper boundary vary according to location. In West Palm Beach, Broward and Dade Counties, the Upper Floridan Aquifer has a thickness of roughly 100 to 300 feet, and a depth to the upper boundary that varies from about 600 to 1,000 feet beneath the ground surface (Miller, 1990). Also, according to that hydrogeologic cross section, in the regions to the immediate north and west of Lake Okeechobee the thickness of the Upper Floridan Aquifer is on the order of 500 feet, and the depth to its upper boundary is about 400 feet beneath the ground surface. The confining layer between the surficial aquifers and the Upper Floridan Aquifer consists of a layer clayey soils, which in places is up to 1,000 feet thick.

Estimated transmissivities of the Upper Floridan Aquifer vary between 10,000 and 50,000 sf/day in Palm Beach, Broward and Dade Counties, and between 100,000 and 250,000 sf/day in the regions just north and just east of Lake Okeechobee (Bush and Johnson, 1988). Bush and Johnson based these estimates on what they described as aquifer tests, geology, and simulation.

The Upper Floridan Aquifer is separated from the Lower Floridan Aquifer by a layer of relatively impermeable rock. This confining layer is roughly 300 to 500 feet thick in Palm Beach, Broward and Dade Counties, and 800 feet thick in the areas just north and east of Lake Okeechobee. The Lower Floridan Aquifer in Palm Beach, Broward and Dade Counties, and in the areas around Lake Okeechobee, begins at depths ranging from about 1,300 to 1,800 feet and ends at depths ranging about 3,500 to 4,000 feet (Miller, 1990). The Lower Floridan Aquifer is up to 3,000 feet thick and is comprised of a complex system of very permeable rock and a series of confining units. This system contains three permeable zones and two confining units. The confining units consist of low-permeability carbonate rock. The deepest permeable zone of the Lower Floridan Aquifer contains a formation known as the Boulder Zone from a depth of about 3,000 to 3,500 feet.

C.3.3.3. Subsurface Geologic Formations of Aquifer Systems

The aquifer systems in Florida are defined primarily on the basis of permeability and not on geologic formations. This is because, in any particular aquifer system, the top and base of that aquifer system does not correspond everywhere with the top and base of any single geologic formation.

C.3.3.3.1. Undifferentiated Surficial Aquifer

The Undifferentiated Surficial Aquifer system is present over much of Florida, but is a major source of ground water only in Martin, Palm Beach, Hendry, Lee, Collier, Indian River, St. Lucie, Glades, and Charlotte counties. In southern Florida, this aquifer system is made up of *"beds of shell and sand of the Anastasia Formation, beds of shell and limestone in the Tamiami formation, or limestones in the upper part of the Hawthorne Formation"* (Hyde, 1965, R 1975).

C.3.3.3.2. Biscayne Aquifer

According to Klein and Causaras, *"The Biscayne Aquifer's most productive water-yielding formations are the Fort Thompson Formation, the Miami Limestone, and, locally, the Anastasia Formation"* (Klein and Causaras, 1982). They also stated, *"the Biscayne is underlain by a thick sequence of low-permeability clay beds that are as much as 1,000 feet thick in places and separate the aquifer from the underlying Floridan aquifer system…"* .

C.3.3.3.3. Floridan Aquifer

Based on a chart by Miller (1986), Randazzo and Jones wrote, *"the most permeable and most productive part of the Upper Floridan aquifer consists mostly of the Suwanee and Ocala limestones and the upper part of the Avon Park Formation."* They also reported, *"the Lower Floridan aquifer consists mostly of the lower part of the Avon Park Formation, the Oldsmar Formation, and the upper part of the Cedar Keys Formation."*

C.3.4 GEOTECHNICAL

C.3.4.1. Above-Ground Impoundments

There are several above-ground impoundments included in the Restudy. The components for which the largest above-ground reservoirs are planned are North of Lake Okeechobee storage (component A), EAA storage (component G), Caloosahatchee storage (component D), and St. Lucie storage (component B). The maximum depth of impoundment ranges from 4 feet (components Q and R), to 12 feet (component VV).

The local geologic information indicates that the surficial soils throughout south Florida are not very deep and that they are underlain by very permeable shallow aquifers. Therefore, core borings and field permeability tests will have to be drilled in all of these areas to determine the thickness and permeabilities of the surficial soils. If it is determined that the surficial soils do not have low enough permeabilities to hold water in the impoundments, alternative approaches to modifying the bottom of the impoundment areas will be necessary. The least expensive of these alternatives would be to modify the in-situ materials. Other alternatives would be to bring in a material to line the impoundment areas. These materials could be a clay liner or a high density polyethylene (HDPE) liner rolled out over the bottom of the impoundment area.

As previously stated, creating a low-permeability liner by modifying the in-situ materials is the most economical alternative. If the in-situ materials are sandy, this could be accomplished by mixing a small percentage by weight of dry bentonite with the sand. When the bentonite-sand mixture becomes moist, it will create a low-permeability liner for the impoundment area. If the in-situ materials are limestone, the top two feet of limestone could be scraped or ripped by bulldozers, processed in-place by crushing and then compacted by steel-wheeled vibratory rollers to create a low-permeability liner. The processed and compacted in-place limestone may, itself, have an appropriate permeability range to provide for the retention of water while allowing some of the water to recharge the surficial aquifer from the impoundment. If necessary, admixtures such as bentonite or portland cement could be added to the limestone to lower the permeability of the processed and compacted limestone liner.

C.3.4.2. In-Ground Reservoirs

Three in-ground reservoirs are included in the Restudy. These are the C-51 and Southern L-8 Reservoir, located in central Palm Beach County, and the North Belt and Central Belt Impoundment Areas, which are located in the north-central Dade County.

C.3.4.2.1. C-51 and Southern L-8 Reservoir

This site is listed in the Restudy as component GGG. Presently, most of this site is farmland. There is a rock quarry located at the site's north end. The reservoir will be constructed over time as the byproduct of a rock mining operation that is currently in its early stages. Subsurface information is not presently available at this site, but field explorations are planned for the near future. It is currently assumed, based on published geologic data, that the subsurface conditions are similar to those at the Central Lake Belt area. If this is so, the installation of a seepage barrier around the perimeter of the site the installation of a seepage barrier around the perimeter of the site to a depth of about 100 feet beneath the ground surface will be required to prevent the drainage of water from the surrounding surficial aquifer during drawdown of the reservoir. The technology for the design and installation of this seepage barrier is discussed in the paragraph below about the North Lake Belt and Central Lake Belt Storage Areas.

C.3.4.2.2. North and Central Lake Belt Storage Areas

The two in-ground reservoirs planned for Dade County are listed in the Restudy as the North Lake Belt Storage Area (component XX), and the Central Lake Belt Storage Area (component S). Rock mining operations are presently being conducted in both of these areas and will continue for a number of years. However, once mining in these areas is complete, the resulting lakes will be utilized as in-ground reservoirs.

The highly permeable Biscayne Aquifer, from which the mined rock is taken, extends to depths of about 80 feet from the ground surface. This depth is based on the experience of the rock quarries local to this area. Although these quarries will not share proprietary information concerning the depth and quality of rock in their mines, some of their representatives have stated in the past that it is common for them to mine rock to depths of 80 feet and then encounter clayey strata. Based on this information, it was decided that a seepage barrier would need to be constructed so that drawdown of the lake will not result in the draining of the surrounding Biscayne aquifer. The three options considered to constuct a seepage barrier were as follows:

1. Soil-Slurry Backfilled Trench. This would be accomplished be excavating a trench through the depth of the Biscayne aquifer and backfilling around the perimeter of the in-ground reservoir with a soil-slurry mixture.

2. Soil-Slurry Backfilled Trench with HDPE Liner. In this option the seepage barrier would be similar to the soil-slurry backfilled trench. However, a HDPE liner would be installed as part of the seepage barrier.

3. Injection Grouting. In this option, a seepage barrier would be constructed be a drilling and injection grouting operation.

The HDPE liner was considered to be the best option from a constructability standpoint due to the highly porous nature of the Biscayne aquifer and the much greater difficulty of attaining a seepage barrier without leaks by the other methods. The extremely high porosity of the limestone in this formation would make the construction of a seepage barrier be the injection grouting method, without significant leakage, almost impossible to achieve. Achieving a reasonably impermeable seepage cutoff wall by the trench and soil-slurry backfill method would also be difficult due to the likelihood that some of the slurry will be lost in the cavernous limestone along the trench alignment and result in holes in the seepage barrier. Therefore, from a constructability standpoint the HDPE seepage barrier was considered the best option for obtaining an impermeable seepage barrier. Also, the cost of constructing the HDPE seepage barrier would likely be only marginally greater than that of the soil-slurry backfilled trench without the HDPE sheeting. This is because the only difference in the two construction procedures is the placement of the HDPE sheeting prior to the backfilling of the trench. The cost of adding the HDPE sheeting would be marginal compared to that of the total construction procedure.

The HDPE seepage barrier would be installed by the use of a trench excavation machine. This type of machine uses four large cutting wheels, with carbide bits, mounted at the tip of a large boom that is suspended in the excavation by a crane. The excavation is made in consecutive cuts of nine feet. The excavation is made as the cutting wheels of the boom grind the rock and as the boom moves downward under its own weight. The cuttings are removed from the excavation by circulating slurry, which is also used to hold the excavation open. When a nine-foot length of excavation is complete, the boom is removed and a nine-foot section of HDPE liner is placed into the excavation, which is subsequently backfilled with the ground rock that was excavated from the trench. The production rate achieved by a contractor at a job in south Florida was 300 sf/hr.

It is estimated that the HDPE liner would have to be keyed about 20 feet into the confining layer under the Biscayne Aquifer (100 to 120 feet beneath the ground surface) in order to prevent seepage under the liner. It is thought that the clay layer encountered by the local rock mines at depths of about 80 feet, is the confining layer under the Biscayne Aquifer. However, subsurface core boring data will need to be obtained to determine the depth to the confining layer around the rock mines.

When the rock quarry operation is completed some years from now, a levee will be constructed around the site to allow for the storage of water above the present ground level. The levee will most likely be constructed from crushed limerock, which is locally available. Since it is anticipated that seepage through the levee will be minimal, a liner will not be required in the levee above grade. The liner that will be installed beneath the original grade will not only function to prevent the draining of the Biscayne aquifer during draw-down of the reservoir, it will also, in conjunction with the levee, enable the reservoir's water level to be raised above the original ground surface without seepage loss into the Biscayne Aquifer.

C.3.4.3. Aquifer Storage and Recovery Wells

There are six components of the Restudy where ASR wells are proposed. The component in which the largest number is proposed is GG4 - Lake Okeechobee ASR. 200 hundred wells are proposed for this component, each of which will have a capacity of 5 million gallons per day (MGD) for a total site capacity of 1,000 MGD.

The other components for which ASR wells are proposed are the Caloosahatchee C-43 Basin (22-10 MGD wells), the WPA in Palm Beach County (25-5 MGD wells), the Lower East Coast Service Area 1 (34 well clusters where each cluster will consist of two 2.5 MGD withdrawal wells and one 5 MGD ASR well), the Hillsboro Canal Water Preserve Area in Palm Beach County (30-5 MGD wells), and the Agricultural Reserve Reservoir (15-5 MGD wells).

C.3.4.3.1. Description of an ASR Well

The purpose of an ASR well is to store excess freshwater that is available during the rainy season and would otherwise be released out to sea. The concept is to pump the excess water from a surface reservoir into the Upper Floridan Aquifer where it can later be recovered for use during the dry season or during a period of prolonged drought.

In south Florida, the Upper Floridan Aquifer contains brackish water that is not suitable for irrigation or for residential or commercial use. However, the Upper Floridan Aquifer is very permeable and can be utilized as an underground reservoir by pumping in freshwater, within the aquifer, which can be recovered for later use. Mixing of the waters pumped into the Upper Floridan Aquifer with those of the surficial aquifers is not a concern because the Upper Floridan Aquifer is located deep beneath the surficial aquifers, and is separated by a very thick confining layer.

It is estimated that the upper boundary of the Upper Floridan Aquifer is located between 600 to 1,000 feet beneath the ground surface, and that the aquifer is between 100 and 300 feet in thickness. Therefore, an ASR well would have to be drilled to depths of up to 1,300 feet, and perhaps deeper depending on local stratification. The width of an ASR well in the water bearing strata would be between 18 and 24 inches. Wells of such depth have to be drilled to a larger diameter (on the order of 42 inches) at the shallower depths in order to provide room for casing in the upper layers. However, as the casing is sleeved to greater depths the diameter will taper to the design diameter in the aquifer range. The experience of others in Florida has shown that, though casing is required at the higher elevations, a deep well can be left uncased in the aquifer strata because of the strength of the limestone. Well designs will be tested and verified during pilot testing programs.

C.3.4.3.2. Sub-Surface Exploration for an ASR Well – Pilot Wells

Depths of core borings drilled using techniques that are standard in geotechnical engineering are limited between 200 to 300 feet. Because it is anticipated that the ASR wells will be drilled to depths on the order of 1,300 feet, these standard drilling techniques will not be feasible for the purpose of performing a preliminary subsurface exploration for the wells. In fact, deep well-drilling techniques are required to construct borings of such great depth. Therefore, the subsurface will be explored by drilling full-scale pilot wells at the proposed ASR locations. The subsurface information obtained from drilling each pilot well will be used in the design of additional permanent wells that will be constructed at their respective locations.

C.3.4.3.3. Associated Buildings and Facilities

The Restudy will incorporate not only the main features described above, but also the levees, canals, and several buildings and facilities that will work in conjunction with the main features. The buildings and facilities will include pump houses, machine and instrument houses, water control structures, water treatment plants, etc. Geotechnical field explorations will be needed for each of these items in order to have the necessary data to design the required foundations.

C.3.5 ENVIRONMENTAL

C.3.5.1. Stormwater Treatment Areas (STAs)

The designs for the stormwater treatment areas in the alternative plans are based on the same concepts outlined for the Everglades Construction Project (ECP) by Burns and McDonnell (reference 9). The analytical relationship used to calculate effective areas needed to reduce phosphorus levels to the interim target of 50 parts per billion (ppb) was based upon research and observations in Water Conservation Area 2A and developed by Walker (reference 10). The only variation from the parameters used in the ECP calculations involve the period of record. Historical data was not always available from the 1979 to 1988 base period of the ECP; therefore, the data utilized was best available. This similarity to the ECP area computation was intentional to allow easy comparison with Everglades Construction Project even though empirical evidence from the Everglades Nutrient Removal project suggests the parameters may be overly conservative. The primary factors involved in the analytical relationship include surface flow hydraulics, water budgets, nutrient uptake and biological factors. The most significant factors in the computation of the required effective area of the STAs are the mean inflow concentration and volumes, the desired outflow concentration and the effective settling rate constant.

Specific fixed parameters used in the Restudy sizing are taken from the Burns and McDonnell calculations (reference 9) and repeated below:

- The effective settling rate constant is 10.2 meters/year.
- The average annual rainfall is 48.53 inches.
- The total atmospheric deposition of phosphorus is 5 ppb.
- The average annual evapotranspiration loss is 45.26 inches.
- The average discharge concentration of phosphorus is targeted at 50 ppb.

The transposition of fixed parameters from the conceptual design calculations for the ECP to other areas within the Central and South Florida Project is deemed acceptable for the conceptual design stage of the Restudy and readily allows comparison with the stormwater treatment areas of the Everglades Construction Project. Similar methods of wetland treatment area calculations available (Kadlec and Knight) should provide equivalent results.

C.3.5.2. Aquifer Storage and Recovery Water Treatment

The EPA imposes water quality requirements on discharges to groundwater. The strictest requirements are mandated for discharge to potable water aquifers. Lake Okeechobee is an agricultural watershed, so it is impacted by pasture and farming operations that produce run-off containing fecal coliform bacteria such as Eschericia coli (associated with avian and mammalian wastes). These total coliforms will likely be the main factor / parameter guiding treatment requirements in this and other areas sighted for ASR.

Coliform water quality data for Lake Okeechobee is unavailable; however, there is extensive total coliform data for the Everglades Nutrient Removal Project (STA-1 West) located in the vicinity. This area is supplied by discharge canals from Lake Okeechobee. The data shows coliform levels are on the order of 1200 organisms per 100 milliliters. Some level of minimal treatment will be required to reduce these coliforms down to 0 organisms per 100 milliliters.

The South Florida Water Management District (SFWMD) has proposed several approaches to treatment ranging from de minimus to ultra filtration via 20-100 micron disk filters. Future work will investigate the actual coliform numbers and determine if higher degrees of treatment are needed. If required, a least cost treatment method will be proposed.

Coliforms (like all living organisms) have a finite lifespan. They die off at a rate governed by temperature. The following equation provides a rate estimate for the 90% reduction of coliforms by natural processes:

$0.10 = e^{(-K_b\ t_{90})}$ where K_b = decay rate (1 to 5.5 for freshwater and 20 °C) and t_{90} = time in days

$t_{90} = 0.4 \text{ to } 2.3 \text{ days}$

One can see that a 30 day storage period will provide 14 orders of magnitude reduction, which essentially reduces coliform numbers to zero.

The discharge of stored water can also be designed to provide further treatment. By using subsurface toe drains, any residual coliforms will be removed. Removal via the toe drains mimics slow sand filtration where coliform removal is almost total. The media envelope around the toe drain can be selected to further maximize treatment. These toe drains will be supply points for surficial wells used for treatment of pre-injection ASR water.

The water will go through several further stages of coliform reduction via the well injection process and subsequent aquifer storage. The well screen and injection into the rock aquifer will reduce pathogens. The lag time between injection, storage, and retrieval is on the order of several months. Therefore, reduction will occur as the aquifer is an anoxic environment and the coliforms are facultative organisms requiring some oxygen. After this storage period, the system will undergo post aeration and disinfection to potable water standards.

Recent correspondence from the EPA indicates that a willingness to consider a flexible approach to constructing and permitting ASR wells proposed in the

Comprehensive Plan (U.S. Environmental Protection Agency. 1999). For these facilities, the EPA believes that the proposed “raw” water ASR components can be implemented consistent with the SDWA and EPA’s regulations if “risk-based” analyses of the projects demonstrate that the USDW will not be endangered in a way that could adversely affect the health of humans. This approach would depend on a number of factors: 1) that a more comprehensive evaluation of the quality of the proposed source waters confirms that total coliform bacteria is the only problematic parameter; 2) that a demonstration can be made that biological contaminants will experience “die-off” such that the presence of these contaminants in the USDW will not cause a violation of the MCL or pose an adverse health risk; 3) that both modeling and test monitoring confirm dieoff after injection of biological contaminants within a reasonable time-space continuum after injection into a saline/brackish aquifer; 4) that the use of ASR technology on the scale and with the number of well proposed, results in recovery of a reasonable amount of injected waters and of reasonable quality; 5) that there are documented environmental benefits to be derived by the storing of water in this manner; and 6) that use, and treatment if necessary, of the recovered water is consistent with its intended primary purpose, ie, for ecosystem restoration.

C.3.5.3. Advanced Wastewater Treatment

The historic Everglades marsh was a low-nutrient (phosphorous limited) ecosystem. The Florida Department of Environmental Regulation (FDEP) has determined that violations of the state water quality standard for nutrients has occurred in the Everglades. These violations have specifically occurred as high concentrations of total phosphorus discharged from the Everglades Agricultural Area (EAA) to the Water Conservation Areas (WCAs). The Everglades Forever Act (EFA) requires the DEP to establish, by rule, a numeric criterion for total water column phosphorus in the Everglades Protection Area. This area includes the Everglades National Park (ENP), where the statutory default phosphorus criterion is 10 parts per billion (ppb). The Settlement Agreement to the federal lawsuit concerning the Everglades establishes a long-term phosphorus concentration limit for Taylor Slough of 11 ppb.

C.3.5.3.1. Water Quality Requirements

The re-use of wastewater effluent will be governed by two major water quality parameters: total phosphorus and fecal coliforms. Re-use of wastewater is regulated by the FDEP, and they categorically require filtration prior to re-use. The area of re-use is proximate to the Everglades where background total phosphorus (TP) levels are below 10 ppb. Implementation will require, perhaps, even further treatment to remove pathogens and TP down to levels that the FDEP will permit for discharge to groundwater. Modeling is required to ascertain impacts to the shallow aquifer, as well as to determine the extent of further treatment and special requirements such as detention or secondary disinfection. The acceptance of any re-use plan will require negotiation and acceptance by the FDEP to be feasible.

Wastewater effluent typically has a TP 1000-7000 ppb, and is high in coliforms (>10,000 organism per milliliter). Advanced municipal wastewater treatment facilities are capable of producing effluent containing approximately 500 ppb TP. This is 10 times the limit for discharges from STA-1 East, and 50 times the limit for ENP. Of concern is that under certain conditions, the hydraulic gradient in the area would be from east to west (toward ENP). The limestone underlying this area is very porous, therefore the released wastewater can possibly migrate to the ENP. The FDEP will likely impose special treatment requirements such as secondary disinfection or detention. Additionally, the distance and routing from the re-use facilities is unknown. These issues will impact costs, but their effect cannot be accurately estimated at this level of investigation.

C.3.5.3.2. Treatment Methods

Filtration systems employ flow equalization, chemical addition rapid mixing, flocculation, and gravity filtration. The chemical addition allows the formation of chemical floc particles. These are passed through 3 feet of media comprising 3 layers: coarse activated carbon, anthracite coal, and fine sand. Filters will require a pumping station to deliver the water to permit down-flow filtration. They are designed for runs of 1-4 days (between backwashes) and flow rates of 1-6 gallons per minute (gpm). The facilities will require a backwashing system, solids treatment, and disposal.

This technology is used on a large scale in Wahnbach, Germany. This plant treats 113 MGD of stormwater with an influent TP ranging from 90-260 ppb, and produces an effluent TP of 10 ppb or less. Filtration is a common method of water treatment in the US, and is used successfully to treat Mississippi River water. It is used to remove large amounts of color and colloidal materials from Lake Washington Pond water in Melbourne, Florida. Wastewater effluent is typically higher in TP (1000-7000 ppb); however, supplemental chemical feed at the existing wastewater plants (and perhaps other process optimization) could be used to reduce effluent TP to 100-200 ppb, and minimize filtration operation and maintenance costs. Treated potable water grade effluent would be delivered to the seepage locations by a pump station and pipeline. Further analysis is needed to determine required seepage areas and ponds.

C.3.6 STRUCTURAL / MECHANICAL

Due to planning constraints, site information for the proposed structures was not available. The lack of specific locations, topography and subsurface conditions, coupled with the large volume of structures did not afford the development of drawings and stability analyses as is usually done during the feasibility phase. As a result, only conceptual designs were performed for a select number of structures. These designs are based on similar, previously built structures taking into account water surface elevations and flow rates determined during hydraulic modeling. Costs estimates for structures in each alternative are generated using the conceptual designs supplemented with construction cost data from the US Army Corps of Engineers and the South Florida Water Management District.

C.3.6.1. Pump Stations

Discharge capacity of the various pump stations in each alternative differs considerably. Some are small and for the purpose of controlling seepage through impoundment levees. Others are larger, for regulating the movement of water from storage and treatment areas through canals to places in need of municipal or environmental supply. Review of previously built structures in the central and southern Florida area has shown that pump station capacity is the most influential parameter in determining construction cost.

C.3.6.1.1. General

The layout and design of pump stations built by the US Army Corps of Engineers is governed by Engineering Manual (EM) 1110-2-3102, "General Principles of Pumping Station Layout and Design." In the manual, three distinct sizes of stations are inferred based on capacity. Small stations are considered less than 100 cfs, medium are between 100 cfs and 1060 cfs, and large are 1060 cfs or greater. EM 1110-2-3104, "Structural and Architectural Design of Pumping Stations," prescribes structural loadings and architectural details to be used.

Pump stations will incorporate a wet pit (sump) with vertical mixed-flow or axial-flow pumps. The two basic types of pump sump used in civil works stations are formed suction intake (FSI) and rectangular wet pit. FSI generally improves flow conditions and thus pump performance, but are more expensive to construct. Therefore, they will only be used in situations where pump performance is in question due to poor alignment of the intake canal or the ability of a large station to deliver its design capacity. The configuration used will conform to the requirements of EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Stations."

C.3.6.1.2. Small Stations

Small stations typically will consist of a single pump enclosed in a small building. A hatch in the roof is required to remove equipment with a mobile crane for servicing unless the location of the structure is extremely remote. In this case an overhead crane must be constructed in the station. Trash racks will be provided except for stations of minor importance. The ability to dewater the pump sump for maintenance and inspection will also be incorporated. Since stations of this size will not be manned, additional facilities such as office space and bathrooms are not usually needed.

C.3.6.1.3. Medium and Large Stations

Because of the importance of medium and larger size stations, two or more smaller pumps are used to provide the station design capacity instead of one large pump. This is necessary to provide backup capability in the event of a malfunction or during maintenance operations. Regulations also require auxiliary appurtenances that increase the size of the structure footprint and elevation. Office space, maintenance work areas, overhead cranes, and sanitary facilities will all be provided. The US Army Corps of Engineers Hydroelectric Design Center (HDC) must engineer large stations. These stations also require a separate Feature Design Memorandum to be prepared for the pumping equipment before design is started on the station.

C.3.6.1.4. Construction Considerations

The type of structure being built coupled with high water table conditions in central and southern Florida necessitates the use of dewatering measures during construction. Depending on the size and location of the station, this can typically be accomplished by two methods. If real estate is available and soil conditions allow a sufficient area can be excavated and well points used to control groundwater. If real estate is limited and/or highly permeable soil is encountered, a more expensive steel sheetpile cofferdam is necessary.

Location of the structure is important for accessibility reasons. Remote sites may require the addition of access roads and utility lines. Additionally, the proximity of ready-mix concrete plants is an issue for stations requiring large pours. Unit costs for concrete may escalate due to delivery distance or the use of on-site batch plants.

C.3.6.2. Gravity Control Structures

The primary purpose of these outlet works is to permit controlled release of water from storage areas. Small flow requirements will be handled with culverts, whereas larger ones will require spillway structures. As with the pump stations, discharge capacity of the proposed gravity control structures differs considerably between alternatives and is very influential in determining construction costs.

C.3.6.2.1. Culverts

There are four types of materials used for culverts: concrete, steel, aluminum, and plastic. Each has a different service life depending on protective coatings used and the project environment encountered. During design, the selection of materials for culverts will be based engineering requirements and life cycle performance. Economic analyses will compare 50, 75, and 100-year project lives depending on the relative importance of each structure. The analyses will include initial construction costs and future costs for maintenance, repair, and replacement associated with the type of material used.

The design and construction of culverts is governed by EM 1110-2-2902, “Conduits, Culverts, and Pipes.” This manual generally follows The American Society for Testing and Materials (ASTM) and The American Association of State Highway and Transportation Officials (AASHTO) standard provisions for the different culvert material types. The culvert shape (circular, box, elliptical, arch), size, and flow control (gated or non-gated) will depend on hydraulic requirements and specific site conditions encountered. Culverts through existing embankments may be constructed by tunneling and jacking when conventional excavation and backfill methods are not be feasible.

C.3.6.2.2. Spillways

The purpose of spillways proposed for this project is to provide a means of controlling the flow of water from reservoirs. Non-gated spillways provide extremely reliable operation and are inexpensive to maintain; however, the relatively flat topography of central and southern Florida along with economical, environmental, and political considerations does not favor this type of structure. Spillways controlled by gates allow a lower maximum reservoir water surface and thus a lower top of levee than non-gated spillways. This reduction will almost always result in savings when available lands and the cost of levee construction are a factor.

To satisfy safety concerns, a gated spillway must include two or preferably three gates. The two types of gates predominantly used by the US Army Corps of Engineers are the tainter gate and the vertical lift gate. Tainter gates are advantageous when large operating heads exist. Their concentric radial geometry causes the resultant hydrostatic force to pass through the pivot point (trunnion), meaning no moment from this force has to be overcome by the gate hoist. For small head situations as has historically been the case in central and southern Florida, vertical lift gates are regularly used. With vertical lift gates the hydrostatic load is transferred to the concrete structure through slots formed into the sides of the piers. The gate moves within these slots on rollers. Mechanical hoist systems used to raise and lower the gates must overcome the friction in the rollers caused by the hydrostatic load.

The layout, structural analyses, stability analyses, reinforcement details, etc., for the design of spillways is governed by EM 1110-2-2400, “Structural Design of Spillways and Outlet Works." The dimensions, elevations and shapes of the approach channel, weir, energy control structure (e.g., stilling basin), and discharge channel must meet the hydraulic requirements of EM 1110-2-1603, "Hydraulic Design of Spillways."

C.3.6.3. Cutoff Walls

Cutoff walls are vertical subsurface barriers designed to reduce or contain ground-water flow and limit fluid loss into surrounding soils. Their effectiveness is highly dependent on soil conditions, especially the presence of a confining layer to "key" the base of the wall into. Without the confining layer at the base of the cutoff wall, groundwater seepage will be reduced but not eliminated.

C.3.6.3.1. Steel Sheetpile

Steel sheetpile walls have been used in civil engineering applications for years. The walls are constructed by driving individual sections of interlocking steel sheets into the ground with impact or vibratory hammers to form an impermeable barrier. The retaining sheetpile walls deflect from water and lateral earth pressure applied to them. The flexure tightens the interlocks making the connection more water-resistant. Sheetpiling has exceptional strength and life expectancy, but is generally an expensive alternative compared to other vertical containment measures. This is especially true for deep walls when stiff soils and rock are encountered which make driving sheetpile difficult.

C.3.6.3.2. Slurry Trench / Synthetic Membrane

These subsurface barriers consist of a vertically excavated trench that is filled with slurry. The slurry hydraulically shores the trench to prevent collapse allowing the membrane panels to be inserted to the desired depth using a steel frame. Synthetic membranes used for vertical cutoff walls are generally made from high-density polyethylene; however, other polymers have been used. Membrane sheets can be continuous, but usually finite length panels that interlock are preferred. The final depth of installation is a function of the trenching equipment capability. Most slurry trenches are constructed of a soil, bentonite, and water mixture, which along with the synthetic membrane provide a low permeability barrier. As with steel sheetpile, the required wall depth and encountered soil conditions significantly affect construction costs.

C.4 PROJECT COST ESTIMATES

The construction cost estimates for the Restudy are accomplished by a variety of means. The volume of estimates to be achieved in a short time frame and the lack of design information necessitated innovative approaches to deriving component cost. The components are similar in that they generally contain a limited variety of features. Namely the features are levees, canals, spillways, culverts, pump stations, aquifer storage and recovery systems, and cut-off walls. The design information was, as a rule, limited to the sizing of the features. For example the design of a canal might be specified as one mile long, bottom width 20 feet, depth 10 feet. The components consist of a combination of features with various individual size parameters. All component features were estimated utilizing MCACES (Micro Computer Aided Cost Engineering System). Spreadsheet models were developed to facilitate quantity calculation, equipment production rates, cost risk assessment, and narrative descriptions. Although all cost estimates for this study were accomplished in MCACES, for conciseness and readability the costs are presented in Attachment A in a spreadsheet format.

C.4.1 BASIS OF COST

C.4.1.1. Labor Rates

Labor rates were developed from several sources. The Davis Bacon General Decision #FL980032, February 1998 (including Dade, Broward, Collier, Lee, Martin, Palm Beach, and St. Lucie counties), was the primary data source. The other sources were the MCACES National Labor Rates Database, and "Open-Shop Wage Rates For Journeymen," published June 29, 1998, in ENR magazine. As is usual practice, rates for all anticipated labor designations were developed for the Review Study Labor Rates Database. Development included interpolation for crafts not expressly identified in the source data. The rates include basic rate, payroll tax and insurance, and fringe benefits. Basic rates were revised to allow for any inconsistencies and to update labor rates to the effective pricing date.

C.4.1.2. Equipment Rates

Equipment rates are from EP 1110-1-8 Volume 3, September 1997, "Construction Equipment Ownership and Operating Expense Schedule Region III" (Southeast Region).

C.4.1.3. Material Costs

Material costs were obtained from the MCACES Unit Price Book database dated January 1996, published cost data, and previous estimates for similar work.

C.4.1.4. Contractor Costs

Prime contractor costs were added to direct costs. The aggregate percentage used was 29.54 percent of direct costs. No subcontractor costs were included.

C.4.1.5. Planning, Engineering, and Design Costs

Planning, engineering, and design costs are included in the estimates. The cost was not estimated. The cost included in the estimates is calculated as a percentage of construction cost.

C.4.1.6. Supervision and Administration Costs

Supervision and Administration cost is included in the estimates. The cost was not estimated. The cost included in the estimates is calculated as a percentage of construction cost.

C.4.1.7. Out of Scope Cost

The cost for each component includes cost for out of scope items. This cost is not properly a contingency cost. The limited designs and estimating models omitted unknown but necessary appurtenant and supporting construction items. A cost for out of scope items was included at the project level in the MCACES estimates.

C.4.2 FEATURE COST BASIS

C.4.2.1. Earthwork

Spreadsheet models were developed and used to calculate various earthwork quantities and equipment production rates. The quantity models accommodated inputs for material swell, material compaction, unsuitable material, amount of rock, incidental construction necessary, and the design criteria. The spreadsheet production rate models were based on methods and data provided in “Caterpillar Performance Handbook,” editions 20 and 24. The earthwork estimates were produced by creating MCACES models and crews for specific tasks. Appropriate MCACES models and crews were imported into the estimate and then the model’s applicable parameters were retrieved from the spreadsheet models.

C.4.2.2. Structures

C.4.2.2.1. Pump Stations

Analysis of historic pump station costs compared with pumping capacity revealed that the costs are directly proportional to the pumping capacity. The method involved updating the historic costs to a particular pricing date before performing a linear regression analysis. The linear regression analysis provided the basis for the MCACES pumping station cost models. There are three models for pumping stations, and all three rely on the direct proportionality of cost to pumping capacity. The first model is for pumping plants with a capacity of 0 to 125 cfs. The model basis is a historic estimate for a seepage pump plant of small capacity. The model plant's design is typical of the design required for small pump plants in the study area. The second model is for pumping plants with a pumping capacity of 126 cfs to 1060 cfs. This model is based on S332D, a 550 cfs pumping plant for which there is a historic MCACES government estimate and bid results. The MCACES estimate for S332D was first proportioned to reflect the winning bid, and then updated to the effective pricing date of October 1998. The third model is for pumping plants with capacity over 1061 cfs. This model is based on recent feasibility cost estimates for S319 and S362. These pump stations have a design capacity of 3800 and 4200 cfs, respectively.

C.4.2.2.2. Spillways

The logic applied to pump station models was also applied to spillway structures. Gated spillways were modeled after S65 for which there were historic estimates. Manipulation of this model from application to application was necessary in order to match not only the flow capacity, but also the number of gates indicated by the design data.

C.4.2.2.3. Culverts

The MCACES corrugated metal culvert model was derived from several different historic estimates. Manipulation of this model from application to application was necessary in order to match the designed culvert diameter. An expressly produced MCACES model for concrete box culverts was used for that type culvert is specified.

C.4.2.2.4. Uncommon Structures

The cost estimates for ASRs, re-use facilities, and deep cut-off walls relied upon data provided by vendors, contractors, and outside agencies. SFWMD provided much of the data incorporated in the ASR cost estimates. Bower of America Corporation provided information related to the excavation and construction of deep cut off walls in rock.

C.4.3 COST RANGE ESTIMATES

C.4.3.1. Contingency Cost

The contingency cost for the construction cost estimates produced for this study is the difference between the point estimate and the "90% confidence level" estimate. The possibility that a particular feature may indeed not be built, or that its capacity or configuration may indeed be radically altered, is not within the scope of cost risk analysis. The range estimates are based on the scope of work presented in the limited design information. The design variances assumed for cost risk analysis are within a range that would not change the fundamental nature of the component feature.

C.4.3.2. Cost Risk

The cost risk associated with each feature was appraised separately. Because of the lack of design information and lack of specific geological information, the cost estimates are considered generic estimates which are not site specific. The unknowns themselves are sometimes unknown. This makes the creation of a range of costs more meaningful as a basis for decisions related to funding and execution of further studies on particular components or features.

The cost estimates were prepared using the data provided and a series of assumptions. The design data itself can not be taken as exact. From the standpoint of cost, it must be assumed that a design specific such as levee length is, in actuality, the most probable value of a range of values. The cost estimates rely on assumed values for criteria essential for the estimate, but for which there is no engineering data. An example is the swell factor for excavated material. For the point estimate, a single value is assumed. While for the range estimate, a variety of values may be assumed. A pessimistic cost estimate could be produced by incorporating the worst case of all input criteria necessary for the estimate. The likelihood of this happing is almost nonexistent. The more likely case is that the different criteria fall at various values within their likely range of values.

C.4.3.3. 90% Confidence Interval

The mechanism utilized to establish a cost range is “Crystal Ball.” It is a computer program Monte Carlo simulator produced by Decisioneering of Denver, Colorado. The high end of the range estimates presented are, as a rule, the 90% confidence level estimates.

C.5 OPERATION AND MAINTENANCE COST ESTIMATES

The estimated operation and maintenance (O&M) costs summarized for the Restudy are based upon work originally developed by Burns & McDonnell (reference 9) for the South Florida Water Management District. Labor rates, equipment costs, equipment replacement, equipment life, fuel consumption, and maintenance expenditures for functions such as mowing, spraying, exotics removal, control structures, pump stations, etc. were generally based upon the historical data of the South Florida Water Management District in operation of the Central and South Florida Project. Costs were updated from fiscal year 1993 to 1998 using current costs or an escalation factor of 3.5 per cent per year as applicable. The following text summarizes the basis for specific facility components:

- Pump Stations. Pump stations above 250 cfs are projected to use manually operated diesel pumps. Crew sizes are based upon District operating experience. Additional support crew members (machinists, mechanics, etc. are added for multiple pump stations on a basis of five members for every six stations. Smaller pump stations are projected to use electric pumps. Estimated costs for the latter stations are based upon remote operations; hence, involve a lump sum annual cost. A thirty-year life expectancy is projected for major components such as engines, pumps and generators.

- Primary Control Structures. Structures such as gated spillways, etc. require regular maintenance estimated at an annual cost per year. Mechanical and electrical components have a life expectancy of 20 years and major renovation is projected at that point.

- Levee Maintenance. District experience is the basis for the average annual estimated costs. Mowing of flat surfaces and sloped surfaces are estimated at established costs per acre. Exotics control and growth retardance estimates are also based upon an established per acre cost. Regular mowing and spraying is projected for top and side slopes of the levees.

- Wetlands and Reservoir Maintenance. Maintenance costs are based upon District experience on a per acre basis for activities such as spot spraying for exotics control, minor structure maintenance (gated culverts, etc.) and similar activities.

Note that operation costs to a great degree and maintenance costs to a lesser degree will be directly influenced by weather conditions; thus, subject to wide variation. Consequently, average costs are the norm. At best, the estimates provided an accurate basis for the comparison of alternatives during selection of the preferred alternative. At this stage of the Restudy, it is incorrect to believe that the O&M costs are any more accurate than the engineering assessments from which they are derived. The estimates are a reasonable assessment of operation and maintenance costs of the recommended components based upon an average weather year. More accurate estimates will be derived as the design of components proceeds to the detailed design stage based upon normal studies and analyses that precede development of plans and specifications for construction. At that point sizes, locations and performance characteristics of the recommended components will be available. Even then, however, the estimated cost accuracy is dependent upon the average weather year concept. As Mother Nature has yet to consistently provide us with average weather years, the estimates will remain simply that…estimates based upon historical data, that over a period of years, will reasonably project the total outlay of funds for the term of study.

C.6 REFERENCES

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ATTACHMENT A

M-CACES COST ESTIMATES

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT A7012P: A7 North L.O. Storage
A7 North L.O. Storage SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CP Canal fm reservoir to C 41			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 Canal -			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	3,000	1,000	3,000
CP_01_09_02_ 2 Other Work	17,000	5,000	21,000
CP_01_09_02_ 3 Mechanical Dredging	143,000	40,000	183,000
TOTAL Canal -	162,000	46,000	208,000
TOTAL Channels and Canals	162,000	46,000	208,000
TOTAL Construction Cost	162,000	46,000	208,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	13,000	4,000	17,000
TOTAL Planning, Engineering and Design	13,000	4,000	17,000
CP_02_31 Construction Management			
CP_02_31_23 Construction Contracts	16,000	5,000	21,000
TOTAL Construction Management	16,000	5,000	21,000
TOTAL Non Construction Cost	29,000	8,000	37,000
TOTAL Canal fm reservoir to C 41	191,000	54,000	245,000
CS Culvert Structure			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_01 Culvert Structure			
CS_01_15_01_ 1 Mob, Demob & Preparatory Work	387,000	36,000	422,000
CS_01_15_01_ 3 Earthwork for Structures	183,000	17,000	200,000
CS_01_15_01_ 4 Foundation Work	836,000	77,000	913,000
CS_01_15_01_ 5 Embedded Metal Work	15,000	1,000	17,000
CS_01_15_01_ 8 Associated General Items	288,000	27,000	315,000
CS_01_15_01_ 9 10 - 6' dia. CMP	784,000	72,000	856,000
TOTAL Culvert Structure	2,494,000	229,000	2,723,000
TOTAL 15 Floodway Control-Divert. Strt	2,494,000	229,000	2,723,000
TOTAL Construction Cost	2,494,000	229,000	2,723,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	202,000	19,000	221,000
CS_02_31 Construction Management	249,000	23,000	272,000
TOTAL Non Construction Cost	452,000	42,000	493,000
TOTAL Culvert Structure	2,946,000	271,000	3,217,000
LP Levee - Reservoir			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	429,000	204,000	633,000
LP_01_09_02_ 2 Mechanical Dredging	8,214,000	3,901,000	12,115,000
TOTAL Borrow Canal	8,643,000	4,105,000	12,748,000
TOTAL Channels and Canals	8,643,000	4,105,000	12,748,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	391,000	155,000	545,000
LP_01_11_01_ 2 Care & Diversion of Water	8,329,000	3,298,000	11,628,000
LP_01_11_01_ 3 Associated General Items	2,236,000	885,000	3,121,000
TOTAL Levees	10,956,000	4,338,000	15,294,000
TOTAL Levees and Floodwalls	10,956,000	4,338,000	15,294,000
TOTAL Construction Cost	19,598,000	8,444,000	28,042,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT A7012P: A7 North L.O. Storage
A7 North L.O. Storage SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	1,567,000	627,000	2,194,000
LP_02_31 Construction Management	1,956,000	782,000	2,738,000
TOTAL Non Construction Cost	3,523,000	1,409,000	4,932,000
TOTAL Levee - Reservoir	23,122,000	9,853,000	32,975,000
LS Levee - STA			
LS_01 Construction Cost			
LS_01_09 Channels and Canals			
LS_01_09_02 Borrow Canal			
LS_01_09_02_ 1 Mob, Demob & Preparatory Work	45,000	22,000	67,000
LS_01_09_02_ 2 Mechanical Dredging	868,000	412,000	1,280,000
TOTAL Borrow Canal	913,000	434,000	1,347,000
TOTAL Channels and Canals	913,000	434,000	1,347,000
LS_01_11 Levees and Floodwalls			
LS_01_11_01 Levees			
LS_01_11_01_ 1 Mob, Demob & Preparatory Work	41,000	16,000	58,000
LS_01_11_01_ 2 Care & Diversion of Water	880,000	348,000	1,229,000
LS_01_11_01_ 3 Associated General Items	236,000	94,000	330,000
TOTAL Levees	1,158,000	458,000	1,616,000
TOTAL Levees and Floodwalls	1,158,000	458,000	1,616,000
TOTAL Construction Cost	2,071,000	892,000	2,963,000
LS_02 Non Construction Cost			
LS_02_30 Planning, Engineering and Design	166,000	66,000	232,000
LS_02_31 Construction Management	207,000	83,000	289,000
TOTAL Non Construction Cost	372,000	149,000	521,000
TOTAL Levee - STA	2,443,000	1,041,000	3,484,000
PS Pump Stations			
PS_01 Construction Cost			
PS_01_13 Pumping Plant			
PS_01_13_01 Pump Plant to Reservoir 4800CFS	38,712,000	1,936,000	40,648,000
PS_01_13_02 Pump Plant - Seepage 94CFS	281,000	14,000	295,000
PS_01_13_03 Pump Plant - Seepage 94CFS	281,000	14,000	295,000
TOTAL Pumping Plant	39,274,000	1,964,000	41,238,000
TOTAL Construction Cost	39,274,000	1,964,000	41,238,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	3,144,000	157,000	3,301,000
PS_02_31 Construction Management	3,932,000	197,000	4,129,000
TOTAL Non Construction Cost	7,076,000	354,000	7,430,000
TOTAL Pump Stations	46,351,000	2,318,000	48,668,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 3 Gate Spillway	5,137,000	473,000	5,609,000
TOTAL 15 Floodway Control-Divert. Strt	5,137,000	473,000	5,609,000
TOTAL Construction Cost	5,137,000	473,000	5,609,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	381,000	35,000	416,000
SW_02_31 Construction Management	476,000	44,000	520,000
TOTAL Non Construction Cost	857,000	79,000	936,000
TOTAL Spillways	5,993,000	551,000	6,545,000
TOTAL A7 North L.O. Storage	81,046,000	14,088,000	95,134,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT B2012P: B2 St Lucie/ C44 Basin
B2 C-44 Basin Storage SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CP Canal - Reservoir to C-44			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 Canal -			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	1,000	0	2,000
CP_01_09_02_ 2 Other Work	4,000	1,000	6,000
CP_01_09_02_ 3 Mechanical Dredging	39,000	11,000	50,000
TOTAL Canal -	44,000	13,000	57,000
TOTAL Channels and Canals	44,000	13,000	57,000
TOTAL Construction Cost	44,000	13,000	57,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	4,000	1,000	5,000
CP_02_31 Construction Management	4,000	1,000	6,000
TOTAL Non Construction Cost	8,000	2,000	10,000
TOTAL Canal - Reservoir to C-44	52,000	15,000	67,000
LP C44 Basin Reservoir Levee			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	103,000	54,000	157,000
LP_01_09_02_ 2 Mechanical Dredging	2,140,000	1,115,000	3,255,000
TOTAL Borrow Canal	2,244,000	1,169,000	3,412,000
TOTAL Channels and Canals	2,244,000	1,169,000	3,412,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	76,000	52,000	128,000
LP_01_11_01_ 2 Care & Diversion of Water	1,624,000	1,111,000	2,735,000
LP_01_11_01_ 3 Associated General Items	505,000	345,000	850,000
TOTAL Levees	2,205,000	1,508,000	3,713,000
TOTAL Levees and Floodwalls	2,205,000	1,508,000	3,713,000
TOTAL Construction Cost	4,449,000	2,677,000	7,126,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	176,000	88,000	265,000
LP_02_31 Construction Management	221,000	110,000	331,000
TOTAL Non Construction Cost	397,000	198,000	595,000
TOTAL C44 Basin Reservoir Levee	4,846,000	2,876,000	7,721,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant to Reservoir 1000CFS	9,593,000	432,000	10,025,000
PS_01_02 Pump Plant 2ea 33cfs Seepage	181,000	16,000	197,000
TOTAL Pumping Plant	9,774,000	447,000	10,221,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	782,000	47,000	829,000
PS_02_31 Construction Management	978,000	59,000	1,037,000
TOTAL Non Construction Cost	1,760,000	106,000	1,866,000
TOTAL Pump Station	11,535,000	553,000	12,087,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 1 Gate Spillway	1,578,000	167,000	1,745,000
TOTAL 15 Floodway Control-Divert. Strt	1,578,000	167,000	1,745,000
TOTAL Construction Cost	1,578,000	167,000	1,745,000

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PROJECT B2012P: B2 St Lucie/ C44 Basin
B2 C-44 Basin Storage

SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	107,000	11,000	119,000
SW_02_31 Construction Management	134,000	14,000	148,000
TOTAL Non Construction Cost	242,000	26,000	267,000
TOTAL Spillways	1,820,000	193,000	2,013,000
TOTAL B2 St Lucie/ C44 Basin	18,252,000	3,636,000	21,888,000

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                                          U.S. Army Corps of Engineers
Eff. Date  10/01/99                     PROJECT D5012P:   D5 C43 Basin
                                             D5 C43 Basin Storage                                  SUMMARY PAGE    1
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                                                                                  CONTRACT    CONTINGN  TOTAL COST
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	CONTRACT	CONTINGN	TOTAL COST
AS Aquifer Storage and Recovery			
AS_01 Construction Cost			
AS_01_13 Pumping Plant			
AS_01_13_01 ASR WellFields 5MGD wells	58,911,000	14,728,000	73,638,000
AS_01_13_02 Pretreatment by Ultrafiltration	88,366,000	22,092,000	110,458,000
AS_01_13_03 Aeration Cost	295,000	74,000	369,000
AS_01_13_04 Chlorination	3,452,000	863,000	4,315,000
TOTAL Pumping Plant	151,024,000	37,756,000	188,780,000
TOTAL Construction Cost	151,024,000	37,756,000	188,780,000
AS_02 Non Construction Cost			
AS_02_30 Planning, Engineering and Design	15,102,000	3,625,000	18,727,000
AS_02_31 Construction Management	30,205,000	7,249,000	37,454,000
TOTAL Non Construction Cost	45,307,000	10,874,000	56,181,000
TOTAL Aquifer Storage and Recovery	196,331,000	48,630,000	244,960,000
BR Bridge			
BR_01 Construction Cost			
BR_01_08 Roads, Railroads, and Bridges			
BR_01_08_01 Bridges	282,000	70,000	352,000
TOTAL Roads, Railroads, and Bridges	282,000	70,000	352,000
TOTAL Construction Cost	282,000	70,000	352,000
BR_02 Non Construction Cost			
BR_02_30 Planning, Engineering and Design	23,000	5,000	28,000
BR_02_31 Construction Management	28,000	7,000	35,000
TOTAL Non Construction Cost	51,000	12,000	63,000
TOTAL Bridge	333,000	83,000	415,000
CP Canal Reservoir to C43			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 Canal -			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	44,000	13,000	57,000
CP_01_09_02_ 2 Other Work	156,000	46,000	202,000
CP_01_09_02_ 3 Mechanical Dredging	1,340,000	399,000	1,739,000
TOTAL Canal -	1,540,000	459,000	1,999,000
TOTAL Channels and Canals	1,540,000	459,000	1,999,000
TOTAL Construction Cost	1,540,000	459,000	1,999,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	122,000	35,000	157,000
CP_02_31 Construction Management	152,000	44,000	197,000
TOTAL Non Construction Cost	274,000	80,000	354,000
TOTAL Canal Reservoir to C43	1,814,000	538,000	2,353,000
LP C43 Basin Reservoir Levee			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	357,000	113,000	470,000
LP_01_09_02_ 2 Mechanical Dredging	7,241,000	2,288,000	9,529,000
TOTAL Borrow Canal	7,598,000	2,401,000	9,999,000
TOTAL Channels and Canals	7,598,000	2,401,000	9,999,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	298,000	98,000	397,000
LP_01_11_01_ 2 Care & Diversion of Water	6,312,000	2,083,000	8,396,000
LP_01_11_01_ 3 Associated General Items	1,133,000	374,000	1,507,000
TOTAL Levees	7,744,000	2,556,000	10,300,000
TOTAL Levees and Floodwalls	7,744,000	2,556,000	10,300,000
TOTAL Construction Cost	15,342,000	4,957,000	20,299,000

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U.S. Army Corps of Engineers
PROJECT D5012P: D5 C43 Basin
D5 C43 Basin Storage

SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	1,213,000	388,000	1,602,000
LP_02_31 Construction Management	1,517,000	485,000	2,002,000
TOTAL Non Construction Cost	2,730,000	874,000	3,604,000
TOTAL C43 Basin Reservoir Levee	18,072,000	5,830,000	23,902,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant 3800 cfs to Reservoir	30,081,000	1,474,000	31,555,000
PS_01_02 Pump Plant 2@ 95cfs Seepage	557,000	48,000	605,000
TOTAL Pumping Plant	30,638,000	1,522,000	32,160,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	2,448,000	122,000	2,570,000
PS_02_31 Construction Management	3,065,000	153,000	3,218,000
TOTAL Non Construction Cost	5,512,000	276,000	5,788,000
TOTAL Pump Station	36,151,000	1,798,000	37,948,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 2 Gate Spillway	3,007,000	481,000	3,488,000
TOTAL 15 Floodway Control-Divert. Strt	3,007,000	481,000	3,488,000
TOTAL Construction Cost	3,007,000	481,000	3,488,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	195,000	31,000	226,000
SW_02_31 Construction Management	243,000	39,000	281,000
TOTAL Non Construction Cost	437,000	70,000	507,000
TOTAL Spillways	3,444,000	551,000	3,996,000
TOTAL D5 C43 Basin	256,145,000	57,429,000	313,574,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT G5012P: G5 EAA Storage Canals
G5 EAA Storage Canals & Enlarge Miami; NNR SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CP Canals for 60k Storage & Enlarge			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 Combined Canals for EAA Storage			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	214,000	50,000	263,000
CP_01_09_02_ 2 Other Work	494,000	115,000	609,000
CP_01_09_02_ 3 Mechanical Dredging	4,112,000	962,000	5,075,000
TOTAL Combined Canals for EAA Storage	4,819,000	1,128,000	5,947,000
CP_01_09_03 Enlarge Miami & NNR Canals			
CP_01_09_03_ 1 Mob, Demob & Preparatory Work	1,667,000	390,000	2,057,000
CP_01_09_03_ 2 Other Work	3,854,000	902,000	4,755,000
CP_01_09_03_ 3 Mechanical Dredging	32,112,000	7,514,000	39,626,000
TOTAL Enlarge Miami & NNR Canals	37,632,000	8,806,000	46,438,000
TOTAL Channels and Canals	42,452,000	9,934,000	52,385,000
TOTAL Construction Cost	42,452,000	9,934,000	52,385,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	3,292,000	757,000	4,049,000
CP_02_31 Construction Management	4,110,000	945,000	5,055,000
TOTAL Non Construction Cost	7,402,000	1,702,000	9,105,000
TOTAL Canals for 60k Storage & Enlarge	49,854,000	11,636,000	61,490,000
LP Reservoir System Levees			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	695,000	135,000	830,000
LP_01_09_02_ 2 Mechanical Dredging	13,996,000	2,729,000	16,725,000
TOTAL Borrow Canal	14,691,000	2,865,000	17,555,000
TOTAL Channels and Canals	14,691,000	2,865,000	17,555,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	681,000	129,000	810,000
LP_01_11_01_ 2 Care & Diversion of Water	16,886,000	3,208,000	20,095,000
LP_01_11_01_ 3 Associated General Items	2,774,000	527,000	3,301,000
TOTAL Levees	20,341,000	3,865,000	24,206,000
TOTAL Levees and Floodwalls	20,341,000	3,865,000	24,206,000
TOTAL Construction Cost	35,031,000	6,729,000	41,761,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	2,719,000	517,000	3,235,000
LP_02_31 Construction Management	3,398,000	646,000	4,044,000
TOTAL Non Construction Cost	6,117,000	1,162,000	7,279,000
TOTAL Reservoir System Levees	41,149,000	7,892,000	49,040,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant #1 2700 Cfs to Comp 1	21,700,000	1,063,000	22,763,000
PS_01_02 Pump Plant #2 to res 2A 4500cfs	36,167,000	1,772,000	37,939,000
PS_01_03 Pump Plant #3 to res 2B 4500 cfs	36,167,000	1,772,000	37,939,000
PS_01_04 Pump Plant #4 hills to 20k 2300	18,485,000	906,000	19,391,000
PS_01_05 Pump Plant #5 Hills to Comp 2A	18,485,000	906,000	19,391,000
PS_01_06 Pump Plant #6 Hills to comp 2B	18,485,000	906,000	19,391,000
PS_01_07 Pump Plant 7&8 60 cfs ea seepage	357,000	31,000	388,000
TOTAL Pumping Plant	149,847,000	7,356,000	157,203,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	12,001,000	600,000	12,601,000
PS_02_31 Construction Management	14,974,000	749,000	15,723,000
TOTAL Non Construction Cost	26,975,000	1,349,000	28,324,000
TOTAL Pump Station	176,822,000	8,704,000	185,527,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT G5012P: G5 EAA Storage Canals
G5 EAA Storage Canals & Enlarge Miami; NNR SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 Total of 29 Gates Spillway	41,709,000	4,379,000	46,088,000
TOTAL 15 Floodway Control-Divert. Strt	41,709,000	4,379,000	46,088,000
TOTAL Construction Cost	41,709,000	4,379,000	46,088,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	3,218,000	322,000	3,540,000
SW_02_31 Construction Management	4,025,000	402,000	4,427,000
TOTAL Non Construction Cost	7,243,000	724,000	7,967,000
TOTAL Spillways	48,952,000	5,104,000	54,056,000
TOTAL G5 EAA Storage Canals	316,776,000	33,336,000	350,112,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT K6020P: K6 L8 Improvements Canal
K6 L8 Improvements Canal SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
AS Aquifer Storage and Recovery			
AS_01 Construction Cost			
AS_01_13 Pumping Plant			
AS_01_13_01 ASR WellFields 5MGD wells	13,377,000	3,344,000	16,721,000
AS_01_13_02 Pretreatment by Ultrafiltration	20,065,000	5,016,000	25,081,000
AS_01_13_03 Aeration Cost	67,000	17,000	84,000
AS_01_13_04 Chlorination	784,000	196,000	980,000
TOTAL Pumping Plant	34,292,000	8,573,000	42,865,000
TOTAL Construction Cost	34,292,000	8,573,000	42,865,000
AS_02 Non Construction Cost			
AS_02_30 Planning, Engineering and Design	3,429,000	857,000	4,287,000
AS_02_31 Construction Management	6,858,000	1,715,000	8,573,000
TOTAL Non Construction Cost	10,288,000	2,572,000	12,860,000
TOTAL Aquifer Storage and Recovery	44,580,000	11,145,000	55,725,000
CP M- Canal Enlargement			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 M canal Enlarge			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	79,000	29,000	108,000
CP_01_09_02_ 2 Other Work	184,000	67,000	251,000
CP_01_09_02_ 3 Mechanical Dredging	1,690,000	617,000	2,307,000
TOTAL M canal Enlarge	1,953,000	713,000	2,666,000
TOTAL Channels and Canals	1,953,000	713,000	2,666,000
TOTAL Construction Cost	1,953,000	713,000	2,666,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	156,000	55,000	211,000
CP_02_31 Construction Management	195,000	68,000	264,000
TOTAL Non Construction Cost	352,000	123,000	475,000
TOTAL M- Canal Enlargement	2,305,000	836,000	3,141,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure			
CS_01_15_02_ 01 4 - 4' dia. CMP	307,000	29,000	335,000
CS_01_15_02_ 02 2 - 4' dia. CMP	268,000	25,000	293,000
TOTAL Culvert Structure	575,000	53,000	628,000
TOTAL 15 Floodway Control-Divert. Strt	575,000	53,000	628,000
TOTAL Construction Cost	575,000	53,000	628,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design			
CS_02_30_21 General Design Memorandum	50,000	0	50,000
TOTAL Planning, Engineering and Design	50,000	0	50,000
CS_02_31 Construction Management			
CS_02_31_23 Construction Contracts			
CS_02_31_23_ 1 Construction Administration	63,000	0	63,000
TOTAL Construction Contracts	63,000	0	63,000
TOTAL Construction Management	63,000	0	63,000
TOTAL Non Construction Cost	113,000	0	113,000
TOTAL Culverts	688,000	53,000	741,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant #1 in M canal	3,075,000	138,000	3,214,000
PS_01_02 Pump Plant #2 to upper M1 Basin	3,075,000	138,000	3,214,000
PS_01_03 Pump Plant #3 to lower M1 Basin	2,050,000	92,000	2,142,000
PS_01_04 Pump Plant #4 water supply	147,000	7,000	153,000
TOTAL Pumping Plant	8,347,000	376,000	8,723,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT K6020P: K6 L8 Improvements Canal
K6 L8 Improvements Canal SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	668,000	33,000	701,000
PS_02_31 Construction Management	835,000	42,000	876,000
TOTAL Non Construction Cost	1,502,000	75,000	1,578,000
TOTAL Pump Station	9,850,000	451,000	10,300,000
TOTAL K6 L8 Improvements Canal	57,423,000	12,485,000	69,908,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT M6012P: M6 Site 1 Impoundment
M6 Site 1 Impoundment SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
AS Aquifer Storage and Recovery			
AS_01 Construction Cost			
AS_01_13 Pumping Plant			
AS_01_13_01 ASR WellFields 5MGD wells	50,640,000	12,660,000	63,300,000
AS_01_13_02 Surficial Wells	15,192,000	3,798,000	18,990,000
AS_01_13_03 Aeration Cost	253,000	63,000	317,000
AS_01_13_04 Chlorination	2,962,000	741,000	3,703,000
TOTAL Pumping Plant	69,048,000	17,262,000	86,310,000
TOTAL Construction Cost	69,048,000	17,262,000	86,310,000
AS_02 Non Construction Cost			
AS_02_30 Planning, Engineering and Design	5,528,000	1,382,000	6,910,000
AS_02_31 Construction Management	6,900,000	1,725,000	8,625,000
TOTAL Non Construction Cost	12,428,000	3,107,000	15,535,000
TOTAL Aquifer Storage and Recovery	81,476,000	20,369,000	101,844,000
CP Canal-Reservoir to Hillsboro C			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 Canal -			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	1,000	0	1,000
CP_01_09_02_ 2 Other Work	2,000	1,000	3,000
CP_01_09_02_ 3 Mechanical Dredging	16,000	5,000	22,000
TOTAL Canal -	19,000	6,000	25,000
TOTAL Channels and Canals	19,000	6,000	25,000
TOTAL Construction Cost	19,000	6,000	25,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	1,000	1,000	2,000
CP_02_31 Construction Management	2,000	1,000	3,000
TOTAL Non Construction Cost	3,000	1,000	5,000
TOTAL Canal-Reservoir to Hillsboro C	22,000	8,000	30,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure			
CS_01_15_02_ 01 4 - 4' dia. CMP	337,000	38,000	376,000
CS_01_15_02_ 02 4 - 6' dia. CMP	404,000	46,000	449,000
CS_01_15_02_ 03 4 - 6' dia. CMP under farm Rd	428,000	48,000	476,000
TOTAL Culvert Structure	1,169,000	132,000	1,301,000
TOTAL 15 Floodway Control-Divert. Strt	1,169,000	132,000	1,301,000
TOTAL Construction Cost	1,169,000	132,000	1,301,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	86,000	10,000	95,000
CS_02_31 Construction Management	107,000	12,000	119,000
TOTAL Non Construction Cost	193,000	22,000	215,000
TOTAL Culverts	1,362,000	154,000	1,516,000
LP Reservoir Levee			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	108,000	3,000	111,000
LP_01_09_02_ 2 Mechanical Dredging	2,678,000	78,000	2,755,000
TOTAL Borrow Canal	2,786,000	81,000	2,866,000
TOTAL Channels and Canals	2,786,000	81,000	2,866,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT M6012P: M6 Site 1 Impoundment
M6 Site 1 Impoundment SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	73,000	23,000	96,000
LP_01_11_01_ 2 Care & Diversion of Water	1,669,000	527,000	2,196,000
LP_01_11_01_ 3 Associated General Items	301,000	95,000	396,000
TOTAL Levees	2,043,000	646,000	2,689,000
TOTAL Levees and Floodwalls	2,043,000	646,000	2,689,000
TOTAL Construction Cost	4,829,000	726,000	5,555,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	538,000	81,000	619,000
LP_02_31 Construction Management	595,000	89,000	684,000
TOTAL Non Construction Cost	1,133,000	170,000	1,303,000
TOTAL Reservoir Levee	5,962,000	896,000	6,858,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant Hillsboro to Reservoi	5,174,000	233,000	5,407,000
PS_01_02 Pump Plant 2ea 21cfs seepage	124,000	11,000	135,000
TOTAL Pumping Plant	5,299,000	243,000	5,542,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	424,000	21,000	445,000
PS_02_31 Construction Management	530,000	26,000	556,000
TOTAL Non Construction Cost	954,000	48,000	1,001,000
TOTAL Pump Station	6,252,000	291,000	6,543,000
TOTAL M6 Site 1 Impoundment	95,074,000	21,718,000	116,792,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT O4012P: O4 WCA 3A,B Levee Seepage Mgt
O4 WCA 3A & 3B Levee Seepage Management SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
LP Levee West of US HiWy 27			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	139,000	33,000	173,000
LP_01_09_02_ 2 Mechanical Dredging	5,051,000	1,212,000	6,263,000
TOTAL Borrow Canal	5,190,000	1,246,000	6,436,000
TOTAL Channels and Canals	5,190,000	1,246,000	6,436,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	110,000	27,000	137,000
LP_01_11_01_ 2 Care & Diversion of Water	2,139,000	522,000	2,661,000
LP_01_11_01_ 3 Associated General Items	475,000	116,000	591,000
TOTAL Levees	2,725,000	665,000	3,390,000
TOTAL Levees and Floodwalls	2,725,000	665,000	3,390,000
TOTAL Construction Cost	7,915,000	1,910,000	9,825,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	634,000	152,000	786,000
LP_02_31 Construction Management	792,000	190,000	983,000
TOTAL Non Construction Cost	1,426,000	342,000	1,769,000
TOTAL Levee West of US HiWy 27	9,341,000	2,253,000	11,594,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 2 Gate Spillway			
SW_01_15_01_ 2 Care and Diversion of Water	1,484,000	249,000	1,734,000
SW_01_15_01_ 3 Earthwork for Structures	61,000	10,000	71,000
SW_01_15_01_ 4 Foundation Work	277,000	47,000	324,000
SW_01_15_01_ 5 Embedded Metal Work	5,000	1,000	6,000
SW_01_15_01_ 6 Gates, Stop Logs-Associated Eqpt	268,000	45,000	313,000
SW_01_15_01_ 7 Overflow Structure	381,000	64,000	445,000
SW_01_15_01_ 8 Associated General Items	146,000	25,000	171,000
TOTAL 2 Gate Spillway	2,622,000	441,000	3,063,000
TOTAL 15 Floodway Control-Divert. Strt	2,622,000	441,000	3,063,000
TOTAL Construction Cost	2,622,000	441,000	3,063,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	210,000	36,000	246,000
SW_02_31 Construction Management	262,000	45,000	307,000
TOTAL Non Construction Cost	472,000	80,000	553,000
TOTAL Spillways	3,095,000	521,000	3,616,000
TOTAL O4 WCA 3A,B Levee Seepage Mgt	12,436,000	2,774,000	15,209,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT Q5012P: Q5 Western C11 Diversion Canal
Q5 Western C11 Diversion SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CP Diversion& Seepage Collect Canal			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 Canal -			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	173,000	42,000	215,000
CP_01_09_02_ 2 Other Work	401,000	98,000	499,000
CP_01_09_02_ 3 Mechanical Dredging	5,945,000	1,456,000	7,401,000
TOTAL Canal -	6,518,000	1,597,000	8,115,000
TOTAL Channels and Canals	6,518,000	1,597,000	8,115,000
TOTAL Construction Cost	6,518,000	1,597,000	8,115,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	514,000	126,000	639,000
CP_02_31 Construction Management	642,000	157,000	799,000
TOTAL Non Construction Cost	1,156,000	283,000	1,439,000
TOTAL Diversion& Seepage Collect Canal	7,674,000	1,880,000	9,554,000
LP STA Impoundment Levee			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	67,000	7,000	73,000
LP_01_09_02_ 2 Mechanical Dredging	2,175,000	213,000	2,389,000
TOTAL Borrow Canal	2,242,000	220,000	2,462,000
TOTAL Channels and Canals	2,242,000	220,000	2,462,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	37,000	5,000	42,000
LP_01_11_01_ 2 Care & Diversion of Water	650,000	87,000	737,000
LP_01_11_01_ 3 Associated General Items	168,000	23,000	191,000
TOTAL Levees	855,000	115,000	970,000
TOTAL Levees and Floodwalls	855,000	115,000	970,000
TOTAL Construction Cost	3,098,000	334,000	3,432,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	244,000	26,000	270,000
LP_02_31 Construction Management	305,000	33,000	338,000
TOTAL Non Construction Cost	549,000	59,000	608,000
TOTAL STA Impoundment Levee	3,647,000	393,000	4,040,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_02 Pump Plant intermediate (P3)	20,244,000	992,000	21,236,000
TOTAL Pumping Plant	20,244,000	992,000	21,236,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	1,616,000	81,000	1,696,000
PS_02_31 Construction Management	2,022,000	101,000	2,123,000
TOTAL Non Construction Cost	3,638,000	182,000	3,820,000
TOTAL Pump Station	23,882,000	1,174,000	25,056,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 2 Gate Spillway	2,813,000	298,000	3,111,000
TOTAL 15 Floodway Control-Divert. Strt	2,813,000	298,000	3,111,000
TOTAL Construction Cost	2,813,000	298,000	3,111,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT Q5012P: Q5 Western C11 Diversion Canal
Q5 Western C11 Diversion SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	224,000	24,000	248,000
SW_02_31 Construction Management	280,000	30,000	309,000
TOTAL Non Construction Cost	504,000	53,000	557,000
TOTAL Spillways	3,316,000	352,000	3,668,000
TOTAL Q5 Western C11 Diversion Canal	38,519,000	3,799,000	42,317,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT R4012P: R4 C-9 Impound & Divert
R4 C-9 Impoundment & Diversion SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CP 2 ea Joining Canals			
CP_01 Construction Cost			
CP_01_09 Channels and Canals			
CP_01_09_02 Canal -			
CP_01_09_02_ 1 Mob, Demob & Preparatory Work	3,000	1,000	4,000
CP_01_09_02_ 2 Other Work	7,000	2,000	9,000
CP_01_09_02_ 3 Mechanical Dredging	146,000	30,000	176,000
TOTAL Canal -	156,000	32,000	189,000
TOTAL Channels and Canals	156,000	32,000	189,000
TOTAL Construction Cost	156,000	32,000	189,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	13,000	3,000	15,000
CP_02_31 Construction Management	16,000	3,000	19,000
TOTAL Non Construction Cost	28,000	6,000	34,000
TOTAL 2 ea Joining Canals	185,000	38,000	223,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure			
CS_01_15_02_ 01 3 - 5' dia. CMP	340,000	34,000	374,000
CS_01_15_02_ 02 Concrete box culvert 2 ea	503,000	51,000	554,000
CS_01_15_02_ 03 5 - 5' dia. CMP	328,000	33,000	361,000
TOTAL Culvert Structure	1,171,000	118,000	1,289,000
TOTAL 15 Floodway Control-Divert. Strt	1,171,000	118,000	1,289,000
TOTAL Construction Cost	1,171,000	118,000	1,289,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	94,000	9,000	103,000
CS_02_31 Construction Management	117,000	12,000	129,000
TOTAL Non Construction Cost	211,000	21,000	232,000
TOTAL Culverts	1,382,000	139,000	1,521,000
LP Reservoir Levee			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal			
LP_01_09_02_ 1 Mob, Demob & Preparatory Work	60,000	24,000	84,000
LP_01_09_02_ 2 Mechanical Dredging	2,506,000	1,020,000	3,526,000
TOTAL Borrow Canal	2,566,000	1,044,000	3,610,000
TOTAL Channels and Canals	2,566,000	1,044,000	3,610,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees			
LP_01_11_01_ 1 Mob, Demob & Preparatory Work	42,000	8,000	49,000
LP_01_11_01_ 2 Care & Diversion of Water	726,000	137,000	863,000
LP_01_11_01_ 3 Associated General Items	190,000	36,000	226,000
TOTAL Levees	958,000	180,000	1,138,000
TOTAL Levees and Floodwalls	958,000	180,000	1,138,000
TOTAL Construction Cost	3,524,000	1,224,000	4,748,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	282,000	99,000	381,000
LP_02_31 Construction Management	352,000	123,000	476,000
TOTAL Non Construction Cost	634,000	222,000	856,000
TOTAL Reservoir Levee	4,158,000	1,446,000	5,605,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant seepage 2@16cfs	96,000	8,000	104,000
PS_01_02 Pump Plant into WPA frm C-9	12,181,000	597,000	12,777,000
TOTAL Pumping Plant	12,277,000	604,000	12,881,000

U.S. Army Corps of Engineers
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R4 C-9 Impoundment & Diversion SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	982,000	49,000	1,031,000
PS_02_31 Construction Management	1,223,000	61,000	1,284,000
TOTAL Non Construction Cost	2,205,000	110,000	2,316,000
TOTAL Pump Station	14,482,000	715,000	15,197,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 2 Gate Spillway	2,806,000	297,000	3,103,000
TOTAL 15 Floodway Control-Divert. Strt	2,806,000	297,000	3,103,000
TOTAL Construction Cost	2,806,000	297,000	3,103,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	224,000	24,000	248,000
SW_02_31 Construction Management	281,000	30,000	310,000
TOTAL Non Construction Cost	505,000	54,000	559,000
TOTAL Spillways	3,311,000	351,000	3,662,000
TOTAL R4 C-9 Impound & Divert	23,518,000	2,689,000	26,207,000

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                                        U.S. Army Corps of Engineers
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                                       S6 Central Lake Belt Storage  P                                  SUMMARY PAGE    1
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                                                                                           CONTRACT    CONTINGN  TOTAL COST
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                                     CO  Subterranean Seepage Barrier
                                     CO_01  Construction Cost
                                     CO_01_15  15 Floodway Control-Divert. Strt
                                     CO_01_15_01  Cut Off Wall Liner                       21,188,000  1,674,000  22,862,000
                                     CO_01_15_02  Cut Off Wall trenching complete         224,856,000 17,764,000 242,620,000
                                                                                          ----------- ----------- -----------
                                                TOTAL 15 Floodway Control-Divert. Strt 246,044,000 19,438,000 265,482,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Construction Cost                   246,044,000 19,438,000 265,482,000


                                     CO_02  Non Construction Cost
                                     CO_02_30  Planning, Engineering and Design            19,709,000  1,557,000  21,266,000
                                     CO_02_31  Construction Management                     24,556,000  1,940,000  26,495,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Non Construction Cost                44,265,000  3,497,000  47,762,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Subterranean Seepage Barrier        290,309,000 22,934,000 313,244,000


                                     CS  Culverts
                                     CS_01  Construction Cost
                                     CS_01_15  15 Floodway Control-Divert. Strt
                                     CS_01_15_02  Culvert Structure
                                     CS_01_15_02_ 01  5 - 6' dia. CMP                         296,000     30,000     325,000
                                     CS_01_15_02_ 02  7 - 6' dia. CMP                         314,000     31,000     346,000
                                     CS_01_15_02_ 03  3 - 6' dia. CMP                         302,000     30,000     332,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Culvert Structure                       912,000     91,000   1,003,000
                                                                                          ----------- ----------- -----------
                                                TOTAL 15 Floodway Control-Divert. Strt     912,000     91,000   1,003,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Construction Cost                       912,000     91,000   1,003,000


                                     CS_02  Non Construction Cost
                                     CS_02_30  Planning, Engineering and Design                73,000      7,000      81,000
                                     CS_02_31  Construction Management                         92,000      9,000     101,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Non Construction Cost                   165,000     16,000     181,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Culverts                              1,077,000    108,000   1,184,000


                                     LP  Levees
                                     LP_01  Construction Cost
                                     LP_01_09  Channels and Canals
                                     LP_01_09_02  Borrow Canal Polish Cell Levee
                                     LP_01_09_02_  1  Mob, Demob & Preparatory Work            35,000      9,000      44,000
                                     LP_01_09_02_  2  Mechanical Dredging                   1,443,000    367,000   1,810,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Borrow Canal Polish Cell Levee        1,478,000    375,000   1,854,000


                                     LP_01_09_03  Borrow Canal Reservoir Levee
                                     LP_01_09_03_  1  Mob, Demob & Preparatory Work           506,000    129,000     635,000
                                     LP_01_09_03_  2  Mechanical Dredging                  20,255,000  5,145,000  25,399,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Borrow Canal Reservoir Levee         20,761,000  5,273,000  26,034,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Channels and Canals                  22,239,000  5,649,000  27,888,000


                                     LP_01_11  Levees and Floodwalls
                                     LP_01_11_01  Levees- Polishing Cell
                                     LP_01_11_01_  1  Mob, Demob & Preparatory Work            24,000          0      25,000
                                     LP_01_11_01_  2  Care & Diversion of Water               439,000      9,000     448,000
                                     LP_01_11_01_  3  Associated General Items                111,000      2,000     113,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Levees- Polishing Cell                  575,000     11,000     586,000


                                     LP_01_11_02  Levees- Reservoir
                                     LP_01_11_02_  1  Mob, Demob & Preparatory Work            34,000      1,000      35,000
                                     LP_01_11_02_  2  Care & Diversion of Water             6,189,000    124,000   6,313,000
                                     LP_01_11_02_  3  Associated General Items                409,000      8,000     417,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Levees- Reservoir                     6,632,000    133,000   6,764,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Levees and Floodwalls                 7,207,000    144,000   7,351,000
                                                                                          ----------- ----------- -----------
                                                TOTAL Construction Cost                    29,446,000  5,793,000  35,239,000
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U.S. Army Corps of Engineers
PROJECT S6012P: S6 Central LB Storage
S6 Central Lake Belt Storage P

SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	2,359,000	464,000	2,823,000
LP_02_31 Construction Management	2,951,000	580,000	3,531,000
TOTAL Non Construction Cost	5,310,000	1,044,000	6,354,000
TOTAL Levees	34,755,000	6,837,000	41,593,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant to CLBSA fm L33	12,226,000	599,000	12,825,000
PS_01_02 Pump Plant to Polishing Cell	8,451,000	380,000	8,832,000
PS_01_03 Pump Plant off L30 to WCA 3B	5,282,000	238,000	5,520,000
PS_01_04 Pump Plant to Snapper Cr.	3,169,000	143,000	3,312,000
TOTAL Pumping Plant	29,129,000	1,360,000	30,488,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	2,326,000	116,000	2,443,000
PS_02_31 Construction Management	2,908,000	145,000	3,053,000
TOTAL Non Construction Cost	5,234,000	262,000	5,496,000
TOTAL Pump Station	34,363,000	1,621,000	35,984,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 2 Gate Spillway	2,813,000	298,000	3,111,000
TOTAL 15 Floodway Control-Divert. Strt	2,813,000	298,000	3,111,000
TOTAL Construction Cost	2,813,000	298,000	3,111,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	225,000	24,000	249,000
SW_02_31 Construction Management	282,000	30,000	311,000
TOTAL Non Construction Cost	507,000	54,000	561,000
TOTAL Spillways	3,320,000	352,000	3,672,000
TOTAL S6 Central LB Storage	363,824,000	31,853,000	395,677,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT T6012P: T6 C-4 Divide Structure
T6 C-4 Divide Structure SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 1 Gate Spillway	1,406,000	149,000	1,555,000
TOTAL 15 Floodway Control-Divert. Strt	1,406,000	149,000	1,555,000
TOTAL Construction Cost	1,406,000	149,000	1,555,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	112,000	12,000	124,000
SW_02_31 Construction Management	141,000	15,000	155,000
TOTAL Non Construction Cost	253,000	27,000	280,000
TOTAL Spillways	1,658,000	176,000	1,834,000
TOTAL T6 C-4 Divide Structure	1,658,000	176,000	1,834,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT U6012P: U6 Bird Drive Basin
U6 Bird Drive Basin Recharge Area SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canals all			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	18,002,000	3,186,000	21,188,000
TOTAL Channels and Canals	18,002,000	3,186,000	21,188,000
TOTAL Construction Cost	18,002,000	3,186,000	21,188,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	1,438,000	254,000	1,692,000
CA_02_31 Construction Management	1,803,000	319,000	2,122,000
TOTAL Non Construction Cost	3,240,000	574,000	3,814,000
TOTAL Canals all	21,242,000	3,760,000	25,002,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_01 Remove Culvert Structure	156,000	19,000	175,000
TOTAL Remove Culvert Structure	156,000	19,000	175,000
CS_01_15_02 Culvert Structure			
CS_01_15_02_ 01 3 - 4' dia. CMP	305,000	38,000	343,000
TOTAL Culvert Structure	305,000	38,000	343,000
TOTAL 15 Floodway Control-Divert. Strt	461,000	58,000	518,000
TOTAL Construction Cost	461,000	58,000	518,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	37,000	5,000	42,000
CS_02_31 Construction Management	46,000	6,000	52,000
TOTAL Non Construction Cost	83,000	10,000	94,000
TOTAL Culverts	544,000	68,000	612,000
LP Levee - Recharge area			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal	1,401,000	248,000	1,650,000
TOTAL Channels and Canals	1,401,000	248,000	1,650,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees	1,176,000	111,000	1,287,000
TOTAL Levees and Floodwalls	1,176,000	111,000	1,287,000
TOTAL Construction Cost	2,578,000	359,000	2,936,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	206,000	29,000	235,000
LP_02_31 Construction Management	258,000	36,000	294,000
TOTAL Non Construction Cost	464,000	64,000	528,000
TOTAL Levee - Recharge area	3,042,000	423,000	3,465,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant inflow	2,105,000	95,000	2,200,000
PS_01_02 Pump Plant to SDCS	8,420,000	379,000	8,799,000
PS_01_03 Pump Plant delivery	8,420,000	379,000	8,799,000
TOTAL Pumping Plant	18,945,000	853,000	19,798,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT U6012P: U6 Bird Drive Basin
U6 Bird Drive Basin Recharge Area SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	1,513,000	76,000	1,589,000
PS_02_31 Construction Management	1,899,000	95,000	1,994,000
TOTAL Non Construction Cost	3,412,000	171,000	3,583,000
TOTAL Pump Station	22,357,000	1,023,000	23,380,000
TOTAL U6 Bird Drive Basin	47,185,000	5,274,000	52,459,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT V4012P: V4 L031 N Levee Improve
V4 L31N Seepage Management SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
LP V4 L31 N Levee Improve			
LP_01 Construction Cost			
LP_01_15 Floodway Control-Divert. Strt			
LP_01_15_10 Seepage Control Cut Off Wall	13,288,000	1,209,000	14,497,000
LP_01_15_20 Seep Control Ground Water Wells	40,013,000	3,641,000	43,654,000
TOTAL Floodway Control-Divert. Strt	53,301,000	4,850,000	58,151,000
TOTAL Construction Cost	53,301,000	4,850,000	58,151,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	4,261,000	388,000	4,649,000
LP_02_31 Construction Management	5,326,000	485,000	5,811,000
TOTAL Non Construction Cost	9,587,000	872,000	10,460,000
TOTAL V4 L31 N Levee Improve	62,888,000	5,723,000	68,611,000
TOTAL V4 L031 N Levee Improve	62,888,000	5,723,000	68,611,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT W2012P: W2 Taylor Creek/ Nubbin Slough
W2 Taylor Creek/Nubbin Slough SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canals Joining			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	1,021,000	181,000	1,202,000
TOTAL Channels and Canals	1,021,000	181,000	1,202,000
TOTAL Construction Cost	1,021,000	181,000	1,202,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	82,000	14,000	96,000
CA_02_31 Construction Management	102,000	18,000	120,000
TOTAL Non Construction Cost	184,000	32,000	216,000
TOTAL Canals Joining	1,205,000	213,000	1,418,000
LE Levee Reservoir and STA			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_02 Borrow Canal	6,983,000	1,236,000	8,220,000
TOTAL Channels and Canals	6,983,000	1,236,000	8,220,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	5,861,000	545,000	6,406,000
TOTAL Levees and Floodwalls	5,861,000	545,000	6,406,000
TOTAL Construction Cost	12,844,000	1,781,000	14,625,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	10,280,000	1,429,000	11,709,000
LE_02_31 Construction Management	1,285,000	179,000	1,464,000
TOTAL Non Construction Cost	11,565,000	1,608,000	13,173,000
TOTAL Levee Reservoir and STA	24,409,000	3,389,000	27,798,000
PS Pump Stations			
PS_01 Pumping Plant			
PS_01_01 Pump Plants Large capacity	36,167,000	1,772,000	37,939,000
PS_01_02 Pump Plants seepage	268,000	23,000	291,000
TOTAL Pumping Plant	36,435,000	1,795,000	38,230,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	2,910,000	145,000	3,055,000
PS_02_31 Construction Management	3,643,000	182,000	3,825,000
TOTAL Non Construction Cost	6,553,000	328,000	6,880,000
TOTAL Pump Stations	42,987,000	2,123,000	45,111,000
TOTAL W2 Taylor Creek/ Nubbin Slough	68,602,000	5,725,000	74,326,000

Eff. Date 10/01/99

U.S. Army Corps of Engineers
PROJECT X6012P: X6 C17 Backpumping
X6 C 17 Backpumping

SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure	1,292,000	128,000	1,419,000
TOTAL 15 Floodway Control-Divert. Strt	1,292,000	128,000	1,419,000
TOTAL Construction Cost	1,292,000	128,000	1,419,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	103,000	10,000	114,000
CS_02_31 Construction Management	129,000	13,000	142,000
TOTAL Non Construction Cost	233,000	23,000	256,000
TOTAL Culverts	1,524,000	151,000	1,675,000
LE Levee - Reservoir			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_02 Borrow Canal	654,000	116,000	770,000
TOTAL Channels and Canals	654,000	116,000	770,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	549,000	52,000	600,000
TOTAL Levees and Floodwalls	549,000	52,000	600,000
TOTAL Construction Cost	1,203,000	167,000	1,370,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	96,000	12,000	108,000
LE_02_31 Construction Management	120,000	14,000	135,000
TOTAL Non Construction Cost	217,000	26,000	243,000
TOTAL Levee - Reservoir	1,419,000	193,000	1,613,000
PS Pump Stations			
PS_01 Construction Cost			
PS_01_02 Pump Plant	5,297,000	238,000	5,535,000
TOTAL Construction Cost	5,297,000	238,000	5,535,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	424,000	21,000	445,000
PS_02_31 Construction Management	530,000	26,000	556,000
TOTAL Non Construction Cost	953,000	48,000	1,001,000
TOTAL Pump Stations	6,250,000	286,000	6,536,000
TOTAL X6 C17 Backpumping	9,194,000	630,000	9,824,000

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Eff. Date 10/01/99 PROJECT Y6012P: Y6 C-51 Backpumping
Y6 C-51 East Backpump to WCA SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal Enlarge			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	1,927,000	341,000	2,268,000
TOTAL Channels and Canals	1,927,000	341,000	2,268,000
TOTAL Construction Cost	1,927,000	341,000	2,268,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	154,000	28,000	182,000
CA_02_31 Construction Management	193,000	35,000	227,000
TOTAL Non Construction Cost	347,000	62,000	409,000
TOTAL Canal Enlarge	2,274,000	403,000	2,677,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure	161,000	16,000	177,000
TOTAL 15 Floodway Control-Divert. Strt	161,000	16,000	177,000
TOTAL Construction Cost	161,000	16,000	177,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	13,000	1,000	14,000
CS_02_31 Construction Management	16,000	2,000	18,000
TOTAL Non Construction Cost	29,000	3,000	32,000
TOTAL Culverts	190,000	19,000	209,000
LE Levee STA			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_02 Borrow Canal	645,000	114,000	759,000
TOTAL Channels and Canals	645,000	114,000	759,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	541,000	51,000	592,000
TOTAL Levees and Floodwalls	541,000	51,000	592,000
TOTAL Construction Cost	1,186,000	165,000	1,350,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	95,000	13,000	108,000
LE_02_31 Construction Management	119,000	17,000	135,000
TOTAL Non Construction Cost	213,000	30,000	243,000
TOTAL Levee STA	1,399,000	195,000	1,594,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_02 Pump Plant	9,517,000	428,000	9,945,000
TOTAL Pumping Plant	9,517,000	428,000	9,945,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	761,000	38,000	799,000
PS_02_31 Construction Management	952,000	48,000	999,000
TOTAL Non Construction Cost	1,713,000	86,000	1,799,000
TOTAL Pump Station	11,230,000	514,000	11,743,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_02 Spillway Structure 155-A	2,261,000	224,000	2,485,000
TOTAL 15 Floodway Control-Divert. Strt	2,261,000	224,000	2,485,000
TOTAL Construction Cost	2,261,000	224,000	2,485,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT Y6012P: Y6 C-51 Backpumping
Y6 C-51 East Backpump to WCA SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	181,000	18,000	199,000
SW_02_31 Construction Management	226,000	23,000	249,000
TOTAL Non Construction Cost	407,000	41,000	448,000
TOTAL Spillways	2,668,000	265,000	2,932,000
TOTAL Y6 C-51 Backpumping	17,760,000	1,396,000	19,156,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT AA302P: L 3AA Additional S345/349 Struct
AA3 Additional S345/S349 Structures SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
SW Additional Structures			
SW_01 Construction Cost S345			
SW_01_09 Channels and Canals			
SW_01_09_01 Channel - Discharge to WCA 3B			
SW_01_09_01_ 1 Mob, Demob & Preparatory Work	987,000	148,000	1,135,000
SW_01_09_01_ 2 Earthwork	9,639,000	1,446,000	11,085,000
SW_01_09_01_ 3 Associated General Items	307,000	46,000	353,000
TOTAL Channel - Discharge to WCA 3B	10,933,000	1,640,000	12,573,000
SW_01_09_02 Channel - west of S345A			
SW_01_09_02_ 1 Mob, Demob & Preparatory Work	25,000	4,000	29,000
SW_01_09_02_ 2 Earthwork	211,000	32,000	243,000
SW_01_09_02_ 3 Associated General Items	33,000	5,000	38,000
TOTAL Channel - west of S345A	270,000	40,000	310,000
TOTAL Channels and Canals	11,203,000	1,680,000	12,883,000
SW_01_11 Levees and Floodwalls			
SW_01_11_01 Construct Tieback Levees			
SW_01_11_01_ 1 Mob, Demob & Preparatory Work	808,000	121,000	930,000
SW_01_11_01_ 2 Earthwork - east of L67A	12,438,000	1,866,000	14,304,000
SW_01_11_01_ 3 Associated General Items	1,081,000	162,000	1,243,000
SW_01_11_01_ 4 Earthwork - west of L67A	280,000	42,000	323,000
TOTAL Construct Tieback Levees	14,608,000	2,191,000	16,800,000
SW_01_11_02 Construct Ring Levee			
SW_01_11_02_ 1 Mob, Demob & Preparatory Work	83,000	12,000	95,000
SW_01_11_02_ 2 Earthwork	126,000	19,000	144,000
TOTAL Construct Ring Levee	208,000	31,000	240,000
SW_01_11_04 Construct Staging Area			
SW_01_11_04_ 1 Earthwork	66,000	10,000	76,000
TOTAL Construct Staging Area	66,000	10,000	76,000
SW_01_11_05 Degrade Ring Levee			
SW_01_11_05_ 1 Mob, Demob & Preparatory Work	67,000	10,000	77,000
SW_01_11_05_ 2 Earthwork	129,000	19,000	149,000
TOTAL Degrade Ring Levee	196,000	29,000	226,000
SW_01_11_06 Degrade staging area			
SW_01_11_06_ 1 Earthwork	62,000	9,000	71,000
TOTAL Degrade staging area	62,000	9,000	71,000
TOTAL Levees and Floodwalls	15,141,000	2,271,000	17,412,000
SW_01_15 Floodway Control-Diversion Struc			
SW_01_15_00 Floodway Control-Diversion Struc			
SW_01_15_00_ 1 Mob, Demob & Preparatory Work	159,000	24,000	183,000
SW_01_15_00_ 2 Earthwork for Structures	258,000	39,000	297,000
SW_01_15_00_ 3 Gates, Stop Logs-Associated Eqpt	761,000	114,000	875,000
SW_01_15_00_ 4 Associated General Items	763,000	114,000	877,000
TOTAL Floodway Control-Diversion Struc	1,941,000	291,000	2,233,000
TOTAL Floodway Control-Diversion Struc	1,941,000	291,000	2,233,000
TOTAL Construction Cost S345	28,285,000	4,243,000	32,528,000
SW_02 Construction Cost S349			
SW_02_09 Channels and Canals			
SW_02_09_02 Canals			
SW_02_09_02_ 1 Mob, Demob & Preparatory Work	37,000	6,000	43,000
SW_02_09_02_ 2 Earthwork	808,000	121,000	930,000
SW_02_09_02_ 3 Associated General Items	103,000	15,000	119,000
TOTAL Canals	949,000	142,000	1,091,000
TOTAL Channels and Canals	949,000	142,000	1,091,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT AA302P: L 3AA Additional S345/349 Struct
AA3 Aditional S345/S349 Structures SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
SW_02_11 Levees and Floodwalls			
SW_02_11_01 Levees			
SW_02_11_01_ 1 Mob, Demob & Preparatory Work	20,000	3,000	23,000
SW_02_11_01_ 2 Earthwork	1,854,000	278,000	2,132,000
TOTAL Levees	1,874,000	281,000	2,155,000
TOTAL Levees and Floodwalls	1,874,000	281,000	2,155,000
SW_02_15 Floodway Control-Diversion Struc			
SW_02_15_00 Floodway Control-Diversion Struc			
SW_02_15_00_ 1 Mob, Demob & Preparatory Work	54,000	8,000	62,000
SW_02_15_00_ 2 Care and Diversion of Water	3,111,000	467,000	3,577,000
SW_02_15_00_ 3 Earthwork for Structures	76,000	11,000	88,000
SW_02_15_00_ 4 Foundation Work	172,000	26,000	198,000
SW_02_15_00_ 5 Embedded Metal Work	94,000	14,000	108,000
SW_02_15_00_ 6 Gates, Stop Logs-Associated Eqpt	1,027,000	0	1,181,000
SW_02_15_00_ 7 Overflow Structure	338,000	51,000	389,000
TOTAL Floodway Control-Diversion Struc	4,873,000	577,000	5,604,000
TOTAL Floodway Control-Diversion Struc	4,873,000	577,000	5,604,000
TOTAL Construction Cost S349	7,696,000	1,000,000	8,850,000
SW_03 Non Construction Cost			
SW_03_30 Planning Engineering & Design	2,733,000	410,000	3,143,000
SW_03_31 Supervision and Administration	3,416,000	512,000	3,929,000
TOTAL Non Construction Cost	6,150,000	922,000	7,072,000
TOTAL Additional Structures	42,130,000	6,165,000	48,450,000
TOTAL L 3AA Additional S345/349 Struct	42,130,000	6,165,000	48,450,000

U.S. Army Corps of Engineers

Eff. Date 10/01/99 PROJECT BB502P: BB5 Dade Broward Levee Improve

BB5 Dade Broward Levee Improvement SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal Conveyance			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	6,706,000	1,187,000	7,893,000
TOTAL Channels and Canals	6,706,000	1,187,000	7,893,000
TOTAL Construction Cost	6,706,000	1,187,000	7,893,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	537,000	97,000	633,000
CA_02_31 Construction Management	671,000	121,000	791,000
TOTAL Non Construction Cost	1,207,000	217,000	1,425,000
TOTAL Canal Conveyance	7,914,000	1,404,000	9,318,000
LE Levee #1			
LE_01 Construction Cost			
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	608,000	58,000	665,000
TOTAL Levees and Floodwalls	608,000	58,000	665,000
TOTAL Construction Cost	608,000	58,000	665,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	49,000	5,000	53,000
LE_02_31 Construction Management	61,000	6,000	66,000
TOTAL Non Construction Cost	109,000	10,000	120,000
TOTAL Levee #1	717,000	68,000	785,000
TOTAL BB5 Dade Broward Levee Improve	8,630,000	1,472,000	10,103,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT CC602P: CC6 Improve Broward Co 2nd Canal
CC6 Improve Broward Co Secondary Canals SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canals			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	6,045,000	1,070,000	7,115,000
TOTAL Channels and Canals	6,045,000	1,070,000	7,115,000
TOTAL Construction Cost	6,045,000	1,070,000	7,115,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	484,000	87,000	571,000
CA_02_31 Construction Management	604,000	109,000	713,000
TOTAL Non Construction Cost	1,088,000	196,000	1,284,000
TOTAL Canals	7,133,000	1,266,000	8,398,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plants small	501,000	44,000	545,000
PS_01_02 Pump Plants Med	1,572,000	71,000	1,643,000
TOTAL Pumping Plant	2,073,000	115,000	2,188,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	166,000	8,000	174,000
PS_02_31 Construction Management	207,000	10,000	218,000
TOTAL Non Construction Cost	373,000	19,000	392,000
TOTAL Pump Station	2,446,000	133,000	2,580,000
TOTAL CC6 Improve Broward Co 2nd Canal	9,579,000	1,399,000	10,978,000

Eff. Date 10/01/99

U.S. Army Corps of Engineers
PROJECT FF402P: FF4 S356 A & B
FF4 Construction of S356 A & B

SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
LE Levee Constructions			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_02 Borrow Canal	1,112,000	197,000	1,309,000
TOTAL Channels and Canals	1,112,000	197,000	1,309,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	889,000	84,000	972,000
TOTAL Levees and Floodwalls	889,000	84,000	972,000
TOTAL Construction Cost	2,001,000	280,000	2,281,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	160,000	22,000	182,000
LE_02_31 Construction Management	200,000	28,000	228,000
TOTAL Non Construction Cost	360,000	50,000	411,000
TOTAL Levee Constructions	2,361,000	331,000	2,692,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_02 Pump Plant	14,712,000	721,000	15,433,000
TOTAL Pumping Plant	14,712,000	721,000	15,433,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	1,177,000	59,000	1,236,000
PS_02_31 Construction Management	1,469,000	73,000	1,542,000
TOTAL Non Construction Cost	2,646,000	132,000	2,778,000
TOTAL Pump Station	17,358,000	853,000	18,211,000
TOTAL FF4 S356 A & B	19,719,000	1,184,000	20,903,000

Eff. Date 10/01/99

U.S. Army Corps of Engineers
PROJECT GG402P: GG4 Lake O ASR
GG4 Lake Okeechobee ASR

SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
AS Aquifer Storage and Recovery			
AS_01 Construction Cost			
AS_01_13 Pumping Plant			
AS_01_13_01 ASR WellFields 5MGD wells	266,163,000	66,541,000	332,704,000
AS_01_13_02 Pretreatment by Ultrafiltration	399,245,000	99,811,000	499,056,000
AS_01_13_03 Aeration Cost	1,333,000	333,000	1,666,000
AS_01_13_04 Chlorination	15,596,000	3,899,000	19,494,000
TOTAL Pumping Plant	682,336,000	170,584,000	852,920,000
TOTAL Construction Cost	682,336,000	170,584,000	852,920,000
AS_02 Non Construction Cost			
AS_02_30 Planning, Engineering and Design	68,234,000	17,058,000	85,292,000
AS_02_31 Construction Management	136,467,000	34,117,000	170,584,000
TOTAL Non Construction Cost	204,701,000	51,175,000	255,876,000
TOTAL Aquifer Storage and Recovery	887,037,000	221,759,000	1108797000
TOTAL GG4 Lake O ASR	887,037,000	221,759,000	1108797000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT II302P: II3 Pump Station 404
II3 Pump Plant G404 Modification SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
PS Pump Station			
PS_01 Pumping Plant			
PS_01_02 Pump Plant	8,188,000	401,000	8,590,000
TOTAL Pumping Plant	8,188,000	401,000	8,590,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	655,000	33,000	688,000
PS_02_31 Construction Management	819,000	41,000	860,000
TOTAL Non Construction Cost	1,474,000	74,000	1,548,000
TOTAL Pump Station	9,662,000	475,000	10,137,000
TOTAL II3 Pump Station 404	9,662,000	475,000	10,137,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT KK402P: KK4 LNWR Internal Canal Struct
KK4 LNWR Internal Canal Structures SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 2 Gate Spillway	2,808,000	295,000	3,103,000
SW_01_15_02 2 Gate Spillway	2,808,000	295,000	3,103,000
TOTAL 15 Floodway Control-Divert. Strt	5,617,000	590,000	6,207,000
TOTAL Construction Cost	5,617,000	590,000	6,207,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	449,000	47,000	497,000
SW_02_31 Construction Management	562,000	59,000	621,000
TOTAL Non Construction Cost	1,011,000	106,000	1,117,000
TOTAL Spillways	6,628,000	696,000	7,324,000
TOTAL KK4 LNWR Internal Canal Struct	6,628,000	696,000	7,324,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT LL602P: LL6 C-51 Regional ASR
LL6 C-51 Regional Groundwater ASR SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
AS Aquifer Storage and Recovery			
AS_01 Construction Cost			
AS_01_13 Pumping Plant			
AS_01_13_01 ASR WellFields 5MGD wells	45,248,000	11,312,000	56,560,000
AS_01_13_02 Surficial Aquifer Wells	27,192,000	6,798,000	33,990,000
AS_01_13_03 Aeration Cost	227,000	57,000	283,000
AS_01_13_04 Chlorination	2,651,000	663,000	3,314,000
TOTAL Pumping Plant	75,318,000	18,829,000	94,147,000
TOTAL Construction Cost	75,318,000	18,829,000	94,147,000
AS_02 Non Construction Cost			
AS_02_30 Planning, Engineering and Design	7,532,000	1,883,000	9,415,000
AS_02_31 Construction Management	15,064,000	3,766,000	18,829,000
TOTAL Non Construction Cost	22,595,000	5,649,000	28,244,000
TOTAL Aquifer Storage and Recovery	97,913,000	24,478,000	122,391,000
TOTAL LL6 C-51 Regional ASR	97,913,000	24,478,000	122,391,000

U.S. Army Corps of Engineers
Eff. Date 10/02/98 PROJECT LL601P: LL6 C-51 Regional ASR
LL6 C-51 Regional Groundwater ASR SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
AS Aquifer Storage and Recovery			
AS_01 Construction Cost			
AS_01_13 Pumping Plant			
AS_01_13_01 ASR WellFields 5MGD wells	47,437,000	11,859,000	59,296,000
AS_01_13_02 Surficial Aquifer Wells	28,508,000	7,127,000	35,635,000
AS_01_13_03 Aeration Cost	238,000	59,000	297,000
AS_01_13_04 Chlorination	2,780,000	695,000	3,474,000
TOTAL Pumping Plant	78,962,000	19,740,000	98,702,000
TOTAL Construction Cost	78,962,000	19,740,000	98,702,000
AS_02 Non Construction Cost			
AS_02_30 Planning, Engineering and Design	7,896,000	0	7,896,000
AS_02_31 Construction Management	15,792,000	0	15,792,000
TOTAL Non Construction Cost	23,689,000	0	23,689,000
TOTAL Aquifer Storage and Recovery	102,650,000	19,740,000	122,390,000
TOTAL LL6 C-51 Regional ASR	102,650,000	19,740,000	122,390,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT QQ702P: Li QQ6 Decarpartment WCA3
QQ7 Decompartmentalize WCA 3 SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
BR Bridges			
BR_01 Construction Cost			
BR_01_08 Roads, Railroads, and Bridges			
BR_01_08_01 20 ea. Bridges - New 100 ft	8,244,000	824,000	9,069,000
BR_01_08_07 Detour roads 20 ea.	1,931,000	193,000	2,124,000
TOTAL Roads, Railroads, and Bridges	10,175,000	1,018,000	11,193,000
TOTAL Construction Cost	10,175,000	1,018,000	11,193,000
BR_02 Non Construction Cost			
BR_02_30 Planning, Engineering and Design	814,000	81,000	895,000
BR_02_31 Construction Management	1,018,000	102,000	1,119,000
TOTAL Non Construction Cost	1,831,000	183,000	2,015,000
TOTAL Bridges	12,007,000	1,201,000	13,208,000
CP Canals			
CP_01 Construction Cost			
CP_01_09 09 Channels and Canals			
CP_01_09_01 Fill Canals	20,426,000	2,043,000	22,468,000
TOTAL 09 Channels and Canals	20,426,000	2,043,000	22,468,000
TOTAL Construction Cost	20,426,000	2,043,000	22,468,000
CP_02 Non Construction Cost			
CP_02_30 Planning, Engineering and Design	1,636,000	164,000	1,800,000
CP_02_31 Construction Management	2,045,000	205,000	2,250,000
TOTAL Non Construction Cost	3,681,000	368,000	4,049,000
TOTAL Canals	24,107,000	2,411,000	26,518,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 4 ea 6 Gate Spillway	33,777,000	2,702,000	36,479,000
SW_01_15_02 Remove Gated Culvert Structure	1,407,000	113,000	1,520,000
SW_01_15_03 8ea Passive Weirs through L 67A	231,000	18,000	250,000
SW_01_15_04 Concrete Box Culvert	94,000	8,000	102,000
SW_01_15_05 S343A Stop Log Riser Culvert	77,000	6,000	83,000
SW_01_15_06 S343B Stop Log Riser Culvert	55,000	4,000	59,000
SW_01_15_07 S-344 Culvert Structure	410,000	33,000	443,000
TOTAL 15 Floodway Control-Divert. Strt	36,051,000	2,884,000	38,935,000
TOTAL Construction Cost	36,051,000	2,884,000	38,935,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	2,885,000	231,000	3,116,000
SW_02_31 Construction Management	3,606,000	288,000	3,894,000
TOTAL Non Construction Cost	6,491,000	519,000	7,010,000
TOTAL Spillways	42,542,000	3,403,000	45,945,000
TOTAL Li QQ6 Decarpartment WCA3	78,656,000	7,015,000	85,671,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT RR402P: RR4 Flow to central WCA 3A
RR4 Flow to central WCA 3A SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal - Spreader Canal			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	375,000	22,000	397,000
TOTAL Channels and Canals	375,000	22,000	397,000
TOTAL Construction Cost	375,000	22,000	397,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	30,000	2,000	32,000
CA_02_31 Construction Management	38,000	2,000	40,000
TOTAL Non Construction Cost	68,000	4,000	72,000
TOTAL Canal - Spreader Canal	443,000	26,000	468,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_02 Pump Plant	16,378,000	803,000	17,181,000
TOTAL Construction Cost	16,378,000	803,000	17,181,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	1,309,000	65,000	1,375,000
PS_02_31 Construction Management	1,634,000	82,000	1,716,000
TOTAL Non Construction Cost	2,943,000	147,000	3,090,000
TOTAL Pump Station	19,322,000	950,000	20,271,000
TOTAL RR4 Flow to central WCA 3A	19,764,000	976,000	20,740,000

Eff. Date 10/01/99

U.S. Army Corps of Engineers
PROJECT SS402P: SS4 Relocate Miami Canal
SS4 Reroute Miami-Dade Co, Water Supply Delivery

SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal Improve			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	32,587,000	5,768,000	38,355,000
TOTAL Channels and Canals	32,587,000	5,768,000	38,355,000
TOTAL Construction Cost	32,587,000	5,768,000	38,355,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	2,612,000	462,000	3,075,000
CA_02_31 Construction Management	3,263,000	577,000	3,840,000
TOTAL Non Construction Cost	5,875,000	1,040,000	6,915,000
TOTAL Canal Improve	38,462,000	6,808,000	45,269,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure	434,000	44,000	478,000
TOTAL 15 Floodway Control-Divert. Strt	434,000	44,000	478,000
TOTAL Construction Cost	434,000	44,000	478,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	35,000	3,000	38,000
CS_02_31 Construction Management	43,000	4,000	48,000
TOTAL Non Construction Cost	78,000	8,000	86,000
TOTAL Culverts	512,000	52,000	564,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 3 Gate Spillway	4,182,000	443,000	4,625,000
TOTAL 15 Floodway Control-Divert. Strt	4,182,000	443,000	4,625,000
TOTAL Construction Cost	4,182,000	443,000	4,625,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	335,000	33,000	368,000
SW_02_31 Construction Management	418,000	42,000	460,000
TOTAL Non Construction Cost	753,000	75,000	828,000
TOTAL Spillways	4,935,000	519,000	5,453,000
TOTAL SS4 Relocate Miami Canal	43,909,000	7,378,000	51,287,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT UU702P: UU7 C23/C24 Storage
UU7 C23 C24 Storage SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure			
CS_01_15_02_ 01 Total 18 Barrel Culvert	1,949,000	195,000	2,144,000
TOTAL Culvert Structure	1,949,000	195,000	2,144,000
TOTAL 15 Floodway Control-Divert. Strt	1,949,000	195,000	2,144,000
TOTAL Construction Cost	1,949,000	195,000	2,144,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	156,000	16,000	172,000
CS_02_31 Construction Management	195,000	19,000	214,000
TOTAL Non Construction Cost	351,000	35,000	386,000
TOTAL Culverts	2,300,000	230,000	2,530,000
LP Levee			
LP_01 Construction Cost			
LP_01_09 Channels and Canals			
LP_01_09_02 Borrow Canal	43,638,000	7,724,000	51,362,000
TOTAL Channels and Canals	43,638,000	7,724,000	51,362,000
LP_01_11 Levees and Floodwalls			
LP_01_11_01 Levees	34,881,000	3,279,000	38,160,000
TOTAL Levees and Floodwalls	34,881,000	3,279,000	38,160,000
TOTAL Construction Cost	78,519,000	11,003,000	89,522,000
LP_02 Non Construction Cost			
LP_02_30 Planning, Engineering and Design	6,276,000	753,000	7,029,000
LP_02_31 Construction Management	7,851,000	942,000	8,793,000
TOTAL Non Construction Cost	14,127,000	1,695,000	15,822,000
TOTAL Levee	92,646,000	12,698,000	105,345,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_01 Pump Plant Small	188,000	16,000	204,000
PS_01_02 Pump Plant Large	139,752,000	6,848,000	146,600,000
TOTAL Construction Cost	139,940,000	6,864,000	146,804,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	11,215,000	561,000	11,776,000
PS_02_31 Construction Management	14,019,000	701,000	14,720,000
TOTAL Non Construction Cost	25,235,000	1,262,000	26,496,000
TOTAL Pump Station	165,174,000	8,126,000	173,300,000
TOTAL UU7 C23/C24 Storage	260,121,000	21,054,000	281,175,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT VV602P: VV6 Palm Beach Co Reservoir
VV6 Central Palm Beach Co. Reservoir w/ASR SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
AS Aquifer Storage and Recovery			
AS_01 Construction Cost			
AS_01_13 Pumping Plant			
AS_01_13_01 ASR WellFields 5MGD wells	20,148,000	5,037,000	25,186,000
AS_01_13_02 Surficial Wells	6,054,000	1,514,000	7,568,000
AS_01_13_03 Aeration Cost	101,000	25,000	126,000
AS_01_13_04 Chlorination	1,181,000	295,000	1,476,000
TOTAL Pumping Plant	27,484,000	6,871,000	34,355,000
TOTAL Construction Cost	27,484,000	6,871,000	34,355,000
AS_02 Non Construction Cost			
AS_02_30 Planning, Engineering and Design	2,749,000	687,000	3,437,000
AS_02_31 Construction Management	5,499,000	1,375,000	6,874,000
TOTAL Non Construction Cost	8,248,000	2,062,000	10,310,000
TOTAL Aquifer Storage and Recovery	35,732,000	8,933,000	44,666,000
CA Canal			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	222,000	39,000	261,000
TOTAL Channels and Canals	222,000	39,000	261,000
TOTAL Construction Cost	222,000	39,000	261,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	18,000	3,000	21,000
CA_02_31 Construction Management	22,000	4,000	26,000
TOTAL Non Construction Cost	40,000	7,000	47,000
TOTAL Canal	262,000	46,000	308,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure	230,000	23,000	253,000
TOTAL 15 Floodway Control-Divert. Strt	230,000	23,000	253,000
TOTAL Construction Cost	230,000	23,000	253,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	18,000	2,000	20,000
CS_02_31 Construction Management	23,000	2,000	25,000
TOTAL Non Construction Cost	41,000	4,000	45,000
TOTAL Culverts	271,000	27,000	298,000
LE Levee			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_02 Borrow Canal	7,306,000	1,293,000	8,599,000
TOTAL Channels and Canals	7,306,000	1,293,000	8,599,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	5,839,000	818,000	6,657,000
TOTAL Levees and Floodwalls	5,839,000	818,000	6,657,000
TOTAL Construction Cost	13,145,000	2,111,000	15,256,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	1,049,000	168,000	1,217,000
LE_02_31 Construction Management	1,312,000	210,000	1,522,000
TOTAL Non Construction Cost	2,361,000	378,000	2,739,000
TOTAL Levee	15,506,000	2,488,000	17,995,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT VV602P: VV6 Palm Beach Co Reservoir
VV6 Central Palm Beach Co. Reservoir w/ASR SUMMARY PAGE 2

	CONTRACT	CONTINGN	TOTAL COST
PS Pump Station			
PS_01 Construction Cost			
PS_01_02 Pump Plant	2,573,000	116,000	2,689,000
TOTAL Construction Cost	2,573,000	116,000	2,689,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	206,000	10,000	216,000
PS_02_31 Construction Management	257,000	13,000	270,000
TOTAL Non Construction Cost	463,000	23,000	486,000
TOTAL Pump Station	3,037,000	139,000	3,176,000
TOTAL VV6 Palm Beach Co Reservoir	54,809,000	11,633,000	66,442,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT WW502P: WW5 C-111 Spreader Canal
WW5 C111N Spreader Canal SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_01 Canal -	3,348,000	593,000	3,941,000
CA_01_09_02 Canal - Fill c111 & c 110	11,287,000	1,998,000	13,285,000
TOTAL Channels and Canals	14,636,000	2,590,000	17,226,000
TOTAL Construction Cost	14,636,000	2,590,000	17,226,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	1,176,000	212,000	1,388,000
CA_02_31 Construction Management	1,465,000	264,000	1,729,000
TOTAL Non Construction Cost	2,641,000	475,000	3,117,000
TOTAL Canal	17,277,000	3,066,000	20,343,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure	838,000	83,000	921,000
TOTAL 15 Floodway Control-Divert. Strt	838,000	83,000	921,000
TOTAL Construction Cost	838,000	83,000	921,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	67,000	7,000	74,000
CS_02_31 Construction Management	84,000	8,000	92,000
TOTAL Non Construction Cost	151,000	15,000	166,000
TOTAL Culverts	989,000	98,000	1,087,000
LE Levee STA			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_02 Borrow Canal	5,710,000	1,011,000	6,720,000
TOTAL Channels and Canals	5,710,000	1,011,000	6,720,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	4,564,000	429,000	4,993,000
TOTAL Levees and Floodwalls	4,564,000	429,000	4,993,000
TOTAL Construction Cost	10,274,000	1,440,000	11,713,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	822,000	148,000	970,000
LE_02_31 Construction Management	1,027,000	185,000	1,212,000
TOTAL Non Construction Cost	1,849,000	333,000	2,182,000
TOTAL Levee STA	12,123,000	1,773,000	13,895,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_01 Pump Plant #1	2,622,000	118,000	2,740,000
PS_01_02 Pump Plant #2	2,622,000	118,000	2,740,000
PS_01_03 Pump Plant #3	5,244,000	236,000	5,480,000
TOTAL Construction Cost	10,489,000	472,000	10,961,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	839,000	42,000	881,000
PS_02_31 Construction Management	1,049,000	52,000	1,101,000
TOTAL Non Construction Cost	1,888,000	94,000	1,982,000
TOTAL Pump Station	12,377,000	566,000	12,943,000
TOTAL WW5 C-111 Spreader Canal	42,765,000	5,503,000	48,268,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT XX602P: XX6 North Lake Belt Storage
XX6 Northlake belt Storage SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	9,545,000	1,689,000	11,234,000
TOTAL Channels and Canals	9,545,000	1,689,000	11,234,000
TOTAL Construction Cost	9,545,000	1,689,000	11,234,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	764,000	137,000	901,000
CA_02_31 Construction Management	9,615,000	1,731,000	11,346,000
TOTAL Non Construction Cost	10,378,000	1,868,000	12,247,000
TOTAL Canal	19,923,000	3,557,000	23,480,000
CO Subterranean Seepage Barrier			
CO_01 Construction Cost			
CO_01_15 15 Floodway Control-Divert. Strt			
CO_01_15_01 Cut Off Wall Liner	21,151,000	1,671,000	22,822,000
CO_01_15_02 Cut Off Wall trenching complete	224,459,000	17,732,000	242,192,000
TOTAL 15 Floodway Control-Divert. Strt	245,610,000	19,403,000	265,014,000
TOTAL Construction Cost	245,610,000	19,403,000	265,014,000
CO_02 Non Construction Cost			
CO_02_30 Planning, Engineering and Design	25,483,000	2,039,000	27,521,000
CO_02_31 Construction Management	31,800,000	2,544,000	34,344,000
TOTAL Non Construction Cost	57,282,000	4,583,000	61,865,000
TOTAL Subterranean Seepage Barrier	302,893,000	23,986,000	326,879,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_01 Pump Plant med	9,452,000	425,000	9,878,000
PS_01_02 Pump Plant large	8,103,000	397,000	8,500,000
TOTAL Construction Cost	17,555,000	822,000	18,378,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	1,403,000	70,000	1,473,000
PS_02_31 Construction Management	1,756,000	88,000	1,844,000
TOTAL Non Construction Cost	3,159,000	158,000	3,316,000
TOTAL Pump Station	20,714,000	980,000	21,694,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 5 spillway gates	7,000,000	742,000	7,742,000
TOTAL 15 Floodway Control-Divert. Strt	7,000,000	742,000	7,742,000
TOTAL Construction Cost	7,000,000	742,000	7,742,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	560,000	62,000	622,000
SW_02_31 Construction Management	700,000	77,000	777,000
TOTAL Non Construction Cost	1,260,000	139,000	1,398,000
TOTAL Spillways	8,260,000	881,000	9,140,000
TOTAL XX6 North Lake Belt Storage	351,789,000	29,404,000	381,193,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT YY402P: YY4 Divert flows to CLBS
YY4 Divert flows to NLBS SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal #1			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	32,859,000	5,816,000	38,675,000
TOTAL Channels and Canals	32,859,000	5,816,000	38,675,000
TOTAL Construction Cost	32,859,000	5,816,000	38,675,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	2,239,000	403,000	2,642,000
CA_02_31 Construction Management	2,796,000	503,000	3,299,000
TOTAL Non Construction Cost	5,034,000	906,000	5,940,000
TOTAL Canal #1	37,893,000	6,722,000	44,615,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure	721,000	72,000	793,000
TOTAL 15 Floodway Control-Divert. Strt	721,000	72,000	793,000
TOTAL Construction Cost	721,000	72,000	793,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	52,000	5,000	58,000
CS_02_31 Construction Management	656,000	66,000	721,000
TOTAL Non Construction Cost	708,000	71,000	779,000
TOTAL Culverts	1,429,000	143,000	1,572,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_02 Pump Plant	12,758,000	625,000	13,384,000
TOTAL Construction Cost	12,758,000	625,000	13,384,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	973,000	49,000	1,021,000
PS_02_31 Construction Management	1,221,000	61,000	1,282,000
TOTAL Non Construction Cost	2,194,000	110,000	2,304,000
TOTAL Pump Station	14,952,000	735,000	15,687,000
SW Spillways			
SW_01 Construction Cost			
SW_01_15 15 Floodway Control-Divert. Strt			
SW_01_15_01 Remove Spillway	3,096,000	328,000	3,424,000
TOTAL 15 Floodway Control-Divert. Strt	3,096,000	328,000	3,424,000
TOTAL Construction Cost	3,096,000	328,000	3,424,000
SW_02 Non Construction Cost			
SW_02_30 Planning, Engineering and Design	224,000	25,000	249,000
SW_02_31 Construction Management	280,000	31,000	311,000
TOTAL Non Construction Cost	504,000	55,000	560,000
TOTAL Spillways	3,600,000	384,000	3,984,000
TOTAL YY4 Divert flows to CLBS	57,875,000	7,984,000	65,859,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT ZZ502P: ZZ5 Divert WCA 3A/B flow CLBS
ZZ5 Divert WCA 3 Flows to CLBS SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CU Culverts			
CU_01 Construction Cost			
CU_01_15 15 Floodway Control-Divert. Strt			
CU_01_15_02 Culvert Structure	368,000	36,000	404,000
TOTAL 15 Floodway Control-Divert. Strt	368,000	36,000	404,000
TOTAL Construction Cost	368,000	36,000	404,000
CU_02 Non Construction Cost			
CU_02_30 Planning, Engineering and Design	29,000	3,000	32,000
CU_02_31 Construction Management	37,000	4,000	40,000
TOTAL Non Construction Cost	66,000	7,000	73,000
TOTAL Culverts	434,000	43,000	477,000
TOTAL ZZ5 Divert WCA 3A/B flow CLBS	434,000	43,000	477,000

U.S. Army Corps of Engineers

Eff. Date 10/01/99 PROJECT BBB62P: BBB6 South Miami Dade Co. Reuse

BBB6 Upgrade South District Waste Water Treat SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
PS Waste Water Treatment Plant	287,760,000	71,940,000	359,700,000
TOTAL BBB6 South Miami Dade Co. Reuse	287,760,000	71,940,000	359,700,000
PS Waste Water Treatment Plant			
PS_01 Construction Cost			
PS_01_02 Treatment Plant	230,208,000	57,552,000	287,760,000
TOTAL Construction Cost	230,208,000	57,552,000	287,760,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	23,021,000	5,755,000	28,776,000
PS_02_31 Construction Management	34,531,000	8,633,000	43,164,000
TOTAL Non Construction Cost	57,552,000	14,388,000	71,940,000
TOTAL Waste Water Treatment Plant	287,760,000	71,940,000	359,700,000
TOTAL BBB6 South Miami Dade Co. Reuse	287,760,000	71,940,000	359,700,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT CCC62P: CCC6 L 28I Modifications
CCC6 L28 Interceptor Mods SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal Spreader			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	76,000	13,000	89,000
TOTAL Channels and Canals	76,000	13,000	89,000
TOTAL Construction Cost	76,000	13,000	89,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	6,000	1,000	7,000
CA_02_31 Construction Management	8,000	1,000	9,000
TOTAL Non Construction Cost	14,000	2,000	16,000
TOTAL Canal Spreader	90,000	15,000	105,000
CS Culverts			
CS_01 Construction Cost			
CS_01_15 15 Floodway Control-Divert. Strt			
CS_01_15_02 Culvert Structure	442,000	44,000	486,000
TOTAL 15 Floodway Control-Divert. Strt	442,000	44,000	486,000
TOTAL Construction Cost	442,000	44,000	486,000
CS_02 Non Construction Cost			
CS_02_30 Planning, Engineering and Design	35,000	4,000	39,000
CS_02_31 Construction Management	44,000	4,000	49,000
TOTAL Non Construction Cost	80,000	8,000	87,000
TOTAL Culverts	521,000	52,000	573,000
LE Levee And Degrade Levee			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_01 Borrow Canal	833,000	147,000	981,000
LE_01_09_02 Borrow Canal	977,000	173,000	1,150,000
TOTAL Channels and Canals	1,810,000	320,000	2,131,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	774,000	73,000	847,000
LE_01_11_02 Levees	660,000	62,000	722,000
LE_01_11_03 Degrade Levees	12,908,000	1,213,000	14,121,000
TOTAL Levees and Floodwalls	14,342,000	1,348,000	15,691,000
TOTAL Construction Cost	16,153,000	1,669,000	17,821,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	1,293,000	129,000	1,423,000
LE_02_31 Construction Management	1,617,000	162,000	1,778,000
TOTAL Non Construction Cost	2,910,000	291,000	3,201,000
TOTAL Levee And Degrade Levee	19,063,000	1,960,000	21,022,000
PS Pump Station			
PS_01 Pumping Plant			
PS_01_01 Pump Plant	4,228,000	190,000	4,419,000
PS_01_02 Pump Plant STA inflow	2,854,000	128,000	2,983,000
PS_01_03 Pump Plant STA inflow	4,546,000	205,000	4,750,000
TOTAL Pumping Plant	11,628,000	523,000	12,152,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	930,000	47,000	977,000
PS_02_31 Construction Management	1,164,000	58,000	1,222,000
TOTAL Non Construction Cost	2,094,000	105,000	2,199,000
TOTAL Pump Station	13,722,000	628,000	14,350,000
TOTAL CCC6 L 28I Modifications	33,396,000	2,655,000	36,051,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT DDD52P: DDD5 Caloosahatchee Backpump
DDD5 Caloosahatchee Backpumping SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal #1			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_01 Canal - connecting	1,141,000	202,000	1,343,000
CA_01_09_02 Canal - Caloo to Pump	571,000	101,000	672,000
CA_01_09_03 Canal - connecting	1,141,000	202,000	1,343,000
TOTAL Channels and Canals	2,853,000	505,000	3,358,000
TOTAL Construction Cost	2,853,000	505,000	3,358,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	228,000	41,000	269,000
CA_02_31 Construction Management	285,000	51,000	337,000
TOTAL Non Construction Cost	514,000	92,000	606,000
TOTAL Canal #1	3,367,000	597,000	3,964,000
LE Levee #1			
LE_01 Construction Cost			
LE_01_09 Channels and Canals			
LE_01_09_02 Borrow Canal	2,088,000	370,000	2,458,000
TOTAL Channels and Canals	2,088,000	370,000	2,458,000
LE_01_11 Levees and Floodwalls			
LE_01_11_01 Levees	1,655,000	154,000	1,809,000
TOTAL Levees and Floodwalls	1,655,000	154,000	1,809,000
TOTAL Construction Cost	3,743,000	524,000	4,267,000
LE_02 Non Construction Cost			
LE_02_30 Planning, Engineering and Design	299,000	36,000	335,000
LE_02_31 Construction Management	374,000	45,000	419,000
TOTAL Non Construction Cost	674,000	81,000	755,000
TOTAL Levee #1	4,417,000	604,000	5,021,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_01 Pump Plant	16,353,000	801,000	17,154,000
PS_01_02 Pump Plant	16,353,000	801,000	17,154,000
PS_01_03 Pump Plant	16,353,000	801,000	17,154,000
TOTAL Construction Cost	49,058,000	2,404,000	51,462,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	3,922,000	196,000	4,118,000
PS_02_31 Construction Management	4,905,000	245,000	5,150,000
TOTAL Non Construction Cost	8,827,000	441,000	9,268,000
TOTAL Pump Station	57,885,000	2,845,000	60,730,000
TOTAL DDD5 Caloosahatchee Backpump	65,669,000	4,047,000	69,715,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT EEE52P: EEE5 Flow to Eastern WCA 3B
EEE5 Flows to Eastern WCA 3B SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal - Swale	202,000	36,000	237,000
TOTAL Channels and Canals	202,000	36,000	237,000
TOTAL Construction Cost	202,000	36,000	237,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	16,000	3,000	19,000
CA_02_31 Construction Management	20,000	4,000	24,000
TOTAL Non Construction Cost	36,000	7,000	43,000
TOTAL Canal	238,000	42,000	280,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_02 Pump Plant	5,304,000	239,000	5,542,000
TOTAL Construction Cost	5,304,000	239,000	5,542,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	424,000	21,000	445,000
PS_02_31 Construction Management	530,000	27,000	557,000
TOTAL Non Construction Cost	955,000	48,000	1,002,000
TOTAL Pump Station	6,258,000	286,000	6,545,000
TOTAL EEE5 Flow to Eastern WCA 3B	6,497,000	328,000	6,825,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT FFF52P: FFF5 Biscayne Bay Coastal Canal
FFF5 Biscayne Coastal Canals SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CA Canal #1			
CA_01 Construction Cost			
CA_01_09 Channels and Canals			
CA_01_09_02 Canal -	1,388,000	246,000	1,633,000
TOTAL Channels and Canals	1,388,000	246,000	1,633,000
TOTAL Construction Cost	1,388,000	246,000	1,633,000
CA_02 Non Construction Cost			
CA_02_30 Planning, Engineering and Design	111,000	20,000	131,000
CA_02_31 Construction Management	139,000	25,000	164,000
TOTAL Non Construction Cost	250,000	45,000	295,000
TOTAL Canal #1	1,637,000	291,000	1,928,000
TOTAL FFF5 Biscayne Bay Coastal Canal	1,637,000	291,000	1,928,000

U.S. Army Corps of Engineers
Eff. Date 10/01/99 PROJECT GGG62P: GGG6 C-51 & L8 Reservoir
GGG6 C-51 And Southern L-8 Reservoir SUMMARY PAGE 1

	CONTRACT	CONTINGN	TOTAL COST
CO Subterranean Seepage Barrier			
CO_01 Construction Cost			
CO_01_15 15 Floodway Control-Divert. Strt			
CO_01_15_01 Cut Off Wall Slurry	16,641,000	1,315,000	17,955,000
CO_01_15_02 Cut Off Wall trenching complete	176,595,000	13,951,000	190,546,000
TOTAL 15 Floodway Control-Divert. Strt	193,236,000	15,266,000	208,502,000
TOTAL Construction Cost	193,236,000	15,266,000	208,502,000
CO_02 Non Construction Cost			
CO_02_30 Planning, Engineering and Design	15,459,000	1,237,000	16,696,000
CO_02_31 Construction Management	19,324,000	1,546,000	20,869,000
TOTAL Non Construction Cost	34,782,000	2,783,000	37,565,000
TOTAL Subterranean Seepage Barrier	228,018,000	18,048,000	246,067,000
PS Pump Station			
PS_01 Construction Cost			
PS_01_01 Pump Plant Inflow	12,169,000	596,000	12,765,000
PS_01_02 Pump Plant Outflow	4,206,000	189,000	4,395,000
TOTAL Construction Cost	16,375,000	786,000	17,161,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	21,336,000	1,067,000	22,403,000
PS_02_31 Construction Management	26,670,000	1,333,000	28,003,000
TOTAL Non Construction Cost	48,006,000	2,400,000	50,406,000
TOTAL Pump Station	64,381,000	3,186,000	67,567,000
TOTAL GGG6 C-51 & L8 Reservoir	292,399,000	21,234,000	313,633,000

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	CONTRACT	CONTINGN	TOTAL COST
PS Advanced WWTP			
PS_01 Construction Cost			
PS_01_02 Treatment Plant	279,039,000	69,760,000	348,799,000
TOTAL Construction Cost	279,039,000	69,760,000	348,799,000
PS_02 Non Construction Cost			
PS_02_30 Planning, Engineering and Design	27,903,000	6,976,000	34,879,000
PS_02_31 Construction Management	41,856,000	10,464,000	52,320,000
TOTAL Non Construction Cost	69,759,000	17,440,000	87,199,000
TOTAL Advanced WWTP	348,799,000	87,200,000	435,998,000
TOTAL HHH6 West Miami Dade Reuse	348,799,000	87,200,000	435,998,000

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APPENDIX D

ENVIRONMENTAL EVALUATION ANALYSES

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APPENDIX D
ENVIRONMENTAL EVALUATION ANALYSES

D.1 INTRODUCTION AND SUMMARY

Formulation of the C&SF Restudy Plans included identifying and evaluating potential environmental responses and water supply impacts for the study area. The Restudy team was composed of many agency representatives and disciplines. This multi-agency-interdisciplinary team developed and documented performance measures/indicators, and other analytical tools including the River of Grass Evaluation Methodology (ROGEM), Across-Trophic-Level System Simulation (ATLSS), and water quality models, so the environmental and other (water supply) benefits and impacts of the plans could be considered during alternatives development. This multi-faceted approach resulted in a comprehensive plan with positive environmental benefits and protection of water supply for environmental and other (urban and agricultural) uses. This appendix includes a description of the performance measures used and the methodologies developed to evaluate the alternative plans. The plan formulation section of the main report- Section 7 - provides a more detailed account of the process followed during plan formulation. This appendix does not repeat the details of Section 7 of the main report; rather, it focuses on the environmental, water quality, and water supply evaluation and results of the analyses.

A preliminary list of benefits and impacts to be assessed during plan development and evaluation was identified in the early phases of the feasibility study. However, it was not immediately obvious how to integrate the different analyses while developing and evaluating plans. An iterative process of developing an alternative plan, evaluating it, and using the results to develop an improved alternative was identified. It was decided that two teams would be formed to carry out these iterative steps: an Alternative Evaluation Team (AET) and an Alternative Development Team (ADT). The AET was charged with evaluating and recommending modifications to alternatives. The ADT was charged with developing and modifying plans that would meet hydrologic targets identified by the AET.

This appendix includes the results of the analyses conducted by the AET and explains how the results were used to produce a Comprehensive Plan. It also explains how the study area with its numerous and often conflicting environmental, water quality, and water supply interests was investigated to include consideration of its unique resources and interests by utilizing appropriate AET subteams (see below) before being evaluated comprehensively by the AET collective. The results of the following evaluations and findings are presented: River of Grass Evaluation

Methodology, ATLSS, water supply measures and targets, and water quality models and methodologies.

D.2 AET ORGANIZATION AND PROCESS

In the fall of 1997 the C&SF Restudy team established the AET for the purpose of providing technical evaluations of alternative plans. The AET was requested to accomplish and document the following:

- approve appropriate ecological and water supply performance measures (specific parameters and targets, discussed in following sections, required to meet ecological and/or water supply objectives) for evaluating the alternative plans,
- evaluate each alternative plan based on how well that plan achieves the targets that are described in the approved performance measures,
- recommend improvements in each alternative plan, based on how well each plan performs relative to the targets identified in the performance measures, and
- identify, at the conclusion of the plan evaluation process, the plan or plans which best achieve the ecological and water supply targets identified by the performance measures.

The AET was a multi-agency team composed of 45-50 biological and physical resource specialists. The 13 federal, state and county agencies with regular representation on the AET are listed in Table D.7.1.1. When it became obvious to the AET that the group was composed of scientists, engineers, and planners with technical expertise in specific areas within the study area, and because the study area was so large the AET decided to divide up into subteams. Consequently, each subteam had the lead responsibility for a specific subregion or topic/issue. A list of the subteams and subteam chairs is provided in Table D.7.1.2.

Each AET subteam was responsible for:

- developing and recommending a set of measures to evaluate performance of the plans in each subregion or topic/issue,
- using the approved performance measures to evaluate how well each alternative plan achieved the targets established for that subregion or topic area,
- collecting and synthesizing all other technical and public comment on each alternative plan, applicable to that subregion or topic,
- reporting to the full AET on recommended performance measures and on the subteam's evaluation of each alternative plan, and
- recommending improvements to the ADT concerning the performance of future alternative plans.

D.3 EVALUATION STRATEGIES

During the initial cycles of the alternative plan evaluation process, the AET developed performance measures. Plans were evaluated using these measures with the expectation that it would be possible to design a plan that would meet all of the performance measure targets. The initial strategy in plan development was that available water in south Florida could be sufficiently increased, and that water could be re-distributed, such that all environmental, urban and agricultural demands could be met.

As the evaluation process proceeded through alternative plans 3-6, it became increasingly certain that, given the physical, operational, legal and societal constraints present in southern Florida, it would not be possible to fully achieve every performance measure target. The affect these constraints had during the evaluation of alternative plans was to create "conflict," where either the volume of water was insufficient, or management options for local or subregional water supplies were sufficiently limited, so that alternative plans could not meet all targets in all areas at all times. Lacking the ability to reach all targets, it became necessary for the AET to establish guidelines for selecting priorities from among conflicting performance measure targets.

The following guidelines were adopted by the AET, as assistance for deciding priorities and strategies for dealing with conflicts among ecological performance measure targets.

1. The hydrological patterns predicted by the Natural Systems Model (NSM), at regional, subregional and indicator region scales, are the patterns that are most likely to lead to the recovery of complete natural systems at the same scales, and generally should be considered to be priority targets for the natural wetlands of south Florida. Indicator regions were created as a means for reducing the degree of uncertainty or error among NSM-based targets, by addressing criticisms raised by a technical review of the NSM (USGS 1997). The USGS review suggests that the NSM is likely to be more accurate in its predictions of regional or subregional hydrological patterns than with predictions of local or point hydrological conditions. The assumption with the indicator regions is that the mathematical means of the hydrological values from a number of adjacent cells with similar topographical and community characteristics will more accurately represent the pre-drainage condition than will a measure from a single cell or point within a cluster of cells.

2. When not all NSM-like hydrological parameters can be recovered within one area, or when meeting these targets in one area reduces the ability of a plan to meet NSM targets in a different part of the natural system, the Conceptual Ecological Models provide additional guidelines for the priority hydrological targets within each landscape and subregion. Each Conceptual Ecological Model identifies critical

ecological pathways, which show the hydrological parameters that are most responsible for the major, adverse ecological changes, and which should be targeted for priority attention in any ecological restoration program. The initial versions of the Conceptual Models are presented in Attachment A of this appendix. These initial versions will under go further revision, as well as peer review. The process that will be followed to review and update the models is described in Section 10, Implementation Plan of the Main Report.

3. In general, no target should have priority, if in meeting the target in one region, long-term ecological damage (compared to current conditions) is caused in some other part of the natural system (i.e., restoration should not cause additional, long-term ecological damage). However, some members of the team, recognizing that substantial changes in community structure and natural system boundaries have occurred over the past 100 years, were willing to see additional local community shifts (short-term “damage”) occur if these would allow the realization of larger scale restoration targets. This view is consistent with the recognition by most Everglades ecologists that a successful Everglades restoration program will be one that recovers those ecological characteristics that defined the original system to a sufficient degree so that a “new” Everglades-type ecosystem is created (Davis & Ogden 1994). While the new Everglades can not possibly duplicate the old, it will be able, if recovery is successful, to sustain Everglades-like ecological patterns in a region which has been substantially reduced in overall spatial extent.

4. It is appropriate to set priorities for ecological targets based on non-NSM criteria, where there is a compelling technical basis for doing so. Refer to the following section titled Performance Measures for an explanation of four situations where it might be suitable to set non-NSM targets.

5. Non-NSM ecological targets may not have priority, if in meeting these targets in one region, it becomes substantially more difficult to reach ecological targets in other regions.

6. Fundamentally different strategies for achieving restoration objectives were previously characterized in the 1994 Restudy Reconnaissance Report as “cookie cutter” vs. “xerox reduction” approaches. The debate is should the goal be “point-for-point” matches with NSM patterns in the remaining portions of the natural system (cookie cutter), or should the goal be to recreate the original community and landscape proportions in an Everglades that is now one-half the original extent (Xerox reduction)? While this question promoted a useful conceptual debate, most recent answers have been, (a) we should do neither (e.g., non-NSM targets have a higher priority), or (b) we should do some combination of the two.

The AET, in setting targets and priorities, developed its own strategy. Subteams used indicator regions for the natural wetlands of south Florida as a basis for evaluating the performance of various alternatives. Indicator Regions were identified as groups of adjacent 2X2 cells within the SFWMM and NSM grids intended to show the hydrological behavior in small, logical subregions common both to the present and pre-drainage Everglades systems. Because indicator regions have ground elevations and community structure that is similar to much more extensive areas of the natural system, the hydrologic patterns predicted to occur in each indicator region were used to evaluate how well alternative plans achieved hydrological restoration targets at subregional and, when considered in aggregate, at regional scales.

Although the team attempted to approximate the NSM targets in the indicator regions (i.e., a cookie cutter approach), the team also recognized that the proportion of long-hydroperiod sloughs to short-hydroperiod prairies in the current Everglades is similar to the proportion between these two landscapes in the pre-drainage system (and therefore, a Xerox reduction strategy was also achieved). The analysis of the proportion of area in the different landscape features of south Florida, in the pre-drainage and current systems, was based on data presented in Davis et al. 1994. Davis et al. used the map in Davis 1943 to calculate "pre-drainage" proportions, and superimposed a modern map over the Davis 1943 map to calculate current proportions. Hydrological models were not used for this analysis. The point of the analysis was that the proportions of the short-hydroperiod and long-hydroperiod wetlands have not changed and that priorities do not need to be given to "correcting" them.

The AET also generally preferred to attempt to meet all hydrological targets for all of the remaining natural area, rather than setting a priority for:

- a discrete subset of the hydrological targets (exceptions here were the priority set for the recovery of NSM-like uninterrupted hydroperiods and for decompartmentalization of the system),
- certain portions of the remaining natural system over others.

The position of the team was that recovery of an Everglades-like system is more likely to occur through recovery of a strong balance of all of the hydrological features that characterized the pre-drainage system (e.g., spatial extent, duration of hydroperiods, sheet flow, flow volumes into estuaries, depth patterns, etc.) than by achieving an NSM target for a small subset of these features, even if the balanced approach falls short of meeting full NSM for any one target. Ultimately, each priority was judged by the question of how likely it is that the target will provide the greatest long-term benefits to the regional system.

D.4 PERFORMANCE MEASURES

Each performance measure was based on one or more ecological or water supply objectives, and described the hydrological parameters, data format and hydrological targets required to meet that objective. Collectively, the performance measures defined the overall, regional hydrological patterns that should result in meeting the ecological and water supply objectives of the project.

Most of the performance measures developed for the natural system were based on hydrologic patterns predicted by the NSM. The AET position was that the NSM is the best available predictor of broad-scaled, pre-drainage hydrologic patterns. The opinion of the AET was that the hydrologic patterns predicted by the NSM are generally consistent with what is known or hypothesized about the optimum hydrological patterns for a number of characteristic animals and communities in the Everglades basin (e.g., soils, plant community patterns, freshwater fishes, alligators, wading birds). The team agreed that it was appropriate to use the NSM as a basis for ecological performance measures so long as appropriate scales were used; that is, for broad patterns of water depth and distribution, and the duration of flooding, but not for cell by cell comparisons, depth targets at scales less than plus/minus 0.5 feet, or precise estimates of flow volumes. As mentioned in Section D.3 paragraph 2 above, the draft Conceptual Models (Attachment A) were relied on to provide guidelines for establishing hydrologic targets which differ from NSM.

The AET agreed that it was appropriate, or even desirable, to set other hydrological targets (i.e., rescaled NSM or non-NSM) where,

(1) the NSM is a relatively poor predictor of pre-drainage conditions such as along model boundaries and where local topographical features are poorly expressed by the models,

(2) biological information for a species or community suggests a hydrological pattern that is different from that predicted by the NSM once existed,

(3) the spatial extent, topography, and the shape and location of natural boundaries have been so altered that restructuring of the remaining natural system may be required in order to achieve ecological or biological balance and long-term restoration objectives, and/or

(4) special consideration is needed for species listed as endangered, threatened, or of special concern by federal or state law.

Initially, the AET approved a large number of performance measures and performance indicators for use in evaluating and interpreting the alternative plans. With increasing experience during the evaluation cycles, the AET subteams learned that a relatively small subset (<100) of the total number of approved performance measures was successful in measuring how well each plan achieved the project objectives. This subset of performance measures became the key set of measures used by the subteams to evaluate the final alternatives. These key performance measures are briefly summarized in Section D.5, AET Results and Documentation**.** The format for documenting the performance measures is presented in Table 3.

The technical documentation for the key performance measures was prepared by the appropriate subteam at the time each new performance measure was submitted to the full AET for approval. Each documentation report followed a standard format. An essential feature of the documentation was the description of the hydrological targets that were prerequisite for meeting the ecological or water supply objective addressed by that measure. The documentation described the desired format for post-processing these data, following the model runs, which allowed the subteams to most effectively evaluate and compare how well one or more plans achieved the essential hydrological targets. The documentation for the performance measures is presented in Attachment B to this appendix.

For most of the ecological performance measures which have NSM-based hydrological targets, the target parameters were established for indicator regions (see Fig. 1 for map of indicator region locations), rather than for single cells or point locations.

D.5 AET RESULTS AND DOCUMENTATION

D.5.1 Development and Evaluation of Plans Starting Point through 5, Identification of Plans A-D

Starting in September 1997, the Restudy team began developing alternative comprehensive plans. During this phase, two base conditions (1995 and 2050) and six alternatives (Starting Point and alternatives 1 - 5) were formulated and evaluated. The results of each of these evaluations were documented and posted on the Restudy webpage as AET reports. Plan 6 was formulated but was evaluated as Plan D for the reasons that follow.

The alternative development phase of the study was an iterative process that began with the Starting Point alternative. Beginning with the Starting Point each subsequent alternative plan was formulated based on the results of the evaluation of the previous alternative. The iterative nature of this phase allowed both the AET and the ADT to learn more about the particular components of the plans including how the components performed under a range of conditions. Further, use of the

Internet provided a medium by which to solicit considerable agency and public comment. The process also gave the teams additional information about the components in regard to engineering and technical feasibility. Therefore, as the teams progressed with formulation of the alternatives, knowledge gained resulted in a refinement (structural and operational) of components in later alternatives.

Repeated modifications to the components created inconsistencies between the alternatives. To ensure that all the alternatives hydrologic output was comparable, the structural and operational components of the alternatives were standardized (i.e. if component x is a component in more than one plan it is modeled the same for each plan). The base conditions were also revised. Because the base conditions and the earlier alternatives were revised, the results of Alternative 6 as well as earlier alternatives were labeled according to a different nomenclature: Revised Alternative 3 was named Plan A, Revised Alternative 4 became Plan B, Revised Alternative 5 became Plan C, and Alternative 6 became Plan D. The changes to the earlier alternatives improved performance and at the same time, equalized the uncertainties between the plans. The final evaluations are presented in an evaluation matrix that displays Alternatives A – D and the 2050 base condition, and Alternatives D, D13R, and the 2050 base condition as described in the following paragraphs.

D.5.2 Decompartmentalization Scenarios and Results

At a joint AET/ADT/Restudy Team meeting on December 15, 1997, various approaches for modeling decompartmentalization were discussed. Three scenarios were formulated as a result of that discussion that progressively removed more of the internal compartments between the WCAs, beginning at the bottom with the L-29 and moving progressively north and east. These scenarios were modeled as variations of Alternative 3. Results were posted on the web site on January 30, 1998, and evaluated at the AET meeting on February 9, 1998.

The AET evaluation showed that as decompartmentalization increased from south to north, flows to Shark River Slough increased. The removal of the L-29 also helped WCA-3A south (Indicator Region 14) where extreme high water conditions were greatly reduced.

Unfortunately, decompartmentalization also caused some unintended consequences. Drying conditions in Loxahatchee NWR (WCA-1), WCA-2A, and northeast Shark River Slough were exacerbated, increasing the dependence on the Lake for water supply. Extreme high water conditions in WCA-3B and eastern WCA-3A increased as decompartmentalization increased. The full decompartmentalization scenario resulted in the most extreme high water conditions in WCA-3B of any scenario.

Because one of the basic tenets of the AET was to “do no harm” to one part of the natural system in order to restore another, the team recommended taking a more moderate approach to decompartmentalization, understanding that if ways to mitigate the problems could be found, decompartmentalization of the upper part of the system could be reexamined at a later date. Therefore, for Alternative 4 and subsequent alternatives, the AET suggested the ADT retain the barriers in the northern part of the system. The barriers between Loxahatchee NWR and WCA-2A and between WCA-2A and WCA-3 were kept to prevent excessive drydowns in the refuge and in WCA-2A and to protect the Lake's littoral zone. The barrier between WCA-2A and WCA-2B was retained to prevent the excessive depths in WCA-2B seen in the more decompartmentalized scenarios. By artificially retaining water in the upper part of the system longer, the team avoided exacerbating the extreme high water conditions in WCA-3B.

D.5.3 Final Development and Evaluation of Alternatives A-D and D13R Process

D.5.3.1 Building the Matrices, River of Grass Evaluation Methodology

The AET reported its final set of evaluations of the revised base conditions and the final alternative plans, A through D, during a 21-22 May 1998 meeting. The AET subteams met to discuss their findings and to develop a way to show and compare the evaluation scores created for each plan. All teams used a final subset of key hydrologic performance measures to develop the numeric scores and related these scores to the habitat and restoration objectives. The procedures used by each of the subteams are discussed in detail in Section D.8. along with an interpretation of the outputs.

The natural systems subteams followed the River of Grass Evaluation Methodology (ROGEM) to develop environmental outputs for the natural areas during the final evaluation of Alternative Plans A-D. The River of Grass Methodology output was used to quantitatively describe the potential habitat quality created by the alternative plans, based on linkages between hydrologic characteristics and habitat restoration targets. The River of Grass Evaluation Methodology used during the Reconnaissance phase of this study used U. S. Fish and Wildlife Service’s Habitat Evaluation Procedure (HEP) to develop community models. HEP uses Suitability Indices in community models to indicate fish and wildlife responses to changes in habitat quality. For this feasibility phase of the study, the Lake Okeechobee, St. Lucie and Caloosahatchee Estuaries subteams followed the HEP procedure to develop Suitability Indices, equations, and numeric output for their subregions. The balance of the AET subteams normalized the performance measure output(s) and used best professional opinion to provide numeric outputs for their subregions.

Key performance measures, by subregion, critical to achieving the ecological objectives of the study were selected for the final evaluation of alternatives A-D and are presented in Section D.6. The River of Grass Evaluation Methodology, through mathematical equations and professional expertise, was used to describe relative habitat quality in the natural system (based on linkages between hydrological patterns and habitat restoration targets) that would result from the plans evaluated. The final performance measures were normalized through mathematical equations to generate numeric outputs (scores) ranging between 0.0 and 1.0 for each subregion and each performance measure. The outputs were treated as ordinal numbers ranging from 0.0, which indicates low habitat quality, to 1.0, which indicates that the plan evaluated fully meets the restoration objective and would provide optimum habitat quality.

Use of the River of Grass Evaluation Methodology equations allowed comparisons of scores among the different base conditions and alternative plans within each of the natural areas. For the water supply objectives a similar method of developing numeric outputs was followed. According to the methodology, the base or alternative plan with the highest numerical score is the best plan for that performance measure (or measures where several are combined in an equation). These results were reported in the matrices.

Although ATLSS and Listed Species (Threatened and Endangered Species) results were not presented during the May meeting (they had not been completed) it was agreed that they would be included when available. Preliminary Water Quality results were presented at the May meeting. It was agreed that the final Water Quality results would also be added to the appropriate matrices for presentation to the full Restudy team during the June meeting.

The numeric outputs (scores) resulting from the ecological and water supply evaluations were entered into a set of matrices. Supporting documentation by each subteam for developing their matrix is explained in each subteam's narrative report. The subteam reports are presented in Section D.8 of this appendix. Each subteam report provides technical documentation for the matrix. The documentation includes a list of the performance measure(s) used, the geographical area or indicator regions covered, and an explanation of the River of Grass Evaluation Methodology or water supply equation(s) used to develop the outputs.

The supporting documentation includes an interpretation of the meaning of the numerical scores relative to the long-term ecological or water supply objectives addressed by the performance measure(s) in that matrix. The documentation provides additional explanations about how the subteam interpreted the scores relative to the targets. The interpretations rely in part on the "best professional opinion" of the subteam members as a means for providing an interpretation of the scores in the matrices.

The numerical matrices were prepared by the AET subteams primarily for use by the full AET; however, it is important to know how the numbers in the matrices were calculated, as a basis for understanding how these numbers should be used and interpreted. For several reasons caution should be used in comparing scores among different matrices or among different rows within a matrix. The most appropriate comparisons among the scores are within a single row for a single subarea (for example, Shark River Slough) as a basis for comparing how well several different plans performed at moving towards or achieving the subareas' target(s). However, because different equations were used among the different matrices, direct comparisons of the scores in the different matrices would not be valid. Due to the documented levels of error in the hydrological models, one should not assume significance in relatively small differences in numerical scores in the matrices, since the numerical scores imply a greater degree of predictive power than is possible. Because ecological thresholds and relationships for the biological elements in the extensively altered natural system are poorly known, the narrative interpretations provided with each matrix should be consulted for an improved understanding of the ecological strengths of each plan.

For these reasons, the full AET made its final comparisons of the 2050 base condition and plans A-D by using three summary evaluation criteria:

- plan ranking
- plan grade
- plan color

These criteria which are further explained in the following section, were designed to convert the numerical scores in the subteam matrices into more qualitative descriptions of plan performance.

D.5.3.2 Summary of AET Results for Alternative Plans A – D

The results of each subteam evaluation for the 1995 and 2050 Bases and Alternative Plans A-D are presented in detail in later sections of this appendix. Refer to the Table of Contents for this Appendix if seeking particular subteam evaluations. The following paragraphs provide a summary of the subteam evaluations.

The AET used the different matrices as a basis for organizing the large numbers of scores for the two base cases and four alternative plans. The documentation and interpretation for these matrices are described in each of the individual subteam's reports, which follow this introduction. References that pertain to documentation of the matrices can be found in the reference section of the Feasibility Report. The matrices allowed comparisons among the two bases and four alternative plans, for purposes of ranking the different plans, and to evaluate how well each plan performed relative to, (1) the targets defined by the performance measures and (2) the performance of the 2050 Base (future without plan condition).

The evaluation criteria - plan ranking, plan grade, and plan color - used to compare the four alternative plans (A – D) and the 2050 Base were derived from the numerical output from the River of Grass Evaluation Methodology by all subteams except the Northern/Central Everglades team. The Northern/Central Everglades subteam ranked, graded, and assigned colors before they used ROGEM, and used these rankings, grades, and colors as inputs to ROGEM.

D.5.3.2.1 Plan Ranking

For each sub-region, the alternative plans and the Without Plan Condition were ranked from one through five. The best plan for each sub-region was awarded a one (1), the worst plan earned a score of five (5), and the intermediate plans received values from two (2) through four (4). Ties were dealt with by averaging. For example, if two plans were tied for first place, they each received a score of 1.5, the average of 1 and 2. If three plans tied for first place, they each received a score of 2, the average of 1, 2, and 3. This system ensured that 15 points for each sub-region were allocated across the alternatives, equalizing the contribution of each sub-region to the final sum of rankings. The results of this evaluation are included in ***Table 7-8***. The plan with the lowest cumulative score received the highest rank. For example, Plan D, the highest ranked plan, scored 45 points compared to the Without Plan condition which received 102 points.

D.5.3.2.2 Plan grades

Plan grades were created based on the numerical output (from the River of Grass Evaluation Methodology or water supply equation) for each subregion/topic. A letter grade (A,B,C,D,or F) was assigned based on these numeric scores. Letter grade A was best at meeting the performance measure targets and restoration or water supply objective; and letter grade F failed to meet the performance measures, similar to the letter grading system used in academia. More than one plan could receive a similar grade for a subregion/topic, if two or more of the plans performed similarly for the performance measures for the subregion/topic. For example, Loxahatchee National Wildlife Reservation earned a letter grade A for plans A-D since it fully met the Performance Measure target and the restoration objective. Table 5 lists all the plan grades for each subteam.

D.5.3.2.3 Plan colors

Plan colors (green, yellow, and red) were created by converting plan grades into a "best professional opinion" prediction by the members of each subteam on how likely each plan and base case would achieve the long-term ecological or water supply objectives which are identified for each performance measure. Each color provides a prediction of how likely a plan will achieve the recovery and long-term sustainability objectives defined by the performance measure(s), and a recommended priority for further improvement in the design and operation of the plan evaluated. Green indicates the current plan is likely to recover and sustain the ecological or water supply objective described by the performance measures, and that further plan improvement is unnecessary or a low priority. Yellow indicates achievement of the long-term objectives is uncertain, and that improvement in the plan is a moderate priority. Red indicates the recovery and long-term sustainability of the target objective are unlikely, and that the current plan requires improvement if these targets are to be met. Refer to Table 6.

D.5.3.2.4 Summary of Plans A-D Based on Rankings, Grades, and Colors

Results of the rankings, grades, and colors show that Alternative D is the best overall plan for meeting the performance measures. For these same criteria, Alternative C is the second best plan. Table 7 shows that for Listed Species, Alternative D ranks slightly higher than the other alternatives, with Alternative C ranking second. All tables show that for almost all performance measures, one or more plans provide substantial benefits (i.e., improvements) over the 2050 Base. The AET recommended Alternative D, with the proviso that steps be taken to correct specific weaknesses in the alternative.

Overall, Alternative D performed best for:

- Lake Okeechobee,
- Caloosahatchee Estuary,
- Lake Okeechobee Service Area,
- Lower East Coast,
- Loxahatchee NWR,
- Holey Land and Rotenberger WMAs,
- southern and southeastern Big Cypress basin,
- southern Everglades Rocky Glades.

Alternative D, as modeled, did not meet (reds in Table 6) performance targets in:

- portions of WCAs 2 and 3, and
- Shark Slough.

Alternative D moved towards meeting (yellows in Table 6) targets for:

- St. Lucie Estuary, and
- Florida Bay.

The AET recommended that ad hoc teams of ecologists, hydrologists and modelers be created to determine both the immediate and long-term strategy for improving the performance of Alternative D in the red and yellow scored areas.

The AET also highlighted three specific strengths of Alternative B, which, if incorporated into Alternative D, would bring the different ecological strengths of these two plans together in a single final plan. These plan B strengths were:

- higher volumes of flow into the Florida Bay estuary compared to other plans,
- greater success at reestablishing system connectivity, and
- improved levels of sheet flow, compared to other plans.

These three features were a consequence of the greater extent of system-wide decompartmentalization, which characterized Alternative B. The AET recommended that an ad hoc team explore the feasibility of merging these features of B into D.

D.5.4 Selection and Refinement of Initial Draft Plan (D13R)

At the Restudy meeting the week of June 2, 1998, Alternative D was selected as the initial draft plan. The full team supported the AET recommendation that Alternative D needed refinement to improve its performance in five key areas: WCA-2, WCA-3, Shark River Slough, Florida Bay, and the St. Lucie Estuary.

During the period from June 5-15, 1998 a team of engineers and ecologists conducted an intense iterative process to attempt to improve the hydrologic performance of Alternative D in the WCAs and Everglades National Park. During this week and a half, many refinements to operations and structures were made to Alternative D. Initially, the refinements consisted of only operational changes (iterations D1-D7) that proved inadequate to meet the desired performance. It was evident that structural changes to the Plan were necessary: Plans D8-D13R were developed and modeled. The final model iteration, D13R, accomplished refinements to the initial draft plan that improve its performance in the remaining Everglades, to provide for a sustainable Everglades ecosystem and move towards restoration.

The fifth area where improvement was desired was the St. Lucie Estuary. During the same time that the Everglades team was working on Plans D1-D13, the Indian River Lagoon Feasibility Study modelers were working to improve the St. Lucie Estuary performance. Improvements made include increasing storage in the C-23, C-24, North Fork and South Fork basins as well as making refinements to the estuary triggers.

Modifications made to the initial draft plan achieved improved performance in the WCAs and Everglades National Park without compromising Lake

Okeechobee water levels or water supply to LOSA and LECSA. The modifications improved adverse high and low water conditions in the WCAs. Flow volumes to Shark River Slough were increased while seasonal distribution of flows as indicated by NSM was maintained. The number of drydowns in Shark River Slough was reduced to three events over the period of record compared to two events under NSM. Salinity in Florida Bay coastal basins as indicated by P33 stages was also improved. These improvements were achieved through partial decompartmentalization of WCA-3 and the Park, which makes Alternative D13R more like Alternative B as desired by the AET and the Restudy Team. Performance in the St. Lucie Estuary came closer to meeting targets.

Table 5 is a summary table of letter grades for the 2050 Base Case, and Initial Draft Plans D – D13R. Table 6 shows the same for color ranking.

D.5.5 Scenarios D13R1-4

During the period November 1998 through January 1999 hydrologic modelers, engineers, and ecologists developed and evaluated a series of scenarios (referred to by some as the “new water” scenarios). The objective of these scenarios was to capture additional volumes of fresh water, primarily to improve the performance of Alternative D13R in the southern Everglades and Biscayne Bay, and to redistribute water in the Water Conservation Areas. The summary of Scenario D13R4 results are presented in Section D.9 of this Appendix. The more detailed report is in Attachment E. to this Appendix. The earlier Scenarios D13R1-3 were not fully documented because the process of developing and documenting them was quick and iterative with improvements being made immediately to develop a new scenario after AET teams completed their analyses. Time was not spent on documenting the results of scenarios D13R1-3 but rather on improving their performance as a new scenario. Scenario D13R4 was documented when time ran out for developing additional scenarios but it had been clearly demonstrated that improvements to D13R could be achieved.

The Alternatives Evaluation Team recognized that much new information regarding the potential performance of D13R was gained through the modeling of the four scenarios. The hydrologic responses during the modeling convincingly demonstrated the operational flexibility and robustness of D13R, and offers encouraging documentation that additional improvements to the natural system can be achieved during the detailed planning phases of the restoration program.

D.6 OVERVIEW OF FINAL PERFORMANCE MEASURES (PMS) USED BY AET SUBTEAMS

This section provides a brief summary of the final subset of performance measures that were used to evaluate Plans A-D and the problem to be improved or corrected by the alternative plans. While the subteam reports presented in Section D.8 include a far more detailed discussion of the Performance Measures, the subregion/topic problem(s) and evaluation results of Plans A-D, the following list and brief discussion of the final Performance Measures was developed to provide a quick and concise guide to what the Alternatives Evaluation Team believed were the most important and desirable hydrologic conditions to be obtained within each of the subregions. Likewise, this section does not discuss the results of the alternative plans because the results are summarized in the tables in Section D.7. Tables showing Plan Rankings, Letter Grades, and Colors, along with a detailed discussion can be found in Section D.8. The final Performance Measures, by subregion/topic are discussed in the following sections.

D.6.1 The Total System Matrix: Continuity, Sheetflow, and Fragmentation

The total system matrix was evaluated according to three attributes: continuity, sheetflow, and fragmentation.

D.6.1.1 Continuity (expressed as Water Surface Elevation Differences Across Barriers)

Water surface elevations on either side of the C&SF Project structures (canals and levees) tend to be very different (i.e. pooling upstream and too dry downstream) from what they were originally. These conditions adversely effect aquatic organisms and their prey. Different species of wading birds, for example, rely on various depths of shallow marsh to capture prey. Abrupt changes in depth, from too deep and to too shallow, limit feeding opportunities in these modified areas.

Final performance measures (PMs) used were based on a count of the number of weeks where the difference in water surface elevations across eight barriers within the remaining Everglades exceed the difference predicted by NSM 4.5F. The eight barriers were L-39 (between Loxahatchee NWR and WCA-2), L-38 (Between WCA-2 and 3), Miami Canal South, Miami Canal North, L-67, Tamiami Trail West of L-67, Tamiami Trail East of L-67, and L-28.

D.6.1.2 Sheetflow (expressed as Overland Flow Volume Transects)

Today's Everglades have been highly modified from a vast expanse of sheetflow to a compartmentalized system. The C&SF Project caused pooling on the upstream side and excess drying on the downstream side of hydrologic barriers. Ponded systems favor some species while flowing systems favor others. Differences resulting from these two systems include: food types and sources, migration of macroinvertebrates, dispersion of nutrients, aeration and diffusion of gases in water, particulate suspension, and thermal stratification. Sheetflow also helps shape tree islands, supports microhabitats on the upstream and downstream sides, enhances the uptake of nutrients from the water column and creates an environment that precipitates phosphorus, along with calcium carbonate, into the substrate.

Final PMs used were flow volumes (wet season and dry season average overland flows) across 26 transects grouped into categories representing their general area: Big Cypress, Central Everglades, Central Everglades, Southern Everglades, Tamiami Trail, and L-67.

D.6.1.3 Fragmentation (expressed as miles of canals and levees)

Levees block the flow of water and thereby restrict the movement of aquatic and semi-aquatic life forms. Land-based predators use levees to invade the marsh interior and prey upon animals that try to cross these terrestrial habitats. Levees also act as conduits by supporting invasion of terrestrial plants into natural areas. Canals act as corridors for non-native animals and plants that extend their ranges from points of introduction and move into wetlands where they alter habitats and affect food webs. Artificial, deep-water habitats provide thermal and spatial refuge to large numbers of both non-native and native aquatic predators in the dry season, enhancing their survival and ultimate population sizes. During the dry season, these predators feed heavily on small marsh fishes and invertebrates that move into the canals from adjacent wetlands.

Final PMs used were the number of miles of canals and levees in the South Florida Water Management Model bordering or bisecting natural areas.

D.6.2 Lake Okeechobee

Lake Okeechobee is a valuable regional as well as local natural resource. Fluctuation and timing of lake stages affect the distribution of native and exotic plant communities, and overall habitat quality (cover, nesting sites, foraging habitat) for fish, birds, and other wildlife. Extreme low lake levels can result in loss of the littoral zone as habitat for aquatic biota and promote expansion of exotic plants into pristine native-plant dominated regions of the lake. Prolonged moderate low lake levels also reduce areas of the littoral zone available for wildlife habitat and promote exotic plant expansion. Extreme high lake levels can result in wind and wave damage to shoreline plant communities, and transport phosphorus-laden pelagic water into pristine inner regions of the littoral zone. Prolonged moderate high lake levels limit light penetration to the lake bottom (which results in loss of benthic plants and algae that stabilize sediments and provide habitat), and promote greater circulation of phosphorus-rich waters from the mid-lake to less eutrophic near-littoral regions, where phosphorus inputs stimulate algal blooms.

While extreme or prolonged high and low lake levels are damaging to the ecosystem, some variation within an intermediate range has great benefits. In particular, a spring recession of lake levels from near 15 feet to 12 feet NGVD has been shown to favor nesting birds and other wildlife in the marsh, allow for re-invigoration of willow stands, and permit fires to burn away cattail thatch. Yearly recessions to 12 feet also facilitate the growth of submerged plant communities, which serve as habitat for commercially and recreationally important fish. The goal is to have a substantial number of these events.

Final performance measures used were:

1. Frequency and duration of extreme low lake stages (number of events <11 ft),

2. Prolonged moderate low lake stages (number of prolonged [>12 months] events <12 ft),

3. Number of extreme high lake stages (>17 ft),

4. Prolonged moderate high lake stages (number of prolonged [>12 month] events >15 ft), and

5. Spring recession patterns based on number of years January through March lake stages decline from near 15 ft to 12 ft. without reversals >0.5 ft.

D.6.3 Lake Okeechobee Service Area (LOSA)

Water supply effects the frequency, duration, and severity of water supply cutback events in the Lake Okeechobee Service Area (LOSA). The service area includes the Everglades Agricultural Area, the Caloosahatchee, St. Lucie, S-4, and L-8 Basins, and the Seminole Indian (Brighton and Big Cypress) Reservations.

Performance measures were developed to evaluate the frequency, duration and severity of water supply cutback events in the Lake Okeechobee Service Area. Water restriction events vary as to how often they occur (frequency), how long an event lasts (duration), and how much of the water that would normally be demanded is not delivered (severity). Scores were developed for each of these characteristics.

The number of years with water restrictions from the "Frequency of Water Restrictions" graphic was used to identify water shortages. The established performance target is that there be no more than three years during which cutbacks occur over the 30-year period of performance available from each simulation.

The "LOSA Supply Side Management Report" was used to develop a combined duration/severity score, for relative comparisons of alternatives only.

D.6.4 Lower East Coast (LEC)

During the dry season structural releases are periodically made from the Water Conservation Areas (WCAs) and Lake Okeechobee to maintain ground water levels and to minimize the possibility of saltwater intrusion along the Lower East Coast. This water is required to recharge secondary canal networks, wellfields and other recharge areas, and lakes. When water stored in the WCAs and Lake Okeechobee is scarce, the urban water supply demands are restricted (cut back) in order to conserve the remaining supplies in the regional system.

Several final PMs were used:

1. The ability to meet the 1-in-10 year water supply planning goal: The planning goal is to find a balance between ability of the regional system to supplement recharge of the aquifer and meet the public water supply planning goal of a 1-in-10 year level of service in the lower east coast of Florida. The planning goal is in terms of the frequency of cutback events and is defined as no more than three cutback events, no more than seven months in duration over the period of record.

2. Percentage of months not in a water supply cutback: The duration of water supply cutbacks was used as an indicator of the reliability of water supplies.

3. Stage duration curves in south Miami-Dade canals: **s**altwater intrusion criteria do not exist for the major canals in southern Miami-Dade County. However, water levels in these canals were evaluated because encroachment of the salt front into the Biscayne aquifer has occurred previously in this area. Also, major public water supply wellfields are located in southern Miami-Dade County. This area was evaluated by using the stage duration curves for the following structures: C-100A @ S-123, C-1 @ S-21, C-102 @ S-21A, and C-103 @ S-20F.

D.6.4.1 Performance Measure Used in the Agricultural Area along the L-31N

Six cells in the western areas of southern Miami-Dade County were evaluated. End of the month stage duration curves for 1983-1993 were used to compare an 11-year target stage duration curve to the 31-year stage duration curves for the bases and alternatives.

D.6.5 Northern/Central Everglades

Modifications to hydropatterns have resulted in adverse impacts on the flora and fauna inhabiting portions of the Everglades that now exist as Water Conservation and other managed areas. The Performance Measures identified for use in the Restudy were developed to evaluate a plan's potential for:

- protection and accretion of peat soils (indicated by a low predicted occurrence of extreme low water [depths more than 1.0 ft below ground surface]);
- persistence of tree island communities (indicated by a low predicted frequency of extreme high water); and
- an inundation pattern suitable for an Everglades sawgrass or ridge-and-slough marsh (indicated by a number and mean duration of inundation events that either closely matched the target for that indicator region, or that fell within the range of patterns predicted by the NSM for that landscape type).

The final set of Performance Measures used was:

(1) Inundation pattern (number and mean duration of inundation periods);

(2) Extreme high water (number and mean duration of high water events); and

(3) Extreme low events (number and mean duration of low water events).

Target variable values for the performance measures were those predicted by NSM 4.5, Final, with four exceptions:

(1) Indicator Region 17, performance was evaluated by comparing values to the average of NSM values for Indicator Regions 14 and 18; this was because the NSM depths in this indicator region had been identified during evaluation of alternatives 1-3 as being lower than desirable for this relatively pristine marsh area;

(2) LNWR, the targets were 1995 Base values, in keeping with the refuge's current regulation schedule;

(3) High water extremes, the performance target was that the number and duration of events be less than or equal to NSM values; and

(4) Low water extremes, the performance target was for frequencies and duration of events to be minimized.

The final evaluation classified the indicator regions into ten subregions that correspond to areas with distinct hydrologic performance. These are:

(1) Loxahatchee NWR (Indicator Regions 26 & 27);

(2) Holey Land & Rotenberger WMAs (Indicator Regions 28 & 29);

(3) WCA-2A (Indicator Regions 24 & 25);

(4) WCA-2B (Indicator Region 23);

(5) NW WCA-3A (N of Alligator Alley & W of Miami Canal; Indicator Regions 20 & 22);

(6) Northeastern WCA-3A (N of Alligator Alley & E of Miami Canal; Indicator Region 21);

(7) Eastern WCA-3A (S of Alligator Alley, E of Miami Canal; Indicator Region 19);

(8) Central & Southern WCA-3A (S of A. Alley, W of Miami Canal; Indicator Regions 14, 17 & 18);

(9) WCA-3B (Indicator Regions 15 & 16); and

(10) Pennsuco Wetlands (Indicator Regions 52 & 53).

D.6.6 Southern Everglades

Southern Everglades were was evaluated according to two regions: Shark River Slough and Rockland Marl Marsh.

D.6.6.1 Shark River Slough

Ecological values and indicators of restoration success in Shark River Slough that are linked to the hydrologic performance measures in the conceptual model include:

- increased nesting success and abundance of American alligators and a corresponding increase in the number of occupied alligator holes to serve as drought refugia and to increase habitat heterogeneity,
- increased population density of aquatic fauna,
- increased abundance of wading birds and wood storks,
- re-establishment of coastal nesting colonies of wading birds and wood storks,
- earlier timing of colony formation by wading birds and wood storks,
- resumption of the return frequency of wading bird and white ibis super colonies,
- enhanced production and community composition of periphyton,
- accelerated accretion of peat soils, and
- persistence and resilience of macrophyte and tree island plant communities including the cessation of sawgrass expansion into wet prairies and sloughs.

Priority performance measures for the ecological restoration of Shark River Slough are identified in the Everglades Sloughs Conceptual Model. Those measures, in order of priority, are:

(1) duration of uninterrupted flooding,

(2) drought severity as measured by the duration of dry conditions,

(3) water depth during periods of flooding,

(4) total annual flow volume, and

(5) seasonal distribution of flow in mid Shark River Slough.

NSM4.5 Final (NSM4.5F) characterized Shark River Slough as a predominantly aquatic system that was continually flooded and flowing during wet and dry seasons and during wet years and all but the most extreme dry years. NSM4.5F indicated that Shark River Slough would have dried only two, three and six times during the 31-year period of record in the NE, Mid and SW indicator regions, yielding uninterrupted periods of inundation that averaged 535, 401 and 226 weeks. Water depths averaged 1.8, 1.6 and 1.2 feet during periods of flooding in the three respective indicator regions. Dry conditions lasted for an average of four, three and six weeks respectively.

D.6.6.2 Rockland Marl Marsh

Ecological values and indicators of restoration success in the Rockland Marl Marsh that are linked to the hydrologic performance measures in the Conceptual Model include:

- re-colonization and population resurgence by American alligators and a subsequent increase in the number of occupied alligator holes to serve as dry season refugia for aquatic fauna and to increase habitat heterogeneity,
- increased population density of aquatic fauna,
- increased seasonal abundance and foraging activity of wading birds and wood storks,
- enhanced production and community composition of periphyton,
- accelerated accretion of marl substrate,
- increased nesting success and population size of Cape Sable seaside sparrows, and,
- persistence and resilience of highly diverse macrophyte and tree island plant communities.

Priority hydrologic performance measures for the ecological restoration of the Rockland Marl Marsh are identified in the Marl Prairie/Rocky Glades Conceptual Model. Those measures, in order of priority, are:

(1) duration of uninterrupted flooding,

(2) drought severity as measured by the duration of dry conditions, and

(3) number of wet season water level reversals when the depth drops to less than 0.2 feet during a period of flooding.

NSM4.5F characterized the Rockland Marl Marsh as a seasonally flooded system where water levels typically dropped below the ground surface during most years, except during prolonged high rainfall periods when the marsh remained flooded for multiple years. NSM4.5F indicated that uninterrupted periods of inundation averaged 44 weeks. Only two wet season water level reversals occurred during 31 years. Dry conditions lasted for an average of 26 weeks.

D.6.7 Florida Bay

Ecological values and indicators of restoration success in the Florida Bay mangrove estuary and coastal basins that are linked to the hydrology/salinity performance measures in the conceptual model include:

- increased production of low-salinity mangrove fish and invertebrates,
- re-establishment of coastal nesting colonies of wading birds and wood storks and eastern Florida Bay colonies of roseate spoonbill,
- earlier timing of coastal colony formation by wading birds and wood storks,
- resumption of the return frequency of wading bird and white ibis super colonies,
- increased growth and survival of juvenile American crocodiles,
- increased cover of low-to-moderate salinity aquatic macrophyte communities in coastal lakes and basins,
- return of seasonal waterfowl aggregations to coastal lakes and basins,
- enhanced nursery ground value for sport fishes and pink shrimp in coastal basins, and
- persistence and resilience of the mangrove, salt marsh and tidal creek vegetation mosaic.

Priority performance measures for the ecological restoration of the Florida Bay coastal basins are identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model. All performance measures are based on relationships between mean monthly salinity in five coastal basins, from Joe Bay to North River Mouth, to water stage at the P33 gage in mid Shark River Slough. The final PMs used are:

(1) number of months during the period of record when stages equal or exceed 6.3 feet msl at P33,

(2) number of months during the period of record when stages equal or exceed 7.3 feet msl at the P33 gage,

(3) cumulative salinity difference (ppt) from the undesirable high salinity levels that were identified for each basin, and

(4) cumulative salinity difference (ppt) from desirable low salinity levels that were identified for each basin during the wet/dry season months of August-October.

D.6.8 Model Lands / C-111

The Model Lands Alternatives Evaluation Matrix consists of the following performance indices, which are applied to each of the four indicator regions in the Model Lands area: 4, 5, 6, and 47:

(1) High water index: The proportion of time that water levels are below the high water threshold which has been specified for the indicator region. The target is 1.00, however proportions down to 0.90 are acceptable to allow for interannual variation. This index quantifies the period of time that water levels are so high that they may stress the vegetation communities naturally characteristic of these areas.

(2) Low water index: The proportion of time that water levels are above the specified low water threshold. The target is 1.00. This criterion seeks to minimize the period of time that water levels are below a specified low water level.

(3) Extreme low water index: The proportion of time that water levels less than 1 ft below the specified low water threshold. Target is 1.00. Values near 1 indicate that dry season levels are above the extreme low water level almost all of the time. Values closer to 0 indicate that dry season water levels typically fall at least another foot below the specified low water level.

(4) Relative dry period slope index: Relative measure of the steepness of the slope of the stage duration curve during dry periods. The index can vary from almost 0 (very steep slope; water levels drop dramatically during dry periods) to approximately 1.0 (slope shallow; water levels relatively stable throughout the dry season). Values closer to one are preferred.

(5) Wet season inundation pattern index: Proportional measure of how many times during the 31-yr simulation that water levels drop below surface elevation during the July-October portion of the wet season. The best alternative received a score of 1.0 and the worst received a score of 0.0. This criterion gives a relative ranking for how many times the aquatic habitat is disrupted by dry-downs during the core months of the wet season. The months June and November were omitted from the analysis to allow for variation early and late in the season.

(6) Late wet season inundation index: Proportional measure of how many times during the 31-yr simulation that autumn periods of inundation ended during the months of November and December. This index was applied only to Indicator Region 5 (Model Lands South), which includes habitat critical for Roseate Spoonbill feeding. A good year for wading bird feeding would be characterized by standing water in this indicator region well into January. Premature drydowns in the early dry season in this region may severely reduce available food to support Roseate Spoonbill nesting. The best alternative received a score of 1.0 and the worst received a score of 0.0.

D.6.9 Big Cypress

The Big Cypress area was evaluated as three areas, North Big Cypress, South Big Cypress, and Southeast Big Cypress. The following is a summary description of the PMs and problems by subarea:

D.6.9.1 North Big Cypress National Preserve.

Impacts in north Big Cypress are due primarily to agricultural development and its associated canals upstream (north) of this area. However, the results were suspect because there are model boundary problems with hydrologic model output in this area since the area to the north is included in the Natural System Model, but not the South Florida Water Management Model. PMs used were:

(1) Percent of North Big Cypress National Preserve that matches NSM (mean NSM hydroperiod matches)/100. This PM provides a spatial measure of one of the more impacted portions of the Big Cypress that lies along its northern border.

(2) Reduction in percent of time inundated from NSM condition based on indicator regions 42-43. This PM provides a measure of deviation from NSM hydroperiod for these indicator regions.

(3) Maximum deviation from NSM stage duration curve using indicator regions 42-43. This PM used normalized weekly stage duration curves to provide a measure of how much water levels have been altered from NSM conditions as a function of the NSM range of fluctuation for these indicator regions.

(4) Average flood duration for indicator regions 42-43. This PM provides a measure of deviation from NSM for average duration of individual flooding events for indicator regions 42-43.

D.6.9.2 South Big Cypress National Preserve.

Final PMs used for the southern portion of the Preserve:

(1) Percent of South Big Cypress National Preserve that matches NSM (mean NSM hydroperiod matches)/100. This PM provides a spatial measure of the relatively unimpacted portion of the Big Cypress.

(2) Reduction in percent of time inundated from NSM condition based on indicator regions 31, and 36-40. This performance measure provides a measure of deviation from NSM hydroperiod for an indicator region.

(3) Maximum Deviation from NSM stage duration curve based on indicator regions 31, 36-40. Normalized weekly stage duration Curves were used to measure how much water levels have been altered from NSM conditions as a function of the NSM range of fluctuation for the indicator regions.

(4) Average flood duration for indicator regions 31, 36-40. This PM provides a measure of deviation from NSM for average duration of individual flooding events for indicator regions 31, 36-40.

(5) Percent change in flow from NSM condition/100. Total flows during the wet and dry season for a flow cross section ("Eastern Big Cypress") were used to express hydrologic conditions and how they changed in response to proposed alternatives.

D.6.9.3 Southeast Big Cypress.

Final PMs used for the southeast Big Cypress were:

(1) Reduction in percent of time inundated from NSM condition. This PM provides a measure of deviation from NSM hydroperiod for indicator region 13.

(2) Maximum deviation from NSM stage duration curve. This PM used normalized weekly stage duration curves to provide a measure of how much water levels have been altered from NSM conditions as a function of the NSM range of fluctuation for indicator region 13.

(3) Average flood duration for indicator region 13. This PM provides a measure of deviation from NSM for average duration of individual flooding events for indicator region 13.

(4) Percent change in flow from NSM condition/100. Total flows during the wet and dry season for a flow cross section ("Lostman's Slough") were used to express hydrologic conditions and how they changed in response to proposed alternatives.

D.6.10 Caloosahatchee Estuary

Caloosahatchee Estuary has been adversely impacted by extreme water delivery events from Lake Okeechobee and local drainage basins. These events cause extreme ranges in salinity as well as severe physical alterations within the estuary. The following are the final performance measures used:

1. Minimum mean monthly flows less than 300 cfs. This PM is based on the number of times the minimum mean monthly flows from the lake and watershed fall below 300 cfs at S-79. Insufficient fresh water discharges had direct effects on estuarine seagrasses, fish and invertebrates, including critical indicator species (eg. Vallisneria) by enabling the estuary to become too saline.

2. Mean monthly freshwater discharges exceeding 2,800 cfs. This PM is based on the number of times mean monthly flow exceeds 2,800 cfs as measured at S-79. High volume discharges to the estuary contribute to poor estuarine water quality conditions including increased turbidity, color and violation of favorable salinity envelopes. These conditions have direct effects on estuarine seagrasses by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat, and contributing to unfavorable salinities for aquatic vegetation, fish and invertebrates, including critical indicator species (e.g., the American oyster, turtle grass, and Vallisneria).

3. Fresh water discharges exceeding 4,500 cfs. This performance measure is based on the number of times mean monthly flows exceed 4,500 cfs at S-79. Mean monthly flows above 4,500 cfs results in freshwater conditions throughout the entire estuary causing impacts to estuarine biota. This volume of flow also begins to reduce water quality and adversely impact biota in San Carlos Bay.

4. Zone A discharges from Lake Okeechobee. This PM is based on the number of days of Zone A discharges from the lake, measured as 7,800 cfs per day at S-79. Zone A discharges have rapid and serious effects on estuarine seagrasses in the Caloosahatchee River Estuary and San Carlos Bay by reducing light penetration necessary for photosynthesis destroying fish and invertebrate habitat, and contributing to unfavorable salinities for estuarine biota.

D.6.11St. Lucie Estuary

The St. Lucie Estuary receives freshwater inputs both through interbasin transfer from Lake Okeechobee and from local watershed contributions. The maintenance of flows to the estuary to achieve the appropriate salinity regime therefore must manage both watershed runoff and regulatory flows from Lake Okeechobee. Final PMs used were:

1. Minimum flows (mean monthly flows <350 cfs). This PM is based on the number of months the mean monthly flows fall below 350 cfs. The target is to have no more than 50 months with mean monthly flow less than 350 cfs. Insufficient freshwater discharges during the dry season contribute to reduced estuarine productivity. Minimum levels of inflow and nutrients usually occur at the end of the dry season (April and May). It is during these months that numerous species of juvenile fish depend on an abundant food supply of phytoplankton and zooplankton which requires a minimum level of fresh water and nutrients.

2. Moderately high flows (mean monthly flows >1,600cfs). This PM is based on the number of months with mean monthly flows > 1,600 cfs. The acceptable violations (target) allowing for natural variation is nine. As flows exceed this limit, salinity is reduced below desirable levels for some estuarine resources. High volume discharges to the estuary contribute to poor estuarine water quality including increased turbidity, and violation of the favorable salinity envelope. These events have direct effects on submerged aquatic (SAV) by reducing light penetration necessary for photosynthesis, degrading fish and invertebrate habitat, and contributing to unfavorable salinity concentrations for aquatic vegetation, fish and invertebrates, including the indicator species (American oyster and SAV).

3. High flows (mean monthly flows>2,500 cfs). This PM measures the number of times mean monthly flows from the lake and watershed exceeds 2,500 cfs. The target is no more than three months with mean monthly flows > 2,500 cfs. Mean monthly flows above 2,500 cfs result in freshwater conditions throughout the entire estuary causing severe impacts to estuarine biota. This volume of flow begins to impact the Indian River Lagoon to the north and south of the St. Lucie Inlet.

4. Zone A discharges. This PM is based on the number of days of Zone A discharges from Lake Okeechobee (7,200 cfs per day at S-80). The target is zero (0) violations. Zone A discharges transport large amounts of sediment and results in freshwater conditions within the entire estuary. These events can have rapid and serious effects on estuarine SAV by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat and contribute to unfavorable salinity concentrations for most aquatic life. Zone A discharges cause adverse effects on large areas of the Indian River Lagoon surrounding the St. Lucie Inlet and possibly influence nearshore ocean habitats adjacent to the Inlet.

D.6.12Lake Worth

Lake Worth has been adversely impacted by altered salinity. The performance measure used in this analysis for the Lake Worth Lagoon was “Wet/Dry season average flows discharged to Lake Worth Lagoon through S-40, S-41, and S-155 for the 31 year simulation.” The restoration target is to create estuarine conditions, to the extent possible, in the Lake Worth Lagoon. An estuarine salinity envelope of 23 ppt to 35 ppt has been chosen as the target salinity range. This is a viable salinity range for a number of organisms, many which are commercially and recreationally important. To attain this salinity a maximum flow needed to be developed. Previous hydrodynamic modeling indicated that 500 cfs creates a steady state salinity of 23 ppt. For the low flow part of the salinity envelope, 0 cfs is the target. Enough ground water occurs that should still allow estuarine conditions. Based on past modeling, this flow range of 0-500 cfs should create the salinity range of 23 ppt - 35 ppt.

Performance Measure: Wet/Dry Season Average Flows Discharged to Lake Worth through S-40, S-41 & S-155 for the 31-year simulation.

D.6.13 Biscayne Bay

Operation of coastal water control structures results in rapid changes in salinity gradients within Biscayne Bay that may occur on a daily basis and over several months, particularly during the rainy season. During the dry season, hypersalinity has been observed as a result of evaporation, retention of canal flow, and bay circulation. The presence and operation of the canals and construction of permanent oceanic inlets has resulted in a loss of estuarine function and shifted Biscayne Bay to more of a lagoon, adversely impacted from freshwater pulses and highly variable salinities. These conditions have been at least partly responsible for the loss of historically abundant estuarine species, such as red drum, black drum, and eastern oyster, the loss of juvenile fish habitat, and the significant increase in stress-tolerant fish species such as the gulf toadfish.

Performance measures were developed based on the potential effect of water management alternatives on surface water reaching Biscayne Bay. Canal discharges from gauged structures on canals that discharge into the bay were used. Based on SFWMM hydrologic model output, the bay was divided into five regions from north to south, based on the mean monthly discharge from water control structures in these regions. The regions were:

- Snake Creek (S29),
- North Bay (G58, S28, S27),
- Miami River (S25, S25B, S26),
- Central Bay (G97, S22, S123), and
- South Bay (S21, S21A, S20F, S20G).

Model output for each alternative provides results as the sum of discharge from the structures in each region in terms of a mean annual wet season and dry season volume. To judge the performance of a water management alternative in meeting restoration targets, model results were compared to surface water budget targets that were considered appropriate to achieving restoration of the Biscayne

Bay ecosystem. These targets consist primarily of the existing average annual inflow to Biscayne Bay as defined by the 1995 Base hydrologic period, with a 2% increase in total inflow budget to be applied in the dry season to the Central and South Bay regions. A separate target for Snake Creek (S29) was also developed based on canal discharge that would maintain salinity suitable for oyster survival.

D.6.14 Keystone/Endangered Species/ATLSS

Evaluation of Restudy Alternatives' performance with regard to threatened, endangered and keystone species was accomplished through a combination of several methods. ATLSS modeling results provided information on expected biological responses of several species and species groups. The nature and extent of information available through ATLSS results varied among species and species groups depending on the progress of each model's development. For example, highly sophisticated results were available for the Cape Sable seaside sparrow's western population and for fish abundance because development of these models was nearly complete at the time of evaluations. Less sophisticated foraging or breeding conditions indices were available for the snail kite, wading birds, and others because these models were in an earlier stage of development. ATLSS results for each Alternative were compared with results for other Alternatives as available, 2050 Base conditions, and in most cases, with 1995 Base conditions. When results indicated that the Alternative would improve species' biological response as compared to other scenarios, the subteam concluded that there was evidence to suggest that the Alternative was beneficial for those species as compared to the other scenarios.

Additional sources of evidence were considered as they were available. These included:

(1) Crocodile Habitat Suitability and Wood Stork Nesting Patterns performance measures;

(2) information on known hydrological responses of species gleaned from Volume I of the Multi-species Recovery Plan for the Threatened and Endangered Species of South Florida, Technical/Agency Draft; and

(3) discussions with research biologists widely recognized as experts on particular species.

These sources of information were considered along with ATLSS modeling results to form a "weight of the evidence" or "consensus" conclusion by the subteam members and species experts. Results of the analyses are presented in Table 7.

D.6.15 Water Quality

The Water Quality Team utilized two water quality models in their analyses: the Lake Okeechobee Water Quality Model, which simulates lake eutrophication processes and the Everglades Water Quality Model, which simulates phosphorus transport in the Everglades Protection Area. In addition, an evaluation of the effect of Restudy alternative plans on hydraulic and phosphorus loads into and predicted performance of the Everglades Construction Project was performed by William W. Walker, Jr. (Walker, 1998) using hydrologic outputs of the South Florida Water Management Model. The Water Quality Team also utilized hydrologic outputs from the South Florida Water Management Model to evaluate the extent of hydrologic change and corresponding water quality impacts or benefits resulting from the implementation of the alternative plans in other subregions of the study area.

The Water Quality Team's evaluation was conducted on a sub-regional basis by dividing the study area up into subregions. The team did not empirically evaluate the effect of Restudy alternatives on water quality conditions in the Big Cypress basin or the Holey Land and Rotenberger Wildlife Management Areas. For those areas, a qualitative assessment was made based upon the proposed operation of the components contained in the alternatives. Results of the water quality team are presented in Table 8.

The Water Quality Team considered in detail existing federal, state, and Tribal water quality regulatory programs in the study area. For each alternative plan, the plan's components were examined to identify potential water quality impacts or benefits resulting from the operation of that component and the regulatory or ecosystem management programs affecting the future implementation of the component. Specific issues which were considered by the Water Quality Team during evaluations of alternative plans include numeric and narrative water quality criteria, designated uses of source and receiving water bodies, special classifications (e.g., Outstanding Florida Waters), and existing and projected pollution loads.

D.7 AET SUMMARY TABLES.

D.7.1 Tables: List of Participating Agencies, AET Subteams, Format for Documentation of Performance Measures, Plan Ranking, Letter Grades, Colors, ATLSS & Listed Species

The following tables provide important background information concerning the AET participants, supporting documentation for the PMs, and the results for Plans A-D13R.

Table D.7.1.1: List of Agencies with Regular Representation on the AET

Federal	U.S. Army Corps of Engineers
	National Park Service
	Fish and Wildlife Service
	U.S. Geological Survey
	Environmental Protection Agency
	National Oceanographic and Atmospheric Agency
State	South Florida Water Management District
	Florida Game and Fresh Water Fish Commission
	Department of Environmental Protection
	Department of Agriculture and Consumer Services
County	Palm Beach County
	Broward County
	Miami-Dade County

Table D.7.1.2: AET Subteams and Subteam Chairs

Subteam	Chair(s)-Agency
Lake Okeechobee	Karl Havens - SFWMD
Caloosahatchee, St. Lucie & Lake Worth Estuaries	Steve Traxler - USACE
Lake Okeechobee Service Area	Carl Woehlcke - SFWMD
Lower East Coast Service Area	Brenda Mills - SFWMD*
Northern/Central Everglades	Lorraine Heisler - FGFWFC Winifred Park, SFWMD
Southern Everglades/Florida Bay	Sue Perry - NPS Robert Doren - NPS Steve Davis - SFWMD
Big Cypress	Mike Duever - SFWMD
Biscayne Bay	Gwen Burzycki - Miami-Dade County Tom Smith - USGS
Model Lands/C-111 Basin	Joan Browder - NOAA
Endangered & Indicator Species	Heather McSharry - FWS
Total Systems	Cheryl Buckingham - FWS
Water Quality	Eric Hughes - EPA Eric Bush - FDEP

* Initially representing Broward County.

Table D.7.1.3: Format for Documentation of Performance Measures.

01. Performance Measure Category (Ecological or Water Supply); Broad Objectives Addressed by this Measure (e.g., from Governor's Commission Conceptual Plan).
02. Name of Performance Measure.
03. Date submitted.
04. Region or Subregion(s).
05. Summary Statement of Specific Objective (e.g., recover sustainable Wood Stork nesting colonies in Everglades basin).
06. Problem Addressed (brief summary of the issue).
07. Restoration Target for this Measure.
08. Specific Hydrological Measures for the Target.
09. Evaluation Tools (i.e., what models, etc.).
10. Literature Cited.

Table D.7.1.4
Performance of the 2050 Base and Alternatives Based on Relative Ranking.

All Subregions					
RELATIVE RANKING					
(1=best, 5=worse)					
Subregion	**2050**	**Alt A**	**Alt B**	**Alt C**	**Alt D**
LOSA	5	3	4	2	1
LECSA	5	3.5	3.5	1.5	1.5
Lake Okeechobee	5	3.5	3.5	1.5	1.5
St Lucie Estuary	5	2.5	2.5	2.5	2.5
Caloosahatchee Estuary	5	2.5	2.5	2.5	2.5
Lake Worth Lagoon	5	4	1	2.5	2.5
LNWR	5	4	2	2	2
Shark River Slough	5	4	1.5	3	1.5
WCA 2 & 3	5	1	3	3	3
Holey Land & Rotenberger	3	3	3	3	3
Rockland Marl Marsh	5	3.5	3.5	2	1
Florida Bay	5	1.5	1.5	3.5	3.5
C-111 Basin	4	5	2	2.5	1.5
SW Dade Agricultural Area	5	2.5	2.5	2.5	2.5
Biscayne Bay	2.7	4.3	4.3	2.2	1.5
No Big Cypress	4	4	4	1.5	1.5
So Big Cypress	4	4	4	2	1
SE Big Cypress	5	2	4	2	2
Connectivity	5	4	1	2	3
Sheet Flow	5	4	1	2.5	2.5
Fragmentation	4.5	4.5	1	2.5	2.5
Water Quality	5	3.5	3.5	1.5	1.5
Total Sum of Rankings	**102.2**	**73.8**	**58.8**	**50.2**	**45**

Table D.7.1.5a - Performance of the 2050 Base and Alternatives Relative to Performance Measures

All Subregions LETTER GRADE A=4 pts, B=3 pts, C=2 pts, D=1 pt, F=0 pts					
Subregion	**2050**	**Alt A**	**Alt B**	**Alt C**	**Alt D**
LOSA	F	B	C	B	A
LECSA	D	B	B	A	A
Lake Okeechobee	C	B	B	A	A
St Lucie Estuary	F	C	C	C	C
Caloosahatchee Estuary	F	A	A	A	A
Lake Worth Lagoon	F	D	B	C	C
LNWR	C	A	A	A	A
Shark River Slough	F	F	D	D	D
WCA 2 & 3	D	C	D	D	D
Holey Land & Rotenberger	C	B	B	B	B
Rockland Marl Marsh	D	C	C	B	B
Florida Bay	F	C	C	C	C
C-111 Basin	F	F	C	B	B
SW Dade Agricultural Area	F	A	A	A	B
Biscayne Bay	C	F	F	C	B
No Big Cypress	F	F	F	D	D
So Big Cypress	B	B	B	B	A
SE Big Cypress	B	A	B	A	A
Connectivity	D	D	A	B	B
Sheet Flow	F	B	B	B	B
Fragmentation	F	F	A	B	B
Water Quality	D	C	C	C	C

Table D.7.1.5b: Performance of 2050 Base and Initial Draft Plans D - D13R Relative to Ecological Performance Measures

LETTER GRADE			
Subregion	**2050**	**Alt D**	**D-13r**
Lake Okeechobee	C	A	A
St Lucie Estuary	F	C	B+
Caloosahatchee Estuary	F	A	A
Lake Worth Lagoon		C	C
Loxahatchee NWR	C	A	A
Holey Land & Rotenberger	C	B	B
WCA 2A	D	D	C
WCA 2B		F	F
Northwestern WCA 3A		B	B
Northeasten WCA 3A		F	D
Eastern WCA 3A		F	D
Central & Southern WCA 3A		D	B
WCA 3B		F	C
Shark River Slough	F	D	B
Rockland Marl Marsh	D	B	B
Biscayne Bay	C	B	B
Florida Bay	F	C	B
Pennsuco		B	B
C-111 Basin	F	B	B
So Big Cypress	B	A	A
SE Big Cypress	B	A	A
Connectivity	D	B	B+
Sheet Flow	F	B	B
Fragmentation	F	B	A

Table D.7.1.6a
Performance of the 2050 Base and Alternatives to Achieve Long-term Objectives

All Subregions COLOR RANKING green=successful, yellow=marginal or uncertain, red=unsucessful					
Subregion	**2050**	**Alt A**	**Alt B**	**Alt C**	**Alt D**
LOSA	R	G	Y	G	G
LECSA	R	Y	Y	G	G
Lake Okeechobee	Y	G	G	G	G
St Lucie Estuary	R	Y	Y	Y	Y
Caloosahatchee Estuary	R	G	G	G	G
Lake Worth Lagoon	Y	R	R	Y	Y
LNWR	Y	G	G	G	G
Shark River Slough	R	R	R	R	R
WCA 2 & 3	R	Y	R	R	R
Holey Land & Rotenberger	Y	G	G	G	G
Rockland Marl Marsh	R	Y	Y	G	G
Florida Bay	R	Y	Y	Y	Y
C-111 Basin	R	R	Y	G	G
SW Dade Agricultural Area	R	G	G	G	Y
Biscayne Bay	Y	R	R	Y	G
No Big Cypress	R	R	R	R	R
So Big Cypress	Y	Y	Y	Y	G
SE Big Cypress	Y	G	Y	G	G
Connectivity	Y	Y	G	G	G
Sheet Flow	R	G	G	G	G
Fragmentation	R	R	G	G	G

Table D.7.1.6b: Performance of the 2050 Base, Alternative D and the Initial Draft Plan to Achieve Long-Term Ecological Objectives

<table>
<tr><th colspan="4">COLOR RANKING</th></tr>
<tr><th>Subregion</th><th>2050</th><th>Alt D</th><th>D-13r</th></tr>
<tr><td>Lake Okeechobee</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>St Lucie Estuary</td><td>R</td><td>Y</td><td>G</td></tr>
<tr><td>Caloosahatchee Estuary</td><td>R</td><td>G</td><td>G</td></tr>
<tr><td>Lake Worth Lagoon</td><td>Y</td><td>Y</td><td>Y</td></tr>
<tr><td>Loxahatchee NWR</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Holey Land & Rotenberger</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>WCA 2A</td><td rowspan="7">R</td><td>R/Y</td><td>G/Y</td></tr>
<tr><td>WCA 2B</td><td>R</td><td>R</td></tr>
<tr><td>Northwestern WCA 3A</td><td>G</td><td>G</td></tr>
<tr><td>Northeasten WCA 3A</td><td>R</td><td>Y</td></tr>
<tr><td>Eastern WCA 3A</td><td>R</td><td>Y</td></tr>
<tr><td>Central & Southern WCA 3A</td><td>R/Y</td><td>G/Y</td></tr>
<tr><td>WCA 3B</td><td>R</td><td>Y</td></tr>
<tr><td>Shark River Slough</td><td>R</td><td>R</td><td>G</td></tr>
<tr><td>Rockland Marl Marsh</td><td>R</td><td>G</td><td>Y</td></tr>
<tr><td>Biscayne Bay</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Florida Bay</td><td>R</td><td>Y</td><td>G</td></tr>
<tr><td>Pennsuco</td><td></td><td>G</td><td>G</td></tr>
<tr><td>C-111 Basin</td><td>R</td><td>G</td><td>G</td></tr>
<tr><td>So Big Cypress</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>SE Big Cypress</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Connectivity</td><td>Y</td><td>G</td><td>G</td></tr>
<tr><td>Sheet Flow</td><td>R</td><td>G</td><td>G</td></tr>
<tr><td>Fragmentation</td><td>R</td><td>G</td><td>G</td></tr>
</table>

Table D.7.1.7
Keystone and Listed Species
(1=best, 5=worse)

Species	2050 Base	Alt A	Alt B	Alt C	Alt D
CSS Sparrow	5	4	1	1	1
Snail Kite	5	3	3	1	1
Wood Stork	5	1	1	1	1
Panther	1	1	1	1	1
Crocodile	5	2	2	2	1
Deer	5	2	1	2	2
Wading Birds	5	3	3	1	1
Fish	5	3	3	1	1

Table D.7.1.8
Water Quality Rankings
1=worse, 6=best (preferred)

Subregion	95B	50B	Alt A	Alt B	Alt C	Alt D
Lake Okeechobee	1.5	4.5	1.5	4.5	4.5	4.5
EAA/ECP	1	2	6	5	3.5	3.5
Water Conservation Areas 2 & 3	1	2.5	5	2.5	5	5
St. Lucie Watershed	1	2	3.5	3.5	5	6
Caloosahatchee Watershed	1.5	1.5	3	4	5	6
LNWR	1	2	4.5	4.5	4.5	4.5
ENP	1.5	5	3.5	6	1.5	3.5
LEC	6	3.5	1.5	1.5	5	3.5
Cumulative Score	***14.5***	***23***	***28***	***31.5***	***34.0***	***36.5***

Footnotes
1) Ranking of alternatives for Lake Okeechobee is based on evaluation of selected performance indicators. Comparing alternatives, differences greater than one percent in relative performance calculated by the model were assigned different ranks. Although the differences between simulated conditions for the alternatives are within the uncertainty of the model, the Water Quality Team felt it was important to rank the plans for Lake Okeechobee from a water quality perspective.
2) Water Conservation Areas 2 & 3 rankings were weighted to account for relative size (acreage).
3) Ranking of the alternatives based on an evaluation of potential water quality impacts/benefits in the LEC is primarily based upon salinity targets in Lake Worth and Biscayne Bay. The presumed water quality benefits resulting from an evaluation of the hydraulic performance of selected reservoirs were also evaluated. For those performance indicators, a score of zero was assigned to alternatives for which no hydraulic performance for the reservoirs was observed.

D.8 SUBTEAM REPORTS ON ALTERNATIVES A – D13R

D.8.1 Total System Subteam Decompartmentalization Matrix

D.8.1.1 Continuity: Water Surface Elevations Across Barriers

One of the problems resulting from using canals and levees to improve water management for water supply and flood control is that water surface elevations on either side of the barriers tend to be very different, i.e. pooling upstream and too dry downstream. The physical disconnection of the two wet areas is not addressed by this index but is addressed in the sheetflow index. The direct effects of pooling and drying on wildlife are addressed in the various measures of hydroperiod and ponding depths within each subregion group. This index addresses the discontinuity in water surface elevations and the effects of unexpected conditions on aquatic organisms and the species that rely on them. Different species of wading birds, for example, rely on various depths of shallow marsh to allow them to capture prey. Abrupt changes in depth, one too deep and one too shallow, limit their feeding area. This index is limited because, by using water level differences >0.5 feet as the top category, differences far greater than that maximum receive the same score.

Performance Measures:

Count of Water Level Differences Relative to NSM Water Level Differences for eight different man-made barriers within the remaining Everglades.

Strategy for Developing Indices:

The Count of Water Level Differences illustrates the number of weeks where the difference in water surface elevations across the barriers exceed the difference predicted by NSM 4.5F by 1) <0.25 feet, 2) <0.5 feet and 3) > 0.5 feet. Using those data, the following formulas were used.

To get an index score that rated highly a large number of weeks where differences in elevations were similar to NSM, this formula was used:

exp(-(x-1612)^2/2*w2)), where w = 900 and x = number of weeks where water surface elevation differences differed from NSM < 0.25 feet.

To get an index score that rated highly a low number of weeks where differences were more than 0.5 feet greater than NSM, the inverse of the formula was used:

1 – [exp(-(x-1612)^2/2*w2))], where w = 900 and x = number of weeks were water surface elevation differences differed from NSM > 0.5 feet.

Using these formulas, the highest scores were received by plans with the highest number of weeks that differed little from NSM *and* the lowest number of weeks differing greatly from NSM. This was done to avoid excluding the intermediate category containing the number of weeks where water level differences were >0.25 feet and <0.5 feet. The two scores were combined by averaging the two values; no weighting was involved. Weighting could have been added to the equation by using a different value for “w” depending on how far above 0.5 feet the difference was. In some cases, it was up to four feet greater than NSM.

Results

Flows through the northern part of the system across L-39 (between Loxahatchee NWR and WCA-2A) and L-38 (between WCA-2A and WCA-3A) remained unchanged between alternatives because the AET chose not to include them in any of the decompartmentalization scenarios. For that reason, their scores remained at zero throughout the analysis. Miami Canal North (MCN) improved slightly in alternatives B, C, and D. Miami Canal South (MCS) remained the same throughout and received a consistent score of 1.0. L-67 scored the best in Alternative B, the alternative in which it was completely removed. Alternatives C and D used other methods, including weirs, to operate flows across the L-67 barrier but were unsuccessful at reaching NSM-like water surface elevations on both sides of the barrier. These results must be tempered with the knowledge that the weirs may still operate successfully once their configuration and operation have been optimized. At the time, there had not been much chance to do so. Tamiami Trail west of L-67 (TTW) received its best score under Alternative B where it was completely removed. Alternatives C and D had fairly good scores with improved operations of the reinstalled structures. Tamiami Trail east (TTE) was removed in alternatives B, C and D and received a 1.0 for those three. L-28 received its best scores in alternatives B and C, although Alternative A and the 2050 Base received a 0.9.

In the table below, AVE1 is the average of the scores for the barriers excluding L-39 and L-38. This was an attempt to see the effect of these two very low scores on the final scores. AVE2 is an average of all eight scores. The AET decided to use AVE1 on which to base its color and grade and ranking scores in order to receive the benefits of the decompartmentalization that did occur. However, it should be noted AVE2 illustrates the overall system-wide benefit to the system, which only improves with alternatives B and D13R.

In Alternative D13R, the differences between water surface elevations on either sides of barriers inside of the remaining natural areas were more like NSM than the 2050 Base. As in Alternative B, the upstream pooling effects disappeared when barriers like Miami Canal, Tamiami Trail and L-28 are removed, but, unlike

Alternative B, water flows more evenly throughout the system than it did in the 2050 Base. The removal of the southern portion of L-67 improved the continuity score slightly.

Continuity ROGEM SCORES: Water Surface Elevational Differences across Barriers

	95	**50**	**A**	**B**	**C**	**D**	**D13R**
L-39	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L-38	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCN	0.1	0.4	0.4	0.5	0.5	0.5	0.5
MCS	1.0	1.0	1.0	1.0	1.0	1.0	1.0
L-67	0.0	0.1	0.1	1.0	0.1	0.1	0.2
TTW	0.0	0.4	0.3	1.0	0.6	0.6	1.0
TTE	0.5	0.7	0.6	1.0	1.0	1.0	1.0
L-28	0.6	0.9	0.9	1.0	1.0	0.7	1.0
AVE1	0.4	0.4	0.4	0.9	0.7	0.6	0.8
AVE2	0.3	0.3	0.4	0.7	0.4	0.4	0.6
Color	-	Yellow	Yellow	Green	Green	Green	Green
Grade	-	D	D	A	B	B	B+
Rank	-	5	4	1	2	3	-

D.8.1.2 Sheetflow: Flow Volume Transects

Justification

The natural system hydrology model (Fennema et al., Chapter 10) indicates that water management produced a significant change in the overland flow patterns in the Everglades. The Everglades was generally more of a flowing system with greater spatial extent and longer periods of inundation than exist today. Regional sheetflow patterns have been significantly disrupted and overland flow volumes reduced by the impoundment of Lake Okeechobee, construction of WCA levees and irrigation / drainage canals in the EAA, and the loss of dry season lag flows from the dense sawgrass plain that formerly covered the present EAA. Flow patterns out of Lake Okeechobee have shifted from primarily wet season flows in response to rainfall to dry season flows in response to urban and agricultural water supply demands.

Impoundment of water in the WCAs and diversion of surface water flows to the east, combined with ground water and levee seepage loses eastward in the modified system, have significantly contributed to reduced flows and the resultant loss of persistent hydroperiods in southern Everglades (Davis and Ogden 1994).

Instead of a vast expanse of sheetflow, the Everglades has become a series of pools, with pooling on the upstream and excess drying on the downstream side of barriers. “Ponded systems favor certain species and flowing systems favor others. There are many physicochemical differences in the two systems: food types and sources, migration of macroinvertebrates, dispersion of nutrients, aeration and diffusion of gases in water, particulate suspension, and thermal stratification are some examples. Ponding in the WCAs amounts to regulation for certain species—the zoo approach, which is not an ecosystem approach. From a water conservation perspective, ponding may be wise; and in a water-limited system, ponded water for fish is a real improvement over no water for fish. It would be possible to match regulated hydroperiods month to month with natural hydroperiods and still have a completely different ecosystem due to the difference in water movement. This is another reason why a hydroperiod analysis is singularly insufficient to create the intended biological conditions." (US Army Corps of Engineers, 1994).

Sheetflow also shapes tree islands, supports microhabitats on the upstream and downstream sides, enhances the uptake of nutrients from the water column and creates an environment that precipitated phosphorus, along with calcium carbonate, into the substrate.

Performance Measure: Flow volume across transects

Strategy for Developing Indices:

The 26 transects were grouped into five categories representing their general area: Big Cypress Group (T24, T25, T26), Central Everglades (WCA-3A) Group (T7, T8, T12), Southern Everglades Group (T21, T23A, B, &C), Tamiami Trail Group (T17, T18) and the L-67 Group (T13, T14). For each group, an index was calculated for each transect based on the wet season and the dry season average annual overland flows. For each base condition and alternative, the flow value was divided by the NSM value to obtain wet season and dry season proportions, which were then scaled. Scaling, using the normalized curve formulas described below, was used to obtain values between 0.0 and 1.0. In cases where the proportion of wet season flows exceeded NSM, they received a value of 1.0. For dry season flows, excess flows were treated the same as insufficient flows. For example, for the Cypress Group:

IF (wet season flows >= NSM volumes, then Index = 1.0, else EXP(-((wet season flow – NSM)/NSM)^2/(2w^2))), where w = 0.5 gave the most reasonable values.

IF (dry season flows = NSM volumes, then Index = 1.0, else EXP(-((dry season flow – NSM)/NSM)^2/(2w^2))), where w = 0.5 gave the most reasonable values.

Then, the wet season and dry season indices were averaged with the dry season weighted twice as heavily:

Index(T7) = CIV(wet) 8 2(CIV(dry))

The overall Central Everglades Score, therefore, was:

Score = (Index(T7) * Index(T8) * Index(T9) /3

Results: Improvements were seen over the 2050 Base in the Big Cypress Group (CYP) in all alternatives. Improvements in C and D over Alternative B echo the results seen by the Cypress subteam. The Central Everglades (CEver) transect groups were best served by the 1995 Base, but all alternatives were better than the 2050 Base. The Southern Everglades (SEver) transect groups received the highest score in Alternative A, but alternatives B, C and D were also very good with scores of 0.9. The Tamiami Trail Group (TT), comprising both east and west portions, also faired best with Alternative A, with good scores in alternatives B, C, and D. L-67 varied from a score of 0.0 in the 2050 Base to a moderate top score of 0.6 in Alternative B. Overall, all the alternatives scored higher than the 2050 Base and, when averaged, over the 1995 Base. Alternative A, which contained no decompartmentalization effort, received some of the highest scores, in the Southern Everglades and Tamiami Trail. The Big Cypress score was improved slightly with the reinstallation of L-28.

In D13R, where L-28 was removed again, the effects on flow volumes in Big Cypress were small and consisted of lower volumes in T25 (Eastern Big Cypress) and higher volumes in T26 (Lostman’s Slough). Flow volumes across transects looked better in D13R than the 2050 Base. Flows across Tamiami Trail not only increased 92% over 2050 Base but the proportion flowing east of the L-67 vs. west of L-67 improved from only 11% in 2050 Base to 55% in D13R. NSM’s east/west proportion was 62%. Flows through southern WCA-3A increased from only 62% of NSM volumes in the 2050 Base to 110% of NSM in D13R without causing excessive high water events. Flows in western WCA-3A were spread more evenly into the dry season in D13R, preventing the premature dry season drydowns seen in the 2050 Base.

Sheetflow ROGEM Scores: Flow Volumes Across Transect Groups.

	95	**50**	**A**	**B**	**C**	**D**	**D13R**
CYP	0.8	0.3	0.9	0.8	0.9	0.9	0.9
CEver	0.8	0.3	0.7	0.7	0.7	0.7	0.7
SEver	0.8	0.3	1.0	0.9	0.9	0.9	0.9
TT	0.6	0.2	1.0	0.8	0.8	0.8	0.9
L-67	0.1	0.0	0.1	0.6	0.1	0.1	0.1
AVE	0.6	0.2	0.7	0.8	0.7	0.7	0.7
Color	-	Red	Green	Green	Green	Green	Green
Grade	-	F	B	B	B	B	B
Rank	-	5	1	2	3.5	3.5	-

D.8.1.3 Fragmentation: Miles of Canals and Levees

Justification

In its effort to control floodwaters and provide water supply, the C&SF Project created miles of canals, levees, and water control structures with associated deep pools. Canals and levees usually coexist; construction of a canal usually means a spoil levee exists alongside it just as a levee requires a borrow canal. Roadway construction usually involves combinations of levees and canals, sometimes with culverts to allow water to flow underneath. Water control structures are usually even more complex, involving combinations of levees, canals and deep pools. In some places, multiple canals, levees and water control structures form intricate patterns - and formidable barriers to wildlife.

When levees block the flow of water, they also restrict the movement of aquatic and semi-aquatic life forms in the water. Land-based predators use the levees to invade the marsh interior, preying upon animals that try to cross the intrusive fingers of terrestrial habitat. Levees also act as conduits, allowing terrestrial plants to invade. Canals act as corridors particularly for non-native animals and plants that can extend their ranges rapidly from points of introduction and can move into wetlands where they can alter habitats and affect food webs (Loftus and Kushlan 1987; Loftus 1986). Artificial, deep-water habitats provide thermal and spatial refuge to large numbers of both non-native and native aquatic predators in the dry season, enhancing their survival and ultimate population sizes. During the dry season, these predators prey heavily on small marsh fishes and invertebrates moving in from the adjacent wetlands (Howard et al. 1995).

Performance Measure Fragmentation Miles of Canals and Levees

Strategy for Developing Index

The Alternatives Evaluation Team chose to focus its attention on reducing the number of canals and levees in the natural areas, believing that these artificial structures affect natural resources more so than those found within urban or agricultural areas. Therefore, the Total System Performance Measure for Fragmentation: Miles of Canals and Levees uses only the number of miles of canals and levees within the Everglades Protection Area, Big Cypress National Preserve, Holey Land, and Rotenberger Wildlife Management Areas. The list of which structures were included can be found on the web site under “View Maps and Tables”, “Individual Maps and Tables” and the last category “Model Inputs.”

The lengths used in the Fragmentation performance measure are as they are modeled by the SFWMM. Model miles are useful for comparative purposes, which was the point of the evaluation, but model miles are unlikely to exactly match the number of miles actually implemented.

The AET discussed including only the "primary barriers to sheet flow" within the natural area in the performance measure, but agreed that the problems with canals and levees go far beyond their direct affect on sheet flow. They also convey exotic species, for example, and canals appear to serve as sinks and refuges for large fish and possibly other predators. Their effect appears to extend into the adjacent marsh. In the interest of including the impacts of all the canals and levees in the natural area, we did not limit ourselves to just those that pass through the center of the system but included perimeter canals around the marshes as well.

Due to the amount of time available, the Alternatives Evaluation Team chose not to continue to track the number of structures because there were cases where single, large structures were replaced with several smaller, passive structures. Alternatives would receive lower scores for having structures that the Alternatives Evaluation Team believed were better - simply because there were more of them.

Using the numbers of miles canals and levees posted for the 1995 Base and the 2050 Base, the larger was considered to be the worst case scenario, the 100% build-out value. For each alternative and base condition, the number of miles of canals and levees were each divided by the maximum value and scaled using the following formula. For example, the index for canals for Alternative A was calculated as follows:

Canals(A) = exp ((x-x*)/x*)^2(2w^2)-1), where w = -2.773, x = # of miles or levees for Alternative A, x* = the worst cast value.

Then, for each alternative and base condition, the canal and levee index scores were combined, canals receiving aweighting of two:

Fragmentation Score = $(Canals_{alt} * Canals_{alt} * Levees_{alt})/3$

The number of structures was available but the AET decided not to use these data in this analysis. The analysis would have been confusing because the weirs added to alternatives C and D were treated as additional structures, nullifying the beneficial effects of the weirs.

Results: Within the "natural" area, the 1995 Base condition had 330 miles of canals and 400 miles of levees. The 2050 Base condition had 311 miles of canals and 400 miles of levees. Alternative A provided no benefits over the 2050 Base because it did not remove any canals or levees. Alternatives B, C, and D reduced the numbers of canals and levees substantially. Alternative B performed the best with 184 miles of canals and 318 miles of levees, 19 and 26 miles respectively fewer than Alternative D. Still, Alternative D had 127 fewer miles of canals and 56 fewer miles of levees than the 2050 Base.

In Alternative D13R, the number of miles of canals and levees fragmenting the remaining natural system was reduced even further to Alternative B amounts. Alternative D13 and the D13R scenario have 184 miles of canals and 318 miles of levees. There were 146 fewer miles of canals and 82 fewer miles of levees in D13R. Thus, the number of miles of canals and levees removed in Alternative D13R (and D13R4) within the natural areas is: 146 + 82 = 228. Miles of canals were reduced by 40% while levees were reduced by 20% over the 2050 Base.

Fragmentation ROGEM Scores: Miles of Canals and Levees Affecting Natural Areas

	95	**50**	**A**	**B**	**C**	**D**	**D13R**
Canals	0.0	0.1	0.0	0.8	0.9	0.9	1.0
Levees	0.0	0.0	0.0	0.7	0.7	0.7	0.5
AVE	0.0	0.1	0.0	0.8	0.7	0.7	0.8
Color	-	Red	Red	Green	Green	Green	Green
Grade	-	F	F	A	B	B	A
Rank	-	4.5	4.5	1	2.5	2.5	-

D.8.1.4 Discontinued Performance Measures

The other AET subteams used conceptual models to develop their performance measures. Although a conceptual model for the total system has yet to be developed, Davis and Ogden have described the defining characteristics of the total system as (1) large spatial extent, (2) habitat heterogeneity, and (3) dynamic storage and sheet flow (Davis and Ogden, 1994). Early performance indicators and measures were based on hydrologic model outputs that the Total Systems team believed could represent some aspects of these defining characteristics. These early measures were used in the evaluations of the Starting Point and Alternatives 1-4, but then discarded. The AET preferred to use the Continuity, Fragmentation and Sheetflow performance measures and therefore used them for the remaining analyses.

The problem with the early performance indicators and measures was that they depended heavily on matching NSM targets. As the iterative process of formulating Alternatives 1-4 proceeded, the number of cells where NSM was no longer the target increased, eventually including Loxahatchee NWR (WCA 1), Rotenberger, Holeyland, central WCA 3A, southern WCA 3B, the western sparrow indicator region, and finally the entire western sparrow range. As a result, these performance indicators and measures no longer represented as much of the system and became, in fact, misleading.

During detailed design, the total system performance measures will be refined and/or new ones designed based on a conceptual model developed by a subteam of the RECOVER team. The total system conceptual model will expand on the defining characteristics of the south Florida ecosystem described above, identify critical pathways, and identify the parameters on which to base the performance measures. At that time, if appropriate targets can be established, some of these early ideas may be resurrected. Until then, they should be viewed only as early attempts to gain an ecosystem-wide perspective of the way some of the alternatives affected the system.

Hydroperiod Distribution. For each plan the Total Systems team compared the number of acres in each of the eight hydroperiod classes (0-30, 30-60, 60-90, etc.) to NSM. The result was a proportion. This measure was discarded when the number of acres where NSM was no longer the target grew so large that it was no longer meaningful.

Hydroperiod Matches. This measure was the percent of acres matching NSM for the Remaining Everglades. It was discarded when the number of acres where NSM was no longer the target grew so large that this measure was no longer meaningful.

Ponding Depths. This measure was the percent of acres matching NSM for the Remaining Everglades. This measure was discarded when the number of acres where NSM was no longer the target grew so large that it was no longer meaningful

Hydroperiod Improvement. This measure consisted of the proportion of total acres where hydroperiods were improved, compared to optimal NSM hydroperiods. This measure was discarded when the number of acres where NSM was no longer the target grew so large that it was no longer meaningful.

Dry year drydown Pattern. A performance indicator using a typical dry year (1989) hydroperiod distribution map. The measure consisted of a best professional judgement of poor, average, good, very good as determined by the Central Everglades Subregion Team comparing it to the NSM. This never became a performance measure for lack of quantifiable targets.

Pond Count. A score based on the number of drydown events and their duration for the Ridge and Slough area only. Because this measure represented a relatively small part of the system, it had limited use during plan formulation. However, it could be expanded into other areas during the detailed design phase.

D.8.2 Lake Okeechobee

Lake Okeechobee Priority Hydrologic Performance Measures

Five priority performance measures are calculated, weighted and summed using the River of Grass Evaluation Model (ROGEM) for Lake Okeechobee. The Lake Okeechobee ROGEM is comprised of metrics (Suitability Index Variables, or SIVs) that concern the fluctuation and timing of lake stages. These variables exert major controls over ecosystem structure and function. Fluctuation and timing of lake stages affect the distribution of native and exotic plant communities, and in turn the habitat quality (cover, nesting sites, foraging habitat) for fish, birds, and other wildlife (Aumen 1995). The ROGEM assumes that restoration of a more natural (within the constraints of the dike system) hydroperiod would result in positive biotic responses of the lake community.

Each SIV ranges from 0 (worst score) to 1.0 (best score). Relationships between hydrologic attributes and SIVs in this model are not linear, but reflect expert opinion that the degree of ecosystem stress is exacerbated by an increasing occurrence of undesirable events. This gives rise to a curvilinear relationship between hydrologic attributes and their SIVs. At a certain point (considered here to be four events or more per decade), the degree of stress is so severe that the ecosystem cannot recover its ecological and societal values.

An <u>extreme low lake stage</u> (<11 ft) performance measure (SIV_{MINX}) indicates the frequency of events that result in a loss of over 95% of the littoral zone as habitat for aquatic biota, and promote expansion of exotic plants into pristine native-plant dominated regions of the lake. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never falls below 11 ft = 1.0
- Lake stage falls below 11 ft on 1 occasion per 10 yrs = 0.9
- Lake stage falls below 11 ft on 2 occasions per 10 yrs = 0.7
- Lake stage falls below 11 ft on 3 occasions per 10 yrs = 0.4
- Lake stage falls below 11 ft on 4 or more occasions per 10 yrs = 0

A <u>moderate low lake stage</u> (<12 ft) performance measure (SIV_{MINM}) indicates the frequency of prolonged (>12 continuous month) events that substantially reduce the littoral area available as wildlife habitat, and promote exotic plant expansion. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never falls below the 12 ft / 12 month criterion = 1.0
- Lake stage falls below the 12 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
- Lake stage falls below the 12 ft / 12 month criterion on 2 occasions per 10 yrs = 0.7
- Lake stage falls below the 12 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
- Lake stage falls below the 12 ft / 12 month criterion on 4 or more occasions per 10 yrs = 0

An <u>extreme high lake stage</u> (>17 ft) performance measure (SIV_{MAXX}) indicates the frequency of events that may cause wind and wave damage to the shoreline plant communities, and transport phosphorus-laden pelagic water into pristine interior regions of the littoral zone. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never exceeds 17 ft = 1.0
- Lake stage exceeds 17 ft on 1 occasion per 10 yrs = 0.9
- Lake stage exceeds 17 ft on 2 occasions per 10 yrs = 0.7
- Lake stage exceeds 17 ft on 3 occasions per 10 yrs = 0.4
- Lake stage exceeds 17 ft on 4 occasions per 10 yrs = 0

A moderate high lake stage (>15 ft) performance measure (SIV_{MAXM}) indicates the frequency of prolonged (>12 continuous months) events that may: limit light penetration to the lake bottom, resulting in a loss of the benthic plants and algae that stabilize sediments and provide habitat for invertebrates and fish; and promote greater circulation of phosphorus-rich turbid waters from mid-lake to less eutrophic near-littoral regions, where phosphorus inputs stimulate algal blooms. The goal is to have a minimal number of these events. The performance measure score is calculated as follows:

- Lake stage never exceeds the 15 ft / 12 month criterion = 1.0
- Lake stage exceeds the 15 ft / 12 month criterion on 1 occasion per 10 yrs = 0.9
- Lake stage exceeds the 15 ft / 12 month criterion on 2 occasions per 10 yrs= 0.7
- Lake stage exceeds the 15 ft / 12 month criterion on 3 occasions per 10 yrs = 0.4
- Lake stage exceeds the 15 ft / 12 month criterion on 4 occasions per 10 yrs = 0

A spring recession performance measure (SIV_{VAR}) indicates the number of years during which January to May lake levels decline from near 15 ft to 12 ft, without any reversals greater than 0.5 ft. These conditions appear to be favorable to nesting birds and other wildlife in the marsh. They also may allow for re-invigoration of willow stands, and permit fires to burn away cattail thatch. The goal is to have a substantial number of events. The performance measure score is calculated as follows:

- Stage recession between January and March from ~15 ft to ~12 ft NGVD, with no reversal greater than 0.5 ft NGVD, occurring every yr = 1.0
- Stage recession occurring, on average, every other yrs = 0.9
- Stage recession occurring, on average, once every three yrs = 0.7
- Stage recession occurring, on average, once every four yrs = 0.4
- Stage recession occurring less frequently than the above = 0

SIV Priority Weights

The five SIVs address important aspects of how water level and its seasonal variation affects the intrinsic ecological (e.g. habitat for wading birds and federally endangered species) and societal (e.g. recreational fisheries) values of Lake Okeechobee. However, the five SIVs are not considered of equal importance in regard to indicating an absolute level of stress (or benefit). A weighting scheme was developed based on best professional judgement to reflect the relative importance of each SIV as an index of lake ecosystem health. For simplicity, a weighting scale of 1 to 5 (1 being least important, and 5 being most important) is used.

The SIVs associated with the >17 ft and >15 ft / 12 month criteria are given priority weights of 5. Extreme or prolonged high water levels have been documented to affect numerous ecosystem attributes, including: littoral plant and periphyton communities; benthic plants and periphyton; fisheries habitat; and water quality (including turbidity, phosphorus, and algal blooms). These effects are well documented by scientific research (Sheng and Lee 1991, Havens 1997, Steinman et al. 1997).

The SIVs associated with the <11 ft and <12 ft / 12 month criteria are given priority weights of 4. Extreme or prolonged low lake stages also may cause harm to the ecosystem, but the impacts are less documented, and are not considered as serious on a lake-wide basis. That is, the effects primarily are restricted to the littoral zone proper, and negative impacts (e.g., loss of fisheries habitat) may in part be compensated for by enhanced growth of submerged plants in the southern near-shore pelagic region.

The SIV for spring lake level recession describes a seasonally-variable hydro-pattern that is considered by experts to benefit a variety of littoral zone values, including wading birds and certain native plant communities (Smith et al. 1995). It is the only SIV that relates to seasonal variation in lake levels, and that variation is considered by experts (Havens and Rosen 1997) to be critical for a healthy ecosystem. However, there is a high degree of uncertainty in scoring the spring recession attribute. For example, do recession events that occur slightly earlier or later than the designated optimal (January-May) period have equal or lesser benefit to the community? Do recession events that occur over higher or lower ranges of water depth than the designated optimum (15 to 12 ft) have equal or lesser benefit to the community? There are no clear answers to these questions, and therefore, until further research results are available, the SIV associated with this attribute is given a weighting of 3.

Integrated Scoring

A Community Suitability Index (CSI) integrates the scores of five hydrologic SIVs and their respective weighting factors, and has an overall range of 0 to 1.0. The weighted CSI model is:

$$CSI = (4*SIV_{MINX} + 4*SIV_{MINM} + 5*SIV_{MAXX} + 5*SIV_{MAXM} + 3*SIV_{VAR}) / 21$$

From the standpoint of Lake Okeechobee ecological values, Alternative D13R performs in an identical manner to Alternative D, and is considered beneficial to the lake ecosystem.

Evaluation of Alternatives A-D and the revised 1995 and 2050 base conditions using the Lake Okeechobee priority hydrologic performance measures, and the ROGEM equations.

Variables	**95Base**		**50Base**		**ALT A**		**ALT B**		**ALT C**		**ALT D**		**ALT D-13r**		**Weight**
	#	Value	#	Value	#	Value	#	Value	#	Value	#	Value	#	Value	
SIV min-x (Extreme Low Stage, <11')	3	0.4	4	0	2	0.7	2	0.7	1	0.9	1	0.9	1	0.9	4
SIV min-m (Prolonged Low,< 12' for 12 mo.)	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	0	1	0	1	4
SIV max-x (Extreme High Stage, > 17')	2	0.7	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	5
SIV max-m (Mod.Stage, > 15' for 12 mo.)	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	1	0.9	5
SIV var (Spring Lake Level Recession)	2	0	2	0	3	0.7	3	0.7	4	0.7	4	0.7	4	0.7	3
Weighted CSI	**0.63**		**0.60**		**0.83**		**0.83**		**0.87**		**0.89**		**0.89**		

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D.8.3 Lake Okeechobee Service Area

The Lake Okeechobee Service Area includes the Everglades Agricultural Area, the Caloosahatchee Basin, the St. Lucie Basin, the S-4 Basin, the L-8 Basin and the Seminole Indian (Brighton and Big Cypress) Reservations.

Performance Measures and Indicators Used.

Performance Measures:

Two performance measure reports are used to evaluate the frequency, duration and severity of water supply cutback events in the Lake Okeechobee Service Area. These are the detailed “LOSA Supply Side Management Report” and the “Frequency of Water Restrictions” graphic. Water restriction events vary as to how often they occur (frequency), how long an event lasts (duration), and how much of the water that would normally be demanded is not delivered (severity) and scores are developed for each of these characteristics.

Scoring Procedures

The number of years with water restrictions from the “Frequency of Water Restrictions” graphic is the piece of information used to develop a score regarding the frequency of water shortages. The established performance target is that there be no more than 3 years during which cutbacks occur over the 30-year period of performance available from each simulation. This implies that all demands will be met in at least 27 years. The relevant period is 30 years because a crop/water service year from October to September is used in counting shortage events, instead of a calendar year. For example, in the 2050 base (revised) there are 14 years when all demands are met and 16 years with restrictions. In each case the score is developed as:

Score = (Number of Years When All Demands Are Met)/(Target years for All Demands Being Met) = (30 – Years With Restrictions)/27 with the limitation that the score is counted as “1” if the calculated score is greater than one.

The detailed “LOSA Supply Side Management Report” was used to develop a combined duration/severity score, for relative comparisons of alternatives only. The duration/severity scores apply only to months that are considered to have significant supply side management cutback volumes. For purposes of calculating the scores, months with less than 18,000 acre feet of supply side management cutback volumes are not considered significant and so are not included in the severity/duration scoring calculations. The duration portion of this score is the sum of the number of months with supply side management cutback volumes greater than 18,000 acre feet for each alternative. The severity portion considers the supply side management cutback volume in the worst month of each shortage event. The severity score given for each annual event is developed using the following table:

The Largest Monthly Supply Side Management Cutback Volume (cut) of Each Event	Severity Score
18,000 ac. ft. <=cut < 50,000 ac. ft.	1
50,000 ac. ft. <=cut < 100,000 ac. ft.	2
100,000 ac. ft. <=cut < 150,000 ac. ft.	3
cut >= 150,000 ac. ft.	4

The total duration/severity score is the sum of the two scores. As an example, the duration/severity score for the revised 2050 Base is developed below.

2050 Base Revised

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score (No. of Months with Supply Side Management Cutbacks > 18,000 ac.ft.)	Combined Duration Severity Score
1968	130,570	3	3	6
1971	62,060	2	3	5
1972	73,380	2	2	4
1973	132,150	3	6	9
1974	154,730	4	6	10
1975	30,610	1	1	2
1976	135,190	3	5	8
1977	99,110	2	6	8
1978	52,360	2	1	3
1981	184,910	4	5	9
1982	104,460	3	9	12
1986	122,620	3	2	5
1989	143,530	3	7	10
1990	103,560	3	8	11
1991	70,060	2	5	7
			Total	109

Because it was desired to put the duration/severity scores on a 0 – 1 scale and because there was no target or allowable number of points, it was decided to make the scale relative to the poorest performing alternative. In this case it is the 2050 Base (revised). Thus the scores for all alternatives and base cases have been developed as:

Scaled duration/severity score = 1 – (Combined Duration Severity Score for the alternative÷Combined Duration Severity Score for the Worst Alternative) = 1 – (Combined Duration Severity Score for the Alternative÷109).

Aggregating Scores

The final step in scoring the alternatives and bases in terms of water supply performance in the Lake Okeechobee Service Area is to aggregate the frequency and the duration/severity scores. This is accomplished by taking a weighted average of the two scores. In this case each of the scores was assigned an equal weight of 0.5, so the result is the simple average of the two scores.

Summary and Interpretation of Water Supply Scoring Results

This summarizes and interprets the scoring results achieved by applying the methodology set forth above. The results of the scoring are presented below in Table LOSA-1. Attachment LOSA-1 presents the calculations of the frequency scores and Attachment LOSA-2 presents the duration/severity scoring calculations contained in Table LOSA-1.

It is the opinion of the LOSA team that the resulting scores provide only an ordinal ranking of the alternatives. Differences or relative difference among the scores should not be interpreted as indicating a proportionate quantitative difference in performance. For this reason a ranking of the alternatives is provided in the rightmost column. A rank for the 2050 Base is provided because it could be selected as a “no action alternative”. No rank is provided for the 1995 Base because it can not be selected as an alternative. It is interesting to note that the rank order of each of the components is the same. This implies that the rank orders of the combined scores will be the same no matter how the components are weighted.

Table LOSA-1 – LOSA Water Supply Scoring Results

Base or Alternative	Frequency Score	Duration/ Severity Score	Combined Score	Rank
2050 Base (revised) (no action alternative)	0.519	0.000	0.259	5
1995 Base (revised)	0.704	0.431	0.567	NA
Alternative A	0.852	0.789	0.820	3
Alternative B	0.778	0.661	0.719	4
Alternative C	0.889	0.789	0.839	2
Alternative D	0.926	0.853	0.890	1

While the scoring procedure provides a ranking of the alternatives, information from the performance measures and performance indicators can be utilized to provide a qualitative interpretation of the performance of the alternatives relative to the goals and relative to each other. The principal goal utilized by the LOSA subteam was that the alternatives should be able to meet all demands in a 1-in-10 year drought. It was also agreed that the best available indicator that this was being done would be if the number of years with water shortage restrictions were not more than three in the 31-year simulation period. In developing the count of years with water restrictions, certain events with very minor restrictions were not counted. None of the alternatives reach this goal (three or less events) but several come close. Alternative D has five events, Alternative C has six events and Alternative A has seven events. By comparison Alternative B has nine events and the 2050 Base 15 events.

Inspection of the events in alternatives A, C and D indicates that some of the events do not involve very many months with supply side management cutbacks and some of the months have relatively small volumes of cutbacks. As part of the effort to produce a duration/severity score, a slightly more restrictive definition of the amount of supply side management cutbacks that were required before it was significant enough to be counted was used. Under this criterion, months with monthly supply side management cutbacks of less than 18,000 acre feet are not counted and the numbers of water years with restrictions become three for Alternative D and five for Alternative C and Alternative A. By contrast Alternative B remains at nine events and the 2050 Base remains at 15 events under the revised criterion.

The strong performance of alternatives A, C and D is further evidenced when the duration (total months of supply side management with restrictions greater than 18,000 acre feet) of the water restriction periods is considered. For Alternative D, LOSA is under restrictions only nine months in the 31-year simulation period. For Alternatives A and C the restrictions are 13 months. By contrast, for Alternative B the restrictions are 21 months and for the 2050 Base they are 69 months.

In summary, alternatives A, C and D are considered to come close to meeting the water supply level of service goal and are judged to have good performance, with Alternative D being clearly the best performer. Alternative B has significantly poorer performance than alternatives A, C and D. The performance of the 2050 Base, the no action alternative, is unacceptable.

Results of Alternative D13R

Modifications to Alternative D that resulted in the revised Alternative – D13R had no significant effect on the good performance of Alternative D with respect to Lake Okeechobee Service Area water supply. This is shown in Table LOSA-2 below. With only five years with shortages, the frequency score is the same. The duration/severity score for D13R is slightly better because there is one less month of category 1 supply side management cutbacks (see Attachment LOSA-2).

Table LOSA-2 – LOSA Water Supply Scoring Results Comparison of Alternative D and Alternative D13R

Base or Alternative	Frequency Score	Duration/ Severity Score	Combined Score
Alternative D	0.926	0.853	0.890
Alternative D13R	0.926	0.862	0.894

Calculation of Frequency Scores

Alternative	Number of Water Years with Restrictions	Frequency Score = (30 – Years with Restrictions)/27
2050 Base (Revised)	16	0.519
1995 Base (Revised)	11	0.704
Alternative A	7	0.852
Alternative B	9	0.778
Alternative C	6	0.889
Alternative D	5	0.926

Calculation of Duration/Severity Scores

Note that the scaled duration/severity score is calculated using the following formula: Scaled duration/severity score = 1 – (Combined Duration Severity Score for the Alternative÷Combined Duration Severity Score for the Worst Alternative) = 1 – (Combined Duration Severity Score for the Alternative÷109).

2050 Base (Revised)

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score (No. of Months with Supply Side Management Cutbacks > 18,000 ac.ft.)	Combined Duration/ Severity Score = Severity Score + Duration Score
1968	130,570	3	3	6
1971	62,060	2	3	5
1972	73,380	2	2	4
1973	132,150	3	6	9
1974	154,730	4	6	10
1975	30,610	1	1	2
1976	135,190	3	5	8
1977	99,110	2	6	8
1978	52,360	2	1	3
1981	184,910	4	5	9
1982	104,460	3	9	12
1986	122,620	3	2	5
1989	143,530	3	7	10
1990	103,560	3	8	11
1991	70,060	2	5	7
Total Combined Duration/Severity Score				109
Scaled Duration/Severity Score				0.0

1995 Base (Revised)

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score (No. of Months with Supply Side Management Cutbacks > 18,000 ac.ft.)	Combined Duration/ Severity Score = Severity Score + Duration Score
1968	34,560	1	1	2
1971	26,580	1	1	2
1972	52,290	2	2	4
1973	113,750	3	6	9
1974	158,930	4	5	9
1978	48,520	1	1	2
1981	187,690	4	5	9
1982	103,030	3	8	11
1990	88,080	2	8	10
1991	39,010	1	3	4
Total Combined Duration/Severity Score				62
Scaled Duration/Severity Score				.431

Alternative A

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1976	47,010	1	1	2
1978	23,610	1	1	2
1981	167,750	4	4	8
1982	94,320	2	3	5
1990	87,480	2	4	6
Total Combined Duration/Severity Score				23
Scaled Duration/Severity Score				.789

Alternative B

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1974	84,660	2	1	3
1976	94,470	2	4	6
1977	35,920	1	1	2
1978	23,600	1	1	2
1981	169,170	4	5	9
1982	96,890	2	3	5
1989	32,000	1	1	2
1990	93,950	2	4	6
1991	21,810	1	1	2

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
Total Combined Duration/Severity Score				37
Scaled Duration/Severity Score				.661

Alternative C

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1974	21,560	1	1	2
1978	22,470	1	1	2
1981	168,680	4	4	8
1982	96,730	2	3	5
1990	76,880	2	4	6
Total Combined Duration/Severity Score				23
Scaled Duration/Severity Score				.789

Alternative D

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1981	168,350	4	4	8
1982	95,040	2	3	5
1990	39,820	1	2	3
Total Combined Duration/Severity Score				16
Scaled Duration/Severity Score				.853

Alternative D13R

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1981	167,720	4	4	8
1982	95,140	2	3	5
1990	39,680	1	1	2
Total Combined Duration/Severity Score				15
Scaled Duration/Severity Score				.862

D.8.4 Lower East Coast Service Area

Procedure and Scores of Alternatives and Base Conditions

Location

The Lower East Coast Service Area (LECSA) is divided into four service areas: North Palm Beach, and Service Areas 1, 2, and 3. The North Palm Beach Service Area extends from northern to central Palm Beach County, encompassing approximately one-third of the county and includes one primary canal, the C-17. Service Area 1 covers the remainder of Palm Beach County and a small portion of Broward County to just below the Hillsboro Canal. There are four primary canals that traverse the service area: C-51, C-16, C-12, and the Hillsboro Canal. Service Area 2 includes most of Broward County and a portion of Miami-Dade County. It extends south from the Hillsboro Basin to just south of the C-9, which lies in Miami-Dade County. Four primary coastal canals extend through Service Area 2: C-14, C-13, North New River, and C-9. Service Area 3 includes the remainder of Miami-Dade County from the C-9 Basin south to near the tip of the peninsula. There are three primary coastal canals in Service Area 3: C-4, C-6 and C-2. Although the county boundaries extend west to the center of the state, the service areas only include those portions of the counties east of the protective levees.

Background: Water Supply

The performance measures used for the Lower East Coast to evaluate Restudy alternatives for water supply relate to the frequency and duration of water supply cutback events and the ability to maintain primary coastal canals. Water supply cutbacks are mandatory reductions imposed by the District on the LECSA utilities and general population to conserve existing water supplies when a shortage is imminent. Water supply cutback events usually occur during the dry season, when replenishment of stored water is limited.

During the dry season structural releases are periodically made from the Water Conservation Areas (WCAs) and Lake Okeechobee to maintain ground water levels and to minimize the possibility of saltwater intrusion along the coast. The Lower East Coast uses this water from the regional system to recharge secondary canal networks, wellfields and other recharge areas, and lakes. These ancillary systems are maintained by the local utilities to continue meeting public water supply demands. During the wet season and under normal conditions, rainfall and seepage account for the vast majority of recharge to the LECSA surface and ground water system that supplies this area. During extended dry periods, Lake Okeechobee and the WCAs are important sources of surface water supply for large regions of South Florida. WCAs 1, 2A and 3A are the primary sources of supplemental surface water supply for the Lower East Coast Service Areas 1, 2, and

3, respectively. When water stored in the WCAs and Lake Okeechobee is scarce, for instance during a drought, the urban water supply demands are restricted (cut back) in order to conserve the remaining supplies in the regional system. Although the service areas are able to continue to meet some demands through local sources, all service areas are dependent on the WCAs and Lake Okeechobee to supplement surface water supply and support urban public water supply demands. This is true for all of the service areas except Northern Palm Beach Service Area, which relies on local supplies.

The availability of recharge water to the LECSA via surface or ground water through either seepage or structural flows from the regional system can be evaluated based on the surface water storage in Lake Okeechobee. The storage volume within the lake gives a more quantitative indicator that a water shortage condition may be approaching. The water supply cutbacks in the LECSA are based partly on the available surface water storage in Lake Okeechobee. However, the primary triggering mechanism for implementing the LECSA cutbacks is related to ground water levels within the LECSA.

Low ground water levels near the coast increase the vulnerability of the Biscayne aquifer to saltwater intrusion. Continuing to meet urban water demands may exacerbate ground water levels and therefore cutbacks are necessary when there is a threat to the resource. Low storage levels in the Lake Okeechobee at the beginning of the dry season are indicative of a prolonged storage problem that dictates when the cutbacks can be removed while low ground water levels indicate immediate problems within the LECSA. Either of these triggers, Lake Okeechobee or local ground water levels, can initiate a water supply cutback and are reflected in the ability to meet the 1-in-10 level of service water supply goal. Although regional water supplies or local ground water levels may rebound during the dry season, cutbacks are continued through the end of the dry season, May, to ensure protection of the Biscayne aquifer.

The availability of water from the regional system to recharge the LECSA via structural discharges can be evaluated based on the ability to maintain the primary coastal canals above their saltwater intrusion criteria. This third performance measure, maintaining the surface water levels and continuing their recharge functions, is critical to protecting the Biscayne aquifer from saltwater intrusion. However, it should be noted that saltwater intrusion could still occur even if the primary canals are maintained. Some areas along the salt front cannot be adequately recharged from the regional system to offset local demands on ground and surface waters or to abate saltwater intrusion. Local conditions and demands can contribute to the movement of the salt front as well by lowering ground water levels.

The primary coastal canal performance measure is indicative of the ability to meet the proposed criteria for minimum flows and levels for the Biscayne aquifer. Chapter 373, F.S. directs all of the water management districts to establish minimum flows and levels for surface waters and aquifers within their jurisdiction. The District will be proceeding with rule development for the minimum level criteria for the Biscayne aquifer in the near future. The minimum level criteria for the Biscayne aquifer was utilized in the SFWMM model to reflect future demands from the regional system.

The performance measures described herein rely upon a linear relationship between performance and the scores developed for comparative purposes. Only the 1-in-10 level of service performance measure was normalized. No weighting was applied to the performance measures since all were considered equally important to continue the functions of the Biscayne aquifer and other resources in the Lower East Coast.

Performance Measures and Indicators

Two performance measures and one performance indicator are analyzed for each service area. In Service Area 3, an additional performance indicator, Ability to maintain South Miami-Dade Canals, was analyzed. These performance measures were selected due to their ability to measure how the alternative performs in protecting the Biscayne aquifer and providing recharge to the aquifer for public water supply. These measures are indicative of how well the conceptual designs may perform together on a regional scale. Additional feasibility studies and detailed designs will need to be pursued prior to implementation of any of the components included in the Comprehensive Plan.

1) Ability to meet the 1-in-10 water supply planning goal: The frequency of water supply cutbacks is indicative of the reliability of regional and local water supplies through various weather and resource conditions. Water supplies in Lake Okeechobee supplement deliveries to the LECSA to maintain ground water levels to prevent saltwater intrusion near the coast. Public water supplies are reduced or cutback at the well field in response to low surface water levels in Lake Okeechobee or ground water levels near the coast. The planning goal is to find a balance between ability of the regional system to supplement recharge of the aquifer and meet the public water supply planning goal of a 1-in-10 year level of service in the lower east coast of Florida. The planning goal is in terms of the frequency of cutback events and is defined as no more than three cutback events, no more than seven months in duration over the period of record. A cutback event can begin in the fall and continue through the spring, therefore the maximum number of cutback events in the period of record is thirty. The score represents the number of cutback events during the period of record minus the three allowed events compared to the maximum number of years the 1-in-10 year level of service planning goal can be

met. Alternatives that equaled or exceeded the goal, i.e. had three or less cutback events, scored 100% (no extra credit was given for exceeding the planning goal).

Score =[1 - ((# of cutback events   3 years)/27 years)]100 = % of years goal met

2) Percentage of months not in a water supply cutback: The duration of water supply cutbacks is another characteristic of a drought event and is used as an indicator of the reliability of water supplies. The number of months of water supply cutbacks incurred in a service area capture the lengths of time urban demands are not met. The increased or decreased length of the cutback events is captured by counting the total number of months when the service area is in a water supply cutback, regardless of the severity of the cutback, as a percentage of the total number of months in the period of record. This percentage of time would be subtracted from one to reflect the improvement, increasing amount of time not in a water supply cutback, attributable to the alternative.

Score =[1-((# of months service area in cutback)/372 months)]100 = % of time in a cutback

3) Ability to maintain saltwater intrusion criteria: Maintaining the primary coastal canals above the saltwater intrusion criteria is critical to protecting the Biscayne aquifer from saltwater intrusion and is part of the proposed criteria for minimum flows and levels. Each Service Area includes several primary coastal canals that have saltwater intrusion criteria developed for them. In the SFWMM, the stage of the coastal canal is compared to the criteria on a daily basis. If the canal is unable to be maintained for a week, the event is counted towards the time the saltwater intrusion criteria was not met. All canals were weighted equally except in Service Area 3, where the C-6 and C-2 were weighted more than the C-4 due to their ability to provide wellfield recharge. The performance measure is reported as the percentage of time the canal stage is below the saltwater intrusion criterion, which is subtracted from one to report the percentage of time the canal is above the saltwater intrusion criterion.

Score = [1- % of time not able to maintain canals]100 = % of time able to maintain canals

4) Maintaining water levels in south Miami-Dade canals: At this time, saltwater intrusion criteria do not exist for the major canals in southern Miami-Dade County. However, it is important to evaluate water levels in these canals because encroachment of the salt front into the Biscayne aquifer has occurred previously in this area. Plus, major public water supply wellfields are located in southern Miami-Dade County. This area was evaluated by using the stage duration curves for the following structures: C-100A @ S-123, C-1 @ S-21, C-102 @ S-21A, and C-103 @ S-20F. The stage duration curves were used to evaluate the alternatives in

two ways: 1) the distance by which an alternative's water level fails to reach two feet NGVD at the 90th percentile of the stage duration curve; and 2) the percentile at which an alternative's stage duration curve meets the 50th percentile of the 1995 Base stage duration curve.

In the first scenario, two feet NGVD was used for comparison in keeping with the Ghyben-Herzberg relationship which estimates that one foot of fresh water head is required to protect 40 feet of aquifer. The aquifer along the coast in southern Miami-Dade is approximately 80 feet that would require two feet of fresh water head. The 90th percentile of the stage duration curve was used since that percentile reflects lower stages of the dry season when the risk of saltwater intrusion is increased. The score is calculated from the distance of the base conditions and alternatives to the two feet NGVD on the stage duration curve. Alternatives that equaled or exceeded the target scored 100% (no extra credit was given for exceeding the target).

Score = [(2 - Distance/2)] x 100 = % of meeting 2 foot target

The second scenario used the 50th percentile of the 1995 Base to evaluate performance since it represents approximately the midpoint between the wet and dry seasons and can be viewed as "average conditions" for the 1995 Base. The score reflects the percentile at which a base condition or alternative meets or exceeds the water level at the 50th percentile of the 1995 Base. Saltwater encroachment has occurred in the period of record and, therefore, exceeding the 50th percentile is considered an improvement but may not prevent further encroachment.

The base conditions and alternative scores were determined by averaging the scores for the two scenarios.

Flood Protection

Flood protection is one of the authorized purposes of the Restudy and will be evaluated and addressed during the detailed design phase of the study. Due to the grid size and type of model used during the Restudy alternative evaluation process, the performance measures available for the Lower East Coast Service Area are of limited value for direct evaluation of an alternative's affect upon flood protection. However, one performance indicator is applicable for the southern Miami-Dade County agricultural areas in Service Area 3, stage duration curves, and is used in this evaluation.

Urban Areas East of the Protective Levee in the Lower East Coast

Flood protection should be improved or at least not degraded by the selected plan. In many instances, the alternatives have reduced or eliminated adverse impacts to flood control associated with the components selected in the urban areas of the Lower East Coast. The alternatives provide additional water storage capacity through water preserve areas, reservoirs and aquifer storage and recovery, reducing the maximum stages in the canals during large rainfall events.

The risk of flooding may be decreased with the additional storage components; however, it is difficult to discern the improvements at this point in the alternative evaluation. The model used to evaluate the effects of the components on regional hydrology is not conducive for evaluating storm and flood events. The model uses a daily time step; storm and flood events occur within hours. One-performance indicator gauges the change in peak stages compared to the 1995 Base on a regional basis. The primary drawback of this performance indicator is that it does not distinguish between ground and surface water levels.

After the final plan is selected, this performance indicator will be used to identify areas of potential decreased flood protection coupled with site specific information regarding flood prone areas. Information regarding existing flood prone areas will be gathered from District and USACE staff familiar with the Lower East Coast supplemented with interviews with local government officials and other who have technical input. These areas will be mapped using the SFWMM grid cell boundaries and will be identified by the appropriate basin. These identified areas will undergo further evaluation in subsequent feasibility reports to determine what actions are necessary. In addition, portions of the study area outside of the boundaries of the SFWMM grid will need to be evaluated for flooding impacts through a separate process as well.

D.8.4.1 Agricultural Area along the L-31N

Performance Measure Used

One performance measure graphic was developed for use in six cells in the western areas of southern Miami-Dade County (Lower East Coast Service Area 3) to compare the relative performances of the different alternatives. It is labeled “end of the month stage duration curve 1983-1993”, and compares an 11-year target stage duration curve to the 31-year stage duration curves representing the performances of the bases and alternatives. The relative comparison of an 11-year curve to a 31-year curve appeared to be appropriate for use at the higher stages, but did not compare as well at the mid to lower stages.

Scoring Procedures

Because the comparisons between the curves are most appropriate at the higher stages, it was decided to use the point where the stage duration curves intersect with the “10 % time equaled or exceeded” line on the graphs. For each of the six indicator cells, the difference between where an alternative or base curve intersects the 10 % line and where the target curve intersects the 10 % line is measured (in tenths of a foot).

Only the increases in stages relative to the target are included in the matrix. In the first matrix, if an alternative falls below the target (performance is better that the target), a score of 0 is given. The values for all of the cells are summed and normalized so the final scores ranges between 0 and 1.

A second scoring methodology that gives credit for flood protection above the target was used for comparison. In order to normalize the alternatives' scores, five (5) was added to each sum so the final numbers were all positive. The resulting values are shown as an "alternative score".

Interpretation of Results

Using the first scoring methodology, all of the alternatives performed equally. There is no measurable difference between the stage duration curves at the 10% line. The operational changes that were implemented in the C-111 basin in all alternatives are thought to be the reason for this result. The 1995 Base produces the best performance, and the 2050 Base the worst, indicating that some of the components associated with the Experimental Water Deliveries Program have the potential to impact the level of flood protection in this area of Miami-Dade County.

In looking at the second scoring methodology where credit is given for an increase in flood protection in some of the northern cells, alternatives B and C perform the best, followed (in order) by alternative A, D, 1995 Base, and the 2050 Base. Since exceedence of the target line is a "bonus", and since it only occurred in some of the cells, it's not recommended to base selection of a preferred alternative on these results. They are presented only for informational purposes.

Alternative D13R performed equally to alternative D. There were no changes in operations in this area, so the performance did not change.

	R10 C25	R13 C25	R15 C26	R17 C27	R19 C27	R20 C27	
			Difference in stage in tenths of a foot				Totals
95Base	1	1	2	-1	0	0	3
50Base	5	7	6	1	1	-2	18
Alt A	0	3	4	-3	-3	-4	-3
Alt B	0	3	4	-3	-3	-5	-4
Alt C	0	3	4	-3	-3	-5	-4
Alt D	0	3	4	-3	-2	-3	-1
Alt D13R	0	3	4	-3	-2	-3	-1
			Increases in stage relative to the Target (tenths)				
95Base	1	1	2	0	0	0	4
50Base	5	7	6	1	1	0	20
Alt A	0	3	4	0	0	0	7
Alt B	0	3	4	0	0	0	7
Alt C	0	3	4	0	0	0	7
Alt D	0	3	4	0	0	0	7
Alt D13R	0	3	4	0	0	0	7
		SCORE			Alternative Score		
95Base		0.9				0.73	
50Base		0.3				0.23	
Alt A		0.8				0.93	
Alt B		0.8				0.97	
Alt C		0.8				0.97	
Alt D		0.8				0.87	
Alt D13R		0.8				0.87	

Other Issues

Isolated wetlands and other natural areas east of the protective levee: Performance measures for isolated wetlands and natural areas east of the protective levee, although important pieces of the remnant Everglades, are not included in this performance matrix. Due to the scale of the SFWMM relative to isolated wetlands, the impact of components cannot be accurately depicted. The scale of the model prevents evaluating features that are smaller than the four square mile grid, with the exception of canals and control structures. In addition, the differences between the alternatives and their components' potential impacts to wetlands may be imperceptible. The influence of the components located primarily west of the levee on ground and surface water levels in areas that have been severed from the regional system by the protective levee is limited. Some of these natural areas are dependent on discharges from primary canals that may be affected by projects located upstream. In these cases, the potential effect of the alternatives can be evaluated to identify problems. Two control structures that supply water to the Pond Apple Slough and North Fork of the New River in Service Area 2, C-11 at S-13 and C-13 at S-38, experience fluctuations in discharge across the alternatives. During the detailed design phase or perhaps as part of an Other Project Element, the potential impact to these areas should be taken into consideration and minimized, and if possible, their discharges increased to meet their demands.

Interpretation of Scores for LECSAs

Summary**:** Based on the above interpretation of the performance measures, Alternatives C and D perform equally well and substantially improve water supplies compared to the 2050 Base for the Lower East Coast Service Area. Alternatives C and D are the preferred alternatives. Alternatives A and B also improve upon the 2050 Base, but do not perform as well as Alternatives C and D.

North Palm Beach Service Area: The North Palm Beach Service Area scores very well, almost reaching the established goals in all alternatives. The average score for the alternatives exceeds 96%, with Alternative D reaching 99%. The performance of the primary canals reaches their goals in all of the alternatives. The 1-in-10 level of service planning goal scores are very high in all alternatives, above 95%. The duration of cutbacks scores are very high as well and are just shy of reaching their goal. Compared to the 2050 Base, any of the proposed plans relying on alternative sources would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in the North Palm Beach Service Area.

Service Area 1: Service Area 1 performs very well almost reaching the established goals in all alternatives. The average score for the alternatives exceeds 96%, with Alternative D reaching 99%. The performance of the primary canals reaches their goals in all of the alternatives. The 1-in-10 level of service planning goal scores very high in all alternatives, above 95%. The duration of cutbacks scores are very high as well and are just shy of reaching their goal. Compared to the 2050 Base, any of the proposed plans relying on alternative sources would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in Service Area 1.

Service Area 2: Service Area 2 performs well in all of the alternatives, with C and D performing better than A and B. The average score for the alternatives exceeds 88%, with Alternative D reaching as high as 95%. This compares very favorably to the 2050 Base, which scores only 54% for Service Area 2. Alternatives C and D perform almost equally as well as each other as Alternative A performs similar to B. The ability to maintain primary coastal canals performed well in all of the alternatives; it is just shy of reaching its goal for the four alternatives. The 1-in-10 level of service planning goal score for all of the alternatives is significantly higher than the 2050 Base, which has cutbacks almost every year, scoring a dismal 4%. Alternatives C and D perform better than alternatives A and B on reducing the frequency of cutbacks. Although Alternative C scores slightly lower than D, the actual difference is nine more months of cutbacks over the period of record in Alternative C. This is reflected in the duration performance measure. The duration of cutbacks scores improve significantly when compared to the 2050 Base. Compared to the 2050 Base, any of the proposed plans would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in Service Area 2. However, alternatives C and D perform better than either A or B and are preferable.

Service Area 3: In Service Area 3, the overall performance improves in all alternatives compared to the 2050 Base, with C and D performing better than A and B. Alternatives C and D perform almost equally as well as each other, as Alternative A performs similar to B. The average score for all of the alternatives exceeds 79%, with Alternative D reaching as high as 92%. This compares favorably to the 2050 Base, which scores only 70% for Service Area 3. All of the alternatives performed well in maintaining the primary coastal canals. The other canals in southern Miami-Dade County do not perform well in Alternatives A or B, showing little to no improvement compared to the 2050 Base. Alternatives C and D do score significantly better for maintaining these canals, but fail to perform well enough to reach their target. All of the alternatives' performance improves significantly over the 2050 Base in meeting the 1-in-10 level of service planning goal, with Alternative D performing the best. The duration of cutbacks scores very high for all alternatives, with Alternative D performing the best. The difference in duration between alternatives C and D is only five additional months of cutbacks over the 31-year period of record. Except for maintaining water levels in southern Miami-Dade canals, the performance of all of the alternatives as evaluated in the matrix exceeds the performance of the 2050 Base. However, alternatives C and D perform better than either A or B and are preferable.

Comparison of Alternative D with Alternative D13R

Alternative D13R performs essentially the same as Alternative D. The two alternatives are indistinguishable in their ability to meet public water demands, minimize the duration of cutbacks, and maintain saltwater intrusion stages in the primary coastal canals. It meets most of the performance measures for the Lower

East Coast Service Area, greatly improving the ability to meet public water supply demands and prevent saltwater intrusion over the 2050 Base.

Considerations

The LEC subteam only considered the scores and their indication of an alternative's ability to meet performance measures when selecting a preferred plan. While the scores may reflect alternatives C and D perform better than alternatives A and B, many of the water supply components chosen for all the alternatives will require greater analysis to assure that they can be implemented. Because of the high-risk based nature of some of the key water supply features (ASR, seepage control, low-phosphorus reuse), plan selection is possible as general guidance only. However, selection of a plan may require selection of components from several of the alternatives, determination of the feasibility of the technologies included, and evaluation of the cost effectiveness of the components. The Implementation Plan should describe and address many of the specific concerns of the LEC subteam.

Subregion: Lower East Coast Service Area*

Performance Measure	1995 Base	2050 Base	Alt A	Alt B	Alt C	Alt D	Alt D13R
Ability to Meet 1-10 water supply planning goal for NPB SA	70%	56%	95%	95%	100%	100%	100%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in NPB SA	100%	100%	100%	100%	100%	100%	100%
% of Months Not in Water Supply Cutbacks in NPB SA	87%	81%	93%	93%	95%	96%	96%
North Palm Beach Service Area Average Score	**86%**	**79%**	**96%**	**96%**	**98%**	**99%**	**99%**
Ability to Meet 1-10 water supply planning goal for SA 1	63%	40%	95%	95%	100%	100%	100%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 1	100%	100%	100%	100%	100%	99%	100%
% of Months Not in Water Supply Cutbacks in SA 1	87%	76%	93%	93%	95%	96%	96%
Service Area 1 Average Score	**83%**	**72%**	**96%**	**96%**	**98%**	**98%**	**99%**
Ability to Meet 1-10 water supply planning goal for SA 2	26%	4%	56%	56%	85%	93%	93%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 2	94%	95%	100%	100%	99%	99%	100%
% of Months Not in Water Supply Cutbacks in SA 2	75%	62%	88%	87%	92%	95%	95%
Service Area 2 Average Score	**65%**	**54%**	**81%**	**81%**	**92%**	**96%**	**96%**
Ability to Meet 1-10 water supply planning goal for SA 3	78%	56%	74%	78%	93%	95%	95%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 3	77%	89%	95%	100%	100%	100%	100%
Ability Maintain Water Levels in South Dade Canals**	58%	56%	55%	57%	76%	77%	77%
% of Months Not in Water Supply Cutbacks in SA 3	89%	79%	90%	91%	94%	95%	95%
Service Area 3 Average Score	**76%**	**70%**	**79%**	**82%**	**91%**	**92%**	**92%**
Average Weighted Score	**77%**	**69%**	**88%**	**89%**	**95%**	**96%**	**96%**

* Flood protection not evaluated in this matrix
**C-100A@S-123, C-103@S20F, C-102N@21A, C-1@S-21

Subregion: Lower East Coast Service Area*

Performance Measure	1995 Base	2050 Base	Alt A	Alt B	Alt C	Alt D	Alt D13R
		SUMMARY					
Ability to Meet 1-10 water supply planning goal for NPB SA	YELLOW	RED	GREEN	GREEN	GREEN	GREEN	GREEN
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in NPB SA	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
% of Months Not in Water Supply Cutbacks in NPB SA	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN
North Palm Beach Service Area Average Score	**GREEN**	**YELLOW**	**GREEN**	**GREEN**	**GREEN**	**GREEN**	**GREEN**
Ability to Meet 1-10 water supply planning goal for SA 1	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 1	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
% of Months Not in Water Supply Cutbacks in SA 1	GREEN	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN
Service Area 1 Average Score	**GREEN**	**YELLOW**	**GREEN**	**GREEN**	**GREEN**	**GREEN**	**GREEN**
Ability to Meet 1-10 water supply planning goal for SA 2	RED	RED	RED	RED	GREEN	GREEN	GREEN
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 2	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
% of Months Not in Water Supply Cutbacks in SA 2	YELLOW	RED	GREEN	GREEN	GREEN	GREEN	GREEN
Service Area 2 Average Score	**RED**	**RED**	**YELLOW**	**YELLOW**	**GREEN**	**GREEN**	**GREEN**
Ability to Meet 1-10 water supply planning goal for SA 3	YELLOW	RED	YELLOW	YELLOW	GREEN	GREEN	GREEN
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 3	YELLOW	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
Ability Maintain Water Levels in South Dade Canals**	RED	RED	RED	RED	YELLOW	YELLOW	YELLOW
% of Months Not in Water Supply Cutbacks in SA 3	YELLOW	YELLOW	YELLOW	YELLOW	GREEN	GREEN	GREEN
Service Area 3 Average Score	**YELLOW**	**RED**	**YELLOW**	**YELLOW**	**GREEN**	**GREEN**	**GREEN**
Average Weighted Score	**YELLOW**	**RED**	**YELLOW**	**YELLOW**	**GREEN**	**GREEN**	**GREEN**

* Flood protection not evaluated in this matrix
**C-100A@S-123, C-103@S20F, C-102N@21A, C-1@S-21

D.8.5 Northern / Central Everglades

Evaluation Methodology

Performance Measures Used in Final Evaluations

Model results for each alternative were evaluated at the level of individual Indicator Regions. Scores were then aggregated into spatially and hydrologically-distinct groups. Initially, evaluations were based on five performance measures, with each measure comprising one or two component variables. The performance measures and variables were:

1. Inundation pattern (variables: number and mean duration of inundation periods);
2. Extreme high water (variables: number and mean duration of high water events);
3. Extreme low events (variables: number and mean duration of low water events);
4. Interannual depth variation (variables: October and May between-year standard deviations); and
5. Average seasonal amplitude (variable: October mean depth minus May mean depth).

Performance measures 1-4 were approved by the AET early in the alternatives development process and had been used in prior evaluations of Alternatives 1-5. Performance measure 5 was added as a means to evaluate seasonal depth variation. After inspection of initial scores, however, use of measures 4 and 5 was discontinued, as it was found that performance for these measures was acceptable and varied little among the alternatives.

Target variable values for the performance measures were those predicted by NSM 4.5, Final, with four exceptions: (1) in Indicator Region 17, performance was evaluated by comparing values to the average of NSM values for Indicator Regions 14 and 18; this was because the NSM depths in this indicator region had been identified during evaluation of alternatives 1-3 as being lower than desirable for this relatively pristine marsh area; (2) in LNWR, the targets were 1995 Base values, in keeping with the refuge's current regulation schedule; (3) for high water extremes, the performance target was that the number and duration of events be less than or equal to NSM values; and (4) for low water extremes, the performance target was for frequencies and duration of events to be minimized.

During the first round of evaluations, the results for individual indicator regions were aggregated into three sub-areas: (1) Central Ridge and Slough (WCAs 2A, 2B, 3B, and most of 3A); (2) Sawgrass Plains (Holey Land, and Rotenberger WMAs plus NE WCA-3A); and (3) Loxahatchee NWR. However, because hydrologic performance of the alternatives did not fall clearly into these landscape-defined categories, the final evaluation classified the indicator regions into ten subregions that correspond with distinct hydrologic performance. These are:

1. Loxahatchee NWR (Indicator Regions 26 & 27)
2. Holey Land & Rotenberger WMAs (Indicator Regions 28 & 29)
3. WCA-2A (Indicator Regions 24 & 25)
4. WCA-2B (Indicator Region 23)
5. NW WCA-3A (N of Alligator Alley & W of Miami Canal; Indicator Regions 20 & 22)
6. Northeastern WCA-3A (N of Alligator Alley & E of Miami Canal; Indicator Region 21)
7. Eastern WCA-3A (S of Alligator Alley, E of Miami Canal; Indicator Region 19)
8. Central & Southern WCA-3A (S of A. Alley, W of Miami Canal; Indicator Regions 14, 17 & 18)
9. WCA-3B (Indicator Regions 15 & 16)
10. Pennsuco Wetlands (Indicator Regions 52 & 53)+

Index Calculation Method

Index values were developed for each performance measure and indicator region in order to simplify comparison of the alternatives. The method for calculating these indices is described below. It is important to note that the indices are valid only for making relative comparisons among different models for a single performance measure averaged over at most a few similar indicator regions. In addition, the scale of the index values for each performance measure does not map directly to any ecological interpretation of restoration potential for the alternative; it is color and letter grade scores that are used for that purpose. Indices and ranks function strictly as a means of ordering the alternatives and base cases relative to each other on the basis of their ability to achieve planning targets.

Inundation Pattern

For inundation pattern, subscores for the two variables, number and mean duration of inundation events, were calculated using the formula:

$$\text{score} = \exp[-2.773(\text{Target value-Alternative value/Target value})^2] .$$

This describes a smooth curve that assigns a maximum score of 1.0 only when the value for the alternative exactly equals the target value, and assigns a score of 0.5 when the alternative's value is 50% larger or smaller than the target value. Values that deviate from the target by less than 50% are assigned scores greater than 0.5 that increase to 1.0 as the alternative's value approaches the target. Values that deviate from the target by more than 50% are assigned scores less than 0.5 that approach zero as the distance from the target value increases.

The summary index for inundation pattern was calculated as the arithmetic average of the two subscores.

High Water Extremes

For high water extremes, subscores were calculated for number of high water events and mean duration of events. If the alternative's value for the variable was less than or equal to the NSM-defined target, then a score of 1.0 was assigned. If the alternative value exceeded the target, then the score was calculated using the formulae:

score for # events = exp[- (Alternative #events -Target #events) ^{2}/8)]; and

score for duration of events = exp[- (Alternative duration-Target duration) ^{2}/18)].

These formulae assign a score of 0.61 when the alternative value exceeds the target value by two events or by three weeks, respectively. Scores fall off toward zero as number and/or duration of events increases. The summary index for high water extremes was then calculated as the simple average of the two subscores.

Low Water Extremes

For low water extremes, scores were calculated for the two variables, number of low water events and mean duration of events, according to the formula:

score = exp[- (Alternative value) ^{2}/2(NSM value)^2)].

This assigns a score of 1.0 when the alternative's value equals zero, and a score of 0.61 when the alternative's value equals the NSM value. Scores between 0.61 and 1.0 identify performance that is "better" than NSM at reducing the number and/or duration of low water events, while scores of less than 0.61 approach zero as the number and/or duration of low water events gets large. As above, the summary index was calculated as the simple average of the two subscores.

Seasonal and Interannual Variability

Scores were assigned to seasonal amplitude, October standard deviation, and May standard deviation, using the same formula as that for inundation pattern. The summary index was then calculated as a weighted average:

Index = (0.5)(seasonal amplitude score) + (0.25)(Oct. st.dev. score+May st. dev. score).

As noted above, use of this index was discontinued after initial inspection of results, because alternatives generally performed well and did not differ appreciably. The few exceptions to this are described in the narrative evaluation below.

Combined Indices

Indices were aggregated in two ways: across performance measures within individual indicator regions; and across indicator regions within subregions. The individual indices and averages are listed in Tables Northern and Central Everglades – 1, 2 and 3 below.

(1) Spatial averages. For each performance measure, an average index value was obtained for each subregion, weighting each indicator region by the approximate spatial area of the landscape that it represented (defined by counting model grid cells in that region of the SFWMM). The weights assigned are listed in Table Northern and Central Everglades – 4 below.

(2) Overall performance average. For each indicator region, the three indices for inundation pattern, high water extremes, and low water extremes were averaged to obtain a summary score. This was a weighted average, with the index for inundation pattern given half the weight assigned to each of the other indices. This weighting was chosen in order to reduce the influence of the differences in inundation pattern indices on the overall average, on the rationale that an exact matching of NSM inundation values within an indicator region was not likely to be significantly better at promoting long-term sustainability of the marsh than was a pattern that was broadly consistent with NSM within that landscape region, but not necessarily a good match for the specific indicator region being scored.

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NORTH/CENTRAL EVERGLADES SUMMARY RANKS FOR 2050 BASE and ALTERNATIVES A-D & AREA COLOR AND LETTER GRADE SCORES FOR ALTERNATIVES A-D

		50B				Alternative A						Alternative B						Alternative C						Alternative D					
Indicator Region	WT	In	Hi	Lo	AVE	In	Hi	Lo	AVE	Co	Gr	In	Hi	Lo	AVE	Co	Gr	In	Hi	Lo	AVE	Co	Gr	In	Hi	Lo	AVE	Co	Gr
South LNWR (WCA-1)	28	5.0	3.0	5.0	**4.3**	1.5	3.0	2.5	**2.3**	**G**		3.5	3.0	2.5	**3.0**	**G**		3.5	3.0	2.5	**3.0**	**G**		1.5	3.0	2.5	**2.3**	**G**	
North LNWR (WCA-1)	28	4.5	3.0	5.0	**4.2**	4.5	3.0	4.0	**3.8**	**G**		3.0	3.0	2.5	**2.8**	**G**		1.5	3.0	2.5	**2.3**	**G**		1.5	3.0	1.0	**1.8**	**G**	
AVERAGE		**4.8**	**3.0**	**5.0**	**4.3**	**3.0**	**3.0**	**3.3**	**3.1**	**G**	**A**	**3.3**	**3.0**	**2.5**	**2.9**	**G**	**A**	**2.5**	**3.0**	**2.5**	**2.7**	**G**	**A**	**1.5**	**3.0**	**1.8**	**2.1**	**G**	**A**
Rotenberger WMA	10	3.0	3.0	3.0	**3.0**	3.0	3.0	3.0	**3.0**	**G**		3.0	3.0	3.0	**3.0**	**G**		3.0	3.0	3.0	**3.0**	**G**		3.0	3.0	3.0	**3.0**	**G**	
Holey Land WMA	14	5.0	5.0	1.0	**3.7**	5.0	2.5	3.5	**3.7**	**G**		2.5	2.5	3.5	**2.8**	**G**		2.5	2.5	3.5	**2.8**	**G**		2.5	2.5	3.5	**2.8**	**G**	
AVERAGE		**4.2**	**4.2**	**1.8**	**3.4**	**4.2**	**2.7**	**3.3**	**3.4**	**G**	**B**	**2.7**	**2.7**	**3.3**	**2.9**	**G**	**B**	**2.7**	**2.7**	**3.3**	**2.9**	**G**	**B**	**2.7**	**2.7**	**3.3**	**2.9**	**G**	**B**
South WCA-2A	19	4.5	1.0	4.5	**3.3**	4.5	2.0	4.5	**3.7**	**Y**		2.0	4.0	2.0	**2.7**	**Y**		2.0	4.0	2.0	**2.7**	**Y**		2.0	4.0	2.0	**2.7**	**Y**	
North WCA-2A	19	1.0	2.0	5.0	**2.7**	2.0	1.0	3.5	**2.2**	**R**		4.0	3.5	3.5	**3.7**	**R**		4.0	3.5	1.5	**3.0**	**R**		4.0	5.0	1.5	**3.5**	**R**	
AVERAGE		**2.8**	**1.5**	**4.8**	**3.0**	**3.3**	**1.5**	**4.0**	**2.9**	**R/Y**	**D**	**3.0**	**3.8**	**2.8**	**3.2**	**R/Y**	**D**	**3.0**	**3.8**	**1.8**	**2.8**	**R/Y**	**D**	**3.0**	**4.5**	**1.8**	**3.1**	**R/Y**	**D**
WCA-2B	28	**5.0**	**4.5**	**5.0**	**4.8**	**2.5**	**4.5**	**1.0**	**2.7**	**R**	**F**	**2.5**	**3.0**	**3.0**	**2.8**	**R**	**F**	**2.5**	**1.5**	**3.0**	**2.3**	**R**	**F**	**2.5**	**1.5**	**3.0**	**2.3**	**R**	**F**
NW WCA-3A	23	5.0	5.0	5.0	**5.0**	2.5	1.5	2.5	**2.2**	**G**		2.5	1.5	2.5	**2.2**	**G**		2.5	3.5	2.5	**2.8**	**G**		2.5	3.5	2.5	**2.8**	**G**	
NW Corner WCA-3A	23	3.0	3.0	5.0	**3.7**	3.0	3.0	2.5	**2.8**	**G**		3.0	3.0	4.0	**3.3**	**G**		3.0	3.0	1.0	**2.3**	**G**		3.0	3.0	2.5	**2.8**	**G**	
AVERAGE		**4.0**	**4.0**	**5.0**	**4.3**	**2.8**	**2.3**	**2.5**	**2.5**	**G**	**B**	**2.8**	**2.3**	**3.3**	**2.8**	**G**	**B**	**2.8**	**3.3**	**1.8**	**2.6**	**G**	**B**	**2.8**	**3.3**	**2.5**	**2.8**	**G**	**B**
NE WCA-3A	5	**4.0**	**2.0**	**3.0**	**3.0**	**5.0**	**1.0**	**1.0**	**2.3**	**G**	**B**	**1.5**	**3.0**	**5.0**	**3.2**	**Y**	**C**	**3.0**	**4.5**	**3.0**	**3.5**	**R**	**F**	**1.5**	**4.5**	**3.0**	**3.0**	**R**	**F**
East WCA-3A	29	**3.0**	**3.0**	**4.0**	**3.3**	**2.0**	**3.0**	**2.0**	**2.3**	**R**	**F**	**1.0**	**3.0**	**5.0**	**3.0**	**R**	**F**	**5.0**	**3.0**	**2.0**	**3.3**	**R**	**F**	**4.0**	**3.0**	**2.0**	**3.0**	**R**	**F**
South WCA-3A	36	1.5	3.5	3.5	**2.8**	1.5	3.5	5.0	**3.3**	**Y**		4.0	1.0	3.5	**2.8**	**G**		5.0	3.5	1.5	**3.3**	**Y**		3.0	3.5	1.5	**2.7**	**Y**	
South Central WCA-3A	36	1.5	4.5	4.5	**3.5**	1.5	2.5	4.5	**2.8**	**G**		4.0	1.0	3.0	**2.7**	**G**		5.0	2.5	1.5	**3.0**	**Y**		3.0	4.5	1.5	**3.0**	**Y**	
North Central WCA-3A	36	1.5	2.5	5.0	**3.0**	1.5	1.0	4.0	**2.2**	**G**		4.0	2.5	3.0	**3.2**	**Y**		4.0	4.0	1.5	**3.2**	**R**		4.0	5.0	1.5	**3.5**	**R**	
AVERAGE		**1.5**	**3.5**	**4.3**	**3.1**	**1.5**	**2.3**	**4.5**	**2.8**	**G/Y**	**B**	**4.0**	**1.5**	**3.2**	**2.9**	**G/Y**	**B**	**4.7**	**3.3**	**1.5**	**3.2**	**R/Y**	**D**	**3.3**	**4.3**	**1.5**	**3.1**	**R/Y**	**D**
West WCA-3B	14	1.0	2.0	5.0	**2.7**	2.0	1.0	1.0	**1.3**	**G**		3.0	4.5	4.0	**3.8**	**R**		4.0	3.0	3.0	**3.3**	**R**		5.0	4.5	2.0	**3.8**	**R**	
East WCA-3B	14	4.0	3.0	4.0	**3.7**	1.0	1.0	1.5	**1.2**	**G**		2.0	5.0	4.0	**3.7**	**R**		3.0	3.0	4.0	**3.3**	**R**		5.0	3.0	1.5	**3.2**	**R**	
AVERAGE		**2.5**	**2.5**	**4.5**	**3.2**	**1.5**	**1.0**	**1.3**	**1.3**	**G**	**A**	**2.5**	**4.8**	**4.0**	**3.8**	**R**	**F**	**3.5**	**3.0**	**3.5**	**3.3**	**R**	**F**	**5.0**	**3.8**	**1.8**	**3.5**	**R**	**F**
Pennsuco North	4	4.0	3.0	5.0	**4.0**	1.0	3.0	3.5	**2.5**			2.5	3.0	3.5	**3.0**			2.5	3.0	2.0	**2.5**			5.0	3.0	1.0	**3.0**		
Pennsuco South	4	4.0	3.0	3.0	**3.3**	4.0	3.0	3.0	**3.3**			4.0	3.0	3.0	**3.3**			2.0	3.0	3.0	**2.7**			1.0	3.0	3.0	**2.3**		
AVERAGE		**4.0**	**3.0**	**4.0**	**3.7**	**2.5**	**3.0**	**3.3**	**2.9**	**Y**	**C**	**3.3**	**3.0**	**3.3**	**3.2**	**Y**	**C**	**2.3**	**3.0**	**2.5**	**2.6**	**Y**	**C**	**3.0**	**3.0**	**2.0**	**2.7**	**G**	**B**

WT – weight   AVE – average   Hi – high   Lo – low   Co – color   Gr – Grade   G- green   Y- yellow   R- red

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ROGEM Analysis for the Northern/Central Everglades

The color and grading exercises (discussed below) offered an opportunity to interpret the index values in terms of their ecological significance and ROGEM scores were developed consistent with these evaluations. The Northern/Central Everglades Region Subteam ranked, graded, and assigned colors before they developed ROGEM values. The letter grades were converted into ROGEM values by assigning "1.0" to the grade of "A", "0.8" to "B", "0.6" to "C", "0.4" to "D" and "0.1" to "F".

Index scores were used for ranking plans to see how far alternatives varied from the targets and from each other. Unlike the color and letter grade scores, they were not useful in determining how successful any plan would be in meeting ecological goals. One additional drydown event over 31 years, for example, may not significantly differ from the target in terms of ecological health, however a 4-week increase in the mean average duration of high water events could indicate a highly significant ecologically deviation.

ROGEM SCORES Northern/Central Everglades	Acres	1995 Score	2050 Score	Alt A Score	Alt B Score	Alt C Score	Alt D Score	Alt D13R Score
Loxahatchee	143,360	1.0	0.6	1.0	1.0	1.0	1.0	1.0
Rotenberger + Holey Land	61,440	0.4	0.6	0.8	0.8	0.8	0.8	0.8
WCA-2A	97,280	0.4	0.4	0.4	0.4	0.4	0.4	0.6
WCA-2B	28,160	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NW WCA-3A	117,760	0.1	0.4	0.8	0.8	0.8	0.8	0.8
NE WCA-3A	53,760	0.1	0.4	0.8	0.6	0.1	0.1	0.4
East WCA-3A	74,240	0.1	0.4	0.1	0.1	0.1	0.1	0.4
Central & Southern WCA-3A	276,480	0.4	0.4	0.8	0.8	0.4	0.4	0.8
WCA-3B	69,120	0.8	0.4	1.0	0.1	0.1	0.1	0.6
Pennsuco	17,920	0.4	0.4	0.6	0.6	0.6	0.8	0.8

Ranking of Alternatives

The indices were used as a basis for ranking Alternatives A-D relative to each other and the 2050 Base. For each performance measure and indicator region, indices were rounded to the nearest 0.1 and then ranked from 1 to 5, with ties given the mean of the tied ranks. These ranks were then averaged across indicator regions using the spatial weights described above, and were also averaged, without weighting, across the three performance measures. This analysis acted as a check for the results obtained with the index values, by creating an ordering of alternatives that was less subject to possible shifts in rank that can occur when non-linear functions are averaged. Ranks for Alternatives A-D and 2050 Base are presented in Table Northern and Central Everglades – 5.

Color and Letter Grade Assignment

The indices and ranks described above allowed alternatives to be compared to the base cases and to each other. However, because the numeric scale is largely arbitrary from a biological perspective, an ecological interpretation of the alternative cannot be deduced from the index scores. A separate evaluation method was done for this purpose. Each performance measure for each indicator region was evaluated using best professional judgment of subteam members as to the ecological consequences of the predicted performance. Values were compared not only to target values and to the 2050 Base, but also to the 1995 Base and to output for other indicator regions where helpful. The subteam then assigned each indicator region a "color" score of Green, Yellow, or Red for each performance measure, and used these to choose a summary color for the indicator region. The criteria for color assignment were as follows.

GREEN. Green was assigned if the model performance was thought to predict conditions expected to promote a sustainable Everglades marsh community. The primary indicators for this were:
(1) protection and accretion of peat soils indicated by a low predicted occurrence of extreme low water (depths more than 1.0 ft below ground surface);
(2) persistence of tree island communities indicated by a low predicted frequency of extreme high water; and
(3) an inundation pattern suitable for an Everglades sawgrass or ridge-and-slough marsh, as indicated by a number and mean duration of inundation events that either closely matched the target for that indicator region, or that fell within the range of patterns predicted by the NSM for that landscape type.

YELLOW. Yellow was assigned if the ecological consequences of the performance were considered uncertain. This uncertainty generally fell into one of two classes: (1) performance deficits that appeared to be "fixable" as part of detailed design or during optimization of operational rules; and (2) uncertainty that could only be resolved via biological monitoring and adaptive management during implementation, because the key issues concerned uncertain biological results of the predicted hydrologic changes. In either case, yellow identified areas where special caution appears to be necessary in implementing any project changes.

RED. Red was assigned if the performance appeared unlikely to support a sustainable Everglades marsh. The primary criteria for this classification were:

(1) high predicted frequencies of extreme dry-outs that seemed certain promote continued peat loss,
(2) high predicted frequencies of extreme high water that would be expected to eliminate tree-island vegetation communities and adversely affect animals that depend on them, and/or
(3) inundation or depth patterns that fell well outside the range of conditions predicted by the NSM for that landscape type.

GRADES. Letter grades were assigned according to the following criteria:
Green areas: "A" or "B," depending on level of confidence in the restoration potential of the alternative;
Mixed Yellow/Green areas: grade of "B";
Yellow areas: "C" or "D," depending on degree and severity of uncertainty;
Mixed Yellow/Red areas: "D"; and
Red areas: "F."

Evaluation/Interpretation of Alternatives A-D

The following text describes, for each subregion, the specific performance evaluation and interpretation that led to the subteam assignments of colors and letter grades, and includes an interpretation of the overall performance of Alternatives A-D.

Loxahatchee NWR (Indicator Regions 26 and 27)

Loxahatchee NWR performs well in all four alternatives, matching targets defined by the 1995 Base. The number and mean duration of inundation events for alternatives B-D are nearly identical to 1995 Base values, with a 99% overall hydroperiod in southern LNWR and a 95% hydroperiod in northern LNWR. This is an improvement over the drier conditions predicted for the 2050 Base (94% hydroperiod in south, 90% hydroperiod in north). Alternative A is slightly drier than the 1995 Base, especially in the north, where there are 20 inundation events averaging 76 weeks in duration, as opposed to 13 events averaging 199 weeks in 1995 Base.

The occurrence of extreme low water is reduced in all four alternatives compared to the 2050 Base, with only one short-duration event in northern LNWR, as compared to the 2050 Base, which has five events averaging five weeks duration in the north, and two events averaging four weeks in the south. All four alternatives are close to the 1995 Base target of no more than one four week-long event in the north and zero events in the south.

All four alternatives also meet performance targets for extreme high water. High water events do not occur in the north, and, although common in the southern part of the refuge, high water events are fewer and of shorter duration than in the 1995 Base. Overall, southern LNWR experiences depths greater than 2.5 ft for 24-25% of the simulation period, as compared to 20% of time in the 2050 Base and 30% in the 1995 Base. There is some uncertainty about the effect of high water on tree islands in southern LNWR; however, the alternatives conform overall to current hydrologic management objectives for the refuge.

Holey Land and Rotenberger WMAs (Indicator Regions 28 and 29)

Both Holey Land and Rotenberger WMAs perform nearly identically in all four alternatives. The regulation schedule assumed for Rotenberger WMA appears to eliminate high water extremes effectively while maintaining suitable NSM-like inundation patterns. In Holey Land, depths greater than 1.5 ft occur 6-8% of time, but depths greater than 1.75 ft occur only 1-2% of time. In both WMAs, the frequencies and durations of extreme low water are less than those predicted by NSM; however, drought conditions still occupy 3-4% of the simulation period. Although there is uncertainty about the minimum conditions needed to protect peat soils, so long as the alternative provides dry season deliveries via the STAs, it should be possible to adjust operational details so as to avoid further soil loss in these areas.

It should noted that in Holey Land WMA, differences in performance relative to the 1995 and 2050 bases do not provide a realistic comparison with the alternatives, because the bases assumed a 0-2' regulation schedule that is not currently in use, nor is it likely to be implemented in the future. Hence, the subteam evaluation in this area was restricted to comparisons with target values.

WCA-2A (Indicator Regions 24 and 25)

In general, alternatives A-D exhibit problematic performance in WCA-2A, with uncertain results for southern WCA-2A (Indicator Region 24) and poor performance in northern WCA-2A (Indicator Region 25).

In southern WCA-2A, inundation patterns were very similar to NSM in all four alternatives, with alternatives B, C, and D performing slightly better than Alternative A. However, in northern WCA-2A, inundation periods were of much longer duration, with less frequent dry-outs, than NSM target values. Here Alternative A performed somewhat better than alternatives B, C, and D, which had only nine inundation events averaging 173 weeks duration, in contrast with the NSM target of 30 inundation events averaging 46 weeks duration. Hence, where NSM predicts that northern WCA-2A would have dried out approximately every year during pre-drainage times, alternatives B-D predict dry-outs to occur less than once every three years, on average, while Alternative A predicts the marsh to dry out in roughly two years out of five. Northern WCA-2A was also one of the only regions in the WCA system that performed poorly for seasonal variability; all four alternatives had annual amplitudes in depth between wet and dry seasons that were smaller than those predicted by the NSM, and the annual mean maximum depth occurred early in the wet season rather than later as predicted by NSM (see performance indicator "Temporal Variation in Mean Weekly Stage for Northern WCA-2A").

Although southern WCA-2A met NSM target values for inundation pattern, it experienced more extreme high water than either base, as well as more extreme low water than might be desired for protection of peat soils. Although extreme high water occurred only 1% of time in alternatives A-D, total high water was greater in all four alternatives than in either base (15-25 weeks as compared to ten weeks in the 2050 Base and three weeks in the 1995 Base). Extreme low water was somewhat reduced relative to both the 1995 and 2050 bases; however, the alternatives still predicted seven - eight extreme dry-downs lasting on average seven weeks duration. Although similar to NSM predictions for extreme low water, and slightly better than the 1995 Base, the subteam was still concerned that this frequency of extreme dry-outs might not be low enough to protect peat soils.

Overall, because northern WCA-2A had a very non-NSM-like hydropattern, and because high and low depth extremes in southern WCA-2A create uncertainty about future marsh conditions in this area, the subteam assigned a score of "yellow" in the south and "red" in the north for all four alternatives. However, it was also felt that performance, especially in the north, could be improved by changes in operational rules during future modeling efforts.

WCA-2B (Indicator Region 23)

WCA-2B was one of two regions in the northern and central Everglades that remained far from targeted performance for all four alternatives. Although the number and duration of inundation events was a good match for NSM targets in alternatives A-D, extremes of high water, low water, or both led to poor performance in all cases.

Alternative A had the weakest performance. Although it showed substantial reduction in extreme low water compared to both bases and the other three alternatives, this improvement was offset by a dramatic 59% of time in which depths exceeded more than 2.5 ft, a performance that was worse than even the 2050 Base, which had high water 56% of the time.

In contrast, alternatives B-D succeeded in reducing extreme high water and providing improvement over both bases. Nonetheless, depths greater than 2.5 ft still occurred 10-11% of time in these alternatives, which is far from the NSM value of 1%. Furthermore, the frequency of extreme low water remained at 5% of time, which is still much higher than the NSM prediction of 1%.

These performance problems are consistent with the observation that WCA-2B is also the area that shows the largest deviation from NSM-like patterns of seasonal and interannual variability, with interannual standard deviations that are one-to-two times the magnitude of those seen in NSM. The reason for this is that WCA-2B experiences very high water during wet periods followed by long periods that are unnaturally dry. This is most pronounced in Alternative A. Overall, the subteam concluded that although alternatives B, C, and D show significant improvement relative to both the 1995 and 2050 bases, the frequent occurrence and long duration of extreme high and low water make it unlikely that this area would be able to function sustainably as either a shorter- or longer-hydroperiod Everglades wetland.

Northwestern WCA-3A (Indicator Regions 20 and 22)

NW WCA-3A was rated “green” for all four alternatives A-D because all four models predict substantially reduced occurrence of extreme low water relative to both 1995 and 2050 bases, while other performance measures are close to target values. In the northwest corner of WCA-3A (Indicator Region 22) dry-downs in excess of 1.0 ft below ground occurred on five - eight occasions for an average of three-five weeks duration (1-2% of total time). Slightly to the south, in Indicator Region 20, extreme dry-outs occurred somewhat more frequently, with nine low water events averaging five – six weeks duration (3-4% of total time). Alternative C performed slightly better than alternatives A, B, or D in both indicator regions. All four alternatives performed better than the 2050 Base and much better than the 1995 Base, which had as much as 11% extreme low water in Indicator Region 22. There remains some concern that the area represented by Indicator Region 20 may still be likely to experience more extreme low water than will be sufficient to protect peat soils. However, it may not be possible to further reduce low water events beyond performance levels comparable to alternatives C and D without causing trade-offs, such as increased risk of cattail proliferation in ponded areas.

Along with the reduction in extreme low water, all four alternatives performed as well or better than both bases at matching NSM inundation patterns. In addition, Indicator Region 20 had lower frequencies of extreme high water relative to both bases, with the best performance occurring in alternatives A and B.

Northeastern WCA-3A (Indicator Region 21)

Alternative A performed best in this region, followed by Alternative B, although performance deficits occurred in all four alternatives. In general, this area has a problem with a tendency toward both too much high and low water.

For inundation pattern, alternatives B, C, and D all did well at matching NSM target values. Alternative A, however, was similar to the 2050 Base, with fewer, longer periods of inundation than NSM. Overall, Alternative D came closest to matching the target values for inundation.

For low water extremes, however, alternatives B, C and D all performed worse than the 2050 Base, with 17 events averaging seven weeks in Alternative B, 14 events averaging six weeks in Alternative C, and 15 events averaging five weeks in Alternative D. Although these values are similar to or less than those predicted by NSM for low water in this area, and all were substantial improvements over the 1995 Base, the subteam felt that the frequency (about one-in-two years) and duration (more than one month, on average) was larger than desired for protection of peat soils. Only Alternative A showed an improvement in low water extremes relative to the 2050 Base, and even it predicts nine low water events averaging six weeks in length.

Alternative A was also the only alternative that showed improvement over the 2050 Base with respect to extreme high water. Alternatives B, C, and D all exhibited an increase in the frequency of depths greater than 2.0 ft, with alternatives C and D showing the least favorable performance. This creates concern about the effect of extreme high water on wading bird rookery vegetation in this region.

Eastern WCA-3A (Indicator Region 19)

None of the alternatives performed well in this area. The region, east of the Miami Canal and South of Alligator Alley, is deeply ponded in both 1995 and 2050 bases and remains so in all four alternatives. Weekly mean depths greatly exceeded NSM targets, with alternatives C and D being the deepest, having depths that exceeded NSM by about 1-1.5 ft year round (see performance indicator, "Temporal Variation in Mean Weekly Stage for East WCA-3A"). Seasonal depth patterns in alternatives A and B are similar to the 2050 and 1995 bases but also exceed NSM depths by 1.0 ft or more through most of the year. As a consequence, only the performance measure for low water extremes shows good performance, in all except Alternative B.

High water extremes are most notable in this area. Alternatives C and D have depths greater than 2.5 ft 27% of the time. Alternative B, with 11% extreme high water, is similar in performance to the 2050 Base. Only Alternative A, with a high water frequency of 9%, predicts improvement over the 2050 Base. Although all the alternatives show substantial improvement over the 53% of extreme high water predicted by the 1995 Base, none of them approaches the NSM target of 0% of time with depths greater than 2.5 ft.

Despite increased depths and frequent extreme high water, Alternative B also shows an increase in low water extremes relative to both bases and the other alternatives, with 11 events where depths dropped to more than 1.0 ft below ground, for an average of six weeks duration. This appears to be a consequence of the decompartmentalization of WCA-3 in Alternative B, which led to an increase in the frequency of both high and low extremes along the eastern side of the WCA (Indicator Regions 21 and 19), including WCA-3B (Indicator Region 16), and extending into northeast Shark River Slough (Indicator Region 11).

Central and Southern WCA-3A (Indicator Regions 14, 17 and 18)

Indicator Region 14

Alternative B performed best in this region. It is the only of the four alternatives in which extreme high water conditions (depths > 2.5 ft) did not occur; it is also the only alternative that had less extreme high water than the 2050 Base. However, only Alternative A had an inundation pattern that closely matched NSM, whereas alternatives B, C, and D, all had fewer, more prolonged inundation periods, with alternatives C and D being the wettest (11 wet periods averaging 139 weeks duration, as compared with NSM's 17 events averaging 88 weeks duration). The total percent inundation, however, was not dramatically different among the alternatives (92% in NSM, 94% in 2050 Base and Alternative B, and 95% in alternatives A, C, and D). All were much improved over the extremely long hydroperiods seen in the 1995 Base. All four alternatives showed better matches for NSM's pattern of seasonal and interannual variation in depth than the 2050 Base.

Indicator Region 17

Alternatives A and B performed well in this region. They are the only alternatives in which high water conditions did not exceed 2.5 ft for more than 1% of the overall simulation period, and they are the only alternatives that had lower frequencies of extreme high water than the 2050 Base.

Performance for inundation pattern is more complex. The target for this area is 21 inundation events averaging 74 weeks duration, which is the average of NSM values for Indicator Regions 14 and 18. Only Alternative A and the 2050 Base had inundation patterns that closely matched this target. Alternatives B, C, D all had fewer and more prolonged inundation periods, with Alternative C being the wettest (13 inundation events averaging 118 weeks duration). Alternatives B and D are nearly identical to the 1995 Base; since this Indicator Region contains grid cells around the 3A-4 gage that are presently affected by ponding along the L67-A levee, this result suggests that alternatives B and D are indeed somewhat wetter than would be ideal in this area.

Indicator Region 18

Alternative A and the 2050 Base both showed good hydrologic performance in this area. Both models exhibit an inundation pattern very similar to NSM, although both are also slightly drier than the 1995 Base. Alternatives B-D deviate greatly from target inundation patterns, with fewer than half the target number of events (ten events versus NSM's 24), and mean durations about 2.5 times as long as target values (155-156 weeks versus NSM's 59 weeks).

For high water extremes alternatives C and D perform worse than either the 1995 or 2050 bases, whereas alternatives A and B show improvement over the 1995 Base and are similar to the 2050 Base, with extreme high water only about 1% of time. For low water extremes, all the alternatives were improvements over the 1995 and 2050 bases; Alternative A, the driest overall, showed the least reduction in extreme low water, while Alternative B performed best.

Overall, Indicator Regions 14, 17 and 18

Overall, in southern and central WCA-3A, alternatives A and B performed reasonably well, and alternatives C and D performed poorly.

Only Alternative A was effective at matching target inundation patterns throughout this region, with performance very similar to the 2050 Base. Alternatives B-D were all less successful than the 2050 Base at achieving target inundation patterns. This may be a result of Component RR4, which relocated and increased the capacity of the S-140 structure, causing increased water releases directly upstream of Indicator Region 18. Combined with increased volumes of water being moved through the WCA, this produced an overall reduction in the frequency of marsh dry-outs to ground surface and a general shift toward hydroperiods that are longer than NSM. The table below illustrates this effect: not only does the total percent inundation in alternatives B-D exceed NSM values, but there is an inversion in the north-to-south gradient in hydroperiods, with the most northerly area (Indicator Region 18) having the longest percent inundation and the most southerly region (Indicator Region 14) the shortest. This is the opposite of NSM predictions for the pre-drainage gradient in hydroperiods in this region.

HYDROPERIODS FOR INDICATOR REGIONS IN SOUTH/CENTRAL WCA-3A

Indicator Region	Target	95BSR	50BSR	Alt A	Alt B	Alt C	Alt D
IR 18	89%	91%	89%	90%	97%	96%	97%
IR 17	*91%	95%	88%	88%	95%	95%	96%
IR 14	92%	99%	94%	95%	94%	95%	95%

*(Target is the average of NSM for Indicator Regions 14 and 18.)

Although Alternative A was best at matching inundation targets, Alternative B was the only alternative that effectively eliminated flooding of tree islands during high rainfall years. Hence, although Alternative A, on balance, showed the best overall performance in the central and southern WCA-3A, none of the alternatives was completely successful at meeting hydrologic performance goals for this region.

WCA-3B (Indicator Regions 15 and 16)

In this area, only Alternative A approaches target hydrologic conditions for WCA-3B. Alternative B is least favorable, primarily owing to predicted high water extremes that are comparable to those seen in WCA-2B in the 1995 Base.

WCA-3B exhibits increased depths in all four alternatives, with weekly mean depths that exceed NSM by 0.5-0.75 ft year round. Alternative B has the deepest water during the wet season, whereas Alternative D has the largest average dry season depths. With respect to inundation pattern, Alternative A was the only alternative that matched NSM, and this only in the southeast (Indicator Region 16). In all other cases, all four alternatives predicted fewer, longer duration inundation events than NSM. The poorest performer for inundation is Alternative D, which predicts only five and six inundation periods lasting an average of 319 and 262 weeks, as compared with NSM's prediction of 20 and 15 events averaging 74 and 102 weeks, for Indicator Regions 15 and 16, respectively. Generally, in western WCA-3B only the 2050 Base is a good match for NSM inundation patterns, and in southeast WCA-3B, only Alternative A and the 1995 Base approach target values.

For low water extremes, all four alternatives show improvement relative to the 2050 Base. In southeastern WCA-3B, however, all four alternatives had more extreme low water than NSM. Of the four model runs, Alternative B had the largest total amount of extreme low water (nine and 16 weeks in indicator regions 15 and 16, respectively), while alternatives A and D had the fewest weeks (0 and 11 weeks in Alternative A; one and seven weeks in Alternative D).

The most serious performance issue for WCA-3B is the high predicted frequency of extreme high water. Alternative A was the only of the four alternatives that met target values for extreme high water, with slightly fewer total high water weeks than those predicted by NSM. Relative to the 1995 Base, Alternative A has a slight increase in high water in the western WCA-3B but a decrease in eastern WCA-3B; Alternative A also performed better than the 2050 Base in both areas. Overall, only the 1995 Base and Alternative A achieved target values for high water extremes. The percents of time with extreme high water are listed in the table below for the four alternatives, the bases, and NSM. For comparison, the table also includes NSM values for indicator regions in Shark River Slough, as well as 1995 Base values for some indicator regions in areas that experience extreme depths under current C&SF Project conditions. It can be seen that alternatives B-D all substantially exceed targets for both indicator regions 15 and 16. Alternative B has the most extreme high water, equivalent to an average three month period with depths over 2.5 ft that would occur in approximately two out of every three years. When the alternatives are compared to the 1995 Base values for indicator regions representing currently deeply-ponded areas of the WCA system, it appears that impacts, even in Alternative B, would not be as extreme as those experienced to date in other areas. However, NSM values from the table suggest that the deepest areas of the pre-drainage Everglades had depths greater than 2.5 ft for up to 9% of time; hence, Alternative B, with 12-17% high water, is predicted to produce conditions outside the range for the pre-drainage system. Such depths and durations would be expected to cause significant damage to tree island vegetation communities in WCA-3B.

Percent of Time Depths Exceeded 2.5 ft in Selected Indicator Region

	Western WCA-3B	Eastern WCA-3B
	Indicator Region 15	Indicator Region 16
95BSR	1%	3%
50BSR	5%	8%
Alternatives:		
Alternative A	2%	2%
Alternative B	12%	17%
Alternative C	6%	9%
Alternative D	8%	10%
NSM Target:	2%	4%

Other NSM Values:

Mid Shark Slough	4%
NE Shark Slough	9%

Other 1995 Base Values (currently deep areas of WCA system)

IR 23:	WCA-2B	17%
IR 26:	S LNWR	30%
IR 14:	S WCA-3A	36%
IR 19:	E WCA-3A	53 %

Pennsuco Wetlands (Indicator Regions 52 and 53)

Extreme low water occurs infrequently in alternatives C and D (1-3% of time), compared with Alternative B (2-4%), Alternative A (3-6%), and especially the 1995 and 2050 bases (7-10% and 9-13% , respectively). High water extremes occur less frequently in all alternatives than under NSM, with Alternative A showing the best performance. The overall inundation pattern varies between the north and south. In northern Pennsuco (Indicator Region 52), alternatives A, B, and C all show good matches for NSM inundation patterns, whereas Indicator Region 53 comes closest to NSM in Alternative D. The NSM inundation pattern in Indicator Region 52 is similar to that for WCA-3B and southern WCA-3A, which is probably a more appropriate and achievable target for this area than is the deeper Shark

Slough-like conditions seen in NSM for Indicator Region 53. Overall, Alternative D appears to provide the best hydrologic performance for this area.

Overall Northern /Central Everglades Performance in Alternatives A-D

The four alternatives performed similarly in the final evaluations over a large area of the northern / central Everglades. Performance was fairly uniformly good in LNWR, Holey Land and Rotenberger WMAS, and northwest WCA-3A. Performance was uniformly poor in WCA-2B and eastern WCA-3A, and was uniformly problematic and uncertain in its implications for WCA-2A.

Where the four alternatives exhibited major differences in performance was in WCA-3B and in southern, central, and northeastern WCA-3A. In these areas, Alternative A provided the best overall hydrologic performance. Alternative B performed very well in southern and central WCA-3A by largely eliminating extreme high water, but this was offset by poor performance in northeastern WCA-3A, an area with important wading bird breeding habitat, and by extremely poor performance in WCA-3B, where extreme high water would be expected to damage tree islands. Alternatives C and D performed poorly in WCA-3B, and were the least favorable alternatives in central, southern and northeastern WCA-3A.

In conclusion, all of the alternatives provided improved conditions relative to the 2050 Base in parts of the northern and central Everglades, but only Alternative A came close to meeting performance targets in a majority of areas, yet it did not prevent extreme high water likely to damage tree island and rookery vegetation in WCA-3A. The only alternative that effectively avoided extreme high water in WCA-3A was Alternative B, and these benefits were offset by high water extremes in WCA-3B. Since south/central WCA-3A and WCA-3B represent the parts of the WCA 2-3 system that have been least damaged by the C&SF Project to-date, and since northeastern WCA-3A is home to currently important wading bird rookery sites, it appears that none of the four alternatives A-D can presently be regarded as likely to provide for overall restoration and sustainability of an Everglades sawgrass and ridge-and-slough ecosystem within the area encompassed by WCAs 2 and 3.

Evaluation of Alternative D13R

Subarea Evaluations

Loxahatchee NWR (Indicator Regions 26 and 27)

Loxahatchee NWR performs identically in Alternative D13R and Alternative D. The overall hydrology is similar to the 1995 Base planning target, and inundation patterns in the north are improved over the drier predictions of the 2050 Base.

Holey Land and Rotenberger WMAs (Indicator Regions 28 and 29)

Holey Land and Rotenberger WMAs perform nearly identically in Alternatives D and D13R. The regulation schedule assumed for Rotenberger WMA appears to eliminate high water extremes effectively while maintaining suitable NSM-like inundation patterns. In Holey Land, depths greater than 1.5 ft occur 7% of time, but depths greater than 1.75 ft occur only about 1% of time. In both WMAs, the frequencies and durations of extreme low water are less than those predicted by NSM; however, drought conditions still occupy 3-4% of the simulation period. Although there is uncertainty about the exact conditions needed to protect peat soils, so long as the alternative provides dry season deliveries via the STAs, it should be possible to adjust operational details so as to avoid further soil loss in these areas.

WCA-2A (Indicator Regions 24 and 25)

Overall, operational changes between Alternatives D and D13R improved performance in northern WCA-2A but reduced performance in the south. While southern WCA-2A experienced more drought conditions in Alternative D13R than in Alternative D, northern WCA-2A experienced improved inundation patterns. In the south (Indicator Region 24), extreme low water occurred 12 times averaging seven weeks in duration; this performance is inferior to the 1995 and 2050 bases and could potentially promote soil loss. In the north (Indicator Region 25), extreme low water occurred less frequently (four times averaging nine weeks duration) than in Alternative D, with frequencies that were comparable to the 2050 Base and an improvement over the 1995 Base.

Inundation patterns in northern WCA-2A were substantially improved over Alternative D. Alternative D13R had 16 wet periods averaging 93 weeks duration, in contrast to Alternative D, which had only nine periods averaging 173 weeks in length. Although neither alternative matches the NSM target of 30 events averaging 46 weeks duration, Alternative D13R comes considerably closer to the target here than does Alternative D.

It appears that water management in WCA-2A imposes trade-offs between providing improved marsh conditions in some areas but worse conditions in others. Overall, the subteam tentatively favored Alternative D13R's performance; however, a more rigorous examination of predicted conditions and effects of different operational rules will be needed in order to provide the best hydrology to those areas expected to yield the most ecological benefits. Historically, southern WCA-2A has lost most of its tree islands to past high water, while many acres of northern

WCA-2A have been overtaken by cattails. The highest quality marsh occurs in central WCA-2A in the vicinity of the 2-17 gage, and to the northwest where tree islands still persist. Inspection of stage duration curves for the 2-17 gage grid cell indicate that alternatives D and D13R are nearly identical, and that both have possibly increased high water frequencies compared to the 1995 and 2050 bases. Hence, implementation of the plan will require careful evaluation of hydrologic objectives in light of performance constraints for this area.

WCA-2B (Indicator Region 23)

WCA-2B was the only region of the northern and central Everglades to receive a “red” color evaluation for Alternative D13R. The reason for this rating is that the alternative continues to have high frequencies of both high and low water extremes. High water extremes are substantially improved over the 1995 and 2050 bases, and the number and duration of inundation events is a good match for NSM targets. However, the combination of frequent extreme low water (14 events occupying 6% of total time) and frequent extreme high water (25 events occupying 10% of total time) make it unlikely that this area will be able to function sustainably as either a shorter- or longer-hydroperiod Everglades wetland.

Northwestern WCA-3A (Indicator Regions 20 and 22)

This region performs similarly in Alternative D13R and Alternative D. Inundation patterns match NSM planning targets and high water extremes are minimal. Low water extremes occur five times for an average of three weeks duration in Indicator Region 22, and nine times for an average of five weeks in Indicator Region 20. This is a substantial improvement over the 2050 Base, and an even larger improvement relative to the 1995 Base. Conditions in this region are thus expected to maintain and promote peat soils. However, there continues to be uncertainty as to whether increased wet conditions will lead to undesirable proliferation of cattails in this area.

Northeastern WCA-3A (Indicator Region 21)

Performance of Alternative D13R is problematic, owing to predicted frequencies of extreme high and low water. The frequency of high water is increased in comparison to both the 1995 and 2050 bases, with periods of continuous depths above 2.0 ft occurring six times for an average of seven weeks in duration. During rainfall year 1994, simulated peak depths and flood durations in Alternative D13R are similar to the 1995 Base, while during rainfall year 1995, depths are deeper and of longer duration than the 1995 Base. This suggests that during high-rainfall years comparable to 1994-95, flooding can be expected to be worse than what actually occurred in this area during 1994-95. This increase in predicted high water raises concerns about potential negative effects on wading bird nesting habitat in this region. One of the most successful nesting sites for wading birds in recent years, Rescue Strand, suffered loss of perhaps as much as 75% of its willows during the 1994-95 high water period (T. Towles, GFC, pers. comm.). This rookery site is located in the same model grid cell as the 3A-3 gage, where stage hydrograph output indicates that, although depths in Alternative D13R are predicted to be lower than the 1995 Base in normal and dry years, during the wettest years (1969-70 and 1994-95) depths are predicted to equal or exceed the 1995 Base. This suggests that willow islands suitable for wading bird nesting in this area would likely be damaged, or possibly destroyed, by high water events. The problem appears to arise from the operation of STA 3/4 during peak rainfall years, when STA operational rules override marsh triggers and lead to excess discharges into this area. Changes in STA operations, additional storage, or re-routing of flood waters might alleviate or reverse this negative impact. In addition, interpretation of net impacts for wading birds is complicated by the fact that conditions to the south of the 3A-3 gage are predicted to be drier than in the 1995 Base. Hence rookery sites in eastern WCA-3A might be expected to do better under Alternative D13R than under current conditions.

An additional source of uncertainty in this area is the high predicted frequency of low water extremes. Alternative D13R performs best of all the alternatives in reducing low water extremes relative to both base cases (15 events averaging four weeks duration as compared to 21 events averaging nine weeks in the 1995 Base, and ten events averaging seven weeks in the 2050 Base). Nonetheless, the predicted frequency and duration of low water events seems large, and may not insure protection of peat soils.

Eastern WCA-3A (Indicator Region 19)

In this area, Alternative D13R has a very similar inundation pattern to Alternative D and to the 2050 Base. Although depths are much greater than NSM, they are lower than in Alternative D and much lower than the 1995 Base. High water extremes are dramatically reduced relative to Alternative D (19% in Alternative D13R compared to 27% in Alternative D). Although this performance is not as good as in the 2050 Base (with only 11% high water), and although Alternative D13R remains far from the NSM target of 0% high water, there is nonetheless enormous improvement relative to the 1995 Base prediction of 53% high water. It seems likely that this is a result of changed operations and retention of a portion of the L-67A canal, which allows more rapid removal of water from this area. Generally, eastern WCA-3A is far from its target values. However, unlike predictions for WCA-2B, extreme high water is not combined with an equivalent frequency of extreme low water. For this reason, the subteam scored the area as "yellow" rather than "red," reasoning that predicted conditions in eastern WCA-3A might support suitable habitat for snail kites and other organisms that depend on deeper water.

Central and Southern WCA-3A (Indicator Regions 14, 17 and 18)

Because performance differed distinctly among the three indicator regions in this area, results are described separately for each.

Indicator Region 14: Green

Alternative D13R performed much better than Alternative D in this area. Most notably, depths exceeded 2.5 ft only 1% of total time, compared with 6% in Alternative D. This is a substantial improvement over the 2050 Base, with 6% high water, and a dramatic improvement over the 1995 Base, which had depths greater than 2.5 ft for 36% of the total simulation. Performance in reducing high water extremes was similar but not quite as successful as Alternative B, the alternative with the best overall performance in this indicator region.

Alternative D13R, however, has more prolonged inundation than target values, averaging 139 weeks inundation duration versus 88 weeks in NSM. This pattern is slightly wetter than the longest inundation periods predicted by NSM for the northern and central Everglades, but it is still “NSM-like,” with dry-outs to ground surface averaging about once every three years. Hence, Alternative D13R was rated “green” because of its superior performance in reducing extremes of high water, while maintaining less than 1% of extreme low water. Overall, predicted hydrologic conditions in this area would be expected to promote recovery and persistence of tree island vegetation communities.

Indicator Region 17: Green

Alternative D13R performed very well in this region. Extreme high water conditions occurred only 1% of time, which is one-half the frequency in the 2050 Base and about one-fourth the frequency in the 1995 Base. This performance was similar but slightly inferior to that seen in Alternative B, the best alternative at reducing overall high water frequencies in southern and central WCA-3A. The frequency of extreme low water did not increase in Alternative D13R relative to Alternative D, and low water performance remained slightly better than the 1995 and 2050 bases.

However, Alternative D13R experienced fewer dry-outs to ground surface than its target value (14 inundation events versus a target of 21 events), with more prolonged periods of inundation (110 weeks average duration versus a target of 74 weeks). This is similar to the longer-than-NSM inundation periods seen in Indicator Regions 14 and 18.

Indicator Region 18: Yellow

In this region, Alternative D13R, like Alternative D, has a predicted inundation pattern that is much wetter than NSM. Inundation periods average 142 weeks as compared with 59 weeks for NSM, and the number of wet periods is less than half the target value (11 versus 24 events). Both the 1995 Base and the 2050 Base are better matches for NSM inundation patterns. Despite long inundation periods, however, this indicator region, like Indicator Regions 14 and 17 to the south, shows reduced occurrence of extreme high water relative to the 1995 Base, suggesting that tree island flooding will be alleviated in Alternative D13R. At the same time, low water extremes do not increase, but are actually fewer in number than in the 1995 and 2050 bases.

Overall, for central and southern WCA-3A as a whole, the principle source of uncertainty in Alternative D13R is the ecological effect of increased inundation durations, with fewer marsh dry-outs, especially within the relatively pristine area spanned by indicator regions 17 and 18. Indicator Region 17 dries out with about the same frequency as in the 1995 Base; however, Indicator Region 18 dries out less frequently. This appears to be a result of the large inflows from the S-140 structure in Alternative D13R, which passes water into and through Indicator Region 18 throughout the dry season, thus preventing the marsh from drying out in most years.

Alternative D13R is expected to be highly beneficial for tree island communities in central and southern WCA-3A. All three indicator regions show greatly reduced frequencies of extreme high water. Extreme flooding is not predicted to occur even during high rainfall years comparable to 1994-95. Furthermore, removal of the L-29 levee eliminates barriers to rapid recession of flood waters, which would be expected to help limit flooding even under more extreme rainfall conditions than those simulated in the model.

WCA-3B (Indicator Regions 15 and 16)

Alternative D13R significantly reduced the frequency of extreme high water in WCA-3B compared to Alternative D. In western WCA-3B (Indicator Region 15) Alternative D had depths that exceeded 2.5 ft for 8% of total time; this decreased to 3% of total time in Alternative D13R. In southeastern WCA-3B (Indicator Region 16), Alternative D had 10% extreme high water, and this decreased to 5% in Alternative D13R. High water performance is also better than in the 2050 Base, which had high water 5% and 8% of time in Indicator Regions 15 and 16, respectively. However, high water performance did not meet the NSM-defined targets for these areas, which predict less than 2% high water in Indicator Region 15 and less than 4% in Indicator Region 16. Only the 1995 Base and Alternative A achieved target values for high water extremes. Although Alternative D13R appears to reduce high water extremes to levels likely to prevent damage to higher hammock tree islands in WCA-3B, impacts on less-elevated tree islands still may occur.

A second source of uncertainty in Alternative D13R is the very long duration of inundation in WCA-3B relative to NSM values for the area. Western WCA-3B (Indicator Region 15) has only four inundation periods in 31 years, hence only about four dry-outs to ground level, and these inundation periods average 398 weeks in length. In eastern WCA-3B (Indicator Region 16), there are six inundation periods that average 262 weeks duration. These results differ substantially from NSM values of 20 events averaging 74 weeks, and 15 events averaging 102 weeks, in Indicator Regions 15 and 16, respectively. Both the 1995 and 2050 bases, as well as Alternative A, are better matches for NSM inundation patterns than is Alternative D13R.

Given removal of the eastern L-29 levee in alternatives B, C, D, and D13R, combined with restoration of long hydroperiods and deeper water in NE Shark Slough, it appears logically inevitable that water depths and inundation durations in WCA-3B would increase. Overall, this creates an inundation and depth pattern in WCA-3B that more closely matches NSM predictions for mid-Shark River Slough than for WCA-3B itself. Because this represents a substantial deviation from both NSM predictions of the pre-drainage hydrology of the area and current conditions in WCA-3B, extreme caution should be used in implementing changes that include such a potentially high degree of uncertainty as to the biological response to change in hydrology.

Pennsuco Wetlands (Indicator Regions 52 and 53)

Extreme low water occurs infrequently in Alternative D13R (1-2% of time); this is an improvement over alternatives A-C (3-4% low water), and a dramatic improvement relative to both 1995 and 2050 bases (7-10% and 9-13% low water, respectively). High water extremes are also rare and occur much less frequently than under NSM. The overall inundation pattern in Alternative D13R differs from NSM predictions, with Indicator Region 52 having fewer inundation events than NSM, while Indicator Region 53 has more than NSM. Inundation durations are significantly increased relative to both the 1995 and 2050 bases. Overall, Alternative D13R predicts "NSM-like" ridge and slough conditions with reduced drought frequencies. This would be expected to protect marsh soils and provide for a sustainable marsh in the area.

Summary Evaluation for Alternative D13R

Alternative D13R appears to provide the best overall performance for the WCA system. While all the alternatives perform well with respect to drought conditions that could damage peat soils, Alternative D13R provides the best overall reduction in extreme high water conditions that would flood out tree island vegetation communities, especially in southern WCA-3A and WCA-3B. Thus, Alternative D13R appears to make substantial progress toward solving the two most significant problems that have resulted from the C&SF Project in this region of the Everglades.

Two notable areas of uncertainty remain, however. One of these is the effect on wading bird populations of changes in depth patterns in northeastern WCA-3A. The more northerly parts of this area (represented by model output for the 3A-3 gage and Indicator Region 21) are predicted to become wetter, while to the south, areas east of the Miami Canal will remain deeper than NSM but will have much reduced high water frequencies compared to the 1995 Base. These conditions could be expected to improve suitable rookery sites in some areas but possibly damage others, and the distribution of suitable foraging areas will undoubtedly be changed. Although overall restoration of the Everglades watershed is expected to improve wading bird nesting habitat regionally, the timing of development of suitable breeding sites to the south of Tamiami Trail, relative to changes in current nesting sites, could have significant effects on regional wading bird populations. A more detailed analysis of anticipated effects of Alternative D13R on wading bird breeding and foraging habitat, combined with a plan for system-wide monitoring, will be important components in implementing the plan.

The second major area of uncertainty is the effect of a shift in the overall hydrologic pattern toward longer periods of inundation with fewer drying events than those predicted by NSM. The best overall match to NSM inundation patterns is Alternative A, where it appears that maintenance of the WCAs as compartments provides more control over water depths in different sections of the Everglades. With partial decompartmentalization such as that in Alternatives B and D13R, exact matches to local NSM predictions for the indicator regions in WCA-3 no longer appear to be possible, given the reduced overall extent of the Everglades watershed north of Tamiami Trail. Hence, the benefits of decompartmentalization in promoting sheetflow and reducing the frequency and duration of flooding appear to conflict with the ability of water management to match local NSM targets. In considering this apparent trade-off, the subteam concluded that the long-term sustainability of the northern and central Everglades marshes probably depended more on the avoidance of extremes of drought and flood than on exact restoration of local pre-drainage hydropatterns. Only Alternatives B and D13R manage to avoid extreme high water in southern and central WCA-3A, and only Alternative D13R accomplishes this in WCA-3B as well.

In conclusion, Alternative D13R provides inundation patterns that are “NSM-like” and that seem likely to promote a sustainable Everglades ecosystem. There nonetheless remain many uncertainties about the biological response that will occur, and these uncertainties can only be overcome by a suitable plan for adaptive management that will allow timely and informed changes in water management as deemed necessary to promoting biological restoration goals.

D.8.6 Southern Everglades

D.8.6.1 Shark River Slough

Three priority performance measures for the ecological restoration of Shark River Slough are identified in the Everglades Sloughs Conceptual Model. Those measures, in order of priority, are the duration of uninterrupted flooding, drought severity as measured by the duration of dry conditions, and the water depth during periods of flooding. Two additional performance measures that are considered in Shark River Slough analyses are the total annual flow volume and the seasonal distribution of that flow in mid Shark River Slough.

NSM45F characterized Shark River Slough as a predominantly aquatic system that was continually flooded and flowing during wet and dry seasons and during wet years and all but the most extreme dry years. NSM45F indicated that Shark River Slough would have dried only two, three and six times during the 31-year period of record in the NE, Mid and SW indicator regions, yielding uninterrupted periods of inundation that averaged 535, 401 and 226 weeks. Water depths averaged 1.8, 1.6 and 1.2 feet during periods of flooding in the three respective indicator regions. Dry conditions lasted for an average of four, three and six weeks respectively.

The 1995 Base (Revised) indicated severely over-drained conditions in Shark River Slough. The average duration of uninterrupted flooding was reduced to 74, 99 and 79 weeks in NE, Mid and SW Shark River Slough becaause the marsh dried 18, 14 and 17 times during the period of record. Water depths averaged approximately one foot during periods of flooding. Dry conditions lasted for an average of 11, 10 and 11 weeks, respectively. Total annual overland flow volume down mid Shark River Slough was 44% of that indicated by NSM45F. The seasonal distribution of that flow volume indicated a much higher proportion of the annual flow during the wet season months of July and August and a much lower proportion during the dry season months of December-February in comparison to NSM45F.

The 2050 Base (Revised) showed a slight improvement over the 1995 Base, although over-drained conditions remained in Shark River Slough. The average duration of uninterrupted flooding increased slightly to 79, 108 and 105 weeks in NE, Mid and SW Shark River Slough because the marsh dried 17, 13 and 13 times during the period of record. Water depths continued to average approximately one foot during periods of flooding. Dry conditions lasted for an average of 11, 8 and 11 weeks, respectively. Total annual overland flow volume down mid Shark River Slough increased to 52% of that indicated by NSM45F. The seasonal distribution of that flow volume indicated a higher proportion of the annual flow during the wet season months of August-October and a lower proportion during the dry season months of December-February in comparison to NSM45F.

Alternatives A-D represented improvement over the over-drained base conditions in Shark River Slough, and Alternative D demonstrated a markedly higher level of achievement of performance measures compared to Alternatives A-C. Alternative D increased the average duration of uninterrupted flooding to 263, 317 and 173 weeks in NE, Mid and SW Shark River Slough by reducing the number of drydowns to five, four and eight events respectively during the period of record. Average water depth during periods of flooding increased slightly to 1.3 feet in NE and Mid Shark River Slough. The duration of dry conditions was reduced to 6-7 weeks in all three indicator regions. Total annual overland flow volume down mid Shark River Slough was increased to 66% of that indicated by NSM45F. The seasonal distribution of that flow volume more closely resembled that of NSM45F, although a slightly higher proportion occurred during May-June, and a slightly lower proportion occurred during November-January.

Although Alternative D was substantially improved over the base conditions, it fell considerably short of the performance targets for Shark River Slough when performance was averaged over the three indicator regions. Relative to NSM45F, the duration of uninterrupted flooding in Alternative D was 53-272 weeks shorter in the three indicator regions, yielding an achievement index for the Slough as a whole of 68% compared to 25% for 1995 Base and 29% for 2050 Base. The deficiency in duration of uninterrupted flooding was due to five dry events over the period of record in Alternative D compared to two in NSM45F. The mean water depth during periods of flooding in Alternative D was deficient by 0.3-0.5 feet compared to NSM45F in the three indicator regions, yielding an achievement index for the entire Slough of 79% compared to 58% for 1995 Base and 67% for 2050 Base. Dry periods in NE and Mid Shark River Slough averaged three weeks longer in Alternative D than the 3-4 week duration indicated by NSM45F. The extended duration of dry conditions lowered the achievement index for that performance measure to 36% for the Slough as a whole. Total annual overland flow volume down mid Shark River Slough in Alternative D, which was 66% of the NSM45F flow volume, yielded an achievement index of 66% compared to 44% for 1995 Base and 52% for 2050 Base. The seasonal distribution of the annual flow volume down mid Shark River Slough, expressed as percent of the annual flow volume during each month of the year, provided a 90% match in Alternative D compared to NSM45F and yielded an achievement index of 90% compared to 76% for 1995 Base and 88% for 2050 Base.

The overall achievement index for the performance measures in Shark River Slough under Alternative D was 64% compared to 16% for 1995 Base and 26% for 2050 Base. The overall score was calculated by averaging the five performance measures over the three indicator regions with weightings of three for duration of flooding, two for duration of dry conditions, and one each for mean depth during flooding, annual overland flow volume and seasonal flow distribution. A 0.6 achievement of the hydrologic performance measures does not provide adequate assurance that the ecological values identified in the Everglades Sloughs Conceptual Model would be restored under Alternative D in Shark River Slough. Furthermore, Alternative D only partially restores hydrological and ecological connectivity of Shark River Slough in Everglades National Park to its upstream reaches in Water Conservation Area 3A due to the presence of western levee L-29. Reasonable assurance that ecological values will be restored in Shark River Slough depends on attaining an achievement index approaching 0.8 for the combined performance measures. Of particular concern is the mean duration of uninterrupted flooding as affected by the number of drydowns during the period of record. Confidence in the restoration of ecological values in Shark River Slough furthermore depends on increasing connectivity between the Park and Water Conservation Area 3, as was attempted in Alternative B.

Alternative D13R. Performance measures for the evaluation Alternative D13R in Shark River Slough were the same as those used to evaluate Alternative D, with one exception. The mean duration of dry conditions, that was used as a measure of drought severity in Shark River Slough for Alternative D, was replaced by the number of dry events during the period of record for Alternative D13R. That change was made because Alternative D13R was successful in achieving its priority goal of reducing the number of dry events in order to increase the mean duration of uninterrupted flooding. However, the dry events that were eliminated were those of shorter duration, and the longer dry events that remained represented major regional droughts when little could be done to keep Shark River Slough flooded. Thus achieving the goal of reducing the number of dry events would have penalized D13R for increasing the mean duration of dry conditions, when actually the duration of the remaining droughts in D13R was similar to that in Alternative D. Since reduction in the number of dry events became a priority for Shark River Slough in the modeling leading to Alternative D13R, it was added as a performance measure to replace mean duration of flooding.

Alternative D13R was successful in reducing the number of dry events during the period of record in order to closely approach the frequency indicated by NSM45F for Shark River Slough. The reduction in the number of dry events in NE, Mid and SW Shark River Slough from 18, 14 and 17 under 19 95BaseR and 17, 13 and 13 under 2050 Base to three, four and eight under D13R, with targets of two, three and six under NSM45F. This reduction represented an 89% achievement of the NSM45F restoration target for the Slough as a whole.

Somewhat less success was realized in increasing the prolonged mean duration of uninterrupted flooding indicated by NSM45F in Shark River Slough because of the extra one to two dry events in Alternative D13R. Alternative D13R increased the mean duration of flooding in NE, Mid and SW Shark River Slough from 74, 99 and 79 weeks under 1995 Base and 79, 108 and 105 weeks under 2050 Base to 395, 318 and 173 weeks. However, mean the mean duration of uninterrupted flooding in Alternative D13R fell short NSM45F values of 535, 401 and 226 weeks for the three indicator regions The increase in mean duration of uninterrupted flooding in NE, Mid and SW Shark River Slough achieved 76% of the NSM45F restoration target for the Slough as a whole, compared to 25% achievement under 1995 Base and 29% under 2050 Base.

Alternative D13R increased the mean water depth during periods of flooding in NE, Mid and SW Shark River Slough from 0.8, 1.0 and 0.8 feet under 1995 Base and 1.0, 1.1 and 0.9 feet under 2050 Base to 1.4, 1.2 and 1.0 feet. NSM45F values were 1.8, 1.6 and 1.2 feet for the three indicator regions. Alternative D13R mean depths during flooding achieved 79% of the NSM45F restoration target for the Slough as a whole, compared to 58% achievement under 1995 Base and 67% under 2050 Base.

Total annual overland flow volume down mid Shark River Slough in Alternative D13R was 70% of that indicated by NSM45F in comparison to 44% under 1995 Base and 52% under 2050 Base. The seasonal distribution of that flow volume, expressed as percent of the annual flow volume during each month of the year, provided a 91% match to NSM45F in Alternative D13R in comparison to a 76% match under 1995 Base and 88% under 2050 Base.

The overall achievement index for the performance measures in Shark River Slough under Alternative D13R was 82% compared to 28% under 1995 Base and 38% under 2050 Base. This score was calculated by averaging the five performance measures over the three indicator regions with weightings of three each for duration of flooding and number of dry events and weightings of one each for mean depth during flooding, annual overland flow volume and seasonal flow distribution. A 0.8 achievement of the hydrologic performance measures is considered to provide reasonable assurance that the ecological values identified in the Everglades Sloughs Conceptual Model would be restored under Alternative D13R in Shark River Slough. Confidence in the restoration of ecological values in Shark River Slough is further increased by the increased connectivity between the Slough in Everglades National Park and its upper reaches in Water Conservation Area 3 due to the removal of L-29 in Alternative D13R.

Ecological values and indicators of restoration success in Shark River Slough that are linked to the above hydrologic performance measures in the conceptual model include 1) increased nesting success and abundance of American alligators and a corresponding increase in the number of occupied alligator holes to serve as drought refugia and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased abundance of wading birds and wood storks,

4) re-establishment of coastal nesting colonies of wading birds and wood storks, 5) earlier timing of colony formation by wading birds and wood storks, 6) resumption of the return frequency of wading bird and white ibis super colonies, 7) enhanced production and community composition of periphyton, 8) accelerated accretion of peat soils, and 9) persistence and resilience of macrophyte and tree island plant communities including the cessation of sawgrass expansion into wet prairies and sloughs.

D.8.6.2 Rockland Marl Marsh

Three priority hydrologic performance measures for the ecological restoration of the Rockland Marl Marsh are identified in the Marl Prairie/Rocky Glades Conceptual Model. Those measures, in order of priority, are the duration of uninterrupted flooding, drought severity as measured by the duration of dry conditions, and the number of wet season water level reversals when the depth drops to less than 0.2 feet during a period of flooding.

NSM45F characterized the Rockland Marl Marsh as a seasonally flooded system where water levels typically dropped below the ground surface during most years, except during prolonged high rainfall periods when the marsh remained flooded for multiple years. NSM45F indicated that uninterrupted periods of inundation averaged 44 weeks. Only two wet season water level reversals occurred during 31 years. Dry conditions lasted for an average of 26 weeks.

The 1995 Base (Revised) indicated severely over-drained conditions in the Rockland Marl Marsh. The average duration of uninterrupted flooding was reduced to 12 weeks. Thirty-one wet season water level reversals occurred during 31 years. Dry conditions lasted for an average of 45 weeks.

The 2050 Base (Revised) improved conditions in the Rockland Marl Marsh, but performance still fell far short of NSM45F targets. The average duration of uninterrupted flooding was nearly doubled to 23 weeks. The number of wet season water level reversals was reduced to 18 in 31 years. The duration of dry conditions was reduced to an average of 31 weeks.

Conditions in the Rockland Marl Marsh, and Alternative D was the most successful in achieving restoration targets. The average duration of uninterrupted flooding increased to 32 weeks. The number of wet season water level reversals was reduced to three in 31 years. Dry conditions lasted for an average of 24 weeks.

Performance of Alternative D came close to achieving the restoration targets for the Rockland Marl Marsh. The mean duration of uninterrupted flooding, which was 12 weeks short of the NSM45F target, scored an achievement index of 73% compared to 27% for 1995 Base and 52% for 2050 Base. The number of wet season water level reversals exceeded NSM45F by only one and yielded an achievement index of 96%. The mean duration of dry conditions was two weeks shorter than NSM45F and thus over-achieved the target by 8%, yielding an achievement index of 92% compared to 27% for 1995 Base and 81% for 2050 Base.

The overall achievement index for the performance measures in the Rockland Marl Marsh under Alternative D was 83% compared to 22% for 1995 Base and 60% for 2050 Base. This score was calculated by averaging the three performance measures with weightings of three for duration of flooding, two for duration of dry conditions, and one for number of wet season water level reversals. A 0.8 achievement of the hydrologic performance measures is considered to provide reasonable assurance that ecological values identified in the Marl Prarie/Rocky Glades Conceptual Model would be restored under Alternative D in the Rockland Marl Marsh.

Alternative D13R. Alternative D13R prolonged the mean duration of uninterrupted flooding in the Rockland Marl Marsh from 12 weeks under 1995 Base and 23 weeks under 2050 Base to 30 weeks, in comparison to the NSM45F duration of 44 weeks. The increase in mean duration of uninterrupted flooding in the Rockland Marl Marsh achieved 68% of the NSM45F restoration target compared to 27% achievement under 1995 Base and 52% under 2050 Base.

The number of wet season water level reversals during the 31-year period of record in the Rockland Marl Marsh was reduced to four under Alternative D13R in comparison to 31 under 1995 Base, 18 under 2050 Base and two under NSM45F. The reduction in the number of reversals represented a 93% achievement of the NSM45F restoration target for the Rockland Marl Marsh.

Dry conditions in the Rockland Marl Marsh lasted for an average duration of 21 weeks under Alternative D13R in comparison to 45 weeks under 1995 Base, 31 weeks under 2050 Base and 26 weeks under NSM45F. The reduction in the mean duration of dry conditions in alternative D13R actually overshot NSM45F by 19% and achieved 81% of the NSM45F restoration target for the Rockland Marl Marsh, compared to 27% achievement under 1995 Base and 81% under 2050 Base.

The overall achievement index for the performance measures in the Rockland Marl Marsh was 76% compared to 22% achievement under 1995 Base and 60% under 2050 Base. This score was calculated by averaging the three performance measures with weightings of three for duration of flooding, two for duration of dry conditions, and one for number of wet season water level reversals. A 0.8 achievement of the hydrologic performance measures is considered to provide reasonable assurance that ecological values identified in the Marl Prairie/Rocky Glades Conceptual Model would be restored under Alternative D13R in the Rockland Marl Marsh.

Ecological values and indicators of restoration success in the Rockland Marl Marsh that are linked to the above hydrologic performance measures in the conceptual model include 1) re-colonization and population resurgence by American alligators and a subsequent increase in the number of occupied alligator holes to serve as dry season refugia for aquatic fauna and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased seasonal abundance and foraging activity of wading birds and wood storks, 4) enhanced production and community composition of periphyton, 5) accelerated accretion of marl substrate, 6) increased nesting success and population size of Cape Sable seaside sparrows, and 7) persistence and resilience of highly diverse macrophyte and tree island plant communities.

D.8.7 Florida Bay Coastal Basins

Four priority performance measures for the ecological restoration of the Florida Bay coastal basins are identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model. All performance measures are based on relationships between mean monthly salinity in five coastal basins, from Joe Bay to North River Mouth, to water stage at the P33 gage in mid Shark River Slough.

One measure is the number of months during the period of record when stages equal or exceed 6.3 feet msl at P33. Stages above 6.3 at P33 correspond to a reduced frequency of undesirable high salinity events in the coastal basins. A second measure is the number of months during the period of record when stages equal or exceed 7.3 feet msl at the P33 gage. Stages above 7.3 at P33 correspond to an increased frequency of desirable low salinity events in the coastal basins. The reduced frequency of undesirable high salinity events when the P33 stage reaches 6.3 is given a higher priority than the increased frequency of desirable low salinity events when the P33 stage reaches 7.3.

A third measure is the cumulative salinity difference (ppt) from the undesirable high salinity levels that were identified for each basin. Cumulative differences from high salinity levels are summed during the dry/wet season transition months of March-June. A fourth measure is the cumulative salinity difference (ppt) from desirable low salinity levels that were identified for each basin. Cumulative differences from low salinity levels are summed during the wet/dry season months of August-October. These differences are summed over the five coastal basins and over the 31-year period of record. Differences above the specified high or low salinity levels are given a positive value, and differences below the specified high or low salinity levels are given a negative value. The performance targets are to reduce cumulative salinity differences to values that do not exceed the cumulative differences produced by NSM45F.

NSM45F characterized the Florida Bay coastal basins as estuarine environments that experienced low to moderate salinity well below seawater concentrations the majority of the time. The coastal basins would have avoided high salinity events, (>15 to >35 ppt depending on the basin) during 258 months of the 372-month period of record when P33 stages rose to 6.3. Low salinity events (<5 to <25 ppt, depending on the basin) would have occurred during 30 months of the period of record when P33 stages rose to 7.3. The cumulative salinity difference from concentrations that marked high salinity events during March-June totaled 440 over the five basins and 31 years, while the cumulative salinity difference from concentrations that marked low salinity events during August-October totaled 525.

The 1995 Base (Revised) indicated a prevalence of high salinity conditions and a paucity of low salinity events that shifted the the estuarine environments of the coastal basins to more marine conditions. The coastal basins experienced high salinity events during two-thirds of the period of record, when P33 stages fell below 6.3 for 247 out of 372 months. Low salinity events occurred only during seven of the 372 months. The 31 year cumulative salinity difference from concentrations that marked high salinity events during March-June totaled 2755, while the cumulative difference from concentrations that marked low salinity events during August-October totaled 1765.

The 2050 Base (Revised) showed only slight improvement over 1995 Base in salinity regimes in the coastal basins. High salinity events were less frequent and occurred during 195 out of 372 months, but low salinity events were also less frequent and only occurred during two out of 372 months. Cumulative salinity differences from concentrations that marked high and low salinity events during the periods of March-June and August to October were slightly reduced to 2515 and 1545, respectively.

Alternatives A-D all substantially improved salinity regimes in the coastal basins, and each alternative was approximately equally effective in overall performance. Alternative D decreased the number of high salinity events to 164 months and avoided high salinity events during 208 months of the 372-month period of record. Alternative D increased the number of low salinity events to 25 during the period of record. The 31 year cumulative salinity difference from concentrations that marked high salinity events during March-June totaled 735, while the cumulative salinity difference from concentrations that marked low salinity events during August-October totaled 1155.

Performance of Alternative D approached restoration targets for the Florida Bay coastal basins for three of the four performance measures. The number of months when P33 stages rose to 6.3 was 81% of NSM45F compared to 48% for 1995 Base and 69% for 2050 Base. The months when P33 stages rose to 7.3 was 83% of NSM45F compared to 23% for 1995 Base and 7% for 2050 Base. The cumulative salinity difference from concentrations that marked high salinity events during March-June scored an achievement index of 87%, but the cumulative salinity difference from concentrations that marked low salinity events during August-October scored an achievement index of only 49%, both relative to an NSM45F score of 100%.

The overall achievement index for the performance measures in the Florida Bay coastal basins under Alternative D was 78% compared to 20% for 1995 Base and 30% for 2050 Base. A similar achievement index, rounded off to 0.8, was also attained for Alternatives A-C. These scores were calculated from the four performance measures with weightings of two for the number of months when stages equaled or exceeded 6.3 at P33, one for the number of months when stages equaled or exceeded 7.3 at P33, two for cumulative salinity differences from undesirable high levels during March-June, and one for cumulative salinity differences from desirable low levels during August-October. A 0.8 achievement of the hydrology/salinity performance measures is considered to provide reasonable assurance that the ecological values identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model would be restored under Alternative D in the Florida Bay coastal basins.

Alternative D13R. Alternative D13R was successful in avoiding high salinity events (>15 to >35 ppt, depending on the basin) in the Florida Bay coastal basins during 228 months of the 372-month period of record when P33 stages rose to 6.3 feet msl. In comparison, high salinity events were avoided during 258 months under NSM45F, 125 months under 1995 Base, and 177 months under 2050 Base. The reduction in the number of high salinity events achieved 88% of the NSM45F restoration target under Alternative D13R compared to 48% achievement under 1995 Base and 69% under 2050 Base.

Alternative D13R was successful in attaining low salinity events (<5 to <15 ppt, depending on the basin) in the Florida Bay coastal basins during 18 months of the period of record when P33 stages rose to 7.3 feet msl. Low salinity events were attained during 30 months under NSM45F, seven months under 1995 Base, and only two months under 2050 Base. The increase in the number of low salinity events achieved 60% of the NSM45F restoration target under Alternative D13R compared to 23% achievement under 1995 Base and 7% under 2050 Base.

The 31 year cumulative salinity difference from concentrations that marked high salinity events during March-June decreased from 2755 under 1995 Base and 2515 under 2050 Base to 660 under Alternative D13R. The NSM45F target was 440. The reduction in the March-June cumulative salinity difference represented a 91% achievement of the NSM45F restoration target for the Florida Bay coastal basins.

The 31 year cumulative salinity difference from concentrations that marked low salinity events during August-October decreased from 1765 under 1995 Base and 1545 under 2050 Base to 1025 under Alternative D13R. The NSM45F target was 525. The reduction in the August-October cumulative difference represented a 60% achievement on the NSM45F restoration target for the Florida Bay coastal basins.

The overall achievement index for the performance measures in the Florida Bay coastal basins under Alternative D13R was 80% compared to 20% for 1995 Base and 50% for 2050 Base. These scores were calculated from the four performance measures with weightings of two for the number of months when stages equaled or exceeded 6.3 at P33, one for the number of months when stages equaled or exceeded 7.3 at P33, two for cumulative salinity differences from undesirable high levels during March-June, and one for cumulative salinity differences from desirable low levels during August-October. A 0.8 achievement of the hydrology/salinity performance measures is considered to provide reasonable assurance that the ecological values identified in the Florida Bay Mangrove Estuarine Transition Conceptual Model would be restored under Alternative D13R in the Florida Bay coastal basins.

Ecological values and indicators of restoration success in the Florida Bay mangrove estuary and coastal basins that are linked to the above hydrology/salinity performance measures in the conceptual model include 1) increased production of low-salinity mangrove fish and invertebrates, 2) re-establishment of coastal nesting colonies of wading birds and wood storks and eastern Florida Bay colonies of roseate spoonbill, 3) earlier timing of coastal colony formation by wading birds and wood storks, 4) resumption of the return frequency of wading bird and white ibis super colonies, 5) increased growth and survival of juvenile American crocodiles, 6) increased cover of low-to-moderate salinity aquatic macrophyte communities in coastal lakes and basins, 7) return of seasonal waterfowl aggregations to coastal lakes and basins, 8) enhanced nursery ground value for sport fishes and pink shrimp in coastal basins, and 9) persistence and resilience of the mangrove, salt marsh and tidal creek vegetation mosaic.

Alternatives A-D

SOUTHERN EVERGLADES: INDICATOR REGIONS

	WET CONDITIONS			DRY CONDITIONS		REVERSALS
	Total # Weeks	Mean # Weeks	Depth Feet	# Dry Events	Mean # Weeks	# of Wet Season Depth Reversals
NE Shark River Slough Indicator Region 11						
NSM4.5	1604	535	1.8	2	4	
95BSR	1406	74	0.8	8	11	
50BSR	1423	79	1.0	17	11	
ALT A	1546	119	1.3	12	6	
ALT B	1567	196	1.3	7	6	
ALT C	1559	195	1.3	7	8	
ALT D	1579	263	1.3	5	7	
Mid Shark River Slough Indicator Region 10						
NSM4.5	1602	401	1.6	3	3	
95BSR	1479	99	1.0	14	10	
50BSR	1505	108	1.1	13	8	
ALT A	1547	172	1.3	8	8	
ALT B	1579	197	1.2	7	5	
ALT C	1579	226	1.2	6	6	
ALT D	1586	317	1.3	4	6	
SW Shark River Slough Indicator Region 9						
NSM4.5	1578	226	1.2	6	6	
95BSR	1426	79	0.8	17	11	
50BSR	1469	105	0.9	13	11	
ALT A	1516	168	1.1	8	12	
ALT B	1535	154	1.0	9	9	
ALT C	1546	155	0.9	9	7	
ALT D	1556	173	1.0	8	7	
Rockland Marl Marsh Indicator Region 8						
NSM4.5	1019	44	0.6	23	26	2
95BSR	341	12	0.3	23	45	31
50BSR	692	23	0.5	30	31	18
ALT A	953	30	0.6	32	21	12
ALT B	935	29	0.5	32	21	17
ALT C	887	31	0.5	29	25	15

ALT D	920	32	0.6	29	24	3
Cape Sable Sparrow E Indicator Region 57						
NSM4.5	744	24	0.3	31	28	
95BSR	331	13	0.3	25	51	
50BSR	513	18	0.3	28	39	
ALT A	740	26	0.4	29	30	
ALT B	748	24	0.4	31	28	
ALT C	686	24	0.3	28	33	
ALT D	718	24	0.3	30	30	
Cape Sable Sparrow A Indicator Region 46						
NSM4.5	1080	36	0.4	30	18	
95BSR	985	35	0.4	28	22	
50BSR	1135	40	0.4	28	17	
ALT A	1023	38	0.4	27	22	
ALT B	954	34	0.4	28	24	
ALT C	1044	36	0.4	29	20	
ALT D	1041	37	0.4	28	20	
Cape Sable Sparrow B Indicator Region 54						
NSM4.5	551	15	0.3	37	29	
95BSR]	558	15	0.3	39	27	
50BSR	560	14	0.3	40	26	
ALT A	582	15	0.3	38	27	
ALT B	579	15	0.3	38	27	
ALT C	572	15	0.3	38	27	
ALT D	574	15	0.3	39	27	

SALINITY RELATIONSHIPS SOUTHERN EVERGLADES: P33/COASTAL BASIN

NUMBER OF MONTHS THAT P33 STAGE IS EQUALLED OR EXCEEDED

	6.3 Feet MSL	7.3 Feet MSL
NSM4.5	258	30
95BSR	125	7
50BSR	177	2
ALT A	226	24
ALT B	204	28
ALT C	204	22
ALT D	208	25

31 YR. CUMULATIVE SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS

FOR NORTH RIVER, GARFIELD BIGHT, TERRAPIN BAY AND JOE BAY

	31yr. cumulative salinity scores MAR-JUN	31 yr. cumulative salinity scores AUG-OCT
NSM4.5	440	525
95BSR	2755	1765
50BSR	2515	1545
ALT A	1005	625
ALT B	670	800
ALT C	665	930
ALT D	735	1155

SOUTHERN EVERGLADES: ACHIEVEMENT INDEX OF PERFORMANCE MEASURES RELATIVE TO NSM4.5F WITH A VALUE OF 100

Shark River Slough

	MEAN DURATION OF UNINTERRUPTED FLOODING REGIONS 9, 10, & 11 (WT – 3)	MEAN DURATION OF DRY CONDITIONS, INDICATOR REGIONS 9, 10, & 11 (WT = 2)	MEAN DEPTH DURING FLOODING INDICATOR REGIONS 9, 10 & 11 (WT = 1)
95BSR	25	-64	58
50BSR	29	-42	67
ALT A	46	- 6	82
ALT B	51	44	77
ALT C	53	28	74
ALT D	68	36	79

	CENTRAL SHARK RIVER SLOUGH ANNUAL OVERLAND FLOW VOLUME (WT = 1)	CENTRAL SHARK RIVER SLOUGH CUMULATIVE DEVIATION FROM MONTHLY FLOW VALUES (WT = 1)
95BSR	44	76
50BSR	52	88
ALT A	80	92
ALT B	72	92
ALT C	64	90
ALT D	66	90

Rockland Marl Marsh Indicator Region 8

	MEAN DURATION OF UNINTERRUPTED FLOODING (WT = 3)	MEAN DURATION OF DRY CONDITIONS (WT = 2)	# OF WET SEASON DEPTH REVERSALS (WT = 1)
95BSR	27	27	0
50BSR	52	81	45
ALT A	68	81	65
ALT B	66	81	48
ALT C	70	96	55
ALT D	73	92	96

FLORIDA BAY COASTAL BASIN SALINITY/GAGE P33 STAGE

	# OF MONTHS WHEN P33 STAGE OF 6.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 2)	# OF MONTHS WHEN P33 STAGE OF 7.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 1)
95BSR	48	23
50BSR	69	7
ALT A	87	80
ALT B	79	93
ALT C	79	73
ALT D	81	83

	31 YR. CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS MARCH-JUNE (WT = 2)	31 YR. CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS AUGUST-OCTOBER (WT = 1)
95BSR	0	0
50BSR	10	18
ALT A	76	92
ALT B	90	78
ALT C	90	67
ALT D	87	49

SOUTHERN EVERGLADES
WEIGHTED MEAN ACHIEVEMENT INDEX OF PERFORMANCE MEASURES

	SHARK RIVER SLOUGH	ROCKLAND MARL MARSH	FLORIDA BAY COASTAL BASINS/P33
95BSR	16	22	20
50BSR	26	60	30
ALT A	48	72	83
ALT B	60	68	85
ALT C	55	76	80
ALT D	64	83	78

Alternative D13R

SOUTHERN EVERGLADES: INDICATOR REGIONS

	WET CONDITIONS			DRY CONDITIONS		REVERSALS
	Total # Weeks	Mean # Weeks	Depth Feet	# Dry Events	Mean # Weeks	# of Wet Season Depth Reversals
NE Shark River Slough Indicator Region 11						
NSM4.5 5	1604	535	1.8	2	4	
95BSR	1406	74	0.8	8	11	
50BSR	1423	79	1.0	17	11	
D13R	1583	395	1.4	3	10	
Mid Shark River Slough Indicator Region 10						
NSM4.5 5	1602	401	1.6	3	3	
95BSR	1479	99	1.0	14	10	
50BSR	1505	108	1.1	13	8	
D13R	1591	318	1.2	4	5	
SW Shark River Slough Indicator Region 9						
NSM4.5 5	1578	226	1.2	6	6	
95BSR	1426	79	0.8	17	11	
50BSR	1469	105	0.9	13	11	
D13R	1559	173	1.0	8	7	
Rockland Marl Marsh Indicator Region 8						
NSM4.5 5	1019	44	0.6	23	26	2
95BSR	341	12	0.3	28	45	31
50BSR	692	23	0.5	30	31	18
D13R	946	30	0.6	32	21	4

SALINITY RELATIONSHIPS SOUTHERN EVERGLADES: P33/COASTAL BASIN

NUMBER OF MONTHS THAT P33 STAGE IS EQUALLED OR EXCEEDED

	6.3 Feet MSL	7.3 Feet MSL
NSM4.5	258	30
95BSR	125	7
50BSR	177	2
D13R	226	24

31Year CUMULATIVE SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS FOR NORTH RIVER, GARFIELD BIGHT, TERRAPIN BAY, LITTLE MADEIRA BAY AND JOE BAY

	31year cumulative salinity scores MAR-JUN	31year cumulative salinity scores AUG-OCT
NSM4.5	440	525
95BSR	2755	1765
50BSR	2515	1545
D13R	660	1025

SOUTHERN EVERGLADES: ACHIEVEMENT INDEX OF PERFORMANCE MEASURES RELATIVE TO NSM4.5F WITH A VALUE OF 100

Shark River Slough

	MEAN DURATION OF UNINTERRUPTED FLOODING REGIONS 9, 10, & 11 (WT - 3)	MEAN DURATION OF DRY CONDITIONS, INDICATOR REGIONS 9, 10, & 11 (WT = 2)	MEAN DEPTH DURING FLOODING INDICATOR REGIONS 9, 10 & 11 (WT = 1)
95BSR	25	0	58
50BSR	29	17	67
D13R	76	89	79

	CENTRAL SHARK RIVER SLOUGH ANNUAL OVERLAND FLOW VOLUME (WT = 1)	CENTRAL SHARK RIVER SLOUGH CUMULATIVE DEVIATION FROM MONTHLY FLOW VALUES (WT = 1)
95BSR	44	76
50BSR	52	88
D13R	70	91

Rockland Marl Marsh Indicator Region 8

	MEAN DURATION OF UNINTERRUPTED FLOODING (WT = 3)	MEAN DURATION OF DRY CONDITIONS (WT = 2)	# OF WET SEASON DEPTH REVERSALS (WT = 1)
95BSR	27	27	0
50BSR	52	81	45
D13R	68	81	93

FLORIDA BAY COASTAL BASIN SALINITY/GAGE P33 STAGE		
	# OF MONTHS WHEN P33 STAGE OF 6.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 2)	# OF MONTHS WHEN P33 STAGE OF 7.3 FEET MSL IS EQUALLED OR EXCEEDED (WT = 1)
95BSR	48	23
50BSR	69	7
D13R	88	60
	31 YR. CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS MARCH-JUNE (WT = 2)	31 YR. CUM. SALINITY DIFFERENCES FROM TARGET CONCENTRATIONS AUGUST-OCTOBER (WT = 1)
95BSR	0	0
50BSR	10	18
D13R	91	60

SOUTHERN EVERGLADES WEIGHTED MEAN ACHIEVEMENT INDEX OF PERFORMANCE MEASURES			
	SHARK RIVER SLOUGH	ROCKLAND MARL MARSH	FLORIDA BAY COASTAL BASINS/P33
95BSR	28	22	20
50BSR	38	60	30
D13R	82	76	80

D.8.8 Model Lands / C-111 Area

Description of Performance Measures:

The Model Lands Alternatives Evaluation Matrix consists of five or six performance indices, which are applied to each of the four indicator regions in the Model Lands area: 4, 5, 6, and 47. Indicator Regions 4 and 47 are located immediately west of US 1 and in proximity to the C-111 Canal. Indicator Regions 5 and 6 are located east of US 1. Initial scores for performance indices 1 through 4 were obtained from stage duration curves. Initial scores for performance indices 5 and 6 were obtained from the data tables supporting the inundation pattern curves. For performance indices 1 through 4, stage durations are examined in relation to specified high and low water depth thresholds, which were based on land elevation and vegetation cover and differ for each indicator region, as follows:

Indicator Region	Name	High (ft)	Low (ft)
4	C111 Perrine Marl Marsh	2	0.5
5	Model Lands South	2	0.5
6	Model Lands North	1.75	0.25
47	C111 North	1.75	0.001

Following is a brief description of each performance index.

High water index: The proportion of time that water levels are below the high water threshold which has been specified for the indicator region (calculated as [1 - proportion of time water levels are above a specified level]). The target is 1.00, however proportions down to 0.90 are acceptable to allow for interannual variation. This index quantifies the period of time that water levels are so high that they may stress the vegetation communities naturally characteristic of these areas.
Low water index: The proportion of time that water levels are above the specified low water threshold. The target is 1.00. This criterion seeks to minimize the period of time that water levels are below a specified low water level.

Extreme low water index: The proportion of time that water levels less than 1 ft below the specified low water threshold. Calculated as (1 – proportion of time water levels are >1 ft below the specified low-water threshold). Target is 1.00. Values near 1 indicate that dry season levels are above the extreme low water level almost all of the time. Values closer to 0 indicate that dry season water levels typically fall at least another foot below the specified low water level.

Relative dry period slope index: Relative measure of the steepness of the slope of the stage duration curve during dry periods. Calculated as (1-(value for low water index divided by value for extreme low water index)). The index can vary from almost 0 (very steep slope; water levels drop dramatically during dry periods) to approximately 1.0 (slope shallow; water levels relatively stable throughout the dry season). Values closer to one are preferred.

Wet Season Inundation Pattern Index: Proportional measure of how many times during the 31-yr simulation that water levels drop below surface elevation during the July-October portion of the wet season. Calculated as (Value for Alternative – Value for Best Alternative) divided by (Value for Worst Alternative – Value for Best Alternative). The best alternative received a score of 1.0 and the worst received a score of 0.0. This criterion gives a relative ranking for how many times the aquatic habitat is disrupted by drydowns during the core months of the wet season. The months June and November were omitted from the analysis to allow for variation early and late in the season.

Dry Season Inundation Pattern Index: Proportional measure of how many times during the 31-yr simulation that water levels rose above surface elevation during the January – May portion of the dry season. (The months November and June were omitted to allow for variations in rainfall early and late in the season.) Calculated as [(Value for Alternative – Value for Best Alternative) divided by (Value for Worst Alternative – Value for Best Alternative)]. The best alternative received a score of 1.0 and the worst received a score of 0.0. This criterion was an attempt to measure the relative effect of dry season flooding on wading bird feeding during the nesting season. Continuous drying, once the dry season commences, is important to wading bird feeding and nesting. Additionally, the region is adjacent to an active nesting population of Cape Sable Seaside Sparrows, who breed in short hydroperiod wetlands during the dry season, provided the ground is not flooded. Since there is some possibility for range expansion into the region if the area is suitable, this index was designed to look at tradeoffs between providing wading bird feeding habitat and sparrow breeding habitat. This index was calculated, but the results were complicated by the already uncharacteristically dry condition of the region, making it difficult to interpret the results. Raw scores for this index are presented, but were not used to calculate the final score.

Late Wet Season Inundation Index: Proportional measure of how many times during the 31-yr simulation that autumn periods of inundation ended during the months of November and December. This index was applied only to Indicator Region 5 (Model Lands South), which includes habitat critical for Roseate Spoonbill feeding. A good year for wading bird feeding would be characterized by standing water in this indicator region well into January. Premature drydowns in the early dry season in this region may severely reduce available food to support Roseate Spoonbill nesting. Calculated as (Value for Alternative – Value for Best Alternative) divided by (Value for Worst Alternative – Value for Best Alternative). The best alternative received a score of 1.0 and the worst received a score of 0.0.

The individual scores were weighted evenly and averaged for each alternative within each indicator region to get comparative scores. Table Model Lands - 1 provides the individual performance index scores, average scores, and ranking of alternatives for each indicator region, followed by an overall evaluation for the Model Lands area. Individual scores for each indicator region are shown separately in Table Model Lands - 1 because of strong differences in results among the regions. Table Model Lands - 2 shows all the scores that were calculated, including some not used in the ranking.

Interpretation:

Alternatives A through D

Overall, alternatives that added water to this region yielded higher scores than alternatives that did not. Alternatives B, C, and D consistently scored higher than the base conditions or Alternative A. There were differences among the indicator regions, however, in which alternative produced the best results. Alternative B had the highest score for Indicator Regions 4 and 47 (areas west of US1), while alternatives C and D were essentially indistinguishable for Indicator Regions 5 and 6 (areas east of US1). Alternative B provided additional water to Indicator Region 4 and Indicator Region 47 via the C-111N canal. Alternatives C and D extended the C-111N to Indicator Region 5, which spread the additional water over a larger area and reduced the water remaining in Indicator Region 4 and Indicator Region 47. Alternatives C and D were the configurations resulting in the greatest benefits to the region as a whole and are preferred to Alternative B for that region. A design that benefits the entire region is preferred to one that benefits only a part of it. Furthermore, should an additional source of high quality water be identified in the future, alternatives C or D will provide the infrastructure necessary to distribute this water throughout the Model Lands area. Regional managers are already attempting to reduce artificial hydrological barriers between these indicator regions and manage the entire area as a connected system. Selecting an alternative that benefits the entire area is consistent with their management objectives.

The alternatives that perform the best in this region still are far from meeting targets relative to low water. The objective was to maintain water levels above the stated low water threshold all the time. These targets were based on land elevations and general requirements for historic vegetation communities. Although alternatives C and D, compared with base conditions, improved conditions in the region as a whole, these alternatives still did not reach stated targets. Water levels were below the low water thresholds more than half the time in all four indicator regions.

Alternative D - D13R

The configuration and operation changes from Alternative D to D13R made no difference to hydrologic conditions in the Model Lands-C111 Area. There were no changes in any of the performance indices from D to D13R. According to the performance indices, the water needs of the Model Lands-C111 Area still are not met, although conditions will be improved if either Alternative D or D13R are implemented.

Concerns

Many concerns should be addressed in the detailed design phase. Additional water is needed for the Model Lands-C111 Area. Furthermore, the quality and quantity of some of the water provided to the South Miami-Dade area in Alternative D13R must be confirmed. Some of the benefits in Indicator Region 5 and Indicator Region 6 may have originated from the regional use of advanced treatment wastewater to maintain canal stages in South Miami-Dade, but this option may prove too costly or too impractical to implement.

The benefits of having higher water levels in the Model Lands-C111 Area are clear. Alternative sources of water should, therefore, be identified and investigated as part of the design process.

The specific location and design for the water delivery system need to be carefully considered to minimize impacts to existing high quality wetlands and avoid disrupting the natural system with excessive infrastructure. To maximize benefits, an effort should be made to improve the design to ensure that the best configuration of components has been achieved.

Table Model Lands – 1

Model Lands/C-111 Summary Matrix, by Indicator Region

Indicator Region: 4 (C-111 Perrine Marl Marsh)

Performance Criteria:	**NSM**	**95Base**	**2050Base**	**Alt A**	**Alt B**	**Alt C**	**Alt D**	**Alt D13R**
High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).		1	1	1	0.93	0.98	0.98	0.98
Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).		0.145	0.17	0.17	0.57	0.45	0.45	0.45
Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).		0.77	0.82	0.77	0.92	0.88	0.88	0.88
Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred)		0.731	0.783	0.723	0.814	0.782	0.782	0.782
Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.)	0.980	0.725	0.294	0.000	1.000	0.941	0.961	0.961
Total Average Score:		0.674	0.613	0.533	0.847	0.807	0.811	0.811
Rank on Total Avg Score (1 = Best of Group)		3	4	5	1	2	2	2

Indicator Region: 5 (Model Lands South)

Performance Criteria:	**NSM**	**95Base**	**2050Base**	**Alt A**	**Alt B**	**Alt C**	**Alt D**	**Alt D13R**
High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).		1	1	1	1	1	1	1
Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).		0.13	0.06	0.06	0.145	0.335	0.335	0.335
Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).		0.75	0.79	0.77	0.89	0.94	0.94	0.94
Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred)		0.713	0.777	0.755	0.871	0.910	0.910	0.910
Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.)	0.486	0.000	0.086	0.057	0.629	1.000	1.000	1.000
Late Wet Season Inundation Index: Comparison among alternatives for number of times any inundation period occurring in the fall ends before January. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.)	0.778	0.000	0.278	0.167	0.944	1.000	1.000	1.000
Total Average Score:		0.432	0.498	0.468	0.747	0.864	0.864	0.864
Rank on Total Avg Score (1 = Best of Group)		5	3	4	2	1	1	1

Indicator Region: 6 (Model Lands North)

Performance Criteria:	**NSM**	**95Base**	**2050Base**	**Alt A**	**Alt B**	**Alt C**	**Alt D**	**Alt D13R**
High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).		1	1	1	1	1	1	1
Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).		0.06	0.06	0.06	0.07	0.07	0.07	0.07
Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).		0.81	0.8	0.79	0.855	0.935	0.935	0.935
Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred)		0.798	0.787	0.777	0.844	0.930	0.930	0.930
Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.)	1.000	0.000	0.063	0.088	0.138	0.175	0.200	0.200
Total Average Score:		0.534	0.542	0.543	0.581	0.622	0.627	0.627
Rank on Total Avg Score (1 = Best of Group)		4	3	3	2	1	1	1

Indicator Region: 47 (North C-111)

Performance Criteria:	**NSM**	**95Base**	**2050Base**	**Alt A**	**Alt B**	**Alt C**	**Alt D**	**Alt D13R**
High Water Index: 1-(Percentage of time water levels are above the specified high-water depth) (Ideal = 1).		1	1	1	0.97	0.95	0.95	0.95
Low Water Index: 1-(Percentage of time water levels are below the specified low water level) (Ideal = 1).		0.16	0.14	0.14	0.47	0.34	0.34	0.34
Extreme Low Water Index: 1-(Percentage of time water levels fall more than 1 ft below specified low-water target) (Ideal = 1).		0.845	0.85	0.75	0.93	0.935	0.935	0.935
Relative dry period slope index: 1-(Value for #3 divided by Value for #2) (Range = 0 - 1; Target = 1 and larger numbers are preferred)		0.815	0.826	0.709	0.868	0.902	0.902	0.902
Wet Season Inundation Pattern Index: Comparison among alternatives for number of times that water levels drop below level necessary to provide aquatic habitat (= 0.2 ft on graph) during wet season period July-Oct. Index = (Alternative-Worst Alternative)/(Best Alternative-Worst Alternative). (Range 0 - 1, 1 Best.)	1.000	0.023	0.000	0.070	0.628	0.488	0.558	0.558
Total Average Score:		0.569	0.563	0.534	0.773	0.723	0.737	0.737
Rank on Total Avg Score (1 = Best of Group)		4	4	5	1	3	2	2

Table Model Lands – 2

Indicator Region Average Score	**NSM**	**95Base**	**2050Base**	**Alt A**	**Alt B**	**Alt C**	**Alt D**	**Alt D13R**
Indicator Region 4 (C-111 Perrine Marl Marsh)		0.674	0.613	0.533	0.847	0.807	0.811	0.811
Indicator Region 5 (Model Lands South)		0.432	0.498	0.468	0.747	0.864	0.864	0.864
Indicator Region 6 (Model Lands North)		0.534	0.542	0.543	0.581	0.622	0.627	0.627
Indicator Region 47 (North C-111)		0.569	0.563	0.534	0.773	0.723	0.737	0.737
Total Regional Average Score		0.552	0.554	0.519	0.737	0.754	0.760	0.760
Regional Average Score Ranking		5	5	4	3	2	1	1

D.8.9 Big Cypress

Area/Subregion/Indicator Regions

Different portions of the Big Cypress subregion are used in the different matrix equations.

Performance Measures
1. Mean NSM Hydroperiod Matches for North Big Cypress National Preserve for the 31 year simulation
2. Mean NSM Hydroperiod Matches for South Big Cypress National Preserve for the 31 year simulation
3. Normalized Weekly Stage Duration Curves for Indicator Regions 13, 31, 36-40, 45, and 42-43
4. Average Annual Overland Flows toward Gulf of Mexico from Big Cypress National Preserve for the 31 year simulation
5. Inundation Duration Summary for Indicator Regions: Average Flood Duration

Scoring Explanation

All of the scores are relative to NSM conditions in the Big Cypress.

A = percent of North Big Cypress National Preserve that matches NSM (PM #1)

This provides a spatial measure of one of the more impacted portions of the Big Cypress that lies along its northern border. Impacts are due primarily to agricultural development and its associated canals upstream (north) of this area. In addition, there may be some model boundary problems in this area, possibly related to the fact that the area to the north is included in the Natural System Model, but not the South Florida Water Management Model.

B = percent of South Big Cypress National Preserve that matches NSM (PM #2)

This provides a spatial measure of the relatively unimpacted portion of the Big Cypress. This area is dominated by rainfall inputs, and as a result, exhibits few effects of hydrologic alterations beyond its boundaries. Hydrologic effects of the Restudy alternatives occur primarily along the Big Cypress boundary with the Everglades.

C (for individual Indicator Regions) = 1 - {absolute number}
[(percent of time flooded for NSM) - (percent of time flooded for Base or Alternative)] /100} (PM #3)

This provides a measure of deviation from NSM hydroperiod for an indicator region. This deviation is almost always a reduction in hydroperiod. The selected indicator regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the alternatives on the western portion of the Big Cypress. Initially all of the indicator regions were evaluated separately (Table Big Cypress - 1).

Equations were developed to combine some indicator regions in a simple additive form because of different influences in different areas (Table Big Cypress - 2). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

D_n(for individual Indicator Regions) = 1 – absolute number [(maximum deviation from NSM hydrograph) / (maximum range of NSM water level fluctuation)] (PM #3)

This provides a measure how much water levels have been altered from NSM conditions as a function of the NSM range of fluctuation for an indicator region. A certain degree of deviation in an area with a large natural fluctuation would be less significant than in an area with a small natural fluctuation. Typically, the greatest deviation occurs when the water table is declining through the first foot or two below the ground surface, it is smallest at its lowest point on the hydrograph, and it is relatively small when the water table is above ground. The selected indicator regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the alternatives on the western portion of the Big Cypress. Initially all of the indicator regions were evaluated separately (Table Big Cypress - 1).

Equations were developed to combine some indicator regions in a simple additive form because of different influences in different areas (Table Big Cypress - 2). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

G = 1 – absolute number [(deviation of average flood duration from NSM average flood duration) / (NSM average flood duration)] (PM #5)

This provides a measure of deviation from NSM for average duration of individual flooding events for an indicator region. This deviation is usually a reduction in the duration of inundation. The selected Indicator Regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the alternatives on the western portion of the Big Cypress. Initially all of the indicator regions were evaluated separately (Table Big Cypress - 1).

Equations were developed to combine some indicator regions in a simple additive form because of different influences in different areas (Table Big Cypress - 2). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

E_w = 1 – absolute number [(deviation of wet season flows from NSM flows) / (NSM wet season flows)] (PM #4)

E_d = 1 – absolute number [(deviation of dry season flows from NSM flows) / (NSM dry season flows)] (PM #4)

Total flows during the wet and dry season provide another way of expressing hydrologic conditions and how they change in response to proposed alternatives in particular portions of the Big Cypress. The flow cross-sections evaluated included the Eastern Big Cypress and Lostman's. Initially the flow cross-sections were evaluated separately by wet and dry season (Table Big Cypress - 1).

The subteam has developed simple additive equations for each flow cross-section to combine the wet and dry season information (Table Big Cypress - 2).

Summary Equations

The subteam subsequently developed summary equations for major geographic regions of the Big Cypress that were distinct in terms of their response to the various Restudy alternatives (Table Big Cypress - 2). These major areas were: **North Big Cypress**, which was only affected by Alternatives C and D where the L-28 Interceptor canal and levee system were modified; **South Big Cypress**, which was affected primarily by alterations to the south end of the L-28 canal and levee and in the adjacent Water Conservation Area 3A; and **Southeast Big Cypress**, which being on the border between the Everglades and southeast portion of the Big Cypress Swamp, is affected by the numerous alterations to the Everglades.

For each of these geographic areas, a simple additive equation was developed to combine variables C_n, D_n and G_n for the same indicator region(s) to summarize information on deviations in hydroperiod, water depth, and average flood event duration in these areas. In North Big Cypress, variable A was included in this simple additive equation. In South Big Cypress, variable B and variable E were included for flows across the Eastern Big Cypress along Tamiami Trail. In Southeast Big Cypress, variable E was included for flows across the Lostman's cross-section south of Tamiami Trail.

A single equation was also developed that combined the three Big Cypress regions.

Discussion

Scores were developed separately for each variable in each indicator region and for each cross-section or boundary (Table Big Cypress - 1). They were then combined in a stepwise fashion, as described above, so that the AET would be able to comment on what is gained and lost as each performance measure was combined with others. Originally two sets were developed (with or without flows) of the three summarizing equations, with the goal of reducing all of the variables to three scores, one for the North Big Cypress, one for the South Big Cypress, and one for the southeastern Big Cypress. Ultimately two whole Big Cypress equations were produced, again depending on whether flow parameters are used or not in the equations.

As a result of discussions at the late May AET meetings, it was decided to focus on using the information contained in the three geographically-separate equations that included the flow cross-section information (Table Big Cypress - 2). Each of these three summary rows of the matrix provided distinctive information relevant to understanding influences that each of the Alternatives had on the Big Cypress.

All of the effects on the North Big Cypress occurred in alternatives C and D, and were retained in D13 and D13R. The effects resulted from filling the L-28 Interceptor Canal and removing its western levee, creating openings for water to move south along the Western Feeder Canal, and replacing S-190 with a pump station to maintain upstream drainage. This scenario also required some sort of water treatment capability to assure that all water moving south and southwest from the upstream canal system would provide only clean water. These components converted an area about two cells wide for most of the length of the L-28 Interceptor along its western side to approximately NSM conditions. Because the locations of the restored cells and the indicator regions available in the vicinity were not the same, the low matrix scores did not adequately reflect the high degree of restoration that actually occurred in portions of this area from the implementation of these components.

In the South Big Cypress, the most significant changes occurred in Alternative D, with the removal of the L-28 Tieback Levee. With this structure removed, hydrologic conditions showed almost complete restoration to NSM conditions, including restored hydroperiods and increased flows across the eastern portion of the Big Cypress. The model results for D13 and D13R were almost identical to one another, and both showed generally small but distinct increased deviations from NSM as compared to Alternative D. The matrix values for D13 were almost identical to the 1995 Base conditions in this area, but were higher than for the 2050 Base. When looking at the hydrologic responses to these alternatives for individual performance measures and indicator regions, the geographic area where the deviations were greatest was in the vicinity and downstream of the jetport. When we first noticed this, we thought it might be a function of how the jetport was configured in the model. However, the jetport and its associated fill are not included in the SFWMM, even though it is large enough that it probably could be included on a 2X2 mile grid scale. We next looked at topography in the area, which turned out to be slightly lower in some grid cells to the east of the south L-28 in the SFWMM than in the NSM. This could probably explain the slightly greater differences from NSM in this area compared to Alternative D, where south L-28 was still pesent and would limit the southest flow of water cominf through the gap creeated by removal of the L-28 Tieback levees. In Alternative D13R, this water could move more easily to the south east since the south L-28 and L-29 were gone.

In the southeastern Big Cypress along its border with the Everglades and below Tamiami Trail, the most significant changes occurred in Alternative B, when the L-28 and L-29 levees and canals were removed. According to the model, there were larger areas showing reduced hydroperiods and the reductions in hydroperiods and flows were greater than in Alternatives A, C, or D, all of which were close to NSM condition. In Alternative C, the L-28 and only the western portion of L-29 were restored, which was sufficient to return conditions in this area close to NSM. The removal of the L-28 Tieback in Alternative D did not seem to affect this portion of the Big Cypress. Alternatives D13 and D13R produced generally small and variable responses among the various performance measures, resulting in an overall minor difference in the summary matrix value for this portion of the Big Cypress.

Summary

The combination of components in Alternative D produced the greatest benefits in terms of restoring the largest amount of area in the Big Cypress to approximately NSM conditions. It also seems that several of the most beneficial components could be implemented in any of the alternatives, since they operate pretty much independently from the rest of the Everglades ecosystem. This would be the situation for the L-28 Interceptor and L-28 Tieback components. Changes to the L-28 South and L-29 have more extensive and complex interactions with other parts of the Everglades.

In using the colors and grades to differentiate restoration success as indicated by the various performance measures for each the bases and alternatives (A-D, D13, D13R), matrix value ranges of 91-100 (green, grade A), 81-90 (yellow, grade B), and <81 (red, grade C) were used. These ranges generally seemed to do a reasonably good job of sorting restoration gains and losses for the Big Cypress region that were associated with each of the alternatives. The only portion of the region where these results could be misinterpreted is the North Big Cypress. The portion of this area influenced by the L-28 Interceptor system should be included in the green grade A category in Alternatives C, D, D13, and D13R. The portion further west still shows severe hydrologic impacts, even in these latter alternatives. However, based on a helicopter overflight of the area to assess its condition and understanding of how the models are operating in this area, it is very likely that these impacts are merely the result of modeling problems, and in reality are much less severe than suggested by the SFWMM.

TABLE 1: Big Cypress Matrix Scores

VARIABLE	NSM FINAL	95BSR	50BSR	ALT A	ALT B	ALT C	ALT D	ALT D13(R)
	Percent of North Big Cypress that Matches NSM / 100							
A	1.00	0.47	0.46	0.46	0.49	0.64	0.64	0.64
	Percent of South Big Cypress that Matches NSM / 100							
B	1.00	0.99	0.97	0.97	0.92	0.99	1.00	0.99
	Reduction in Percent of Time Inundated from NSM Condition							
C-13	1.00	0.99	0.93	0.99	0.95	0.99	0.99	0.99
C-31	1.00	0.90	0.90	0.90	0.91	0.94	0.94	0.94
C-36	1.00	0.94	0.92	0.92	0.91	0.95	1.00	0.94
C-37	1.00	0.93	0.91	0.91	0.91	0.94	0.99	0.95
C-38	1.00	0.97	0.97	0.97	0.97	0.98	0.98	0.98
C-39	1.00	0.94	0.93	0.93	0.94	0.95	0.95	0.95
C-40	1.00	0.97	0.97	0.96	0.96	0.97	1.00	0.98
C-45	1.00	0.99	0.97	0.97	0.98	0.99	0.99	0.99
C-42	1.00	0.81	0.81	0.81	0.81	0.92	0.92	0.92
C-43	1.00	0.35	0.34	0.34	0.34	0.63	0.63	0.63
	Maximum Deviation from NSM Stage Duration Curve							
D-13	1.00	0.95	0.92	0.98	0.95	0.96	0.97	0.99
D-31	1.00	0.94	0.94	0.94	0.95	0.96	0.96	0.96
D-36	1.00	0.97	0.95	0.95	0.95	0.96	0.98	0.97
D-37	1.00	0.95	0.95	0.95	0.95	0.96	0.99	0.96
D-38	1.00	0.98	0.98	0.98	0.98	0.98	0.98	0.98
D-39	1.00	0.97	0.97	0.97	0.97	0.98	0.98	0.98

D-40	1.00	0.98	0.98	0.98	0.96	0.98	0.99	0.98
D-45	1.00	0.98	0.98	0.97	0.98	0.98	0.99	0.98
D-42	1.00	0.89	0.89	0.89	0.89	0.94	0.94	0.94
D-43	1.00	0.51	0.50	0.50	0.51	0.57	0.57	0.57
				Percent Change in Flow from NSM Condition / 100				
Ew-eastern BC	1.00	0.76	0.72	0.72	0.73	0.80	0.99	0.84
Ed-eastern BC	1.00	0.65	0.55	0.45	0.50	0.53	0.78	0.65
Ew-Lostman's	1.00	0.60	0.68	0.93	0.79	0.98	0.96	0.98
Ed-Lostman's	1.00	0.63	0.42	0.91	0.63	0.91	0.88	0.98
				Average Flood Duration				
G-13	1.00	0.93	0.89	0.96	0.86	1.00	1.00	0.86
G-31	1.00	0.93	0.93	0.93	0.93	0.93	1.00	1.00
G-36	1.00	0.89	0.78	0.72	0.78	0.83	0.94	0.83
G-37	1.00	0.82	0.71	0.71	0.71	0.76	0.94	0.82
G-38	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90
G-39	1.00	0.86	0.86	0.86	0.86	0.86	0.86	0.86
G-40	1.00	0.91	0.87	0.83	0.87	0.91	1.00	0.96
G-45	1.00	0.91	0.91	0.91	0.91	0.91	1.00	0.91
G-42	1.00	0.55	0.55	0.55	0.55	0.73	0.73	0.73
G-43	1.00	0.13	0.13	0.13	0.13	0.45	0.45	0.45

TABLE 2:

VARIABLE	**NSM FINAL**	**95BSR**	**50BSR**	**ALT A**	**ALT B**	**ALT C**	**ALT D**	**ALT D13(R)**
				NORTH BIG CYPRESS				
				Percent of North Big Cypress that Matches NSM / 100				
A	1.00	0.47	0.46	0.46	0.49	0.64	0.64	0.64
				Reduction in Percent of Time Inundated from NSM Condition				
C42-C43	1.00	0.58	0.58	0.58	0.58	0.78	0.78	0.78
				Maximum Deviation from NSM Stage Duration Curve				
D42-D43	1.00	0.70	0.70	0.70	0.70	0.76	0.76	0.76
				Average Flood Duration				
G42-G43	1.00	0.34	0.34	0.34	0.34	0.59	0.59	0.59
				Summary - North Big Cypress				
	1.00	0.52	0.52	0.52	0.53	0.69	0.69	0.69
				SOUTH BIG CYPRESS				
				Percent of South Big Cypress that Matches NSM / 100				
B	1.00	0.99	0.97	0.97	0.92	0.99	1.00	1.00
				Reduction in Percent of Time Inundated from NSM Condition				

C31, C36-C40	1.00	0.95	0.94	0.94	0.94	0.96	0.98	0.96
				Maximum Deviation from NSM Stage Duration Curve				
D31, D36-D40	1.00	0.97	0.96	0.96	0.96	0.97	0.98	0.97
				Average Flood Duration				
G31, G36-G40	1.00	0.89	0.85	0.84	0.85	0.87	0.95	0.90
				Percent Change in Flow from NSM Condition / 100				
(Ew+Ed)/2 East BC	1.00	0.70	0.63	0.58	0.62	0.66	0.88	0.74
				Summary - South Big Cypress				
	1.00	0.90	0.87	0.86	0.86	0.89	0.96	0.92
				SOUTHEAST BIG CYPRESS				
				Reduction in Percent of Time Inundated from NSM Condition				
C-13	1.00	0.99	0.93	0.99	0.95	0.99	0.99	0.99
				Maximum Deviation from NSM Stage Duration Curve				
D-13	1.00	0.95	0.92	0.98	0.95	0.96	0.97	0.99
				Average Flood Duration				
G-13	1.00	0.93	0.89	0.96	0.86	1.00	1.00	0.86
				Percent Change in Flow from NSM Condition / 100				
(Ew+Ed)/2 Lostman's	1.00	0.61	0.55	0.92	0.71	0.94	0.92	0.98
				Summary - Southeast Big Cypress				
	1.00	0.87	0.82	0.96	0.87	0.97	0.97	0.95

D.8.10 Caloosahatchee Estuary

Variables and Performance Measures. The following variables were developed using existing performance measures for Caloosahatchee Estuary. The variables / performance measures have targets based on flow which would support optimum hydrologic conditions conducive of optimum quality habitat for fish, wildlife, and other aquatic resources. The targets are based on optimization model outputs, natural variation that would occur during the period 1965-1995, and desirable salinity conditions for existing and potential aquatic resources within the Caloosahatchee Estuary. These are not all of the existing performance measures for the Caloosahatchee Estuary but are a subset selected by the subteam to be used to evaluate Restudy Plans. There are additional performance measures posted on the Restudy webpage that provide additional detailed information. These additional performance measures were determined to be a lower level priority to be used in the present Restudy evaluation and may not be included in Restudy AET presentations/evaluations.

Variables, SIVs. The four variables / performance measures for the Caloosahatchee Estuary are as follows:
SI**V*min*** = # months mean monthly flow< 300 cfs from C-43 & LOK during dry season (Nov – May)

SIV*max2800* = # months mean monthly flow > 2,800 cfs
SIV*max4500* = # months mean monthly flows were > 4,500 cfs
SIV*max7800* = # days LOK Reg. Discharges>7,800 cfs.

SIV*min*. This variable is based on the number of months with mean monthly flow< 300 cfs. This variable is based on the number of times the minimum mean monthly flows from the lake and watershed fall below 300 cfs at S-79 for the 1965-1995 period. The alternative with the least number of times flows fall below 300 cfs, as measured at S-79, will be considered better for protecting estuarine aquatic biota. The target number of months not to be exceeded is 60 for the 1965-1995 period.

Principal Objective: Maintain sufficient minimum mean monthly flows from the lake to augment basin runoff, when necessary, in order to maintain favorable salinities and water quality within the estuary.

Rationale: Insufficient fresh water discharges, contribute to poor estuarine water quality including inadequate fresh water to maintain desirable salinity envelopes. These events have had direct effects on estuarine seagrasses, fish and invertebrates, including critical indicator species eg. Vallisneria, by enabling the estuary to become too saline

Outputs for SIV*min*: As stated above, the ROGEM indices are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling indicate that the optimum senario would have no more than 60 months of mean monthly flows of <300 cfs. The Caloosahatchee data for the alternatives is taken from the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target)}}$$

Note: The output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*min* are presented in Table Caloosahatchee Estuary - 1.

SIV*max2800*. This variable is based on the number of times mean monthly flow exceeds 2,800 cfs as measured at S-79 from the lake and the watershed for the 1965-1995 period. The maximum number of months (target) allowing for natural variation is 22 for the 1965-1995 period of record. The alternative with the least number of times flows exceed 2,800 cfs as measured at S-79, at any time of year, will be considered better for maintaining desirable salinity and water quality within the estuary.

Principal Objective: Achieve an overall reduction in high volume discharge events to the estuary, and improve estuarine water quality. This will benefit estuarine vegetation, invertebrates, and fish communities.

Rationale: High volume discharges to the estuary contribute to poor estuarine water quality including increased turbidity, color and violation of favorable salinity envelopes. High flow events have direct effects on estuarine seagrasses by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat, and contributing to unfavorable salinities for aquatic vegetation, fish and invertebrates, including critical indicator species e.g., the American oyster, turtle grass, and Vallisneria.

Outputs for SIV*max2800:* As stated above, the ROGEM scores are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling of this period indicate that the optimum scenario would have no more than 22 months of mean monthly flows of >2,800 cfs. The Caloosahatchee Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target)}}$$

Note: The maximum output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*max2800* are presented in Table Caloosahatchee Estuary - 1.

SIV*max4500*. This variable is based on the number of times mean monthly flows exceed 4,500 cfs at S-79 for the 1965-1995 period of record. The acceptable number of months (target) allowing for natural variation is 6 for the 1965-1995 period. The alternative with the least number of months that discharges exceed 4,500 cfs as measured at S-79, will be considered better for protecting estuarine resources, including those downstream in the San Carlos Bay region.

Principal Objective: Reduce the occurrence of extreme discharge events and improve water quality in the lower estuary, including San Carlos Bay, in order to protect estuarine resources.

Rationale: Mean monthly flows above 4,500 cfs results in freshwater conditions throughout the entire estuary causing impacts to estuarine biota. This volume of flow also begins to reduce water quality and adversely impact biota in San Carlos Bay.

Outputs for SIV*max4500:* The ROGEM scores are ordinal numbers. The total allowable number of monthly violations, based on natural variation of hydrologic conditions, and hydrologic modeling of this period indicate that the optimum condition is to have no more than 6 months of mean monthly flows of >4,500 cfs. The Caloosahatchee Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the Caloosahatchee Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target)}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions

Results for SIV*max4500* are presented in Table Caloosahatchee Estuary - 1.

SIV*max7800*. This variable is based on the number of days of Zone A discharge from the lake for each alternative for the period 1965-1995. The target is zero (0) violations. This variable considers the number of days of Zone A discharge from the lake (7,800 cfs per day at S-79, not S-77) for each alternative for the 1965-1995 period of record. The alternatives with the least number of days of Zone A release according to output from the SFWMM will be considered better for protecting the integrity of the estuarine environment.

Principal Objective: Reduce the occurrence of extreme discharge events from the lake to the estuary, and improve estuarine water quality with a view to protecting estuarine aquatic biota.

Rationale: Zone A discharges have rapid and serious effects on estuarine seagrasses in the Caloosahatchee River Estuary and San Carlos Bay by reducing light penetration necessary for photosynthesis. Zone A discharges destroy fish and invertebrate habitat, and contribute to unfavorable salinities for estuarine biota, including critical indicator species e.g., the American oyster, Vallisneria, and other vegetation. The longer Zone A discharges persist, the greater the damage to the various ecosystems, and the further the damage extends.

Outputs for SIV*max7800*: No Zone A discharges of this magnitude are desirable. Furthermore, the results of hydrologic modeling of the period 1965-1995 indicate that no daily flows of >7,800 cfs would have occurred during this period. The Caloosahatchee Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled “Number of times Salinity Envelope Criteria were NOT met for the Caloosahachee Estuary.”

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of days}}{\text{range (observed max \# days for all alts)}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates maximum conditions.

Results for SIV*max7800* are presented in Table Caloosahatchee Estuary - 1.

ROGEM equation and final scores for Caloosahatchee Estuary

The variables can be prioritized from lowest to highest, according to the following: SIVmin is the lowest priority variable, followed by SIVmax 2800, which is lower than SIVmax 4500, which is followed by SIVmax7800 (Zone A regulatory releases >7,800 cfs from Lake Okeechobee, the highest priority variable for the Caloosahatchee). Note, however, that all these variables / performance measures are considered first order priority variables even though it is possible to rate them relatively among each other. All variables are weighted equally in the ROGEM equation.

ROGEM scores for Caloosahatchee are calculated according to the following:

1/4 (SIV*min* + SIV*max2800* + SIV*max4500* + SIV*max7800)*

Scores for all of the plans and the two base cases are presented in Table Caloosahatchee Estuary - 1. To summarize: Alternatives A through D13R all scored 1.0 on a scale of 0.0 to 1.0. The Caloosahatchee subteam agrees that any of the alternatives would be considered very good for Caloosahatchee Estuary. All the alternatives greatly exceed the target values set in the performance measures (except for regulatory releases, which meets the target). Furthermore, alternatives A through D show major improvements over the 1995 Base, which scored 0.0, and the 2050 Base, which scored 0.1. Because all but one of the regulatory releases were eliminated in plans A through D13R, SIV*max7800* was not weighted more heavily than the other variables. However, if the plans had not been so successful in eliminating the Zone A regulatory discharges then SIV*max7800* would have been weighted.

D.8.11 St. Lucie Estuary

Variables and Performance Measures Evaluation

The suitability index variables (SIVs) were developed using existing performance measures for St. Lucie Estuary. The variables / performance measures have targets based on flow that would support optimum hydrologic conditions conducive of optimum quality habitat for fish, wildlife, and other aquatic resources. The targets are based on optimization model outputs, natural variation that would occur during the period 1965-1995, and desirable salinity conditions for existing and potential aquatic resources within the St. Lucie Estuary. These are not all of the existing performance measure for the St. Lucie Estuary but are a subset selected by the St. Lucie subteam to be used to evaluate Restudy plans. There are additional performance measures posted on the Restudy web page that also provide information for the estuary. However, the additional performance measures were determined to be a lower level priority for the present Restudy evaluation and are not included in the present presentations / evaluations.

The St. Lucie Estuary River of Grass Evaluation Methodology (ROGEM) is comprised of four metrics (suitability index variables, or SIVs) that concern maintenance of desirable salinity conditions within the St. Lucie Estuary. The SIVs are based on research, empirical findings, and a hydrologic analysis of the period 1965 through 1995. The ROGEM outputs are ordinal numbers. Ordinal scores are calculated based on performance measure (PM) targets for each of the variables. The highest possible score of 1.0 represents optimum hydrologic conditions conducive of optimum quality habitat for the estuarine indicator species chosen (oysters and SAV). Decreasing scores to 0.0 represent decreasing habitat quality.

The St. Lucie Estuary receives freshwater inputs both through interbasin transfer from Lake Okeechobee and from local watershed contributions. The maintenance of flows to the estuary to achieve the appropriate salinity regime therefore must manage both watershed runoff and regulatory flows from the lake. Several performance measures from the SFWMM dealing with various inflows to the estuary were selected for ROGEM to compare alternative restoration scenarios. On the most basic level, inflow problems can be divided into two categories: 1) High inflow events, when large regulatory releases from the Lake and / or the watershed cause poor estuarine water quality and 2) Maintaining dry season base flows. Minimum levels of inflow and nutrients usually occur at the end of the dry season (April and May). It is during these months that numerous species of juvenile fish depend on an abundant food supply of phytoplankton and zooplankton, which requires a minimum level of fresh water and nutrients. In order for the estuary to act as a nursery for juvenile fish, plankton populations should be at a high enough density for fish to easily feed.

To determine appropriate water quantity inflows to the estuary, biological indicators with definable salinity preferences were chosen. A favorable range of salinities for the estuary were determined (referred to as the salinity envelope) based on the requirements of SAV and oysters. Woodward-Clyde, in a literature review report developed for the District in 1998, summarizes the approximate salinity tolerances for selected SAV and American oyster. A report on the abundance and type of SAV species by Phillips and Ingle (1960), provided the most complete source of information on SAV occurrence and abundance in the St. Lucie Estuary. This survey of SAV which was conducted from September 1957 to March 1959 revealed that the three most commonly found species of SAV in the estuary at the time were shoal grass (outer and middle estuary), manatee grass (outer estuary), and widgeon grass (north fork). They also reported on the salinity tolerance, normal, common and optimum range for all species. The normal tolerance range for shoal grass is 5-55pptt; for manatee grass, 17-44 ppt; and for widgeon grass, 0-45 ppt. These numbers were based on reviewed literature, and all species can withstand even greater salinity fluctuations for short periods of time. The salinity tolerance ranges were also summarized for the different life cycle stages of the American oyster. The optimum range for adults and juveniles is 10-20 ppt, 20-23 for spat, 23-27 for larvae and embryos and 15-20 ppt for a sustainable population (Woodward-Clyde 1998). More details can be found in tables 13-3 and 13-4 of the report. These favorable ranges of salinity (salinity envelope) have been related to volumes of freshwater flow to the estuary and a target range of flows was determined. In order to meet the salinity envelope criteria the surface water flows coming from the watershed as well as from ground water should be in the range of 350 cfs – 1,600 cfs. The ROGEM model for the estuary is based on four sets of variables (or performance measures). Each variable has an acceptable number of violations of the upper and lower flow range to take into consideration natural variation of flow.

Variables, SIVs. The ROGEM equation for St. Lucie Estuary includes the following four variables:

SIV*min* = # of months with mean monthly flow < 350 cfs
SIV*max 1600* = # of months with mean monthly flows > 1,600 cfs
SIV*max 2500* = # of months with mean monthly flows were > 2,500 cfs
SIV*max 7200* = # of days with Lake Okeechobee Zone A discharges > 7,200 cfs

Values range from 0.01 (the least desirable condition) to 1.0 (the most desirable condition).

Variable SIV*min*. This variable is based on the number of months the mean monthly flow from the lake and watershed fall below 350 cfs for the 1965-1995 period. The target is to have no more than 50 months with mean monthly flow less than 350 cfs for this period of analysis.

Principal Objective: This variable addresses the importance of low flow conditions (mean monthly flows<350 cfs). The objective is to maintain sufficient minimum mean monthly flows in order to maintain favorable conditions for estuarine organisms. This includes the importance of fresh water and nutrient input into the system in the appropriate quantity and timing to support primary and secondary productivity (discussed in more detail in the following paragraphs).

Rationale: Insufficient freshwater discharges during the dry season contribute to reduced estuarine productivity. Minimum levels of inflow and nutrients usually occur at the end of the dry season (April and May). It is during these months that numerous species of juvenile fish depend on an abundant food supply of phytoplankton and zooplankton which requires a minimum level of fresh water and nutrients. In order for the estuary to act as a nursery for juvenile fish, plankton populations should be at a high enough density for fish to easily feed.

The target salinity gradients in St. Lucie Estuary were determined by a hydrodynamic salinity model (Morris 1987) combined with estimates of salinity requirements for two indicator species in the estuary, Halodule wrightii (shoal grass) and Crassostrea virginica (American oyster). Target minimum mean monthly flows to the estuary are 350 cfs to protect oysters near the Roosevelt Bridge, promote brackish aquatic plant growth, and support juvenile fish populations. This flow could come from the watershed (including groundwater), Lake Okeechobee (via S-80), or a combination of the two.

Outputs for SIV*min*: As stated above, the ROGEM indices are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling indicate that the optimum senario would have no more than 50 months of mean monthly flows of <350 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target)}}$$

Note: The output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*min* are presented in Table St. Lucie Estuary - 1.

Variable SIV*max1600*: This variable is based on the number of months that mean monthly flow exceeds 1,600 cfs as measured from the lake and the watershed for the

1965-1995 period of record. The acceptable violations (target) allowing for natural variation is nine for the 1965-1995 period of record.

Principal Objective: Reduce high volume discharge events to the estuary to improve estuarine water quality and protect and enhance estuarine habitat and biota.

Rationale: Recent analysis has determined that mean monthly flow should not frequently exceed 1,600 cfs. As flows exceed this limit, the salinity is reduced below desirable levels for some estuarine resources. Also, high volume discharges to the estuary contribute to poor estuarine water quality including increased turbidity, and violation of the favorable salinity envelope. These events have direct effects on SAV by reducing light penetration necessary for photosynthesis, degrading fish and invertebrate habitat, and contributing to unfavorable salinity concentrations for aquatic vegetation, fish and invertebrates, including the indicator species (American oyster and SAV).

Outputs for SIV*max1600:* As stated above, the ROGEM scores are ordinal rather than cardinal numbers. The total allowable number of monthly violations is based on the natural variation of hydrologic conditions during the period 1965 to 1995. The results of hydrologic modeling of this period indicate that the optimum scenario would have no more than nine months of mean monthly flows of >1,600 cfs. The St. Lucie Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target)}}$$

Note: The maximum output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions.

Results for SIV*max1600* are presented in Table St. Lucie Estuary - 1.

Variable SIV*max2500:* This variable measures the number of times mean monthly flows from the lake and watershed exceeds 2,500 cfs for the 1965-1995 period of record. The target is no more than three months with men monthly flows > 2,500 cfs for the 1965-1995 period of record.

Principal Objective: Reduce the occurrence of extreme discharge events and improve water and sediment quality in the estuary to protect estuarine vegetation, invertebrates, and fish communities.

Rationale: Mean monthly flows above 2,500 cfs result in freshwater conditions throughout the entire estuary causing severe impacts to estuarine biota. This volume of flow begins to impact the Indian River Lagoon to the north and south of the St. Lucie Inlet.

Outputs for SIV*max2500:* The ROGEM scores are ordinal numbers. The total allowable number of monthly violations, based on natural variation of hydrologic conditions, and hydrologic modeling of this period indicate that the optimum condition is to have no more than three months of mean monthly flows of >2,500 cfs. The St. Lucie Estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of months - target \# of months}}{\text{range (observed max \# of months for all Alts - target)}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates optimum conditions

Results for SIV*max2500* are presented in Table St. Lucie Estuary - 1.

Variable SIV*max7200:* This variable is based on the number of days of Zone A discharge from the Lake, (7,200 cfs per day at S-80) for each alternative for the period 1965-1995. The target is zero (0) violations. Because of the magnitude of Zone A releases on the environment, this variables is the highest priority of the four ROGEM variables and would normally have been weighted in the overall ROGEM equation. However, since alternatives A – D13R eliminate all except for two days of the Zone A releases, this variable was not weighted.

Principal Objective: Eliminate the occurrence of extreme discharge events from the lake to the estuary, and improve estuarine water quality in order to protect existing and potential habitat for estuarine vegetation, invertebrates, and fish communities.

Rationale: Zone A discharges transport large amounts of sediment and results in freshwater conditions within the entire estuary. These events can have rapid and serious effects on estuarine SAV by reducing light penetration necessary for photosynthesis, destroying fish and invertebrate habitat. They contribute to unfavorable salinity concentrations for most aquatic life, including the American oyster and SAV, as well as contributing to the occurrence and severity of fish diseases. These large volume discharges also cause adverse effects on large areas of the Indian River Lagoon surrounding the St. Lucie Inlet and possibly influence nearshore ocean habitats adjacent to the Inlet. Prolonged Zone A discharges result in even greater damage to the various ecosystems, and more widespread adverse effects.

Outputs for SIV*max7200*: No Zone A discharges of this magnitude are desirable. Furthermore, the results of hydrologic modeling of the period 1965-1995 indicate that no daily flows of >7,200 cfs would have occurred during this period. The estuary data for the alternatives is presented in the performance measures bar graphs and tables titled "Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary."

The ROGEM output for this variable is calculated using the formula:

$$1 - \frac{\text{observed \# of days}}{\text{range (observed max \# days for all alts)}}$$

Note: Output is set at 1.0 (i.e. does not exceed 1.0) which indicates maximum conditions.

Results for SIV*max7200* are presented in Table St. Lucie Estuary - 1.

ROGEM equation and final scores for St. Lucie Estuary

The variables can be prioritized from lowest to highest, according to the following: SIVmin is the lowest priority variable, followed by SIVmax 1600, which is lower than SIVmax 2500, which is followed by SIVmax7200 (Zone A regulatory releases >7,200 cfs from Lake Okeechoobee, the highest priority variable for St. Lucie. Note, however, that all these variables/performance measures are considered first order priority variables even though it is possible to rate them relatively among each other. All variables are weighted equally in the ROGEM equation.

ROGEM scores are calculated according to the following:

1/4 (SIV*min* + SIV*max1600* + SIV*max2500* + SIV*max7200)*

Scores for all of the plans and the two bases are presented in the attached table. To summarize: alternatives A through D all scored 0.8 on a scale of 0.0 to 1.0. The St. Lucie subteam agrees that any of the alternatives would be considered fair for St. Lucie Estuary. The principle reason for this is that the basin runoff results are still about 4 times greater than their targets. The reason that the ROGEM score was 0.8 was because the regulatory release and low-flow targets were almost met.

While there is very little difference between alternatives A through D they all show improvements over the 1995 Base, which scored 0.0, and the 2050 Base, which scored 0.1. Because most regulatory releases were eliminated in plans A through D, SIV*max7200* was not weighted more heavily than the other variables. However, if the plans had not been so successful in eliminating the Zone A regulatory discharges then SIV*max7200* would have been weighted.

In Alternative D13R, for flows <350 cfs, (target = 50), the performance was 51. For flows >1,600 cfs, (target = nine), the performance was 15. For flows >2,500 cfs, (target = five) and the performance was eight. These output values are a vast improvement over the previous alternatives. As for grades and color codes; the grade would be a B+ and the color would be green.

D.8.12 Lake Worth Lagoon

The performance measure used in this analysis for the Lake Worth Lagoon was “Wet/Dry season average flows discharged to Lake Worth Lagoon through S-40, S-41, and S-155 for the 31 year simulation.” The restoration target is to create estuarine conditions, to the extent possible, in the Lake Worth Lagoon. An estuarine salinity envelope of 23 ppt to 35 ppt has been chosen as the target salinity range. This is a viable salinity range for a number of organisms many of that are commercially and recreationally important. To attain this salinity a maximum flow needed to be developed. Previous hydrodynamic modeling displayed that 500 cfs creates a steady state salinity of 23 ppt. For the low flow part of the salinity envelope, 0 cfs is the target. Enough ground water occurs that should still allow estuarine conditions. Based on past modeling, this flow range of 0-500 cfs should create the salinity range of 23 ppt - 35 ppt.

The following protocol was used for the Lake Worth Lagoon:

Ranking: The alternatives and bases were ranked from 1-5 (one being best, see Table Lake Worth Lagoon - 1). Alternatives A, B, C, D, and the 2050 Base were ranked. The rankings for the two performance measures were added and Alternative B was best, followed by C, than D and A, and lastly the 2050 Base. After closely examining the model output, the minimum flow performance criteria for D has a number of small releases that are above 0 cfs, but small enough that they do not effect the estuaries salinity. So in actuality D is probably tied with C in the ranking.

Colors: None of the alternatives were colored green. Alternatives B, C, and D were colored yellow and A, 2050 Base, and 1995 Base were colored red.

Grades. Alternative B was graded a B, alternatives C and D were graded a C, Alternative A was a D, and the 2050 Base and 1995 Base were graded an F. Once again, Alternative D was probably very close to a B after reviewing the model output.

Alternative D13R has the same numbers as D and so would be ranked, colored, and graded the same.

Table Caloosahatchee Estuary

Variables (from PMs) **Caloosahatchee Estuary ROGEM Values (based on PMs)**

	95Base	50Base	ALT A	ALT B	ALT C	ALT D	ALT D13R	TARGET	PRIORITY
	# Value	# Value	# Value	# Value	# Value	# Value	# Value	# Value	RANKING
SIV min (mean monthly flow < 300 cfs)	107= 0.08	111= 0	36 = 1	36 = 1	36 = 1	36= 1	36= 1	60 = 1	4th
SIV max 2800 (mean monthly flow > 2,800 cfs)	69 = 0	61= 0.17	11 = 1	11 = 1	11 = 1	11= 1	11= 1	22 = 1	3rd
SIV max 4500 (mean monthly flow >4,500 cfs)	29= 0	26 = 0.13	4 = 1	2 = 1	3 = 1	3= 1	3= 1	6 = 1	2nd
SIV max7800 (flow > 7,800 cfs, reg. release)	23 = 0	17 = 0.26	1 = 0.96	1 = 0.96	1 = 0.96	1= 0.96	1= 0.96	0 = 1	1st
Sum of SIVs	0.08	0.56	3.96	3.96	3.96	3.96	3.96	4	
ROGEM Scores	0.02	0.14	0.99	0.99	0.99	0.99	0.99	1	

NOTE: # refers to the number of events (# of months for all except reg. releases which is # of days) per period of analysis (31 yrs)

Table St. Lucie Estuary - Variables (PMs)

St. Lucie Estuary ROGEM Values (Based on PMs)

	95Base	50Base	ALT A	ALT B	ALT C	ALT D	ALT D13R	Target
	# Value	# Value	# Value	# Value	# Value	# Value	# Value	# Value
SIV min (mean monthly flow < 350 cfs)	154= 0.08	163= 0	61 = 0.9	64 = 0.88	60 = 0.91	60 = 0.91	51= 0.99	50 = 1
SIV max1600 (mean monthly flow > 1,600 cfs)	77= 0	71= 0.09	35 = 0.62	34 = 0.63	35 = 0.62	35= 0.62	15= 0.91	9 = 1
SIV max2500 (mean monthly flow >2,500 cfs)	40= 0	36= 0.11	11 = 0.83	9 = 0.84	12 = 0.76	12= 0.76	8= 0.86	3 = 1
SIV max7200 (flow > 7,200 cfs, reg. release)	40= 0	29= 0.28	2 = 0.95	1 = 0.98	2 = 0.95	2= 0.95	2= 0.95	0 = 1
Sum of SIVs/4	0.08	0.48	3.3	3.33	3.24	3.24	3.71	4
ROGEM Scores	0.02	0.12	0.83	0.83	0.81	0.81	0.93=0.9	1

NOTE: # refers to the number of events (# of months for all except for reg. release which is # of days) per period of analysis (31 yrs)

Table Lake Worth Flows

Lake Worth Outputs for Minimum and Maximum Flows

	95Base	**50Base**	**Alt A**	**Alt B**	**Alt C**	**Alt D**	**Alt D13R**	**Priority**
	# months	# months	# months	# months	# months	# Value	# Value	ranking
Minimum Flow (mean monthly flow = 0 cfs)	30	42	45	49	42	24	24	Second
Maximum Flow (mean monthly flow > 500 cfs)	299	216	157	124	121	96	96	First

NOTE: The outputs denote the relative ranking of the Alternatives to each other and the 95Base and 50Base.
(The goals for Lake Worth are to eliminate zero flows and flows >500cfs.)

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D.8.13 Biscayne Bay Surface Water Matrix Documentation

Geographical Region

For the purposes of this evaluation, Biscayne Bay is considered to be bounded by Snake Creek to the north (Oleta River State Park) and the southern border of Biscayne National Park to the south. Influence of proposed water management alternatives on Card and Barnes sounds to the south of Biscayne Bay will be considered as part of the Model Lands Other Project Element.

Derivation of Performance Measures

Based on historical accounts and scientific studies, Biscayne Bay has been classed as a positive, shallow, tidal, bar-built estuary (Kohout and Kolipinski 1967). The term positive refers to the condition of salinity being less than seawater (Hela et al. 1957). The salinity gradient that established estuarine habitat in Biscayne Bay is dependent on both surface and ground water flows (Fatt and Wang 1987). The effect of regional drainage projects on these flows has been to disrupt salinity patterns and impair coastal ecosystem function by altering the timing and amounts of freshwater input to the bay.

Historically (pre-1910), freshwater input to the bay was through numerous coastal streams, sloughs, and springs and from wet season sheetflow flow to the tidal zone. Currently, ground water and surface water flow to the bay that contributed to estuarine salinities is reduced and hydroperiods have been altered. Surface water input to the bay is now intercepted and delivered through 14 regulated canals that are characterized by high amplitude, short duration storm flows during the wet season and low base flow during the dry season.

While accomplishing the goal of flood control, the presence and operation of the canals has had profound hydrological and ecological consequences on Biscayne Bay (Teas et al. 1976, Thorhaug et al. 1976, Hoffmeister 1974). The temporal and spatial pattern of freshwater inflow to the bay was fundamentally altered to one of point source discharges (canal mouths) that are characterized by abrupt periods of high discharge and minimal or no discharge to the bay. Although the general pattern of wet and dry seasons still persist, operation of coastal water control structures results in rapid changes in local salinity gradients that may occur on a daily basis and over several months, particularly during the rainy season (Fatt 1986). During the dry season, hypersalinity has been observed as a result of evaporation, retention of canal flow, and bay circulation (Lee 1975). While abrupt changes in salinity can occur naturally in nearshore habitats, they usually result from infrequent events such as hurricanes and tropical storms. The effects of salinity changes have been documented for fish (e.g. Davenport & Vahl 1975, Provencher et al. 1993, Serafy et al. in press) and for invertebrates (e.g. Brook 1982, Montegue and Ley 1993, Irlandi et al. in press). The presence and operation of the canals and construction of permanent oceanic inlets has resulted in a loss of estuarine function and shifted Biscayne Bay to more of a lagoon, adversely impacted from freshwater pulses and highly variable salinities. These conditions have been at least partly responsible for the loss of historically abundant estuarine species, such as red drum, black drum, and eastern oyster, the loss of juvenile fish habitat, and the significant increase in stress-tolerant fish species such as the gulf toadfish (Serafy et al., in press).

Biscayne Bay ecosystem restoration plans were initially considered by the South Florida Water Management District in a planning process that resulted in a water management plan, Surface Water Improvement and Management Plan for Biscayne Bay (SWIM Plan, Alleman 1995). This document provides a detailed discussion and analysis of water management needs in the Biscayne Bay watershed, including initial restoration plans for canal flow redistribution. It clearly outlines the rational for 1) reducing excessive canal discharges by flow management, 2) providing a stable brackish water habitat during the wet season, and 3) providing more water during dry periods to prevent hypersaline conditions from impacting important marginal wetlands and nearshore habitats. It also outlines research needs to further refine restoration designs and actions. Based on this plan and the consensus of government resource managers and university researchers, performance measures that would promote restoration of the Biscayne Bay ecosystem were established to permit evaluation of proposed water management alternatives.

Performance Measures

Performance measures were developed based on the potential effect of water management alternatives on surface water reaching Biscayne Bay. Canal discharges from gauged structures on canals that discharge into the bay were used. Based on SFWMM hydrologic model output, the bay was divided into five regions from north to south, based on the mean monthly discharge from water control structures in these regions. The regions were Snake Creek (S29), North Bay (G58, S28, S27), Miami River (S25, S25B, S26), Central Bay (G97, S22, S123), and South Bay (S21, S21A, S20F, S20G). Model output for each alternative provides results as the sum of discharge from the structures in each region in terms of a mean annual wet season and dry season volume. To judge the performance of a water management alternative in meeting restoration targets, model results were compared to surface water budget targets that were considered appropriate to achieving restoration of the Biscayne Bay ecosystem. These targets consist primarily of the existing average annual inflow to Biscayne Bay as defined by the 1995 Base hydrologic period, with a 2% increase in total inflow budget to be applied in the dry season to the Central and South Bay regions. A separate target for Snake Creek (S29) was also developed based on canal discharge that would maintain salinities for oyster survival.

Performance of individual alternatives was scored by comparing the predicted mean annual discharge for each alternative to the appropriate target for each region. A straight proportion of achieving the target was used to represent the degree to which the alternative achieved the target value, scaled from 0.0 to 1.0, for wet season, dry season, and for the total mean annual flow for that region. In instances for which an alternative exceeded the target, the score was automatically set to 1.0. An overall (total) bay performance measure was calculated using the total bay inflow from each of the regions defined by the SFWMM model.

Performance Evaluation

The scores in the following matrix are to be used only to rank the performance of the regional water management alternative in terms of supplying surface water to Biscayne Bay. They assume all components, especially the use of 're-use' water in alternatives C and D, are present. This refers to the use of 're-used' water or tertiary-treated domestic wastewater to replace water that will be withdrawn from the existing water management plan. The assumption that is implicit is that 're-used' water will be both available and appropriate for use in a valuable, pristine, marine environment that sustains Biscayne National Park. Additional feasibility studies must be pursued and completed before any component of an alternative will be considered appropriate. The use of this matrix does not constitute endorsement of any of the alternatives.

Biscayne Bay currently receives surface water in amounts that will, when properly distributed, permit partial restoration of the coastal ecosystem. Therefore, matrix scores for the bay that are less than 1.0 indicates a potential adverse impact to wildlife and fishery resources in the bay and in Biscayne National Park. Alternative D performs the best in terms of available water, but in terms of total bay inflow, Alternative D does not improve conditions for restoration beyond currently existing (1995 Base) conditions. As such, all alternatives currently proposed are considered as having a negative effect on the potential of achieving restoration of the Biscayne Bay ecosystem.

The following is a summary of water management alternative performance scores based on a comparison between SFWMM model output and restoration targets for mean annual surface water budgets for bay regions and for the total bay freshwater input.

Biscayne Bay Water Management Performance Scores

	1995 Base	2050 Base	Alternative A	Alternative B	Alternative C	Alternative D
North Bay						
Dry Season	1.00	0.90	0.51	0.93	0.93	0.93
Wet Season	1.00	0.96	0.52	0.97	0.98	0.98
Annual	1.00	0.94	0.51	0.96	0.96	0.96
Snake Creek						
Dry Season	0.55	0.46	0.15	0.31	0.33	0.30
Wet Season	1.00	1.00	0.85	1.00	1.00	1.00
Annual	1.00	0.98	0.44	0.70	0.74	0.69
Miami River						
Dry Season	1.00	0.65	0.40	0.45	0.37	0.32
Wet Season	1.00	0.62	0.55	0.39	0.33	0.33
Annual	1.00	0.63	0.50	0.41	0.34	0.33
Central Bay						
Dry Season	0.77	0.88	0.29	0.49	0.59	0.76
Wet Season	1.00	0.94	0.53	0.65	0.75	0.87
Annual	0.92	0.92	0.45	0.60	0.69	0.83
South Bay						
Dry Season	0.76	0.76	0.57	0.60	1.00	1.00
Wet Season	1.00	0.96	0.77	0.79	1.00	1.00
Annual	0.93	0.90	0.71	0.73	1.00	1.00
Dry Season	0.78	0.71	0.35	0.51	0.66	0.73
Wet Season	1.00	0.96	0.63	0.75	0.85	0.93
Annual	**0.98**	**0.87**	**0.53**	**0.66**	**0.78**	**0.86**

Biscayne Bay Groundwater Matrix Documentation

Groundwater Index

The index is the measure of the degree to which groundwater levels produced by each alternative match projected comparison conditions (NSM = primary comparison, Ghyben-Herzburg relationship for that indicator region = minimum target). Groundwater flows into Biscayne Bay are potentially important as a source of freshwater. Under conditions where high water stages occurred west of the Atlantic Coastal Ridge to within three miles of Biscayne Bay, historic groundwater flows were sufficient to support flowing springs that allowed the collection of drinking water for ships (Parker et al. 1955). Present day rates of groundwater discharge are evidently insufficient to produce such flowing springs (Mulliken and VanArman 1995). The desired groundwater levels for restoration are those that match historic conditions. The minimum acceptable groundwater levels to support the Biscayne Bay estuary are those sufficient to eliminate salt water intrusion to the Biscayne Aquifer, as theoretically measured by the Ghyben-Herzburg relationship.

The groundwater indicator regions are located at the edge of the SFWMM grid, and output results for NSM are, therefore, not accurate. They do, however, provide a relative measure for current vs. historical groundwater levels and are, therefore, a reasonable approximation for the direction in which groundwater levels should be restored in order to return historic groundwater flows to Biscayne Bay.

Since groundwater values were normalized to ground elevation, they are negative numbers and direct comparisons are difficult. Two indices were defined, therefore, to create proportional relationships that could be compared. The first index looks at the midpoint of the stage duration curve, and the second index uses the values representing the 90^{th} percentile of the stage duration curve. The midpoint was chosen to give an indication of the relative performance of the alternatives under moderate conditions. The 90^{th} percentile comparison gives an indication of the relative performance of the alternatives under severe drought conditions. NSM values consistently represented the wet extreme of the modeling scenarios, and one or more alternatives represented the dry extreme. The index sets up a comparison between the absolute difference between a particular alternative and NSM and the absolute difference between the dry and wet extremes, i.e. the worst alternative and NSM.

Indicator Regions Covered: 48, 49, 50, 51

Formula

The following formula sets up a proportional relationship showing the relative wetness of the alternative when compared to the range available. The index values vary from 0.0 to 1.0, with 1.0 equal to NSM conditions and 0.0 equal to the worst alternative.

Groundwater Index 1 = 1 - [(alternative value at 50% mark of stage duration curve)-(NSM value at 50% mark of stage duration curve)]/[(worst alternative value at 50% mark of stage duration curve)-(NSM value at 50% mark of stage duration curve)]

Minimum Target 1 = 1- [(low water target value for indicator region)-(NSM value at 50% mark of stage duration curve)]/[(worst alternative value at 50% mark of stage duration curve)-(NSM value at 50% mark of stage duration curve)]

Groundwater Index 2 = 1 - [(alternative value at 90% mark of stage duration curve)-(NSM value at 90% mark of stage duration curve)]/[(worst alternative value at 90% mark of stage duration curve)-(NSM value at 90% mark of stage duration curve)]

Minimum Target 2 = 1 - [(low water target value for indicator region)-(NSM value at 90% mark of stage duration curve)]/[(worst alternative value at 90% mark of stage duration curve)-(NSM value at 90% mark of stage duration curve)]

Note: For Indicator Region 51 (South Biscayne Bay), the NSM value was less than the low water target at the 90^{th} percentile, so the equation for this indicator region was changed to use the low water target as the standard for comparison. The equation for this indicator region was:

Groundwater Index 2 (IR51) = 1 - [(alternative value at 90% mark of stage duration curve)-(low water target for IR51)/(worst alternative value at 90% mark of stage duration curve)-(low water target for IR51)]

The minimum index for comparison was:

Minimum Target 2 (IR51) = 1 - [(low water target value for IR51)-(low water target for IR51)]/[(worst alternative value at 90% mark of stage duration curve)-(low water target for IR51)]

Summary Matrix

The summary matrix was derived by averaging the results from each indicator region for each alternative. Values for the Central and South Biscayne Bay indicator regions (IR50, IR51) were weighted more heavily in the analysis by adding them twice into the average. This weighting system was selected to give priority to alternatives that improved conditions within Biscayne National Park. NSM values were not included because NSM values were presented for comparison purposes only; it is not a target.

Interpretation

The matrix for the 50th percentile of the stage duration curves shows almost no difference among the alternatives. The raw index scores varied from 0.000 to 0.080 on a scale of zero to one. None of the alternative scores exceeded the low water target for that region, although Alternative D in Indicator Region 50 came closer than any other scenario. For three of the four indicator regions, the 1995 Base condition was the best among the alternatives. When the indices were averaged, 1995 Base conditions were slightly better than alternatives C and D, though the separation among the three was very small. These results indicate that under average conditions, almost nothing in the Restudy has had any effect on groundwater elevations near the Atlantic Coastal Ridge, and nothing proposed to date in the Restudy has made any difference with respect to restoring groundwater flows to Biscayne Bay. Results for Alternative D13R were identical to those for Alternative D.

The matrix for the 90th percentile of the stage duration curves shows some differences among the alternatives. The 90th percentile represents conditions of severe drought, and any improvement in this part of the curve over base conditions would probably mean some maintenance of groundwater flows under drought conditions. The raw index scores varied from 0.000 to 0.463, with the low water target index at 1.000 for comparison. The alternative with the best scores varied by indicator region, but the 1995 Base, Alternative C and Alternative D were usually close, except for Central Biscayne Bay (IR50), where the 1995 Base was clearly the worst alternative. Alternative B produced moderately good results for Indicator Region 48 and Indicator Region 50. When the indices were averaged, however, alternatives C and D came out much better than base conditions or Alternative B, with Alternative D performing slightly better than Alternative C. The provision of additional water appears to help maintain groundwater levels in the region during extreme drought conditions, and may play an important role in maintaining some degree of groundwater flow to Biscayne Bay during periods of extreme drought. Results for Alternative D13R were identical to those for Alternative D.

It should be emphasized that these conclusions were made on the basis of a very small improvement to groundwater conditions under severe drought conditions. None of the alternatives come close to meeting the minimum water level targets set for the indicator regions. The overall conclusion must be that although Alternatives D/D13R perform better than the other alternatives, nothing proposed to date in the Restudy has made a significant difference with respect to restoring groundwater flows to Biscayne Bay. It is hoped that additional means for improving groundwater flows will be sought and implemented as part of the design phase of the project.

Notes on Biscayne Bay Groundwater Matrix Interpretation

It is clear from these results that additional water sources can make a noticeable contribution toward maintaining groundwater levels for Central and South Bay during drought conditions. These results mirror effects seen in the surface water output. The source of the water is, however, a concern. Treated wastewater has not yet been unequivocally shown to be an economically and environmentally feasible alternative, and dependence upon this source to supplement water supplies to the bay could prove short sighted, should it be eliminated as a source in the future. It is strongly recommended, therefore, that alternative sources of water be identified during the design phase that could be used to provide water deliveries for the bay.

Notes on Biscayne Bay Surface Water Matrix Interpretation

The alternative analysis has only addressed surface water timing issues in a very superficial manner and only in the vicinity of Biscayne National Park. More needs to be done to address this problem in the more urbanized areas of the bay.

The alternative analysis has not adequately addressed water quality issues for either surface water or groundwater moving to the bay. In areas where less surface water is delivered to the bay via canals, pollutants from urban sources are likely to increase in concentration. This is a particularly formidable problem in the Miami River, where the source for many pollutants is well downstream from where water is being stored (the Lakebelt Reservoir). By the time the river water is discharged into the bay, the large reduction in volume may result in a substantial increase in pollutant concentration. More attention should be given to addressing such concerns prior to finalizing a project design.

Biscayne Bay Evaluation Matrix, by Indicator Region, Final Draft 7/31/98

Values vary from 0 to 1, with larger values preferred. Preferred alternatives produce index values greater than the minimum index value for that percentile.

Indicator Region: 48 (North Biscayne Bay Groundwater 1)	**Alt #**	**Raw Value, 50%**	**G.W. Index 1 (50%)**	**Min.Index 1 (50%)**	**Rank by Region**	**Raw Value, 90%**	**G.W. Index 2 (90%)**	**Min. Index 2 (90%)**	**Rank**
Low Water Target		**-5.11**				**-5.11**			
Worst Alternative Value	50Base	**-7.65**				**-8.00**			
NSM		**-2.00**	**1.000**	**0.450**		**-4.45**	**1.000**	**0.814**	
95Base		**-7.50**	**0.027**	**0.450**	**1**	**-7.85**	**0.042**	**0.814**	**1**
50Base		**-7.65**	**0.000**	**0.450**	**3**	**-8.00**	**0.000**	**0.814**	**3**
Alternative A		**-7.65**	**0.000**	**0.450**	**3**	**-8.00**	**0.000**	**0.814**	**3**
Alternative B		**-7.60**	**0.009**	**0.450**	**2**	**-7.95**	**0.014**	**0.814**	**2**
Alternative C		**-7.60**	**0.009**	**0.450**	**2**	**-7.95**	**0.014**	**0.814**	**2**
Alternative D/D13		**-7.60**	**0.009**	**0.450**	**2**	**-7.95**	**0.014**	**0.814**	**2**

Indicator Region: 49 (North Biscayne Bay Groundwater 1)	**Alt #**	**Raw Value, 50%**	**G.W. Index 1 (50%)**	**Min.Index 1 (50%)**	**Rank by Region**	**Raw Value, 90%**	**G.W. Index 2 (90%)**	**Min. Index 2 (90%)**	**Rank**
Low Water Target		**-5.00**				**-5.00**			
Worst Alternative Value	Alt A	**-6.00**				**-6.45**			
NSM		**-0.15**	**1.000**	**0.171**		**-2.65**	**1.000**	**0.382**	
95Base		**-5.90**	**0.017**	**0.171**	**1**	**-6.35**	**0.026**	**0.382**	**1**
50Base		**-6.00**	**0.000**	**0.171**	**2**	**-6.40**	**0.013**	**0.382**	**2**
Alternative A		**-6.00**	**0.000**	**0.171**	**2**	**-6.45**	**0.000**	**0.382**	**3**
Alternative B		**-6.00**	**0.000**	**0.171**	**2**	**-6.35**	**0.026**	**0.382**	**1**
Alternative C		**-6.00**	**0.000**	**0.171**	**2**	**-6.35**	**0.026**	**0.382**	**1**
Alternative D/D13		**-6.00**	**0.000**	**0.171**	**2**	**-6.35**	**0.026**	**0.382**	**1**

Indicator Region: 50 (Central Biscayne Bay Groundwater)	**Alt #**	**Raw Value, 50%**	**G.W. Index 1 (50%)**	**Min.Index 1 (50%)**	**Rank by Region**	**Raw Value, 90%**	**G.W. Index 2 (90%)**	**Min. Index 2 (90%)**	**Rank**
Low Water Target		**-7.51**				**-7.51**			
Worst Alternative Value	Alt A(50), 95B(90)	**-7.85**				**-8.70**			
NSM		**-4.35**	**1.000**	**0.097**		**-6.40**	**1.000**	**0.517**	
95Base		**-7.65**	**0.057**	**0.097**	**2**	**-8.70**	**0.000**	**0.517**	**5**
50Base		**-7.70**	**0.043**	**0.097**	**3**	**-8.60**	**0.043**	**0.517**	**4**
Alternative A		**-7.85**	**0.000**	**0.097**	**5**	**-8.60**	**0.043**	**0.517**	**4**
Alternative B		**-7.80**	**0.014**	**0.097**	**4**	**-8.50**	**0.087**	**0.517**	**3**

Biscayne Bay Evaluation Matrix, by Indicator Region, Final Draft 7/31/98

Values vary from 0 to 1, with larger values preferred. Preferred alternatives produce index values greater than the minimum index value for that percentile.

Alternative C		**-7.65**	**0.057**	**0.097**	**2**	**-8.20**	**0.217**	**0.517**	**2**
Alternative D/D13		**-7.60**	**0.071**	**0.097**	**1**	**-8.10**	**0.261**	**0.517**	**1**

Indicator Region: 51 (South Biscayne Bay Groundwater)	**Alt #**	**Raw Value, 50%**	**G.W. Index 1 (50%)**	**Min.Index 1 (50%)**	**Rank by Region**	**Raw Value, 90%**	**G.W. Index 2 (90%)**	**Min. Index 2 (90%)**	**Rank**
Low Water Target		**-2.97**				**-2.97**			
Worst Alternative Value	Alt A	**-3.27**				**-4.05**			
NSM		**-1.55**	**1.000**	**0.174**		**-3.45**	**0.556**	**1.0**	
95Base		**-3.13**	**0.081**	**0.174**	**1**	**-3.85**	**0.185**	**1.0**	**2**
50Base		**-3.23**	**0.023**	**0.174**	**3**	**-4.05**	**0.000**	**1.0**	**4**
Alternative A		**-3.27**	**0.000**	**0.174**	**5**	**-4.05**	**0.000**	**1.0**	**4**
Alternative B		**-3.25**	**0.012**	**0.174**	**4**	**-3.95**	**0.093**	**1.0**	**3**
Alternative C		**-3.15**	**0.070**	**0.174**	**2**	**-3.55**	**0.463**	**1.0**	**1**
Alternative D/D13		**-3.15**	**0.070**	**0.174**	**2**	**-3.55**	**0.463**	**1.0**	**1**

Biscayne Bay Evaluation Matrix Summary, Final Draft 5/27/98

Alternative #:	95BSR	50BSR	Alt A	Alt B	Alt C	Alt D
50th Percentile Average Index*:	0.053	0.022	0.000	0.010	0.044	0.049
50th Percentile Rank:	1	3	5	4	2	2
90th Percentile Average Index*:	0.073	0.017	0.014	0.067	0.234	0.248
90th Percentile Rank:	2	3	3	2	1	1

*Central and South Biscayne Bay Regions given a weight of 2 each for averaging in consideration of National Park issues.

D.8.14 Keystone / Endangered Species / ATLSS

Performance Based Comments

For Alternative D13R ATLSS high resolution hydrology results and breeding potential index, individual-based simulation and Population Viability Analysis results for the Cape Sable seaside sparrow are available. Fish abundance, snail kite foraging conditions index, wading bird foraging conditions index and white-tailed deer breeding potential index results are presented. American crocodile performance measure results are also presented.

Fish

The ATLSS fish model results have consistently predicted higher overall fish abundances as flow volume and inundation duration have moved closer to NSM conditions. Continuing this trend, ATLSS results suggest that Alternative D13R hydrologic conditions should produce average fish abundances higher than those expected for 2050 Base, and slightly higher than other alternatives as expected hydroperiods increase consistent with NSM. In particular, increased hydroperiods in NE Shark River Slough, Taylor Slough, WCA-3B, northeast WCA-3A, and WCA-1 should lead to greater fish abundance. This is also true when only prey-sized fish at appropriate wading bird foraging depths are counted except for the deepest parts of Shark River Slough and WCA-3B.

Wading Birds

Alternative D13R reduces many of the excessive high water conditions and excessive inundation durations that had caused concern for eastern WCA-3A, southern WCA-3A and WCA-3B in several previous alternatives. These improvements should provide relatively larger areas suitable for wading bird foraging and decreased flood-induced losses of wading bird nesting substrates in WCA-3 under Alternative D13R as compared to Alternative D. When compared to the 2050 Base, Alternative D13R provides mixed results for wading birds in WCA-3, with improvements in southern WCA-3A (due to reduced high water) and in northern WCA-3A (due to reduced drydowns), and losses in northeastern WCA-3A and WCA-3B (due to increased high water).

Results for the southern Everglades and for Florida Bay also indicate that Alternative D13R better matches natural conditions in these areas than other alternatives. The improvement in the timing and duration of freshwater flows to Florida Bay estuaries and improved timing of food-concentrating drydowns should lead to better wading bird foraging and breeding conditions in the southern Everglades under Alternative D13R relative to both base cases. Greater fish abundances expected under Alternative D13R, as compared to the 2050 Base, also suggest improved foraging conditions for wading birds.

Wood Storks

ATLSS long-legged wading bird results and a wood stork performance measure recently developed by John Ogden are used to evaluate wood stork responses under Alternative D13R. Both the ATLSS high resolution hydrology results and inspection of the Shark Slough inundation duration and mainland estuary flow volume information used in the performance measure reveal significant improvements in hydroperiods, volume and timing of flows under all alternatives, including Alternative D13R as compared to 2050 Base. This should provide significantly improved forage availability in the Florida Bay estuaries that historically supported the majority of wood stork nesting, and may result in beneficial earlier nest initiation cues for wood storks. Comparison of Alternative D13R with Alternative D provides mixed results, with improved inundation duration in Shark Slough Indicator Region 10 but not Indicator Region 9, and no significant difference for freshwater flows to Florida Bay estuaries. Therefore, Alternative D13R cannot be distinguished from alternatives A-D in terms of wood stork habitat suitability.

Snail Kites

In general, comparison of hydrology expected under Alternative D13R vs. the 2050 Base shows significant progress toward natural conditions represented by NSM. Such a shift towards more natural conditions produces a slight improvement in overall foraging conditions for snail kites due to an overall increase in extent of longer hydroperiod areas conducive to apple snail production, and a reduction in artificially impounded areas having persistent deep water that causes long-term loss of snail kite nesting substrates. Snail kite foraging habitat would probably shift from some current high-use areas such as WCA-2B and southern WCA-3A to central and eastern WCA-3A, northern WCA-3B and the flanks of Shark River Slough where Alternative D13R would provide longer hydroperiods suitable for sustained apple snail production. Benefits would be particularly apparent in low water years due to the overall increase in water available to the natural system under Alternative D13R and the snail kite's particular sensitivity to reduction of suitable foraging habitat during drought. Benefits to snail kites under Alternative D13R cannot be distinguished from those expected under alternatives C and D. Expected benefits under Alternative D13R would probably not influence long term trends in the overall snail kite population because other habitats, outside the area modeled for Restudy alternatives, are thought to be more important to the species as a whole.

White-tailed Deer

Alternative D13R reduces many of the excessive high water conditions and excessive inundation durations that had caused concern for eastern WCA-3A, southern WCA-3A and WCA-3B in several previous alternatives. These improvements provide slightly better foraging conditions and reduced drowning losses for white-tailed deer in WCA-3 under Alternative D13R as compared to Alternative D. Overall increased hydroperiods in most of the WCAs and northeastern Big Cypress under Alternative D13R as compared to the 2050 Base would slightly decrease habitat quality in these marginal deer habitats. Small areas of northeastern and southern WCA-3A and the Big Cypress-ENP border area are exceptions. Alternative D13R continues progress towards NSM-like conditions in most of ENP and would be expected to continue to produce reduced white-tailed deer habitat suitability in many already poor deer habitats there. For those few areas with high deer breeding potential (Long Pine Key and surrounding short hydroperiod marsh and NW Big Cypress), there is little difference between Alternative D13R and the 2050 Base.

Florida Panther

Review of the Alternative D13R ATLSS high resolution hydrology results shows that no change is expected in the higher elevation pine flatwood and hardwood hammock habitats preferred by Florida panthers. Additionally, discussions with panther experts Dennis Jordan and Sonny Bass (personal communications, June 1, 1998) indicate that slight reductions in the quality of already poor deer habitats, as expected under Alternative D13R, would not have an effect on panther populations.

Cape Sable Seaside Sparrow

Predicted results for Alternative D13R rely on ATLSS modeling results and April 24 and June 1, 1998, discussions with species experts Stuart Pimm, Sonny Bass, Phil Nott, and John Curnutt.

ATLSS Breeding Potential Index results showed consistently lower breeding potential for Cape Sable seaside sparrows in eastern habitats and in the southeastern part of the western subpopulation habitat under Alternative D13R as compared to Alternatives B, D and the 2050 Base. However, the sparrow Breeding Potential Index does not take population dynamics or fire return frequencies into account. When reductions in damaging fire return frequencies in the sparrow's eastern habitats expected to result from hydroperiod increases like those in Alternatives B-D and D13R are factored in, these alternatives are likely to significantly improve sparrow habitat suitability in the eastern marl prairie areas. The central population is unlikely to be affected by any of the alternatives due to its higher elevation.

The ATLSS individual-based sparrow model includes detailed simulations of population dynamics, and therefore provides better information on the expected effects of management scenarios than does the Breeding Potential Index. The ATLSS individual-based sparrow simulation is applied only to the western sub-population, and predicts persistence of this sub-population under Alternative D13R and the 2050 Base. Alternative D13R produced higher population levels and a lesser risk of extirpation than alternatives B and D. A Population Viability Analysis using the individual model predicts that the western subpopulation will be more likely to remain above minimum numbers and reach or exceed maximum numbers under Alternative D13R than under alternatives Band D or either base.

Overall, Alternative D13R should improve conditions for the Cape Sable seaside sparrow as compared to the 2050 Base, and will likely contribute to the recovery of this subspecies.

American Crocodile

The Crocodile habitat suitability performance measure shows that Alternative D13R would produce significantly lower salinity ranges in important Florida Bay crocodile habitats as compared to the 2050 Base. This should provide improved nursery habitat availability for hatchling crocodiles and increase availability of low salinity habitats preferred by adult crocodiles. These results are not distinguishable from those for alternatives A-D.

Performance Measures and Indicators Used

ATLSS High Resolution Hydrology
Breeding Potential Index for the Cape Sable seaside sparrow
Foraging Conditions Index for the snail kite
Foraging Conditions Index for short and long-legged wading birds
ATLSS Cape Sable seaside sparrow Individual-based Simulation
ATLSS Cape Sable seaside sparrow Population Viability Analysis
ATLSS Fish Model
American Crocodile Performance Measure
Wood Stork Nesting Patterns Performance Measure

Recommendations

Continue development and use of ATLSS modeling as a tool for further planning, design and adaptive management.

Subteam Issues

The sparrow west indicator region shows that NSM predicts longer hydroperiods in the western sub-population area that would lead to further declines in sparrow habitat suitability. The subteam urges Restudy participants to reconsider NSM-based targets when biological information, such as sparrow breeding needs, suggests different targets.

Table - ATLSS and Listed Species

Summary Table for ATLSS & Listed Species Rankings

Species	2050 Base	Alt A	Alt B	Alt C	Alt D	D13
CSS Sparrow	5	4	1	1	1	1
Snail Kite	5	3	3	1	1	1
Word Stork	5	1	1	1	1	1
Panther	1	1	1	1	1	1
Crocodile	5	2	2	2	1	1
Deer	5	2	1	2	2	2
Wading Birds	5	3	3	1	1	1
Fish	5	3	3	1	1	1

D.8.15Water Quality

For each of the alternative plans A – D13R, plan components were examined to identify potential water quality impacts or benefits resulting from the operation of that component and the regulatory or ecosystem management programs affecting the future implementation of the component. The Water Quality subteam considered in detail existing federal, state, and Tribal water quality regulatory programs in the study area. Specific issues which were considered by the Water Quality subteam during evaluations of alternative plans include numeric and narrative water quality criteria, designated uses of source and receiving water bodies, special classifications (e.g., Outstanding Florida Waters), and existing and projected pollution loads.

In addition, an evaluation of the effect of Restudy alternative plans on hydraulic and phosphorus loads into and predicted performance of the Everglades Construction Project was performed by William W. Walker, Jr. (Walker, 1998) using hydrologic outputs of the South Florida Water Management Model. The Water Quality subteam also utilized hydrologic outputs from the South Florida Water Management Model to evaluate the extent of hydrologic change and corresponding water quality impacts or benefits resulting from the implementation of the alternative plans in other sub-regions of the study area. It should be noted that the subteam was not able to empirically evaluate the effect of Restudy alternatives on water quality conditions in the Big Cypress basin or the Holey Land and Rotenberger Wildlife Management Areas. For those areas, a qualitative assessment was made based upon the proposed operation of the components contained in the alternatives.

Alternative plans A – D13R and the 1995 and 2050 base conditions were compared. A ranking matrix was prepared which indicated the relative performance of the base conditions and the alternative plans utilizing the key water quality performance measures and indicators identified by the Water Quality subteam (see Table X). The subteam concluded that from a water quality perspective, Alternative D13R was preferred over Alternatives B, A, and C. The 1995 Base and the 2050 Base alternatives were not acceptable from a water quality perspective. Alternative D13R was preferred over the other alternatives based primarily on improved results for key performance indicators in Everglades National Park, the St. Lucie River estuary, and the Lower East Coast.

Specifically, for Everglades National Park, the structural phosphorus load delivered into the Park calculated by the EWQM was “zero” for Alternatives D13R and B due to decompartmentalization features of those alternatives. The Water Quality subteam determined that this was a preferred condition for the Park. For the St. Lucie River estuary, regional storage volume and modifications to the operation of the regional water supply system were optimized in Alternative D13R to achieve hydrologic targets in the St. Lucie River estuary. In the Lower East Coast sub-region, the pollutant attenuation functions of selected reservoirs (as expressed by the reservoir hydrographs and stage duration curves) was best in Alternative D13R.

TABLE
Restudy Water Quality Subteam's Combined Ranking Matrix
Recommendations/Comments to the Restudy Team

The base conditions and alternative plans were ranked on a scale of 1-7, with higher scores indicating a more preferred condition from a water quality perspective.

Subregion	95B	50B	A	B	C	D	D13R
1. Lake Okeechobee (see footnote 1)	2.5	2.5	2.5	6.5	4.5	6.5	4.5
2. EAA/ECP	1	3.5	7	6	3.5	2	5
3. WCAs 2 & 3 (see footnote 3)	1	6	7	2	3	4.5	4.5
4. St. Lucie Watershed	1	2	3.5	3.5	5	6	7
5. Caloosahatchee Watershed	1.5	1.5	3	4	5	6.5	6.5
6. LNWR	1	2	5	5	5	5	5
7. ENP	1.5	5	3.5	6.5	1.5	3.5	6.5
8. LEC (see footnote 4)	4.5	4.5	1	2	3	6.5	6.5
Cumulative Score	***14***	***27***	***32.5***	***35.5***	***30.5***	***40.5***	***45.5***

FOOTNOTES

Ranking of alternatives for Lake Okeechobee is based on evaluation of selected performance indicators. Comparing alternatives, differences greater than one percent in relative performance calculated by the model were assigned different ranks. Although the differences between simulated conditions for the alternatives are within the uncertainty of the model, the Water Quality Team felt it was important to rank the plans for Lake Okeechobee from a water quality perspective.

Water Conservation Areas 2 & 3 rankings were weighted to account for relative size (acreage).

Ranking of the alternatives based on an evaluation of potential water quality impacts/benefits in the LEC is primarily based upon salinity targets in Lake Worth and Biscayne Bay. The presumed water quality benefits resulting from an evaluation of the hydraulic performance of selected reservoirs were also evaluated. For those performance indicators, a score of zero was assigned to alternatives for which no hydraulic performance for the reservoirs was observed.

Recommendations/Comments to Restudy Team

From a water quality perspective, Alternative D13R was preferred over Alternatives B, A, & C. The 95 Base and the 50 Base were not acceptable.

The Water Quality Team determined that the Base Conditions and alternative plans should not be ranked based upon the U. S. Environmental Protection Agency's preliminary mercury model results (model needs further development). Atmospheric deposition is the dominant contributor of mercury in the Everglades Protection Area. Restudy alternative plans are not expected to significantly affect mercury in the Everglades Protection Area.

Due to a lack of model results (particularly Everglades Landscape Model results), Restudy alternative plans could not be ranked based upon water quality impacts or benefits in Big Cypress National Preserve and the Holeyland and Rotenberger Wildlife Management Areas.

D.9 SUMMARY REPORT OF SCENARIO D13R4

The Alternative Evaluation Team conducted a preliminary evaluation of the D13R4 scenario during a meeting of the full AET on 20 January 1999. The objective of this modeling exercise was to determine the feasibility of improving D13R, by capturing additional surplus water from the amount discharged to tide each year, and of conveying that "new" water (plus redistributing excessive water in the Water Conservation Areas) to better meet performance targets in the natural system. Scenarios designed to convey urban runoff water into the natural system have not previously been considered during the lengthy AET/ADT plan formulation process. The D13R4 scenario reported on here was clearly the most successful of four scenarios (R1–R4) that were developed during an intensive, multi-agency planning and modeling process, which began in November 1998.

The AET found that the overall performance of Scenario D13R4, as modeled on 13-14 January, included both gains and losses when measured against the 1995 base, 2050 base, and D13R conditions. D13R4 captured an average of 245,000 acre feet/year of new water for the natural system from Palm Beach and Broward counties. This new water, combined with excessive water from the WCAs, provided an average of 271,000 acre feet of new water each year to Everglades National Park and an average of 77,000 acre feet of new water to Biscayne Bay each year. The increased annual mean flows to the park and Biscayne Bay are expected to produce substantial improvements towards meeting the hydrological performance targets for these two areas. Although D13R4 also provided modest improvements in northeast WCA 3A and northeast 2B, by reducing the number of undesirable high water events in these two subregions, this scenario increased the number of undesirable high water events in WCAs 2A and 3B to a level greater than that predicted for the two base conditions. D13R4 also created undesirable increases in the depth and duration of flooding in the Pennsuco wetlands. By delivering urban water to the natural system, this scenario raises a number of new water quality questions.

The AET recognizes that much new information regarding the potential performance of D13R was gained during the modeling of the four scenarios R1-R4 of D13R. The hydrological responses during the modeling of these four scenarios convincingly demonstrated the operational flexibility of D13R, and offers encouraging documentation that additional improvements can be achieved during the detailed planning phases of the restoration program.

The AET recommended that the specific features of D13R4 that allowed for the capture and conveyance of substantial amounts of new water for the natural system be incorporated into the Recommended Plan, D13R, contingent upon:

- finding ways to reduce the number of damaging high water events in WCA 2A and 3B to a level at or below the level predicted for D13R;
- adequately treating the stormwater runoff from the C-51 east/C-13/14 basins directed into the Everglades Protection Area to meet all state and federal water quality standards to enable ecological restoration to be achieved; and
- moderating excessive high water events in the Pennsuco wetlands.

It was agreed that these concerns can best be resolved during the finer scale modeling and planning which will occur as a part of detail design work. The addition of these features should allow greater operational flexibility during future efforts to improve the overall performance of D13R. An issue paper may be required from the Restudy's water quality team, to more fully explore the questions being raised by the use of urban water to meet natural system targets in Everglades National Park.

D.9.1 AET Subregional "Bullet" Summary Evaluations of D13R4:

Water Quality

For the first time, 245,000 acre feet/year of urban runoff was captured, treated, and sent into the natural system to augment flows to Everglades National Park and Biscayne Bay, raising the following questions:

D13R4 assumes that the technology exists for treating urban stormwater for a whole suite of water quality parameters beyond nutrients.

There may not be sufficient land available to adequately treat the volume of wet season runoff this scenario requires.

Due to complex pollutant loads associated with urban runoff, future permitting of new discharges of treated urban runoff to Outstanding Florida Waters (ENP & Biscayne Bay) is expected to be difficult for the responsible regulatory agencies.

The additional treatment and routing facilities add a new layer of complexity to the sequencing of the implementation plan

Benefits of the new water will not be seen until all necessary water treatment components are up and running.

Total System

Connectivity was similar to D13R except for an increase in extreme depth differences between WCA-2 and WCA-3.

Sheetflow in WCA-2B showed an NSM-like pattern for the first time. Flows also improved across Tamiami Trail east of L-67 and the eastern part of Everglades National Park.

Fragmentation was the same as D13R. No additional canals and levees were removed within the natural system.

Northern Estuaries

Caloosahatchee: No change.

St Lucie Estuary: One additional discharge event over the 31-year period of record.

Lake Worth: Far fewer adverse discharges of fresh water.

Lake Okeechobee

No change.

Lower East Coast

Water supply performance is the same as D13R except there are two additional months in Broward County of low water conditions along the coast in the 31-year period of record.

Northern and Central Everglades

Eastern and northeastern WCA-3A and WCA-2B are better, but still far from the NSM envelope. New problems arose in WCA-2A and WCA-3B. The modest benefits were seen in some of the more degraded areas but serious problems developed in more pristine parts of the system.

Southern WCA-2A: Much worse than all plans and base conditions in extreme high water and extreme low water conditions. Increasing the flows through WCA-2A during the wet season only raised depths without helping increase hydroperiods into the dry season.

WCA-2B: Extreme lows improved in the northern part, extreme highs increased slightly in some areas and there were substantial improvements in hydroperiod. Part of WCA-2B is approaching NSM-like conditions; the rest is still outside the NSM envelope.

Eastern WCA-3A: General improvement in extreme high water conditions, particularly the area east of the Miami Canal. South of Alligator Alley, high water conditions are still poor. Extreme low water conditions did not change. The area is still outside the NSM envelope for both high and low water extremes.

WCA-3B: High water conditions worsened. In the west, they are worse than the 1995 base, in the east they are worse than both bases. Both the frequency and depths of high events are far outside the NSM envelope for any NSM landscape. This problem must be resolved.

Pennsuco

Both water levels and hydroperiods worsened relative to D13R. Water levels in the Pennsuco increased sufficiently higher to present a threat to tree islands.

Biscayne Bay

An additional 77,000 acre feet/year of water was sent to Biscayne Bay, greatly improving conditions. Flows could be balanced better between parts of the bay but there is obviously the flexibility within the plan to do so.

With some minor redirection of wet season flows between Central and South Biscayne Bay, D13R4 could meet targets in Central and South Biscayne Bay without reuse water from the proposed South Miami-Dade coastal reuse facility.

Model Lands

D13R4 slightly increases water levels in coastal wetlands, particularly east of U.S. 1 during the dry season.

Big Cypress

No change from D13R. Some water that used to flow west toward Roberts Lake Strand under NSM conditions still tends to move east as it did in D13R, apparently because of topography differences between NSM and SFWMM in the jetport vicinity. This is not good, but not a major problem.

Southern Everglades

D13R4 delivered 271,000 acre feet/year of "new" water to Everglades National Park and performance measures closely approached targets for Shark River Slough and the Florida Bay coastal basins and exceeded targets in Rockland Marl Marsh.

Endorsement of D13R4 by the AET regarding benefits to the southern Everglades should be strongly conditional on reversing potentially damaging effects to WCA-2A and WCA-3B and on providing adequate water quality treatment during detailed design and modeling.

Endangered Species

Preliminary analysis shows no change to Cape Sable Seaside Sparrow, maybe a slight improvement for eastern populations.

Improved conditions for wood storks, crocodiles, and manatees.

ATLSS modeling results may show some snail kite concerns.

D.9.2 Uncertainties

The NSM topography in NE Shark River Slough is assumed to be the same as current topography, although recent data collected by EPA scientists indicate that substantial soil subsidence has occurred since the 1940's. This discrepancy in the topographic model very likely affects the depth targets for NESS. If the NSM topography were altered to have comparable soil subsidence assumptions for WCA-3B north of Tamiami Trail and NESS south of Tamiami Trail, then target depths in NESS would probably be shallower, less water will be needed to meet those targets, and excess depths in WCA-3B would be reduced.

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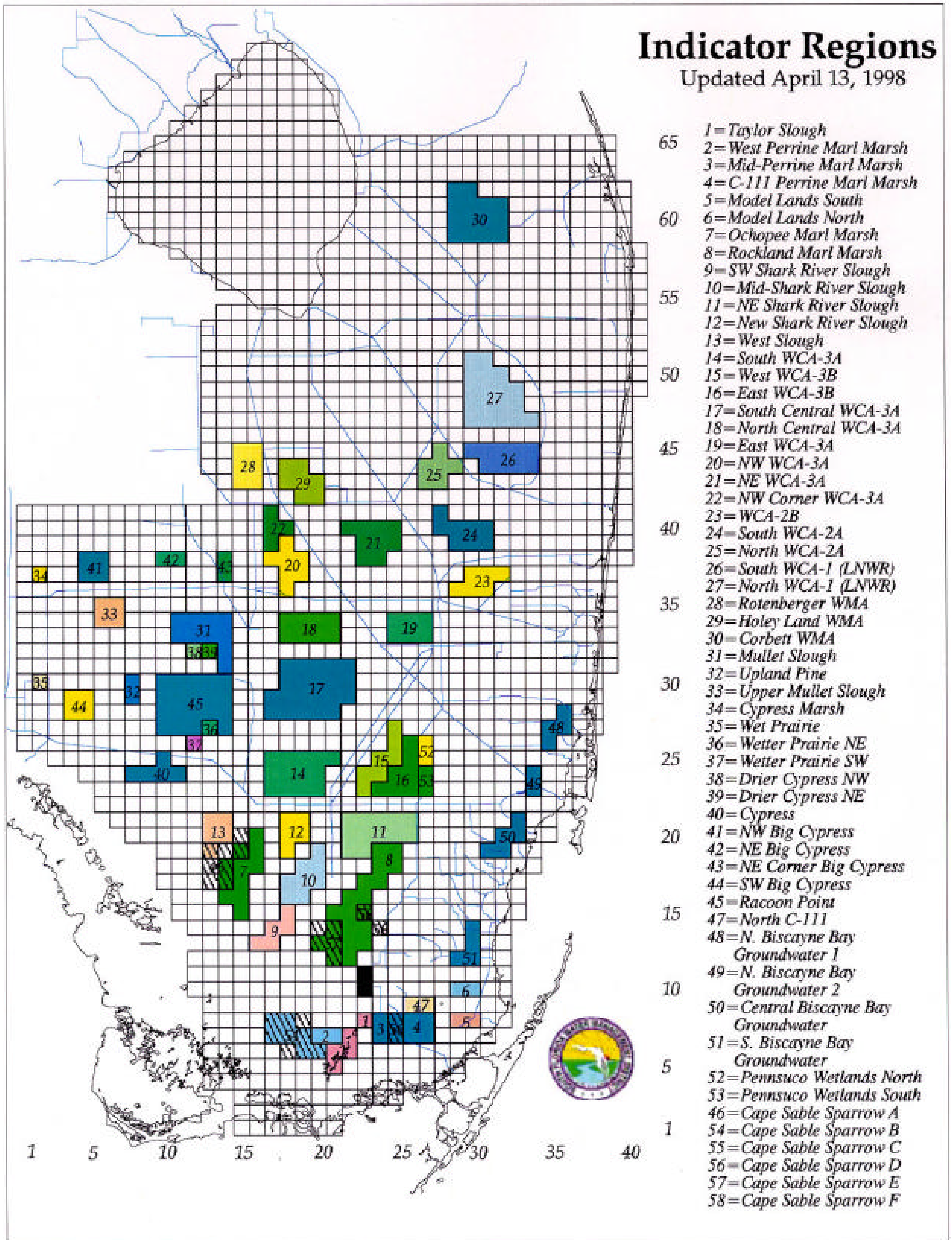

FIGURE 1 . INDICATOR REGIONS

ATTACHMENT A

DRAFT CONCEPTUAL MODELS

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ATTACHMENT A
DRAFT CONCEPTUAL MODELS

D-A.1 OVERVIEW OF THE CONCEPTUAL ECOLOGICAL MODELS

This Section describes the role of the Draft Conceptual Ecological Models in the Planning and Evaluation of the South Florida Ecosystem Restoration Program.

D-A.1.1 PREPARERS

John C. Ogden and Steven M. Davis, Senior Ecologists, Executive Office, South Florida Water Management District, West Palm Beach, Florida.

D-A.1.2 INTRODUCTION

The Central and South Florida Restudy and the Southern Everglades Restoration Alliance have adopted the “Applied Science Strategy” as a process for effectively linking science and management during all phases of the planning and evaluation of the south Florida ecosystem restoration programs (SCT 1997, Ogden et al. 1997). The thrust of this strategy is to organize our current, technical understandings of the biology and ecology of natural systems in south Florida into formats that maximize the effectiveness of this information in influencing and supporting policy and management actions. The Applied Science Strategy is a regional and multi-disciplinary process for determining the most appropriate measures of success, and for measuring and evaluating natural system responses resulting from each iteration of the restoration programs. These tasks are prerequisite to the successful application of adaptive assessments during the implementation of the restoration programs. The Applied Science Strategy has been endorsed by the Science Coordination Team of the South Florida Ecosystem Restoration Working Group.

An essential step in the Applied Science Strategy is the creation of a set of conceptual ecological models of the major wetland landscape features in south Florida. These simple, non-quantitative models are an effective means for developing a consensus regarding a set of causal hypotheses, which explain the affects that the major anthropogenic stressors have on the wetland systems. Each model shows the ecological and biological effects of these stressors, the attributes in the natural systems that are the best indicators of the changes which have occurred as a result of the stressors, and the most appropriate measures for each of the attributes. The development of a consensus regarding the components and linkages in the conceptual models is the basis for developing specific hydrological, ecological, and biological performance measures, and for designing a regional, performance-based ecological monitoring program. Conceptual models have been widely used for similar purposes in other regions of North America (e.g., pp. 31-38 in Gentile 1996; also see Rosen et al. 1995).

This report presents the schematic and narrative descriptions for eight conceptual ecological models that are being used by the C&SF Restudy team. The models serve as a basis for developing performance measures and for designing a performance-based monitoring program, for assessing and adaptively managing the south Florida ecosystem restoration program. These eight models are for Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, the ridge and slough Everglades, the Big Cypress basin, the southern marl prairies, the southern mangrove estuary, Biscayne Bay, and Florida Bay .

D-A.1.3 METHODS

The set of conceptual models were developed and reviewed by over 100 scientists and resource managers who participated in a concentrated program of workshops between October 1996 and August 1997. These workshops were open to all interested participants. Special efforts were made to invite the field scientists in south Florida who have had considerable "hands-on" research experience in these landscapes, and who could bring strong, intuitive perspectives for these systems to the modeling discussions.

The initial steps in the development of each model were to use the informal format of the workshops to identify and discuss the major causal hypotheses relevant to each landscape. From these discussions, the participants created lists of the appropriate stressors, ecological effects, and attributes (endpoints) in each landscape. The objective was to identify the physical and biological components and linkages in each landscape which best characterized the changes explained by the hypotheses. A coordinator for each model used the hypotheses and lists of components to lay out an initial draft of the model, and prepared a supporting narrative document to explain the organization of the model. The drafts and narratives were reviewed in subsequent workshops, resulting in revisions to the models.

D-A.1.4 DISCUSSION

The Applied Science Strategy being used to link science and management in the south Florida ecosystem restoration programs is derived from the "Ecological Risk Assessment" process being used by the U.S. Environmental Protection Agency as a guideline for conducting ecological assessments in North America and Europe (EPA 1992, Gentile 1996). A similar approach was used by the Man and the Biosphere Human Dominated Systems program to define sustainability goals and identify ecological endpoints for a series of restoration scenarios for south Florida (Harwell and Long 1992, Harwell et al. 1996).

Gentile (1996) suggested that risk assessment and recovery of ecological systems "…can be viewed as opposite sides of the same coin." Risk assessment "… is the process of determining the probability (with associated uncertainty) of a particular event occurring as a result of the action of a specific agent or stressor…" Recovery of ecological systems "…can be viewed as the process for determining the probability (with associated uncertainty) of a particular event occurring (e.g., recovery to a…ecologically desired sustainable state) as the result of mitigating the action of a specific agent (e.g., canals, berms) or stressor (e.g., phosphorus). Gentile (1996) listed three principal functions of the risk assessment process: 1) identification of potential causal relationships between stressors and effects; 2) selection of endpoints (attributes), indicators, and success criteria; and 3) development of a scale-dependent conceptual model that describes the inter-relationships between multiple stressor pathways and multiple ecological receptors.

The development and application of conceptual models provides benefits to the scientists who create the models, and to the managers and public who use them to guide and implement resource policy (Gentile 1996, Ogden et al. 1997, SCT 1997). The process of creating and reviewing conceptual models aids scientific endeavors by, 1) creating a forum for open, multi-disciplinary exchanges of ideas and information pertaining to complex ecological issues (i.e., an informal level of peer review); 2) developing scientific consensus regarding current understandings of ecosystems; 3) creating working hypotheses which serve to guide both research and management; 4) better defining and reducing areas of scientific uncertainty; and 5) providing a framework for continuing discussions and revisions as new information becomes available. For managers and the public, the models serve to, 1) de-mystify the science; 2) provide a means for converting broad policy level goals and objectives into specific, measurable targets; 3) provide a visual description of the rationale for the prevailing hypotheses and management priorities; 4) reduce the complexity and dimensionality of the problems; 5) separate essential from non-essential information; 6) provide a tool for improved communication.

Gentile (1996) summarized the importance and appropriateness of the risk assessment and conceptual model process for setting ecological targets and conducting ecological evaluations in regional ecosystem restoration and management programs. The points emphasized by Gentile were, 1) that there is a large body of peer-reviewed literature that describes these methods and processes for conducting ecological assessments; 2) this literature represents an internationally accepted framework for structuring assessments; and 3) considerable effort has been devoted during recent years to formalize the process of selecting and classifying the endpoints, indicators, and metrics used in assessments.

D-A.1.5 CONCEPTUAL MODELS IN THE RESTUDY

The overall Restudy strategy is to use the conceptual models as a basis for developing performance measures and targets for the stressors and attributes in each model. These targets, collectively, describe the physical and biological conditions, respectively, that will be used to define successfully restored natural systems. The rationale for having performance measures and targets for each stressor is that the stressors are known or hypothesized to be the immediate sources of the ecological problems in each landscape. A successful restoration program must remove the adverse affects created by each stressor. A performance measure identifies which elements of each stressor must be corrected, how those elements should be measured, and how those elements must change (i.e., the restoration target) to “neutralize” their adverse effects.

Performance measures are also developed for each attribute in the conceptual models. The attributes have been identified as the biological or ecological elements that are the best indicators of responses in the natural systems to the adverse effects of the stressors. The hypotheses used to construct the conceptual models link each attribute to the stressor(s) which are most responsible for change in that attribute. If the hypotheses are correct, neutralizing the adverse affects of the stressor will result in a predictable positive response by the attribute. The performance measure developed for each attribute identifies the element of that attribute which should respond, how that element should be measured, and how that element should change (i.e., the restoration target) once the affects of the stressor are removed.

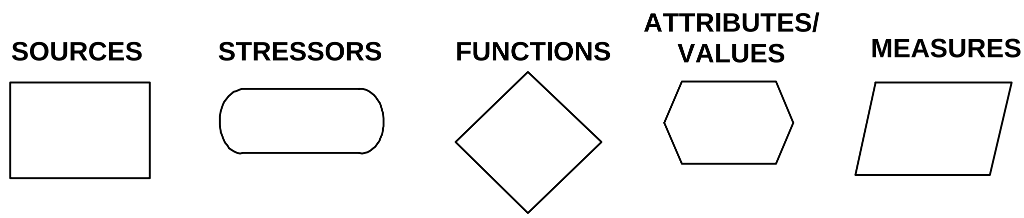
The conceptual model teams have assumed that for the attributes to adequately reveal how the system responds to changes in the stressors, they must reflect responses at a range of temporal and spatial scales, and from different taxonomic and hierarchial levels in ecological systems. They must also be measurable, and their historical patterns, relationships and functions well enough understood, so that responses can be correctly determined and interpreted. The model teams also considered the need for a mix of attributes that can serve either as indicators of ecological conditions or of societal priorities (e.g., endangered species and high quality sports fishing). Finally, the model teams considered the most appropriate number of attributes for each model. The desirable trade-off was to have a sufficient number to adequately reflect the major system responses, while not having more than would be necessary for this purpose or that would contribute to an unmanageably large monitoring program.

The modeling teams also identified critical linkages in the conceptual models. Critical linkages were defined as the links between one or more stressors and attributes, which seemed to explain much of the ecological or biological change in the systems. The assumption was that the stressors that are a part of critical linkages should have a priority over other stressors where restoration programs can not fully negate the adverse affects of all stressors shown in the models. The Restudy alternative evaluation teams generally placed higher priority on meeting performance targets for critical linkage stressors than for other stressors in the models. For example, the ridge and slough conceptual model suggests that stresses caused by reductions in the duration of uninterrupted surface water hydroperiods may explain much of the adverse changes that have occurred in the long-hydroperiod slough systems. Correction of this stressor became the highest priority in evaluating the predicted affects of alternative restoration plans in the central sloughs of the Everglades.

The performance measures and targets from both the stressors and attributes are being used for two primary purposes. The role of the performance measures during the planning phases of the restoration projects is as assessment tools for alternative plans designs. What combination of structural and operational components is most likely to achieve the desired objectives of the project, as determined by how well a plan is predicted (by modeling) to meet each of the targets set by the performance measures? In this planning role, the measures and targets not only are used to measure which plan is most likely to be successful in achieving its objectives, but also are used to influence the design of the project as efforts are made to determine the combination of features which can best moderate or eliminate the adverse affects of the stressors.

The second primary use of the measures and targets is in the design of a system-wide, ecological monitoring program. The purpose of system-wide monitoring is to measure how elements in the natural system actually respond to the management changes brought about following each iteration of a restoration program. Because the design of a restoration program is determined by the features that are predicted to best achieve a suite of regional-scaled performance measure targets, the monitoring program must measure the responses by the same set of measure targets. Comparisons between the predicted responses among stressors and attributes and the actual responses among the same stressors and attributes provide a basis for making revisions to the causal hypotheses and conceptual models, and a means for structuring an adaptive assessment strategy throughout the implementation of the restoration program. The overall focus of the monitoring program must be performance-based, i.e., the elements of the natural systems to be monitored must be those that provide actual measures of the stressor and attribute targets.

A figure of the conceptual models is included with the narrative for each model. The conceptual models follow a top - to - bottom hierarchy of anthropogenic and natural drivers, their respective stressors, the ecological effects resulting from the stressors, and ecological attributes/values and measures. Each attribute is linked to one or more stressor. The measure for each attribute is a priority component for a comprehensive monitoring program. The symbols used in the figures are:



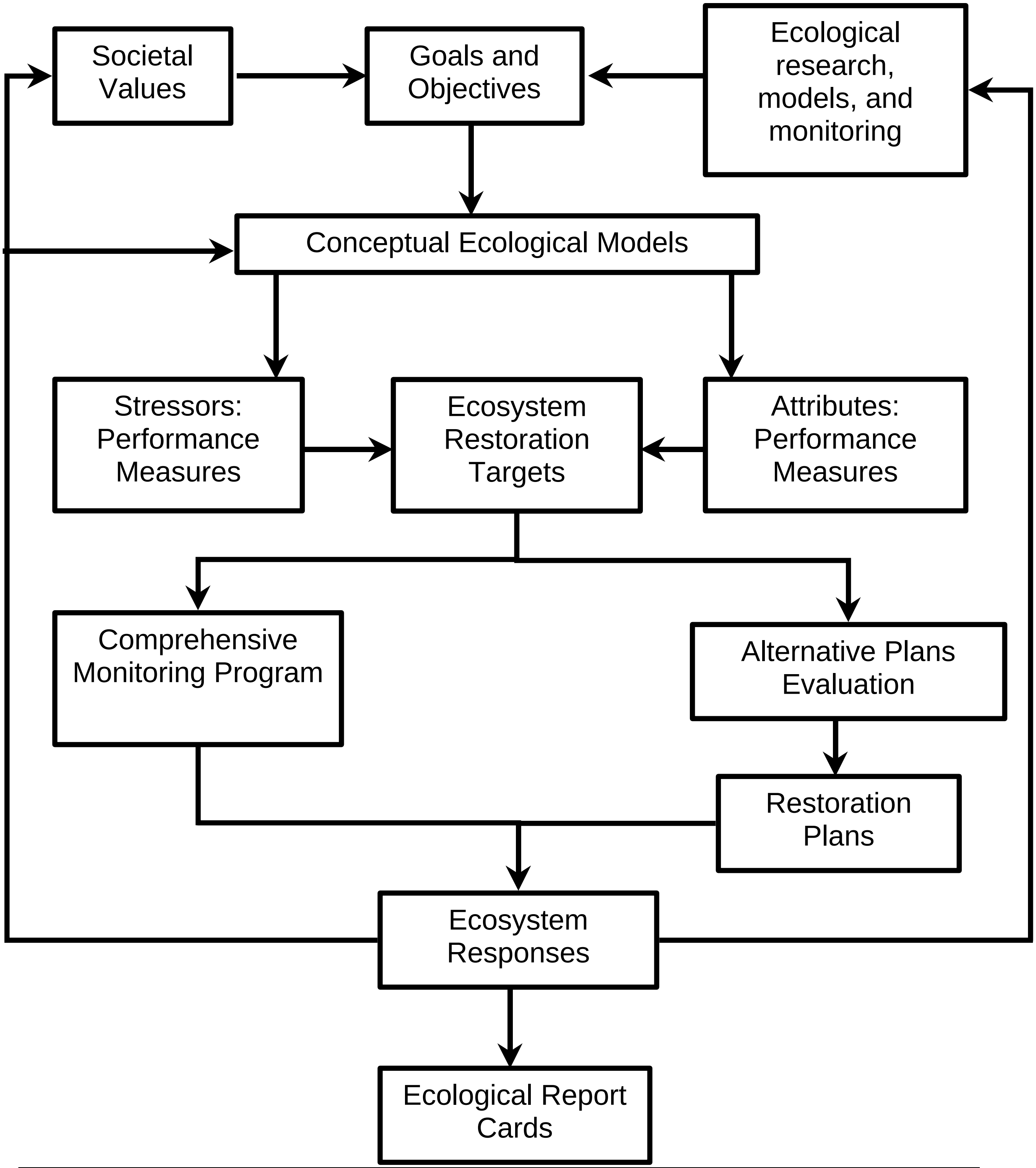
D-A.1.6 ADAPTIVE ASSESSMENT

The key to successful implementation of a regional ecosystem restoration program, e.g., maximizing the effectiveness of the program and reducing uncertainty during its implementation, is an adaptive assessment strategy. The conceptual ecological models are an integral part of the overall adaptive assessment strategy. The conceptual models are revised based on interpretations of actual system responses following the implementation of each restoration project. These revisions in the conceptual models influence predictions of system responses for future iterations during the implementation process. As the accuracy of the hypotheses and conceptual model linkages improve, the opportunities for making pre-construction improvements in project design are also enhanced. Greater accuracy in the conceptual models leads to improvements in the choice of measures and targets used to judge the predicted performance of each project design.

D-A.1.7 FUTURE TASKS

The conceptual ecological models, and the planning and evaluation tools coming from the models, still require several priority improvements. These are: 1) completion of a conceptual model technical report, and peer review of this report; 2) a new series of workshops to complete the development of performance measures for the biological attributes identified by the models; 3) workshops to design a performance-based monitoring program for the south Florida ecosystem restoration program; and 4) the development of a consensus among the participating agencies for a system-wide adaptive assessment strategy for the ecosystem restoration program.

Figure 1
Applied Science Strategy for Ecosystem Restoration



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D-A.2 DRAFT LAKE OKEECHOBEE CONCEPTUAL MODEL

D-A.2.1 PREPARERS

Karl E. Havens and Barry H. Rosen, South Florida Water Management District, West Palm Beach, Florida.

D-A.2.1.1 Contributors:

Steve Davis (SFWMD), Carole Goodyear (NOAA/NMFS), Charles Hanlon (SFWMD), R. Thomas James (SFWMD), Kang-Ren Jin (SFWMD), Liz Manners (USACE), Linda McCarthy (FDACS), Robert Pace (USFWS), Garth Redfield (SFWMD), Alan Steinman (SFWMD), Todd Tisdale (SFWMD),Gary Warren (FGFWFC), Herb Zebuth (FDEP), and Mark Ziminske (USACE)

D-A.2.2 INTRODUCTION

Lake Okeechobee is a large (1,730 km^2) freshwater lake located at the center of the interconnected south Florida aquatic ecosystem. The lake is shallow (average depth <3 m), originated about 6,000 years ago during oceanic recession, and under natural conditions probably was a slightly eutrophic and had vast marshes to the west and south. The southern marsh was contiguous with the Florida Everglades, which received water as a broad sheet flow from the lake during periods of high rainfall (Gleason 1984).

Modern-day Lake Okeechobee differs in size, range of water depths, and connections with other parts of the regional ecosystem (Havens et al. 1996a). Construction of the Herbert Hoover Dike in the early to mid-1900s reduced the size of the lake's open-water zone by nearly 30%, resulted in a considerable reduction in average water levels, and produced a new littoral zone within the dike that is only a fraction of size of the natural one (yet still it is a vast expanse, at over 400 km^2). The lake also has been impacted in recent decades by excessive inputs of nutrients from agricultural activities in the watershed (Flaig and Havens 1995). These nutrients have exerted the most dramatic impacts on the open-water region, where large algal blooms have occurred, along with accumulation of soft organic mud bottom sediments, which cause the lake water to become highly turbid when they are resuspended during windy periods (Maceina and Soballe 1991). The littoral zone has been invaded by 15 species of exotic plants, most notably *Melaleuca quinquenervia* and *Panicum repens* (torpedo grass), which have expanded over large areas, displacing native plants. Despite these human impacts, and a consensus that the lake's overall health has been greatly degraded by human actions, Lake Okeechobee continues to be a vital aquatic resource of south Florida, with irreplaceable natural and societal values. These values and their responses to anthropogenic stressors are described in the following sections.

D-A.2.3 MODEL STRUCTURE

The conceptual model is comprised of a top-to-bottom hierarchy of **sources**, **stressors**, **ecosystem effects**, **values**, and **measures** (refer to figure on page D-A-21). It is a complex model that includes two distinct but highly interconnected components, the open-water and littoral zones; each zone has different ecological effects and endpoints, and different responses to stressors. Stressors in one zone may have indirect effects that cross the boundary into the other. The Lake Okeechobee model was developed in the context of the lake's existing spatial extent, recognizing that the functioning of the modern-day system is drastically different from that of the historic lake.

D-A.2.4 STRESSORS AND EXTERNAL SOURCES

Eight in-lake stressors, which exert significant impacts on the lake's natural and societal values, originate from six external sources. Elevated concentrations of **chemical contaminants**, including, chloride (Cl^-), pesticides, and total dissolved solids (TDS), are by-products of agriculture or other human activities in the watershed. A much greater concern, in terms of ecosystem impacts, are the massive quantities of **nutrients**, in particular nitrogen (N) and phosphorus (P), which are discharged to the lake from agriculture. The C&SF Project, which includes deep canals that allow water to enter the lake with little interaction with natural wetlands, facilitates the delivery of these chemical stressors to Lake Okeechobee, and as such, it also is considered a source.

The open-water region experiences elevated concentrations of **suspended sediments**, whose source is a region of soft organic mud that covers about 50% of the lake bottom. When winds mix the shallow water column, the upper few cm of mud are resuspended. The spatial extent, depth, and nutrient content of this mud have increased rapidly in the last 100 years, coincident with agricultural development and increased nutrient inputs from the watershed (Brezonik and Engstrom, 1997). The Herbert Hoover Dike may facilitate sediment accumulation by preventing natural flushing that once may have occurred during high water events.

The C&SF Project, along with natural variations in regional rainfall, have the potential to cause **prolonged or extreme high or low water levels**. Because the lake is constrained within the dike system, these two stressors can cause severe damage on the lake ecosystem. Extreme high or low lake levels of <u>any</u> duration, or moderate high or low lake levels of <u>prolonged</u> duration, are considered to cause significant harm (an adverse change in ecological values that cannot recover under natural conditions). In contrast to the harmful effects of extremes, a certain degree of natural variation in lake levels, between 13 and 15 ft NGVD, has been shown to be benefit the ecosystem (Smith et al. 1995; Smith 1997).

Lake Okeechobee has suffered in recent decades from the expansion of **exotic and nuisance plants** and **exotic animals**. Today there 15 species of exotic plants in the littoral zone. Species of greatest concern are *Melaleuca* and torpedo grass, both of which were purposely introduced to the region, for dike stabilization and cattle forage, respectively. Other exotic plants that have stressed the lake's values include *Hydrilla* sp., water hyacinth (*Eichhornia crassipes*), and water lettuce (*Pistia stratiotes*). Exotic animals in the lake now include fish (*Tilapia aurea),* mollusks (*Corbicula fluminea*), and microinvertebrates (*Daphnia lumholtzii*). Each of these species exerts different impacts on the ecosystem, as discussed below. The final major stressor in Lake Okeechobee is **increased frequency and extent of fire**, which occurs due to natural causes (e.g., lightening strikes), arson, and controlled burns conducted by the South Florida Water Management District and Florida Game and Fresh Water Fish Commission, under permit from the US Department of Forestry.

D-A.2.5 ECOLOGICAL VALUES / ATTRIBUTES

Seven natural and societal values are associated with the Lake Okeechobee ecosystem. These values may be broken down into those which are <u>intrinsic</u> to the lake (fisheries, wildlife habitat, ecotourism) and those which are <u>extrinsic</u> (water supplies for urban areas, agriculture, and other ecosystems). The extrinsic values differ in that they are regional in nature, and dependant upon water supply in general, rather than on Lake Okeechobee per se. It is largely for this reason that lake hydrologic performance measures (below) are based on the lake’s intrinsic values, while extrinsic values are addressed separately, by performance measures ascribed to the Lake Okeechobee Service Area. Nevertheless, the conceptual model can serve as an integrating framework for these different values.

The lake is an important source of **water for urban and agricultural uses,** and **environmental water** that is discharged from the lake to other ecosystems, including the east and west coast estuaries, and the Everglades water conservation areas. For each of these extrinsic values, the quantity, timing, and quality of water are critical features. The lake is important to the regional economy, whose income depends in part on use of the ecosystem for **ecotourism and recreation**, including bird and wildlife observation, hiking, camping, and recreational boating. The lake also supports a **commercial and recreational fishery**, with an estimated "total economic value" in excess of $480 million US dollars (Furse and Fox 1994). Some of the most important intrinsic ecological values of the lake are the **wading birds and waterfowl**, which include numerous species and large resident or migratory populations (Smith et al. 1995), and the **diverse mosaic of native vegetation** that characterizes the lake's littoral marsh zone (Richardson and Harris 1995). This diverse vegetation is critical to birds, fish, and other wildlife that inhabit the zone, and it is an aesthetically pleasing region that is visited by thousands of persons each year -- thereby supporting the ecotourism, recreation, and fisheries values mentioned above. The community also is a critical habitat for the federally-endangered **snail kite**, whose principal food resource, the apple snail, occurs at high densities in a large pristine region of the lake's marsh known locally as Moonshine Bay.

D-A.2.6 QUANTITATIVE MEASURES

To quantify the current status of Lake Okeechobee, and its predicted or realized responses to restoration efforts, a suite of measures were selected that collectively characterize the condition of each ecological value. Measures were based on the results of scientific research, or in some cases, best professional judgement that indicates a strong relationship between measures and the values being assessed. The measures for Lake Okeechobee ecological values are as follows.

(1) Urban water quality and quantity. Key measures of the quality of water for urban uses include concentrations of the various Class I numeric water quality standards (for drinking water use), as well the concentrations of Class IV numeric standards (for agriculture). Water quantity can be assessed as days per year with water use restrictions.

(2) Environmental water quality and quantity. Water discharged from Lake Okeechobee may impact downstream ecosystems, including the east and west coast estuaries, the WCAs, and the Everglades, if it contains high concentrations of P, N, toxins, or turbidity. Quantities of water depend on needs of particular ecosystems, and must include a seasonal component.

(3) Ecotourism and recreation. These ecological values may be best assessed on the basis of numbers of visitors to the lake region each year and cash flow into the local economy, associated with designated lake uses, including bird and wildlife observation, hunting, boating, and hiking.

(4) Sport and commercial fishery. Measures of fishing success may be obtained from information on catch per unit effort by anglers and commercial fishers, while more quantitative information can be obtained by FGFWFC studies of population size and age structure for selected fish (largemouth bass, black crappie, bluegill).

(5) Wading birds and migratory waterfowl. Populations of selected birds may be surveyed in order to determine population sizes and nesting success.

(6) Diverse mosaic of native vegetation. Geographic Information System (GIS) maps of the littoral zone may be used to evaluate indices of overall spatial heterogeneity - several standard ones are available. It also may be important to quantify changes over time the spatial extent of selected vegetation assemblages, especially those known to be critical wildlife habitats (e.g., *Eleocharis, Scirpus, Salix*). The ratio of exotic+nuisance to native plant coverage also may be a useful metric of overall vegetation quality. The marsh community is reported to include one threatened

plant species, the Okeechobee gourd, and a regular census of its population density and distribution should be undertaken.

(7) Snail kite. Snail kites are an important endangered species in south Florida, and there needs to be a continued regular census of their population size and nesting success in Lake Okeechobee.

D-A.2.7 ECOSYSTEM EFFECTS

The pathways linking ecosystem stressors to the natural and societal values are complex, and have a solid foundation in research and modeling conducted by scientists at the SFWMD, FGFWFC, and Florida universities (e.g., Aumen and Wetzel 1995, Havens et al. 1995, James and Bierman 1995, Reddy et al. 1995, Havens et al. 1996a). As we learn more about how the system functions, it is likely that additional pathways could be added to the model, or adjustments made to existing pathways. The model is a flexible tool that at any given time, reflects the current state of our best available scientific information.

Chemical contaminants in the lake water have the potential to directly impact all seven of the ecological values. Toxic materials in drinking water are dangerous to human users, or at a minimum, costly to remove during treatment operations; toxic chemicals also can kill or harm agricultural crops and the biota residing in downstream ecosystems that receive environmental water deliveries or flood control discharges from the lake. Toxic chemicals also may kill or harm native invertebrates, fish, birds, littoral plants, and other flora and fauna in the lake ecosystem, including the endangered species. Some of the chemical contaminants, including Hg and pesticides, undergo biomagnification in the food web, and thereby indirectly harm animals near the top of the web (e.g., predator birds, fishes, and other animals such as the American alligator).

Nutrients, in particular N and P, stimulate the growth of phytoplankton, and at the extreme, can cause noxious surface blooms of blue-green algae (Paerl 1988). When these algal blooms senesce, they can cause oxygen depletion and a build-up of ammonia and potentially toxic decay products in the water. Depending on the location where this occurs, these decay products can harm components of the lake's biota, including littoral macroinvertebrates and fish. This in turn can secondarily affect the predators that utilize those food resources. To date, the only documented harm, following a large bloom in summer 1986, was to the lake's apple snail population (Jones 1987), the primary food item for the endangered snail kite. The products of algal bloom decay also are detrimental to water quality for urban and environmental deliveries, and to the ecotourism & recreational uses of a lake (Heiskary and Walker 1988). The high nutrient inputs that have impacted Lake Okeechobee since human development began pre-1900 also have left their mark on the lake sediments (Reddy et al. 1995), which now contain large quantities of N and especially P. While there is a natural loss of N from the lake, by microbial degradation in a process called denitrification, there is no such loss for P, except by gradual burial in deeper sediment layers. High concentrations of P and organic material promote rapid growth of bacteria, which in turn deplete the oxygen from surface sediments (Hutchinson 1957). Only a small subset of benthic macroinvertebrates can tolerate low oxygen levels, and it is for this reason that the Lake Okeechobee community, once dominated by a diverse array of species, now is strongly dominated by a few species of pollution-tolerant oligochaete worms (Warren et al. 1995). This change radiates upward through the food web, affecting fishes and other animals that ultimately depend on the benthic invertebrates as a food source (Havens et al. 1996b).

Suspended sediments in the water column can cause increased P concentrations if soluble P is released from the sediment particles. This is a complex situation that is largely controlled by the concentrations of P on the particles and in the water column (Reddy et al. 1995). Under most circumstances, the particles adsorb P, and therefore sediment suspension (followed by sediment settling to the lake bottom) is a net sink for P. Suspended sediments exert another important impact. If they are present in the water column at high concentrations, they greatly reduce the amount of light that reaches the lake bottom. It the sediments are circulated to shallow near-littoral regions of the lake (this circulation appears to be enhanced by high water levels), then they may suppress the growth of submerged plants and algae that naturally occur on the lake bottom. Those plants and algae are important because they provide food and habitat for macroinvertebrates and fish (and ultimately wading birds and other animals), and they help to stabilize the sediments. If the plants are reduced or eliminated, these functions are lost. One particularly troubling result is a "positive feedback loop" that may occur, making it very difficult for the lake to recover from a highly turbid condition: turbid water reduces benthic plants, less benthic plants means more resuspension, this makes more turbid water, even less plants........etc. This situation may be occurring today at the south end of Lake Okeechobee, where turbid, P-rich water and declines in benthic algae (*Chara*) coincided with the prolonged high lake stages in 1995 and 1996 (Steinman et al. 1997). Research results also have documented that benthic algae compete for nutrients with phytoplankton (Havens et al. 1996c). Thus, when benthic algae are reduced, there is a greater potential for phytoplankton blooms. Finally, there also is a complex relationship between light penetration in the water column and phytoplankton biomass. While sediment resuspension may indirectly promote phytoplankton growth by suppressing benthic algae, at the extreme, it may be so severe as to cause light limitation of the phytoplankton too. In this case, which is typical of the mid-lake region during winter (Phlips et al. 1997), there may be little growth of any algae in the water column or on the lake bottom. At other times, when a high biomass of phytoplankton does occur (e.g., during calm mid-summer periods), phytoplankton cells may bring about a reduction in light penetration, and also contribute to the decline in benthic algae.

Prolonged or extreme high lake levels cause substantial harm to the ecosystem. When sustained high lake levels (>15 ft for nearly 2 yrs, and exceeding 17 ft at the extreme) occurred in 1995 and 1996, wind and erosion caused emergent plants to be torn loose from their habitats, resulting in a loss of important fish and wildlife habitat (e.g., bulrush, a critical spawning habitat for largemouth bass). These "islands" of dislodged plant material also interfered with recreational uses of the lake, as they blocked canals and boat trails. During the two years of high lake levels, District scientists also documented the loss of submerged vegetation at the lake's south end, likely due to light limitation caused by the deep, turbid water (Steinman et al. 1997).

High lake levels also bring about changes in the nature and extent of mixing within the lake. A Lake Okeechobee hydrodynamic model indicates that when water levels are high, nutrient and sediment-rich water from mid-lake is mixed throughout the basin, including into the littoral zone (Sheng and Lee 1991). At low water levels, the nutrient and sediment-rich water circulation is constrained towards mid-lake because an extensive rock reef along with south and west edges of the open-water region restricts water movement into the near-littoral region (Maceina 1993). When high water levels promote nutrient transport into the marsh *via* greater horizontal mixing, those nutrients have the potential to cause changes in the biomass and composition of both marsh plants and algae, as has been documented in the Everglades Water Conservation Areas (WCA) by Koch and Reddy (1992) and McCormick et al. (1996).

High lake levels also may affect vertical mixing in the mid-lake region. During summer calm periods, the water column may become thermally stratified for one to two week-long periods (Jin et al. 1997). When this occurs, bottom waters may become anoxic, and this in turn allows diffusion of soluble P from lake sediments. These events may be a precursor to development of mid-lake blooms of blue-green algae (Havens et al. 1997). Because it takes a greater amount of wind energy to break down the stratification and mix a deeper water column than a shallow one, high lake levels might promote longer-lasting mid-summer stratification, anoxia, and algal blooms (Havens 1996). High lake levels also may threaten the endangered Okeechobee gourd, which cannot tolerate prolonged flooding.

Prolonged or extreme low lake levels also cause significant harm to the ecosystem and its values. Low water levels expose large areas of the marsh (including native plant communities such as *Scirpus* and *Eleocharis*) to desiccation, and render them useless as habitats for fish and waterfowl. Low water levels also may promote the expansion of exotic plants. The large *Eleocharis* habitat found in Moonshine Bay is an important habitat because it is a primary foraging area for largemouth bass and other recreational fish, and it supports a thriving population of snail kites. This habitat now is encircled by torpedo grass, which may readily overtake the region if low water levels suppress the growth and survival of the native *Eleocharis*. Torpedo grass grows most rapidly when water levels are at or near the soil surface, and displays considerable growth suppression when submerged under >30 cm of water (Thayer and Haller 1990). *Eleocharis,* on the other hand, thrives when submersed, even when water depths are near 1 m. There also is evidence that germination of Melaleuca seeds is inhibited by standing water (Lockhart 1995). Hence, if large areas of the marsh become dry for long periods of time, there could be increased expansion of this exotic plant. Indeed, one of the most rapid *Melaleuca* increases occurred shortly after the 1990 drought, when lake levels declined below 11 ft NGVD for just 150 days. Low lake levels also impact ecotourism and recreation, by making it difficult or impossible to access large regions of the marsh (many former boat trails become dry land at 11 ft NGVD). Finally, there is evidence that low water levels directly impact the snail kite, which requires standing water beneath the macrophytes upon which it constructs its nest.

While it is clearly the case that prolonged or extreme high and low water levels have negative impacts, these attributes alone do not describe the hydrologic variation that is required to maintain a healthy ecosystem. There is considerable evidence that the "optimal" situation would also include a certain degree of variation. In particular, a January to May recession in lake levels from near 15 ft NGVD to below 13 ft NGVD has been shown to be beneficial to wading bird and fish populations. Infrequent (every 5 to 7 years) spring recessions to below 12 ft NGVD may benefit the entire community, by exposing prey-rich submersed macrophyte beds to predators, invigorating willow (*Salix*) stands, and by allowing fires to burn away *Panicum* and *Typha* wrack (Smith et al. 1995). These points must be taken into account when evaluating the impacts of regional restoration programs or lake regulation schedules, although they are not readily portrayed as stressors in a conceptual model of this format.

Exotic and nuisance plants have been discussed in the context of water levels and other stressors. These plants, which now cover a large portion of the marsh, exert a variety of direct and indirect impacts on the lake's ecological values. As they spread and displace native vegetation, they directly alter the vegetation mosaic. Because of their growth characteristics, they may provide poor habitat for fish and other wildlife. Torpedo grass, for example, grows in large monocultures resembling “hayfields,” with little or no standing water. Fish simply cannot swim through such a habitat, and any wildlife that depend upon those fish as a food resource are indirectly affected when torpedo grass becomes dominant in a region of the lake. *Hydrilla* and other exotic submerged plants have negative impacts on human uses of the system, by blocking canals and waterways, and often requiring repeated herbicide treatments. These plants are secondarily responsible for any adverse impacts that the herbicides have on natural vegetation in the lake or downstream ecosystems. One of the troubling patterns observed in the lake's marsh is expansion of cattail (*Typha*). This plant is a native, but once occurred at considerably lower densities and over a smaller spatial area (Richardson and Harris 1995). Its spread may be related to water level regimes and/or eutrophication of the lake. In either case, it displaces other native plants and impacts the value of the marsh as a wildlife habitat. There is some concern that cattail expansion in to valuable bulrush habitat may be facilitated by low lake levels (particularly those < 11 ft NGVD). Following the drought in 1989, when the lake declined to nearly 10.5 ft NGVD, large areas of bulrush became infested. These events may degrade the value of the habitat for fish and other wildlife that utilize bulrush for nesting or foraging.

Exotic animals in Lake Okeechobee can directly displace native animals through competition and predation, and they also can exert other direct and indirect effects. *Tilapia aurea*, for example, is an exotic fish that feeds and burrows at the benthos, and destroys submerged vegetation stands. It also transforms particulate nutrients, from sediments, macroinvertebrates, and plants, into soluble nutrients that are excreted into the water column where they may stimulate localized algal blooms. Not all impacts of exotic animals are negative, however. The mollusk *Corbicula fluminea* is a major food source for diving ducks and shell crackers, and the microinvertebrate *Daphnia lumholtzii* grazes phytoplankton, and could suppress algal blooms if its densities become very high. It also may be a good food source for plankton-feeding forage fish.

Fire is a natural forcing function in Lake Okeechobee, as well as in other south Florida ecosystems, often occurring due to natural causes, such as lightening strikes. However, in recent years, fires have been set in the lake's littoral zone by humans -- both in acts of arson, and as part of controlled burn management efforts. Arson fires are reportedly set by hunters and others who desire to visit the littoral zone for recreational purposes. The focus is most often on regions of dense torpedo grass, where plant growth has restricted access to the marsh. Interestingly, the controlled burn programs target similar regions, but for a different reason -- to burn away the exotic plant material, in order to give native plants a chance to recolonize the area from a rich buried seed bank that is known to occur in the marsh soil. In either case, fires impact the vegetation mosaic, as well as the animals that occur therein.

D-A.2.8 HYDROLOGIC PERFORMANCE MEASURES

A significant feature of the Lake Okeechobee conceptual model is the high degree of interconnectedness; any given stressor may impact ecological values directly, or impact those same values indirectly, by exacerbating the effects of other stressors. Two stressors that display particularly strong effects (direct and indirect) on the values are high and low water levels. Taken together, they have the potential to affect the rate of lake eutrophication, the spatial extent and overall health of submerged and emergent plant communities, fisheries, birds, other wildlife, and the quality of water taken from the lake from human uses.

Water inputs and lake levels also are the variables most directly impacted by the various Alternatives considered in the C&SF Restudy. Therefore, a suite of hydrologic performance measures were developed based on water depth (and seasonal variations in those depths). These measures serve as integrative predictors of overall lake ecosystem health.

The hydrologic performance indicators and measures for Lake Okeechobee are concerned with: extreme high lake levels (> 17 ft NGVD) of any duration; moderate high lake levels (> 15 ft NGVD) of prolonged duration; extreme low lake levels (< 11 ft NGVD) of any duration; and moderate low lake levels (< 12 ft NGVD) of prolonged duration; as well as the degree of variability in lake levels, within what is considered to be an "optimal" window for the lake's biota (13 to 15 ft NGVD).

D-A.2.8.1 Performance Indicator – Daily Stage Hydrographs

Visual inspection of daily stage hydrographs, for the period from January 1965 to 1995, can provide information regarding the frequency of extreme high and low lake levels. One simply draws horizontal lines across these plots at 17 ft and 11 ft NGVD water levels, and counts the number of cases wherein the hydrograph goes above or below the lines. The fewer the events, the "better" the result, in terms of protecting the lake's values. The restoration goal for the lake is to have no such events.

D-A.2.8.2 Performance Indicator – Stage Duration Curves

Visual inspection of stage duration curves for various alternatives and base conditions can provide additional information that is directly related to the lake's values. By drawing horizontal lines across the plot at 17 ft and 11 ft NGVD, one can quantify the percent of times that lake stage exceeded or fell below these critical values. Lower percentages in a given scenario equate to a "better" result. The restoration goal for the lake is to have zero % for each extreme type of event.

D-A.2.8.3 Performance Measure – Similarity in Duration of Stage Events > 15 ft

This performance measure consists of box and whisker plots, which indicate median, maximum, minimum, and 25^{th} / 75^{th} percentiles, for duration of moderate high lake stage events. As indicated above, prolonged lake levels above 15 ft NGVD cause significant harm to the lake's ecological values, and should be avoided. For this measure, lower median values and extremes are better. The restoration goal for the lake is to have a median duration near zero, and a maximal duration no greater than 1 year.

D-A.2.8.4 Performance Measure – Similarity in Duration of Stage Events < 12 ft

This performance measure is analogous to the preceding one, except that it is concerned with the duration of moderate low lake levels. Lower median and extreme values are better. The restoration goal for the lake is to have a median duration near zero, and a maximal duration no greater than 1 year.

D-A.2.8.5 Performance Measure – Similarity in Duration of Stage Events > 11 ft

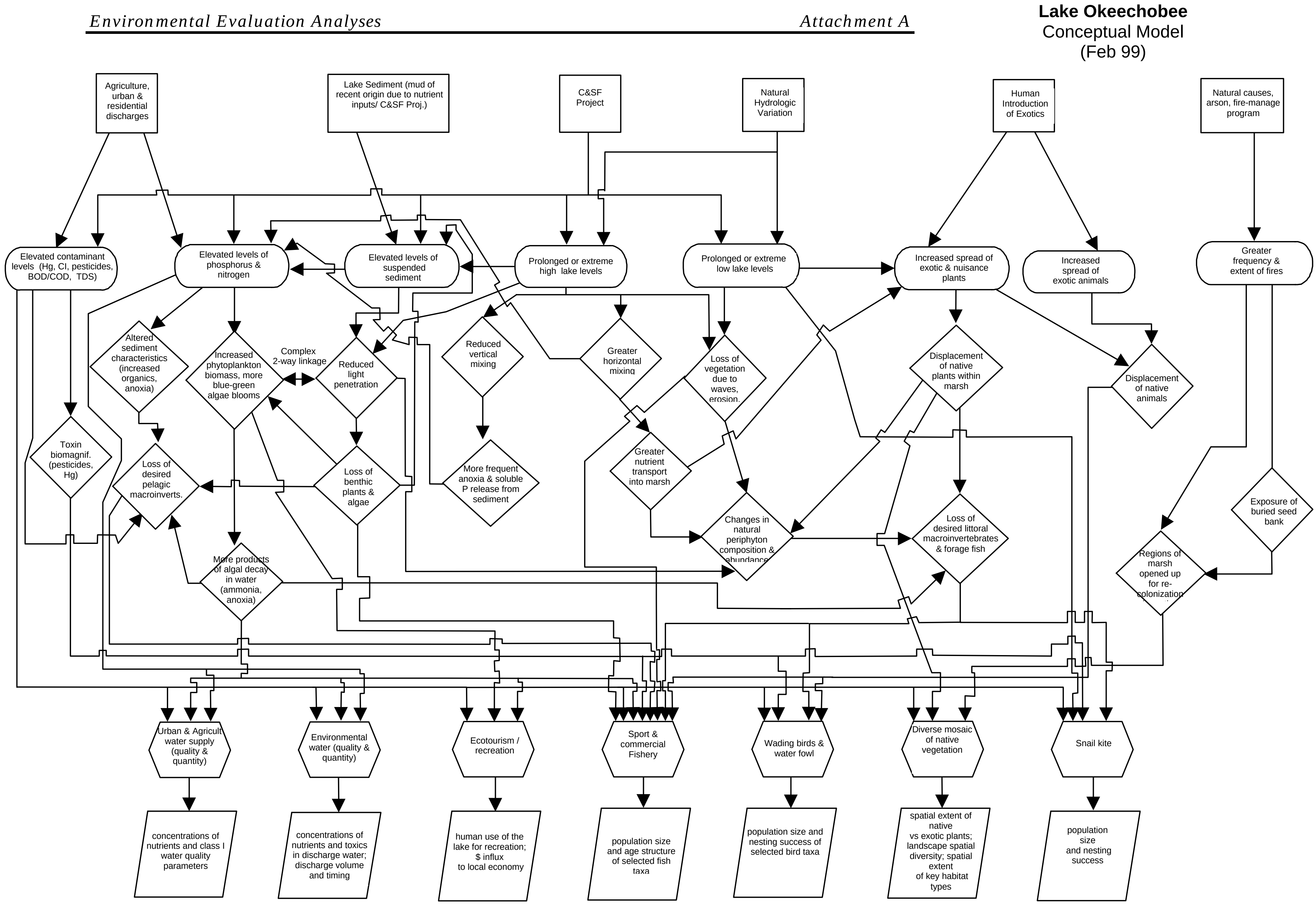
When lake stage falls below 11 ft NGVD, significant harm ensues, even if the duration is short. Nevertheless, during regional droughts, lake levels have declined to as low as 9.6 ft NGVD. Alternatives that increase the duration of < 11 ft events are considered especially harmful to the ecosystem. This performance measure uses box and whisker plots, as in the previous item. Lower medians and extremes are better. The restoration goal for the lake is to have no such events (i.e., duration median and extreme = zero).

D-A.2.8.6 Performance Measure – Similarity in Duration of Stage Events > 17 ft

This performance measure is analogous to the preceeding one, except that it is concerned with the duration of extreme high lake levels. Lower median and extreme values are better. The restoration goal for the lake is to have no such events (i.e., duration median and extreme = zero).

D-A.2.8.7 Performance Measure – Daily Stage Hydrographs with Spring Recession Windows

In an effort to evaluate the degree to which intra-year variations in lake levels match the optimal pattern described by Smith et al. (1995), that is, a January to May recession, without reversal, from near 15 ft to below 13 ft NGVD, “windows” were drawn over the daily hydrograph plots. Years in which the lake levels recede smoothly from the upper left to lower right corners of the box are considered “good” for wading birds and other wildlife in the lake. Years in which lake levels remain far above or below the box, or those with water levels passing through the box with no trend or an increasing trend in lake levels are considered “bad.” A greater number of years with “good” scores is considered a better result. More elaborate methods may be utilized to score the results, however, it is unclear whether this is called for, given existing uncertainties about the true relationship between spring lake level recession and fish / wildlife health. Furthermore, it is uncertain whether the goal for this measure is to have the designated recession every year, or at a return frequency corresponding to some selected reference period.


Lake Okeechobee
Conceptual Model
(Feb 99)
Agriculture, urban & residential discharges
Lake Sediment (mud of recent origin due to nutrient inputs/ C&SF Proj.)
C&SF Project
Natural Hydrologic Variation
Human Introduction of Exotics
Natural causes, arson, fire-manage program
Elevated contaminant levels (Hg, Cl, pesticides, BOD/COD, TDS)
Elevated levels of phosphorus & nitrogen
Elevated levels of suspended sediment
Prolonged or extreme high lake levels
Prolonged or extreme low lake levels
Increased spread of exotic & nuisance plants
Increased spread of exotic animals
Greater frequency & extent of fires
Altered sediment characteristics (increased organics, anoxia)
Increased phytoplankton biomass, more blue-green algae blooms
Complex 2-way linkage
Reduced light penetration
Reduced vertical mixing
Greater horizontal mixing
Loss of vegetation due to waves, erosion
Displacement of native plants within marsh
Displacement of native animals
Toxin biomagnif. (pesticides, Hg)
Loss of desired pelagic macroinverts.
Loss of benthic plants & algae
More frequent anoxia & soluble P release from sediment
Greater nutrient transport into marsh
Changes in natural periphyton composition & abundance
Loss of desired littoral macroinvertebrates & forage fish
Exposure of buried seed bank
Regions of marsh opened up for re-colonization
More products of algal decay in water (ammonia, anoxia)
Urban & Agricult water supply (quality & quantity)
Environmental water (quality & quantity)
Ecotourism / recreation
Sport & commercial Fishery
Wading birds & water fowl
Diverse mosaic of native vegetation
Snail kite
concentrations of nutrients and class I water quality parameters
concentrations of nutrients and toxics in discharge water; discharge volume and timing
human use of the lake for recreation; $ influx to local economy
population size and age structure of selected fish taxa
population size and nesting success of selected bird taxa
spatial extent of native vs exotic plants; landscape spatial diversity; spatial extent of key habitat types
population size and nesting success

D-A.2.9 REFERENCES

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D-A.3 DRAFT ST. LUCIE AND CALOOSAHATCHEE CONCEPTUAL MODEL

D-A.3.1 PREPARERS

Susan Gray and Daniel E. Haunert, South Florida Water Management District, West Palm Beach, Florida.

D-A.3.1.1 Contributors

The following persons contributed to the development of the estuary conceptual model: Robert Day (Indian River Lagoon NEP); Tom Fraiser (W. Dexter Bender & Assoc.); Ernie Estevez (Mote Marine Lab); Keith Kibby (Lee County); Doug Strom (FDEP); Greg Graves (FDEP); Herb Zebuth (FDEP); Kalani Cairns (USFWS); Robert Pace (USFWS); Steve Traxler (USACE); Dennis Hanisak (Harbor Branch Oceanographic Institute); Tony Janicki (Coastal Environmental); Ralph Montgomery (Coastal Environmental); Patti Sime (SFWMD); Bob Chamberlain (SFWMD); Peter Doering (SFWMD); David Rudnick (SFWMD); Chris Madden (SFWMD); Steve Davis (SFWMD); Barry Rosen (SFWMD); Joel Van Arman (SFWMD)

D-A.3.2 ABSTRACT

A conceptual model of the St. Lucie and Caloosahatchee Estuaries was developed by scientists working in these systems to identify major stressors, measurable attributes of the ecosystem that are sensitive to the stressors, and linkages between the two. Both estuaries have been highly modified. The St. Lucie Estuary, located on the southeast coast of Florida, discharges into the Indian River Lagoon and Atlantic Ocean through the St. Lucie Inlet. The Caloosahatchee Estuary, located on the southwest coast of Florida, discharges into Charlotte Harbor, and then into the Gulf of Mexico. Due to extensive urban and/or agricultural drainage projects in both watersheds, the historic watershed area has been greatly expanded. In addition, both estuaries are linked to Lake Okeechobee via canals that provide both navigation and releases of floodwaters. In the Caloosahatchee, the construction of a water control structure downstream of Lake Okeechobee has also decreased the tidally influenced portion of the Caloosahatchee Estuary. The major effects of anthropogenic changes in both watersheds are significant alterations in the timing, distribution, quality, and volume of freshwater entering the estuaries. Understanding how these systems respond to stress will provide a basis for well-informed management decisions on restoration activities.

D-A.3.3 INTRODUCTION

The St. Lucie Estuary is located on the southeast coast of Florida, and discharges into the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. The estuary encompasses about eight square miles, and the historic watershed was estimated to be about 1/3 the size of its present configuration. Due to extensive agricultural and urban drainage projects beginning in the 1910s, the present day watershed area has been expanded to almost 775 square miles. Major canals in the watershed include the C-23 and C-24 canals, part of the Central and South Florida Flood Control Project. In addition, the estuary is linked to Lake Okeechobee by the C-44 canal that is utilized for both navigation and the release of floodwaters from the lake.

The Caloosahatchee Estuary is located on the southwest coast of Florida, and discharges into Charlotte Harbor, and then into the Gulf of Mexico. The Caloosahatchee Estuary is also connected to Lake Okeechobee through the C-43 canal (Caloosahatchee River), and there are a series of smaller drainage works in association with substantial agricultural development in the watershed. The construction of a water control structure (Franklin Lock and Dam) downstream of Lake Okeechobee has decreased the tidally influenced portion of the estuary, allowing for the convenient use of the C-43 as a potable water supply.

The major effects of anthropogenic changes in both watersheds are significant alterations in the timing (excess wet season flows, insufficient dry season flows), distribution, quality, and volume of freshwater entering the estuaries. In addition, alterations within the estuaries through dredging of navigation channels, filling of marshes, and construction of bridges and causeways has also contributed to a number of documented declines in some mollusc species and submerged aquatic vegetation. Restoration of these important species is considered critical to the overall health of these systems. Despite these impacts, the estuaries continue to be an important resource, with significant environmental and economic values.

D-A.3.4 ESTUARY MODEL STRUCTURE

The conceptual model for the St. Lucie and Caloosahatchee Estuaries follows the format used for other south Florida ecosystem models, with a top-to-bottom hierarchy of **sources**, **stressors**, **ecosystem effects**, **attributes** and **measures**. Refer to figure on page D-A-30. The model is similar to those developed for other ecosystems, including Florida Bay and Lake Okeechobee. One significant difference is that a single model diagram is proposed for both estuaries. During the development of this model, it became apparent that one design would serve both systems, but that the emphasis or relative importance of each segment could vary between the systems.

D-A.3.5 ECOLOGICAL & SOCIETAL VALUES / ATTRIBUTES

Nine ecological and societal values associated with a healthy estuarine ecosystem were identified, along with measures that will provide information on current ecological status, as well as long-term trends. These include the following:

- **Mollusc abundance & distribution –** Oysters, clams and scallops are natural components of southern estuaries, and have been documented in the past to be abundant in these systems. Oyster reefs provide several important functions, including habitat and food for other species. Scallops, clams and oysters may be a commercial and/or recreational resource.

- **Sediment quality** directly affects the occurrence and abundance of benthic and sessile species. Sediments are a sink for nutrients and other materials, such as pesticides and metals.

- **Water quality** is a major determinate of the health and condition of aquatic systems, and changes in water quality are often the linkage between the stressor and the ecosystem value.

- **Submerged aquatic vegetation (SAV) distribution and abundance -** Seagrasses are considered to be a key feature of estuaries due to the functions that they perform. These functions include sediment stabilization, primary productivity, and nursery and refugia habitat.

- **Habitat structure and function**, as considered on a landscape scale, integrates many of the other values. An example of a landscape-scale attribute is defining a preferred salinity regime for the estuary. Work on the St. Lucie and Caloosahatchee Estuaries has identified preliminary salinity ranges and seasonal and spatial distributions, termed “salinity envelopes” to meet the physiological requirements for the establishment and productivity of key estuarine species, including seagrasses and oysters.

- **Benthic invertebrate community structure -** The composition of invertebrate species in the benthos serves as an indicator of the nutrient and contaminant loading to the system. Changes in species diversity and abundance have been documented in the presence of increased pollutant loadings.

- **Manatee population dynamics -** Manatees are a very visible and popular feature of the estuary, and impacted by changes to the ecosystem. Their status as an endangered species adds considerable importance to their protection and stabilization of their populations.

- **Fisheries population dynamics -** Fishes are an integral component of the estuary food web. In addition, they have a significant societal value for recreation and commercial harvesting.

▸ **Fish-eating birds population dynamics -** Fish eating birds are one of the more visible keystone species in the estuarine ecosystem. Their dependence on fish for food serves as an indicator of the health and status of their prey populations.

D-A.3.6 LINKS FROM STRESSORS TO VALUES

Seven stressors that exert significant impacts on the estuary's ecological and societal attributes were identified for these systems. However, the linkages between ecosystem stressors to the environmental and societal values are complex, and considerable uncertainties remain. As more is learned about how these systems function, these linkages may be changed or new ones included. One aspect of the model is that it is flexible and can be adjusted as new information is available.

▸ ***Altered hydrology*** is one of the predominant stressors on the system. This stress is the result of managing the runoff of the watershed to accommodate agricultural and urban development, along with flood control releases from Lake Okeechobee. Accompanying these hydrologic changes are increased sediment transport, transport of floating freshwater vegetation (Hyacinth and Pistia) into the estuarine portion of the ecosystem, and alterations in water residence time and biological flushing of the estuary. Salinity, a key organizing parameter for the estuary, is directly affected by changes in inflows and tidal exchange. All of these factors combined have been shown to impact indicator species of estuarine health, namely seagrasses and oysters.

▸ ***Physical alterations*** to the ecosystem have also had a significant effect on the presence and abundance of species normally found within these systems. These alterations have occurred through a variety of activities, including shoreline hardening, inlet dredging and stabilization, removal of oyster shell for road bed material, snagging of navigation hazards, decrease in spatial extent of the estuary through construction of barriers [S-79], and the impoundment of salt marshes for mosquito control (on the east coast). Changes in the physical dimensions of the estuaries, most notably in the Caloosahatchee, have significantly reduced the euryhaline portion of the estuary, an important nursery area, feeding area and refugia for juvenile stages of desirable sport and commercial fishes. Construction and operation of the water control structures have interfered with the migration patterns of many estuarine species, and have also resulted in the death of manatees attempting to pass through these structures.

▸ ***Nutrients and dissolved organics*** enter the system as a result of anthropogenic activities in the watershed, primarily agricultural and water management, although urban use of fertilizers is also a contributor. In addition, atmospheric deposition contributes to the nitrogen loading of the system. These constituents interact with alterations in salinities and sediment loading to reduce light penetration which, in turn, leads to declines in seagrasses. The shift in the species composition of benthic invertebrates to more pollution-tolerant organisms is also linked to increases in nutrients.

- ***Toxics***, which include pesticides, fungicides, herbicides, brine from reverse osmosis plants, coliforms from sewage treatment plants (STPs), oils, greases, and mercury are introduced into these systems from urban development, agricultural practices, and boating. Direct toxic effects have been noted on some zooplankton and fish. Indirect effects occur through the process of bioaccumulation or biomagnification through the food web, increasing the toxic load to top predators. The problem of eggshell thinning in pelicans and osprey was the result of bioaccumulation of DDT.

- ***Temperature extremes*** are the result of both rare natural events, such as freezes, and human activities due to discharges from nuclear power plants and STPs. Severe freezes have resulted in the direct decline of mangroves and manatees. In addition, the unnatural congregation of manatees in waters warmed by plant discharges is thought to contribute to the spread of disease and exposure to red tide.

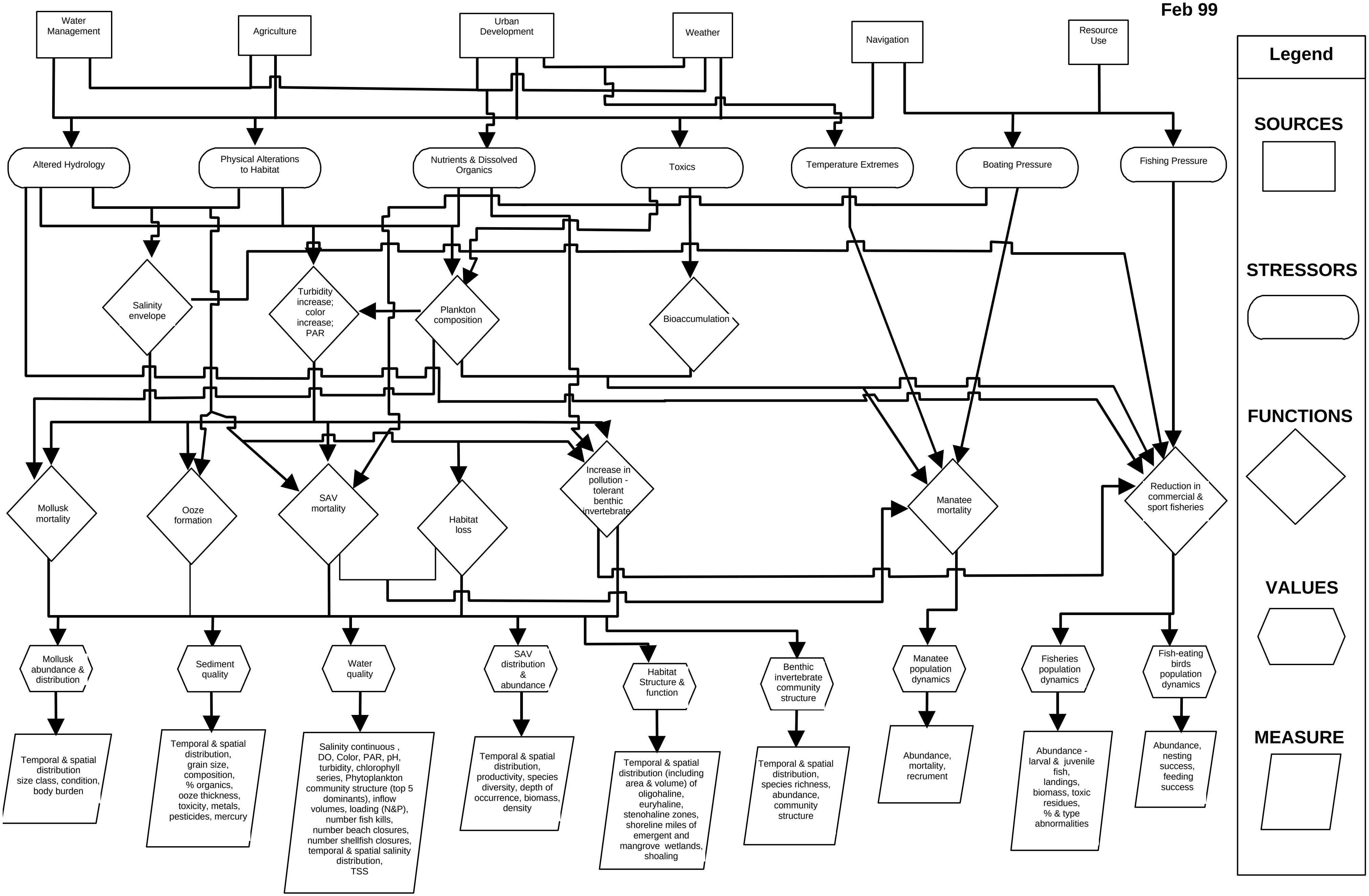
- ***Boating pressure*** is a significant stress to the estuaries through direct impacts such as scouring, wake erosion, and construction of boating channels. In addition, boat collisions are the leading anthropogenic cause of manatee deaths.

- ***Resource harvesting*** of sport and commercial fisheries has impacted the standing stocks of many species where over-fishing has occurred. This in turn impacts those species that depend on fish as their primary food source.

D-A.3.7 SUMMARY

A conceptual model was developed for the St. Lucie and Caloosahatchee Estuaries. The model illustrates major linkages between stressors on the system and ecological and societal values. The purpose of the model is to provide a basis for management decisions on proposed restoration activities and to assist in the development of an integrated ecological monitoring program.

St. Lucie and Caloosahatchee Estuaries Conceptual Model Feb 99



D-A.3.8 REFERENCE

Havens, K.E. and B.H. Rosen. 1995. Plan for quantifying long-term ecological trends in Lake Okeechobee. Report, South Florida Water Management District, West Palm Beach, Florida.

D-A.4 DRAFT BIG CYPRESS REGIONAL ECOSYSTEM CONCEPTUAL MODEL

D-A.4.1 PREPARER

Michael Duever, The Nature Conservancy, Kissimmee, Florida.

D-A.4.2 INTRODUCTION

The Big Cypress region covered by this conceptual model includes the freshwater portions of the area extending from the southern edge of the Caloosahatchee River watershed boundary in Lee, Hendry, and northern Collier Counties, and west of the Everglades, as delimited approximately by L-28 in the north and a diagonal line running from Forty-Mile Bend on Tamiami Trail southwest to the coast. In this region historic water flows were primarily south to the Gulf of Mexico, with minor flows in small creeks that pass through the west coast ridge to the Gulf and somewhat more significant flows east into the Everglades (Klein et al. 1970).

There are three distinct subregions within the Big Cypress Region, based on the kind and degree of development present in each (Lehman 1976). The most pristine area, because the hydrology is largely rainfall-driven, is located within the Big Cypress National Preserve in the southeastern portion of the region (Duever et al. 1986). The Preserve, along with a portion of the adjacent Seminole Indian Reservation to the north, is the Big Cypress subregion that was included in the Restudy Alternatives analyses, although only the eastern portion of this area was affected by components included in the various restoration alternatives. The most developed portion of the area, including both urban and agricultural development, is located on and just east of the coastal ridge from Naples north to Ft. Myers. The rest of the area is a mixture of agricultural lands, suburban and rural communities, and small-to-large natural areas that have been altered to varying degrees by upstream and/or adjacent development. Despite the very different degrees of development in the three subregions, the kinds of stressors and their effects on ecosystem attributes are similar throughout the Big Cypress Region and they differ only in the severity of their impacts.

The Big Cypress region is comparable to the freshwater Everglades in terms of natural community diversity, although the communities tend to form more of a mosaic as opposed to vast expenses of a single community type. The most extensive natural communities in the Big Cypress are distributed throughout the region along very gentle topographic gradients from short-hydroperiod pinelands on the uplands through marshes to long-hydroperiod cypress forests on lower elevations (Craighead 1971, Davis 1943, Duever 1984, Klein et al. 1970). Small open-water ponds are found in scattered deeper depressions, and small islands of hardwood forest occur on elevated sites among or along the edges of deeper herbaceous and forested wetlands. While the Big Cypress is dominated by temperate species, there is a small but unique tropical component that is most prevalent in forested upland and swamp communities (Duever et al. 1986). This component is most abundant and diverse close to the coast, but occurs further inland in association with larger and deeper wetlands, where it is protected from cold winter weather by their canopy and/or the moderating effects of standing water. Under natural conditions, the range of annual fluctuation in water levels above and below ground and the duration of inundation are the primary factors influencing the distribution of these communities, although frequent fires exert a secondary influence by controlling the kinds and structure of their dominant plant species (Craighead 1971, Duever 1984, Harper 1927, Klein et al. 1970). Cypress and marsh communities tend to be more common towards the south as elevations approach sea level, while pinelands are more common in the higher and deeper-sand substrates to the north and on the west coast ridge along the Gulf of Mexico.

D-A.4.3 ECOLOGICAL STRESSORS

The ultimate source of all ecological stressors in the Big Cypress ecosystem is development for agriculture and residential use (refer to figure on page D-A-42). The area's seasonally high water table required the construction of an extensive system of small ditches connected to larger and larger canals to assure that water levels remain below ground throughout the year, in order to make the land suitable for crops and housing (Lehman 1976). The drainage systems produce <u>lowered water tables and shortened hydroperiods</u> for considerable distances in otherwise unaltered lands around and downstream of them (Carter et al. 1973, Klein et al. 1970, Swayze and McPherson 1977). These drier conditions can facilitate upgradient shifts in the characteristics of affected plant communities and an associated increased fire severity (Robertson 1953, Wade et al. 1980). In addition, the water in canals draining these lands normally has a different chemistry than that found in natural Big Cypress waters. This is particularly true in terms of undesirably <u>higher concentrations of nutrients and dissolved minerals</u> (Duever et al. 1986), which can encourage the spread and potential dominance of sites by nuisance native and exotic vegetation. The human response to South Florida's dry season produces an additional hydrologic stress on natural systems in the Big Cypress in terms of <u>lowered water tables and shortened hydroperiods</u>. When weather conditions are dry for extended periods, water use for crops, lawns, etc. goes up substantially, which results in lower than normal water levels in and for considerable distances around the wells that provide this water (Lehman 1976, Rochow 1985). Excessive drawdowns associated with canals and wellfields can produce very significant impacts on native amphibian, fish, and crayfish populations that depend on the presence of at least some inundated wetlands for their survival through the dry season. These drawdowns can also eliminate the standing water that normally protects tropical components from winter freezes (Duever et al. 1978).

Changes in land use associated with agricultural and residential development not only cause habitat loss on the affected lands, but fragmentation of the habitat mosaic. Habitat loss directly impacts the availability of resources required by organisms that utilize these areas. However, the distribution of these habitats across the landscape is even more important because few organisms utilize only one habitat type, particularly in a landscape that can fluctuate seasonally from inundated to completely dry and that may be affected by widespread and sometimes severe fires. Thus, when wetland connections to adjacent uplands are severed, innumerable biologically important flows are interrupted and ecosystem diversity and viability are severely compromised (Forman and Godron 1986, Harris 1984). Fragmentation and habitat loss also affects populations by reducing the spatial extent of their resource base to the point where it is no longer able to support viable populations. Exposure to hazards associated with development also increases dramatically as habitats become smaller and are more and more fragmented.

As development increases in an area, the seasonality and frequency of fire in natural communities becomes increasingly unnatural (Wade et al. 1980). Natural fires were normally most common during the summer wet season as a result of the high frequency of lightning (Duever 1984). However, they were most widespread at the end of the dry season, when the region was at its driest and lightning storms were just beginning to occur. Early in this century, cattlemen greatly increased the frequency of dormant season fires to provide more forage for their cattle during the winter months (Ackerman 1976, Alvarez no date, Kennard 1915). More recently, fire has been suppressed over much of the more developed portions of the area, which has caused unusually severe fires when they finally occur, as they always do eventually (Hofstetter 1984). The lack of fire has allowed succession to proceed in many areas, so that herbaceous communities are being invaded by dense shrub thickets and pine and cypress forests are being invaded by shrubs and hardwoods (Hofstetter 1984).

Exotic plants and animals produce drastic alterations in the composition and structure of natural communities, although many of these changes are poorly documented, such as the impacts resulting from the spread of feral hogs and exotic fish (Crowder 1974, Dineen 1984, Duever et al. 1986, Layne 1984). Some that are well documented include the spread of melaleuca and other exotic plants (Duever et al. 1986, Myers 1975). Some species, such as melaleuca and feral hogs, can readily utilize undisturbed natural communities. However, development has facilitated the invasion of exotics by creating an abundance of disturbed sites that normally would have been recolonized by native species, but these species are now being outcompeted by more rapidly invading exotics (Elton 1958, Odum 1971). In addition, farms and residential areas create new habitats that are more suitable to new species, which then invade adjacent natural areas and impact native populations either directly by predation or indirectly through competition for resources.

Bioaccumulation of mercury and other toxins pose a threat to fauna at all trophic levels in all South Florida ecosystems, including the Big Cypress Region, as discussed under generic issues.

D-A.4.4 ECOLOGICAL ATTRIBUTES / VALUES AND MEASURES

Vegetation community and habitat mosaic. This attribute is affected by all of the stressors except mercury and other toxins, which tend to be more impacting on animal populations than on plant communities. Hydrologic and fire regimes control the character and distribution of the major types of Big Cypress plant communities (Craighead 1971, Davis 1943). The most frequent and widespread hydrologic alterations typically result in reduced depth and duration of inundation, which shifts the affected plant communities upgradient towards shallower wetland types, or with sufficient drainage to upland types (Alexander and Crook 1973, Duever 1984). Fires are more frequent and severe in these drier environments, in some areas resulting in dense stands of fire-tolerant cabbage palms and woody exotics (Gunderson and Loope 1982, Tabb et al. 1976). Drainage can also impact tropical components of the communities by eliminating the moderating effect of standing water on cold winter temperatures (Duever et al. 1978). Less frequent alterations involve increasing depths and/or duration of inundation, which can convert uplands to wetlands and wetlands to aquatic habitats. In some situations, altered hydrology can produce unnatural permanently disturbed habitats that are at times too deeply flooded to support upland vegetation, but for too short a period to produce wetland communities.

Natural communities in South Florida are adapted to surface waters with a chemical composition that contains very low concentrations of dissolved minerals and nutrients. Changes in surface water quality typically involve increased nutrient and mineral concentrations coming from ditch and canal outflows into natural wetlands (Drew and Schomer 1984). These increased concentrations can produce dramatic shifts from diverse herbaceous communities to communities dominated by a few native and exotic nuisance species adapted to high nutrient and dissolved mineral concentrations, such as cattails and primrose willow (Duever pers. comm.).

Dormant season fires and reduced fire frequencies can result in shifts from herbaceous to shrubby communities and from open pinelands and cypress forests to shrub and hardwood dominated forests (Alexander and Crook 1971, Duever 1984). As fuels build up in these sites, the inevitable severe wildfire will eventually occur (Hofstetter 1984), and the sites will most likely be converted to early successional communities dominated by weedy herbaceous, vine and shrub species, a large proportion of which are much less abundant, if even present, in natural communities.

Land use changes reduce the area of affected communities and often eliminate the transitions from one to another, particularly along upland to aquatic hydrologic gradients. Since wetlands have more legal protection and are more difficult to develop than uplands, habitat loss is greatest in historical uplands, although this may not be obvious because new upland habitat is being created by the drainage occurring throughout much of the area. Upland development is also resulting in wetlands becoming more and more isolated from each other as well as from other natural parts of the system, which is in turn affecting their faunal populations and fire regimes.

All of the ecosystem alterations associated with development are facilitating the increasingly rapid spread of nuisance and exotic species throughout the Big Cypress Region landscape (Drew and Schomer 1984, Duever et al. 1986). In many areas, exotic woody vegetation such as melaleuca, Brazilian pepper, or downy rosemyrtle completely dominates what were previously herbaceous communities or open pinelands. Cattails and primrose willow have replaced marsh communities that once supported diverse herbaceous species assemblages. Feral hogs annually "plow" thousands of acres, with unknown impacts on what they are foraging on, but quite visible soil disturbance effects that further exacerbate the spread of exotic plants (Duever et al. 1986, Layne 1984).

Measurements of changes in the vegetation mosaic in terms of <u>community distribution, composition, and acreages</u> would provide a basis for assessing habitat gains and losses in the Big Cypress Region. The above discussion is not meant to be exhaustive, but provides examples of the kinds of changes that would be useful to monitor, particularly in any areas that are established as major restoration sites or are set aside for preservation. Rates of change in these communities in response to increased or decreased levels of stressors will vary from three to twenty or more years depending on community type and the management required to accomplish restoration. Early succession communities tend to respond more rapidly to changes than do later successional communities. Management that directly affects vegetation, such as herbiciding or prescribed fire, will produce more rapid responses than will management actions that indirectly affect it, such as changes in hydrology or a reduction in fire frequency.

Logging of old growth pines, which occurred in the Big Cypress through the 1950s, has removed many of the prime red-cockaded woodpecker nesting trees throughout its range (Ligon 1971, Patterson and Robertson 1981). In addition, conversion to agriculture and housing is eliminating their habitat, and the current altered fire regime is resulting in the invasion of native and exotic woody vegetation into remaining pinelands, which is eliminating the open character of these pinelands that is needed to support this species (Patterson and Robertson 1981, Jackson 1971). <u>Red-cockaded woodpecker nesting and nesting success</u> is recommended as a measure of pineland condition, since this species is dependent upon mature, open pinelands. Suitable habitat should be extensive enough so that it would burn regularly, while having a hydrology that would prevent excessively severe fires. Sites should not support nuisance exotics that would tend to grow up and both eliminate the site's open character and produce fuel loads that would result in excessively severe fires. Response to restoration that increases the suitability of habitat would like be expected within five to ten years, where reestablishing the open character of a pineland is involved, but could be twenty or more years, where young pine stands need to reach large enough sizes to provide suitable nest sites.

Native fish, crayfish, and amphibians. These species are affected primarily by altered hydrology and land use changes, both of which are resulting in habitat loss and fragmentation over large areas of the Big Cypress. Abundance of marsh fishes has been correlated with duration of flooding in the Everglades (Loftus and Eklund 1994), suggesting a decline in fish populations in remaining Big Cypress wetlands where water tables have been lowered and hydroperiods shortened. Habitat fragmentation is particularly damaging to these species, which in more natural settings take advantage of the wet season expansion of surface waters into the surrounding uplands by increasing their numbers and biomass, which then becomes available to wading birds and other predators during the surface water's subsequent retreat during the dry season (Carlson and Duever 1979, Kolopinski and Higer 1969, Kushlan et al. 1975). A poorly known influence on them are exotic fish and amphibian species that have invaded the area, which are both preying on native species and competing with them for resources (Dineen 1984, Duever et al. 1986). Documenting the abundance, distribution, and diversity of these taxa will provide useful measures of how the stressors affecting them are being minimized in protected areas and are being ameliorated in areas being restored. Since these populations show a dramatic annual cycle in their numbers and biomass, responses to increasing or decreasing levels of stressors should be detectable within three to five years.

Wood Stork. The Big Cypress region supported the two largest nesting colonies of wood stork in North America between 1900 and 1965 (Ogden Pers comm.). During that period, 6,000-10,000 pairs nested annually in the Corkscrew colony, the Sadie Cypress colony of Okaloacoochee Slough, and smaller subsidiary colonies. Since 1965, wood stork nesting in Big Cypress has declined and has ranged from less than 500 to 1500 pairs since 1990 (Ogden pers. comm.). The subsidiary colonies have been largely lost. Accompanying the decline in numbers of nesting pairs has been a reduction in nesting success in the remaining colonies. The decline in success is attributed to a change in the timing of the initiation of nesting from November to February (Kushlan et al. 1975, Ogden et al. 1987, Ogden 1994). Delay in nesting until February puts nesting out of sync with seasonal rainfall patterns. With the onset of the wet season, rising water levels decrease food availability before the young storks fledge, causing nestling mortality due to starvation. The reduction in numbers of nesting pairs and nesting success is attributed to the loss of early dry season foraging habitat of the higher elevation wetlands of the Big Cypress region that have been drained and developed. Recovery of fish production in the higher elevation wetlands by raising water tables in preserved areas in the western and northern portions of the Big Cypress basin is expected to halt the decline in wood stork nesting in Big Cypress. A trend of increasing numbers of nesting pairs and nesting success and reestablishment of subsidiary colonies should be evident over a decade time scale after water table recovery.

Florida Panther. The Big Cypress Region supports the only viable population of Florida panthers (Logan 1993). The downward spiral of habitat loss and fragmentation leading to isolation and inbreeding has resulted in a single population struggling to survive in the largest remaining contiguous block of land within its historic range. Seventeen years of monitoring indicate a stable but saturated population in the northern portion of its current range, which encompasses public lands north of I-75 and adjacent private lands (Jansen pers. comm.). Habitat vacancies in southern Big Cypress National Preserve and Everglades National Park have not been filled due to the difficulty of population increase when there are few individuals, at times only a single sex, and infrequent ingress. Panther require dry areas for daytime resting but readily travel through inundated habitats (Jansen 1987). Deer, a preferred prey species, benefit from a hydroperiod that promotes nutritious wetland vegetation (Loveless 1959), and prescribed fire improves the nutritional quality of food used by panther prey species. Stressors for the panther include continued habitat loss, inbreeding, and mercury toxicosis. Whether the panther can survive on only existing public lands is unknown, but further habitat reduction will likely increase its vulnerability to catastrophic events. Efforts to improve genetic diversity have been initiated through the introduction of another cougar subspecies. The sources of methyl mercury, reported as the cause of death of at least one panther and known to compromise normal biological functions, have yet to be confirmed and remedied (Roelke et al. 1991). Habitat protection and restoration of natural hydroperiods with clean water would benefit the panther by providing suitable land for population expansion, as well as an uncontaminated and abundant prey base (Jansen, pers. comm.). Improvements in population size, reproductive success, and mercury body burden would likely take decades to document, given the current small population size, low reproductive rate, and the slow turnover of mercury in the body, although improvements in the prey base could be apparent in less than a decade.

Health of Aquatic Fauna. Potential inputs of mercury and other toxins in agricultural and urban runoff water, which may be needed for hydropattern restoration in the Big Cypress, could result in reduced health, behavioral and physical abnormalities, and loss of reproductive vigor unless measures are taken to restrict loads of these toxins in waters flowing into natural areas. Measures of aquatic faunal health that reflect responses to the mercury and pesticide inputs include body burdens of mercury and other toxins in representative species.

D-A.4.5 HYDROLOGIC PERFORMANCE CRITERIA FOR RESTORATION

Successful protection of undisturbed areas and restoration of disturbed areas require the establishment of hydrologic targets that define the desired characteristics of a site's hydrologic regime, and hydrologic measures that evaluate the current status of the site relative to the target. In the portions of the Big Cypress that are included in both the Natural System Model (version NSM4.5F) and the South Florida Water Management Model (SFWMM), NSM conditions were defined as the hydrologic target. The following performance measures were used to evaluate the hydrologic condition of various distinct portions of the area as they were shown to be affected by proposed restoration Alternatives included in a modified version of the SFWMM. Plans are underway to create an expanded version of the SFWMM that will include all of the Big Cypress Region. At the moment there are no plans to create a NSM for the area, although this would be more feasible after the SFWMM is available, since the original NSM was created by modifying the existing SFWMM. Until this model is available, it will be difficult to accurately utilize the following performance measures for the remaining portion of the Big Cypress. Information on the hydrologic regimes of the major Big Cypress freshwater plant community types are described in Duever (1984), and these could be used as interim hydrologic targets for particular communities.

All aspects of a plant community's hydrologic regime are significant in determining its taxonomic and structural characteristics, as well as its distribution across the Big Cypress landscape. The annual duration of inundation, or hydroperiod, is the most important aspect of the hydrologic regime (Duever 1984), largely because of South Florida's minimal topographic relief and its distinct wet and dry seasons. Short hydroperiods eliminate wetland species that are intolerant of the more frequent and severe fires on sites that are dry most of the year, while long hydroperiods eliminate upland species intolerant of extended inundation in low areas (Duever et al. 1978). Maximum and minimum water levels are also important. Wet season water depths can eliminate emergent species that cannot tolerate extended periods of being submerged. The extent of dry season water level declines can influence the frequency and severity of fires entering wetlands, particularly those with organic soils, which maintain a relatively moist substrate and microclimate as long as they are in contact with the water table (Coultas and Duever 1984). During the wet season, water naturally moved as sheet flow across the Big Cypress (Klein et al. 1970). The fact that the water is moving is important, particularly in terms of the resulting water column mixing, which produces a very different water quality than is found in ponded water.

Duration of inundation was evaluated using a number of performance measures. One that provided a spatial perspective of hydroperiod was the percentage of acres within a defined area with a mean hydroperiod for the 31 year simulation that was within 30 days (longer or shorter) of NSM conditions. Another compared average hydroperiod for the 31 year simulation in a specified area in terms of the absolute difference between NSM and current or proposed conditions, which is divided by 100 and then subtracted from 1. This deviation was almost always a reduction in hydroperiod, but any deviation is documented by using the absolute value for the deviation. Another perspective is provided by determining the absolute difference in the average duration of individual flooding events for NSM compared to current or proposed conditions in a defined area, dividing this difference by the NSM duration, and subtracting this value from 1.

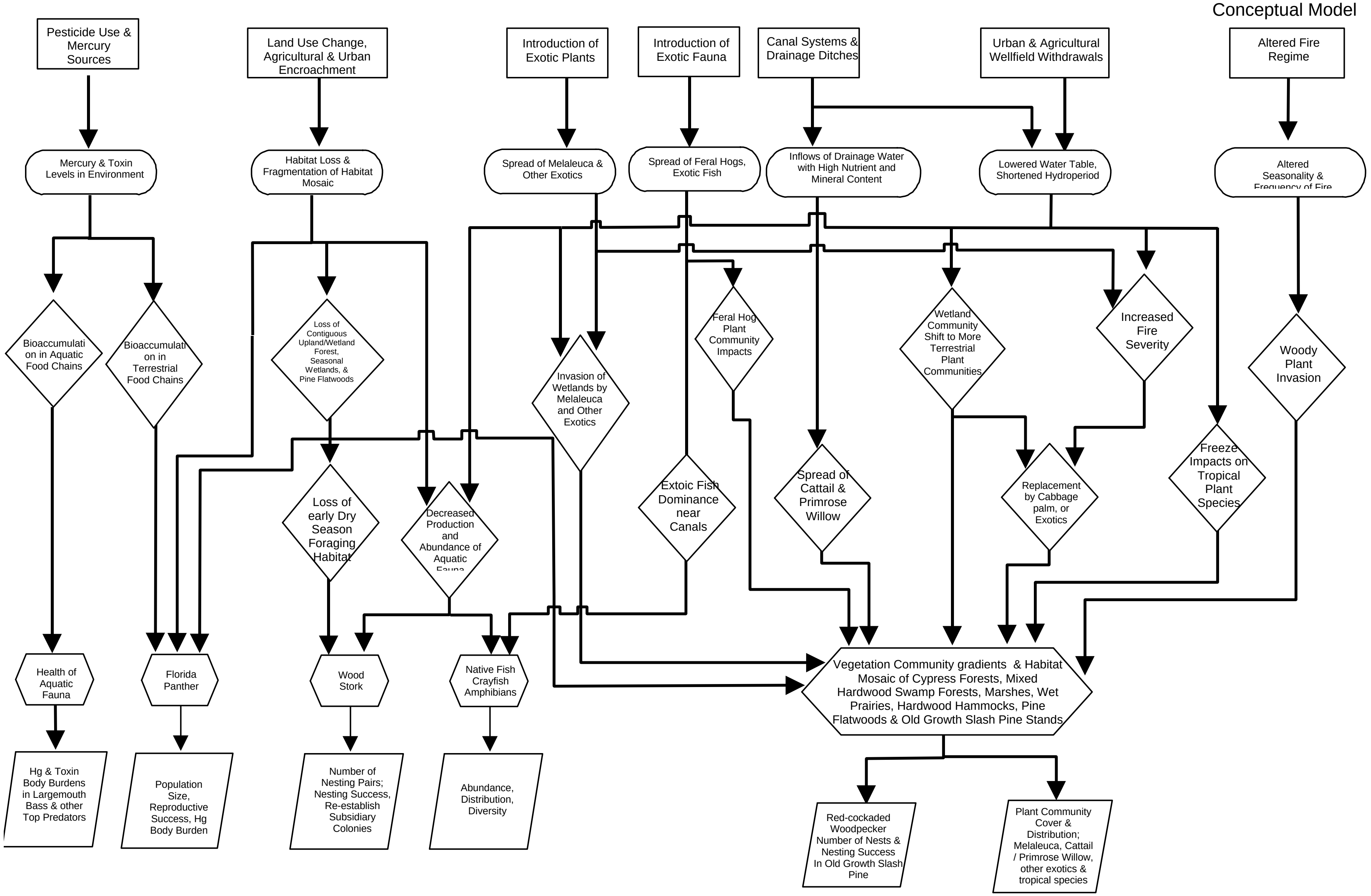
Deviations from NSM water levels above and below ground were evaluated by examining the normalized weekly stage-duration curve from a 31 year simulation for a defined area. The performance measure involved examining the current or proposed condition stage-duration curve and determining its maximum vertical deviation from the NSM curve, and dividing this value by the maximum vertical range of NSM water level fluctuation at the site. The reason for dividing the absolute deviation by the maximum NSM water level fluctuation is that a certain degree of deviation in an area with a large natural fluctuation would be less significant than the same degree of deviation in an area with a small natural fluctuation. Typically, the greatest deviation occurred when the water table was declining through the first foot or two below the ground surface, it was smallest at its lowest point on the hydrograph, and it was relatively small when the water table was above ground.

Documenting total flows during the wet and dry season provides a measure of water movement across a defined boundary and how it changes in response to proposed hydrologic alterations in a particular portion of the Big Cypress. The absolute deviation between NSM and current or proposed condition flows was determined first, this value was divided by NSM flows, and the resulting value subtracted from 1. Initially flows were evaluated separately for the wet and dry season, so that the greater volumes of water moving during the wet season wouldn't overshadow the smaller dry season flow volumes. Simple additive equations were then developed for a flow cross-section to combine the wet and dry season information.

In the final analyses, all of the performance measures for a defined area were combined in a simple additive equation. Since there could be three measures for flooding duration and only one each for water level and flows, this automatically weighted flood duration more strongly than either of the other two components of the hydrologic regime.

It is important to be aware that the above performance measures are based on long-term averages, and there is a great deal of natural year-to-year variability in these values. In addition, the same types of communities vary substantially from one place to another, because of differences in their setting and site history. Even though extreme environmental events can have major affects in shaping natural communities, they don't normally produce shifts from one community type to another because the overall ecosystem has evolved in the context of these events.

Big Cypress Regional Ecosystem
Conceptual Model



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D-A.5 DRAFT EVERGLADES RIDGE AND SLOUGH CONCEPTUAL MODEL

D-A.5.1 PREPARER

John C. Ogden, South Florida Water Management District, West Palm Beach, Florida.

D-A.5.2 INTRODUCTION

As natural systems, the Ridge and Slough landscape features of the Everglades were extensive, long-hydroperiod, freshwater marshes, characterized by low-velocity "sheet flow", moderate to deep organic soils and sawgrass "ridges (Davis et al. 1994, Gunderson 1994, Gunderson and Loftus 1993, McVoy, Park & Obeysekera in prep.)". The ridge and slough systems were dominated by sawgrass strand (Cladium), water lily, and wet prairie (Eleocharis) communities. A spatially variable mosaic of discreet tree islands occurred throughout, ranging from widely spaced in the central Everglades to more densely distributed in the Loxahatchee basin and Shark Slough. The Ridge and Slough systems modeled here are defined by the portion of the Everglades basin where there were Loxahatchee Peat soils (McVoy, Park and Obeysekera, in prep.; the combined "wet prairie/slough, tree island, sawgrass mosaic" and "sawgrass dominated mosaic" in Davis et al. 1994). These sloughs made up the deeper central portions of the total Everglades basin, and occurred to a more limited extent in a series of much smaller scale flow systems located on both the eastern and western flanks of the Shark Slough in the southern Everglades (Taylor, East, Middle, Lostman's sloughs). The ridge and sloughs were principal centers for primary and secondary production and inter-annual survival of aquatic organisms in the freshwater wetlands of southern Florida.

The major, known alterations in the ridge and slough systems have been caused by changes in land use, drainage and water management practices in south Florida (Davis and Ogden 1994, Science Subgroup 1993). The effects from these regional "drivers" include compartmentalization and reduced spatial extent of the natural system, loss of organic soils, altered water depth, distribution and flow patterns, altered water chemistry, and the introduction of exotic species. It is the effects from these "stressors" which are modeled in the conceptual ecological model for the ridge and slough systems, which is presented here.

D-A.5.3 THE SOCIETAL DRIVERS, ECOLOGICAL STRESSORS, AND ECOLOGICAL EFFECTS.

The workshops of the SERA Natural Systems Team and the C&SF Restudy Alternative Evaluation Team have identified four major categories of societal influence (drivers) on the Everglades Ridge and Slough systems, leading to five major ecological stressors. The combined effects from these stressors explain much of the ecological changes which have occurred in the ridge and slough systems (refer to figure on page D-A-56). The four societal drivers and their respective stressors, and the ecological effects resulting from the stressors, are as follows.

Urban and Agricultural Expansion. Drainage of wetlands, and the subsequent conversion of slough habitat into agricultural and urban uses has **reduced** the total **spatial extent** of the ridge and slough system in the main Everglades from 490,000 ha in the pre-drainage system to 365,000 ha in the current system (Davis et al. 1994). The biological and physical effects from this 26% loss in spatial extent include, (a) a substantial reduction in habitat options for wildlife, and (b) a reduction in the system-wide levels of primary and secondary production.

Space was the one physical characteristic of the south Florida wetlands that was necessary for all other physical and ecological components of these systems to be in place. The broad spatial extent of the pre-drainage sloughs was essential for collecting and storing the amount of regional rainfall that was required to maintain the ecological vigor of these systems. Large spatial scale provided the foundation for the processes that created and maintained a mosaic of habitats in a low profile terrain (Craighead 1971, DeAngelis & White 1994). Disturbances, such as fire, freezes, tropical storms, and animal related impacts (e.g., an abundance of alligator-created ponds and trails) served to increase the complexity of habitats, as well as the range of habitat choices for species of wildlife with both small and large home ranges (Craighead 1968, DeAngelis 1994, Duever et al. 1994, Gunderson & Snyder 1994, Davis & Ogden 1994). Extensive space was necessary for supporting robust numbers of animals requiring extensive feeding or hunting ranges throughout different seasons and a range of hydrological conditions For example, the location of feeding and nesting sites for white ibis and other wading birds, snail kites, and other common aquatic birds shifted across large spatial scales and across seasons and years, in response to variability in hydrological patterns (Kushlan 1979, Bennetts et al. 1994, Hoffman et al. 1994, Ogden 1994). The large number of ponds and depressions occurring over an extensive region allowed for comparatively sedentary species such as the alligator to maintain very large, regional numbers (Craighead 1968). Greater space enabled the system-wide aquatic production in a nutrient-poor ecosystem necessary to support large numbers of wading birds and alligators (Browder 1976, Mazzotti and Brandt 1994).

(2.) **Influences from Industrial and Agricultural Practices**. Increased loads of Phosphorus (P) and Mercury (Hg), originating as bi-products from an array of agricultural and urban industrial practices, were identified as the two alterations in **water quality** which have been demonstrated or hypothesized, respectively, to have had the greatest ecological significance in the slough systems (Roelke et al. 1991, Spalding & Forrester 1991, Lange et al. 1994, Browder et al. 1994, Davis 1994, Frederick et al. 1997). Increased phosphorus loading in a low-nutrient system has, (a) caused a substantial expansion of "nutrient-loving" plants (monocultures of cattail) into other communities, (b) contributed to shifts in the species composition in periphyton mats, from communities dominated by green algae/diatoms to communities dominated by blue-green algae, and (c) contributed to reductions or alterations in primary and secondary production patterns. Increased levels of environmental mercury, and the conversion to the toxic methyl mercury form, has considerable potential to substantially reduce survival rates, and alter behavior patterns, for omnivorous and carnivorous animals dependent on wetland food chains.

(3.) **Water Management Practices**. All five of the major ecological stressors acting on the slough systems (reduced spatial extent, the introduction and spread of degraded water, **reduced water storage capacity, compartmentalization**, and the introduction and spread of exotic species) have had part or all of their origins in water management practices. Major objectives of water management have included water supply and flood control, which have been achieved by means of a complex system of structural and operational modifications to the natural system. These modifications have, (a) contributed to the substantial reduction in spatial extent, (b) provided a network of canals and levees which have accelerated the spread of degraded water and exotic species, (c) greatly reduced the water storage capacity within the remaining natural system, (d) altered sheet flow velocities and directions, and (e) created an unnatural mosaic of impounded and over-drained marshes in the Water Conservation Areas (Science subgroup 1993, Davis and Ogden 1994, Light and Dineen 1994, Fennema et al. 1994).

Ecological effects from (a) and (b) are summarized in (1) and (2) above. The combined effects from reduced water storage capacity, altered sheet flow patterns and compartmentalization have, paradoxically, included both a reduction in the duration of annual and multi-year hydroperiods and an increase in the frequency of unnatural high water events.

Shortened hydroperiods (i.e., an increase in the frequency and duration of surface water dryouts) have resulted in a substantial increase in the frequency and extent of over-drained marshes, primarily during dry season months. Over-drained marshes have contributed to a broad array of adverse ecological impacts, including the spread of woody species of plants into marshes, reduced alligator nesting effort, reduced levels of aquatic production, reduced survival by aquatic organisms over multi-year periods, and considerable loss of peat soils due to increased frequencies and intensities of fire and increased levels of soil oxidation (e.g., Craighead 1971, Davis and Ogden 1994, Fleming 1991, Gunderson and Loftus 1993, Loftus et al. 1990, Loftus et al. 1992, Loftus and Eklund 1994, Mazzotti and Brandt 1994, Myers 1983, Stober et al. 1996).

The unnaturally distributed mosaics of impounded water in the southern portions of the WCAs, caused by compartmentalization, have contributed to the flooding of tree islands, have altered marsh community structure, and have caused an artificial re-distribution of the centers of aquatic production and animal survival throughout the WCA portion of the ridge and slough system (Armentano 1996, Bancroft et al. 1994, Davis et al. 1994, Fennema et al. 1994, Frederick and Spalding 1994). The break-up of the large, traditional wading bird nesting colonies and relocation of smaller, less successful colonies to the WCAs, are hypothesized to be responses by wading birds to the combined affects of marsh drainage and the relocation and fragmentation of the region's aquatic production and survival centers (Ogden 1994).

Societal influences on the species composition of regional floras/faunas. The introduction, both intended and unintended, of large numbers of **non-native species** of plants and animals that have been brought into south Florida because they have been considered to be desirable additions to the region, from the perspective of a wide range of human values, has resulted in substantial alterations to the Everglades sloughs. The most blatant examples affecting the sloughs have been, (a) the invasions by Melaleuca, and the conversion of extensive marshes into woody swamps (Bodle et al. 1994, Laroche and Ferriter 1992), and (b) the spread by 15-20 species of introduced fishes throughout much of the region of the ridge and slough systems (Courtenay 1994, Robertson and Frederick 1994). Although the ecological consequences of these fishes has been largely unmeasured, it must be assumed that their presence has substantially altered the characteristics of marsh fish communities.

D-A.5.4 CRITICAL ECOLOGICAL PATHWAYS

The principal, broad-scale ecological responses from the combined affects of the five major ecological stressors acting on the ridge and slough systems have been, (a) a substantial alteration and degradation in the natural patterns of plant community composition and structure, and (b) substantial changes in the distribution, and reductions in abundance, among many of the native animals that are dependant on aquatic habitats and food chains. The relative contribution made by each of the stressors, along the different pathways shown in the model, to these two primary responses is not well known. For example, the presence of physical and biological thresholds, some of which may have been crossed as a result of the affects of the stressors, have yet to be demonstrated for most functions and relationships in the sloughs (an exception might be the 10 ppb value for Ph). Never-the-less, current understandings of the ridge and slough systems, as expressed by the NST and AET workshop participants, suggest that four ecological pathways have been most important for explaining how these two principle, broad-scale, ecological responses have been linked to the stressors. These four pathways are:

(1.) The pathway that links the reduction in water storage capacity and the substantial increase in the extent and frequency of over-drained marshes (shortened hydroperiods), with an array of ecological effects characterized by a spread in woody vegetation, reduced numbers of nesting alligators, reduced marsh production, reduced dry season survival by aquatic organisms, and the loss of peat soils.

(2.) The pathway that links compartmentalization, and the adverse affects that levees have on water depth/distribution patterns and sheet flow, with altered patterns of nutrient cycling and reduced marsh production, and relocated animal distribution, production and survival centers.

(3.) The pathway that links the reduction in water storage capacity, compartmentalization and the adverse affects of regulatory releases, with flooded tree islands and flooded alligator nests.

(4.) The duel pathways that link degraded water quality and the affects of canals with increased phosphorus loading, resulting in the spread of cattail monocultures, degraded periphyton communities, and reduced marsh production.

D-A.5.5 ECOLOGICAL ATTRIBUTES AND MEASURES.

The NST and AET workshops recommended seven ecological attributes of the Everglades ridge and slough systems, which, collectively, will provide the best measure of system responses to restoration projects (Fig. X). The model shows how each attribute is linked to one or more stressor. The recommended measures for each attribute should be treated as priority components for a comprehensive ecological monitoring program.

(1.) Peat Soils. A recovery of more natural patterns in the duration of uninterrupted surface flooding, and in water depths, should result in the return of pre-drainage rates of accretion for peat soils. Conversely, unnatural rates of loss of organic soil due to oxidation and excessive fires should be curtailed.

(2.) Community of Marsh Fishes, Invertebrates & Herps. Improved water quality, longer hydroperiods, improved patterns of nutrient cycling and primary production, and reductions in the influences of exotic fishes, should be reflected by measures of the composition, size structure and abundance of these animals.

(3.) Tree Islands. Reductions in the adverse affects of flooding, fire, and exotic plants should be reflected by measures of tree island distribution, and by the species composition and structure of woody plants on the islands.

(4.) Marsh Plant Communities. Elimination of the adverse impacts due to excessive fire, soil oxidation, shortened hydroperiods, unnaturally deep impoundments, overdrained marshes, the spread of exotic plants, and degraded water quality should be reflected by measures of the distribution, composition and structure of the dominant marsh communities in the sloughs.

(5.) Alligators. An increase in the abundance and density of alligator nests and active alligator ponds is an expected response from lengthened hydroperiods, increased marsh production rates, and reductions in wet season regulatory releases and the unnatural affects of impoundments.

(6.) Periphyton. Improvements in water quality and in the depth and duration of flooding should be reflected by shifts in species composition and production rates in the periphyton communities.

(7.) Wading Birds. The size, timing and location of wading bird nesting colonies, as well as the occurrence and frequency of "super colonies", should reflect improvements in foraging habitat options under a range of climatological conditions, in marsh production rates, survival rates of marsh organisms during dry periods, and in the location of the major production and survival centers in the slough systems.

D-A.5.6 HYDROLOGICAL PERFORMANCE MEASURES.

The four critical pathways (above) suggested by the Everglades ridge and slough model are driven by hydrological stressors (over-drained marshes due to reduced storage capacity; unnatural depth-distribution patterns due to levees; wet season flooding due to regulatory releases and the affects of canals and levees; increased phosphorus levels due to agricultural practices and canals). These pathways suggest that the most important hydrological targets for meeting the ecological objectives of the SERA and Restudy projects are, (a) reduction in the frequency, duration, extent and magnitude of marsh dryouts during dry seasons, (b) reduction in the unnatural spatial mosaics of deep impoundments and over-drained marshes, reductions in the duration and unseasonable timing of unnatural high water events during wet seasons, and (d) reductions in the input and rapid distribution of phosphorus. The shortened dry-season hydroperiods characteristic of the managed system are a response to substantially reduced water storage capacity in the system, coupled with the affects of compartmentalization. The unnatural mosaics of deep and shallow water are caused by compartmentalization; more specifically, by the network of levees and the operational schedules associated with the WCAs. The unnatural wet season depth patterns have been due to the combined affects of water storage in WCA-3A, and regulatory releases through the S-12s. These three stressors working in concert have caused a loss of natural patterns of inter-seasonal and inter-annual water depth distribution and depth, which is thought to have substantially disrupted the pulses in marsh production that once characterized the natural system. The increased phosphorus loading has been due to the rapid transport of water with elevated phosphorus levels into much of the Everglades ridge and slough system.

Of these four priority hydrological targets, three are characterized by measures of water depth, and the duration and timing of surface and ground water flooding. For these three, hydrological performance measure targets can be established, based on regional hydrological patterns predicted by the Natural Systems Model. These performance targets, and a suggested order of priority relative to the magnitude of the ecological issues associated with each, are as follows.

Priority 1. The highest priority for ecological restoration of the Everglades ridge and slough systems is the establishment of annual and interannual patterns in the duration of uninterrupted surface flooding, which are generally consistent with predictions of the NSM, in Everglades National Park and the WCAs. Included in this priority is the increase in duration of flooding in the overdrained, northern ends of the WCAs without an increase in flooding in the southern WCAs, and a recovery of the pre-drainage patterns of multi-year hydroperiods in Shark Slough.

Priority 1 Measure. For the 30 year period of record, compare patterns of uninterrupted surface water flooding for cells at key indicator regions. The performance criterion is the difference between the duration patterns shown by the NSM and the 2X2 simulations for each plan alternative. The target is a mean difference of zero. Examine annual hydrographs to insure trends are correct and that the annual drydown in any given year does not occur before the time indicated by the NSM.

Priority 2. Elimination of compartmentalization effects, characterized by unnatural mosaics of deep and shallow water across levee alignments, and by loss of sheet flow.

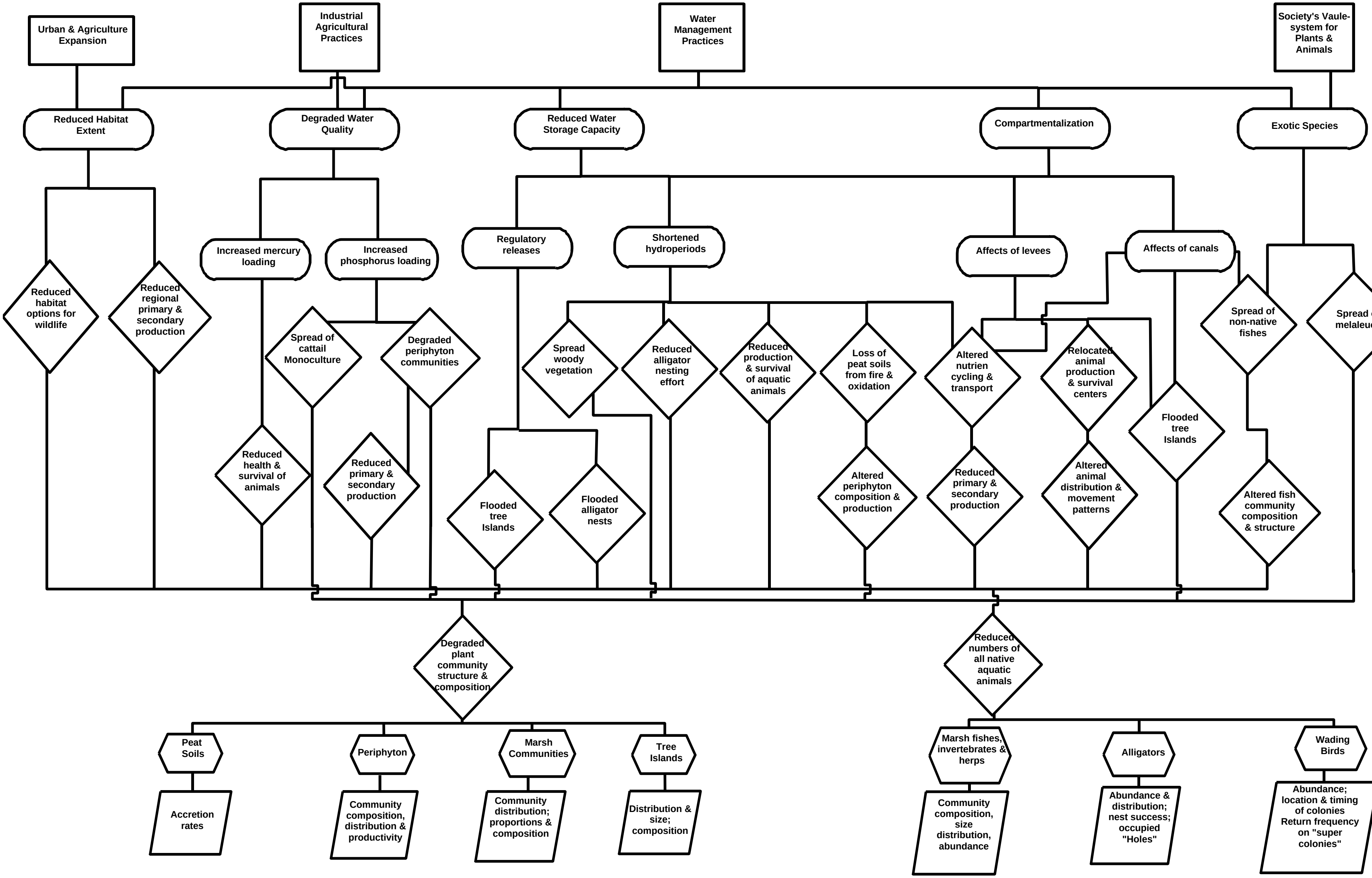
Priority 2 Measure. Compare monthly surface and ground water depth patterns for selected sets of cells representing opposite sides of levees, for all major structural divides within the WCAs, and between WCA 3 and Everglades National Park. The performance criterion is for water depths between paired sets of cells to not differ more than 0.2 foot during any given month, and for these depth patterns to be consistent with NSM predictions. For sheet flow, compare numbers of miles of levees and canals internal to the ridge and slough systems, and separating the ridge and sloughs from adjacent wetlands (i.e., sawgrass plain; Big Cypress).

Priority 3. A third priority in the ecological restoration of the Everglades sloughs is the elimination of regulatory schedules and other operational practices, and internal levees, which cause unnaturally deep water patterns, primarily during wet seasons.

Priority 3 Measure. For the 30 year period of record, compare monthly patterns of surface water depth for cells at key indicator regions. The performance criterion is the difference between the depth patterns shown by the NSM and the 2X2 simulations for each plan alternative. The target is a mean difference of zero.

Examine monthly depth pattern graphs to insure trends are correct for timing and location, relative to NSM patterns.

Everglades Ridge & Slough Conceptual Model
(Feb 99)



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D-A.6 DRAFT MARL PRAIRIE/ROCKY GLADES CONCEPTUAL MODEL

D-A.6.1 PREPARER

Steven M. Davis, South Florida Water Management District, West Palm Beach, Florida.

D-A.6.2 INTRODUCTION

In 190,000 ha of higher-elevation, freshwater marshes on either side of Shark River Slough, water levels typically drop below the ground surface each year (Davis et al., 1994). Consequently peat accretion is inhibited, and substrates consist either of marl produced by periphyton mats, or exposed limestone bedrock with solution holes (Gleason, 1972). The landscape consists of a mosaic of wet prairie, sawgrass, tree island, and tropical hammock communities that support a high diversity of plant species (Olmstead and Loope, 1984). The ephemeral characteristics of the hydrology of marl prairies and rocky glades pose stresses to the wetland animal communities regarding survival through the dry season when standing water is usually absent (Loftus and Eklund, 1994; Loftus et al., 1990). In that respect, the American alligator represents a keystone species in the marl prairie/rocky glades because alligator holes provide important refugia for aquatic fauna during dry periods (Craighead, 1968).

D-A.6.3 ECOLOGICAL STRESSORS

The dominant sources of stressors on the marl prairie/rocky glades ecosystem are water management practices and agricultural and urban development (refer to the figures on pages D-A-72 &73). The water management system has altered hydropatterns of remaining wetlands primarily through the lowering of water tables and through the unseasonable regulatory release of water from upstream (Van Lent et al., 1993). A network of canals and levees, particularly the C-111 system, has resulted in the compartmentalization of the remaining marl prairie/rocky glades wetland system. The canals and pump stations are conduits for inputs of nutrients, mercury, other toxins, and exotic fishes into the remaining wetland system

Agricultural and urban development represents a direct loss of spatial extent of the marl prairie/rocky glades wetland system through conversion of marshes to farmland and housing (Davis et al., 1994). Development provides potential sources of nutrients, mercury and other toxins to the natural system via runoff water that may need to be captured and stored for hydropattern restoration.

<u>Shortened hydroperiod (duration of uninterrupted flooding)</u>. Much of the marl prairie/rocky glades remains dry most of an average year under present conditions,

compared to a duration of uninterrupted flooding averaging nine months pre-drainage as indicated by the Natural System Model (Van Lent et al., 1993; Fennema et al., 1994; VanZee, in preparation). Shortened hydroperiod directly affects ecosystem food webs through the 1) decrease in diatoms, desmids, and other green algae associated with the periphyton mat and the related reduction of the primary production food base (Browder et al., 1994), 2) reduced secondary production and altered species composition of fish based on comparisons of long and short hydroperiod sites in Shark River Slough (Loftus and Eklund, 1994; Loftus et al., 1990; Turner et al., 1999 in press) and possibly crayfish, 3) reduced pupolation density and altered species composition of small herpetofauna, based on abundance in short-hydroperiod habitats in relation to rainfall and water levels on Big Pine Key (Diffendorfer et al., in preparation; Dalrymple, 1987; Dalrymple, personal communication), 4) loss of the potential for hypothetical wading bird and wood stork foraging during the early dry season (Fleming, personal communication in Ogden, 1994), and 5) decline in the American alligator population in the landscape where it was once abundant (Craighead, 1968; Mazzotti and Brandt, 1994). Shortened hydroperiod directly affects plant community and habitat structure, in addition to the already noted alteration of the periphyton mat and filling in of alligator holes, by enabling the invasion of woody plants such as willow and exotics such as Brazilian pepper and melaleuca in a naturally herbaceous landscape (Armentano et al., 1995; Jones and Doren, 1997), and by altering the plant species composition of macrophyte vegetation toward more terrestrial plant species (Hofstetter and Hilsenbeck, 1980; Hilsenbeck et al., 1979). Shortened hydroperiod indirectly affects plant community and habitat structure through altered fire regime: hotter and more severe fires due to the prolonged dry season (Gunderson and Snyder, 1994) further alter herbaceous plant species composition and reduce plant community heterogeneity by burning out hardwood hammock tree islands (Loope and Urban, 1980). Shortened hydroperiod, in combination with increased drought severity, threatens Cape Sable sparrow reproductive success and survival in the marl prairies to the east of Shark River Slough by increasing the frequency and severity of nest-destroying fires, or by enabling the invasion of woody plants in the absence of fire (Pimm, 1995)

<u>Increase in drought severity</u>. In a system where water levels typically fall below the ground surface each year, remnant pools of standing water in solution holes and alligator holes during the dry season are critical to the survival of aquatic and amphibious fauna such as fish, crayfish, herpetofauna, and alligators (Loftus et al., 1992; Mazzotti and Brandt, 1994; Diffendorfer et al., in prep.; Dalrymple, 1987; Dalrymple, personal communication). When dry conditions are prolonged, and minimum water levels during a dry season fall below the bottoms of the solution holes and alligator holes, the function of these dry season refugia is diminished or eliminated.

Wet season water level reversals. Field observations indicate that when water depth drops to less than 0.2 feet during a period of flooding, aquatic fauna population densities decline, survivors retreat to refugia in solution holes or alligator holes, and population recovery is slowed (Loftus and Eklund, 1994; Loftus, personal communication).

Drying pattern reversals due to upstream regulatory releases. Reversals in the seasonal timing of water level recessions due to regulatory releases from WCA3A detrimentally affect nesting density and success of the endangered Cape Sable sparrow (Pimm, 1995). Drying pattern reversals have been particularly detrimental to sparrow nesting in the marl prairies to the west of Shark River Slough, in an area that is affected by water releases from the S-10 A and B outflow gates from Water conservation Area 3A. Unnaturally high flow volumes to the west of Shark River Slough, rather than via Northeast Shark River Slough under NSM conditions, exacerbates the problem of the sparrow. The Cape Sable sparrow depends on predictably dry conditions during its spring nesting period which corresponds to the late dry season (Pimm, 1995). Drying pattern reversals and their effects on the sparrow are analyzed as an endangered species issue.

Increased nutrient inputs. Agricultural and urban runoff water from the lower east coast that may be needed for hydropattern restoration is anticipated to bring with it increased inputs of phosphorus, nitrogen and other nutrients. Cattail has already dominated portions of Taylor Slough downstream of the Park road since pump station S332 commenced to deliver canal water to Taylor Slough (Davis, personal observation). A probable effect of nutrient additions to the marl prairie/rocky glades would be the loss in the periphyton mat and the dominance of blue-green algae, with resulting reductions in the primary production food base and reductions in marl substrate accretion (Browder, 1994).

Compartmentalization. The levees that bound and dissect the marl prairie/rocky glades on the east side of the Everglades, and the C-111 system in particular, may create barriers that genetically isolate populations of aquatic fauna, as demonstrated by the genetic structure of mosquitofish and grass shrimp in the Water Conservation Areas compared to Everglades National Park (Trexler et al., in review). Canals adjacent to the levees provide corridors of permanently flooded, deep-water habitat that would not otherwise occur in the marl prairie/rocky glades. These corridors allow the expansion of exotic and higher trophic level fishes into areas where they could not survive naturally (Howard et al., 1995). The prevalence of higher trophic fishes in the canals diminishes the value that this habitat might otherwise serve as a dry season refugium for aquatic and amphibious fauna.

Loss of spatial extent. The conversion of eastern portions of the marl prairie/rocky glades to agriculture and housing has reduced the spatial extent of primary production that provides the base of the food webs of fish, crayfish, herpetofauna, alligators, and wood storks and wading birds. The spatial loss of the aquatic habitat has also directly reduced populations of these organisms. The extent of loss in production and aquatic habitat is directly proportional to the spatial extent of the area that has literally been taken out of production as wetland (Davis et al., 1994). Loss of spatial extent may have reduced the range of habitat options that are available at any given time for faunal populations (DeAngelis and White, 1994), including nesting by the Cape Sable sparrow nesting (Pimm, 1995) and potential foraging by wood storks and wading birds (Fleming, personal communication in Ogden, 1994).

Introduction of exotic plants. Melaleuca, Brazilian pepper and Australian pine are the three most widespread exotic plant species that have spread into native plant communities of the marl prairie/rocky glades, due to their introduction combined with shortened hydroperiod which allows their expansion (Olmstead and Loope, 1984; Armentano et al., 1995; Jones and Doren, 1997).

Burning practices. Burning practices, particularly from illegally set fires, have shifted the seasonal timing of fires from the May-June early wet season, due to lightning strikes, to the winter-spring dry (Gunderson and Snyder, 1994). Fire severity has been exacerbated by shortened hydroperiod and increased drought severity. The road access provided by levees contributes to fire ignition by humans by allowing arsonists access to the marshes and by creating a source of ignition from vehicle sparks (Burzycki, personal communication). Intense, dry season fires have burned out hardwood hammock tree islands in the marl prairies and rocky glades to the east of Shark River Slough. Fire hazard due to over-drainage also poses a threat to Cape Sable sparrow nesting success and survival in the marl prairies to the east of Shark River Slough.

D-A.6.4 ECOLOGICAL EFFECTS OF WATER MANAGEMENT: CRITICAL LINKAGES BETWEEN STRESSORS AND ATTRIBUTES

Four major causal pathways appear to account for the decline in the ecological values of the marl prairies and rocky glades as a result of water management-induced stressors. Each pathway, other than that of the Cape Sable sparrow, has been most severely impacted in the marl prairies and rocky glades to the east of Shark River Slough.

1) The periphyton mat has been altered in ways that reduce its contribution to aquatic food chains and marl formation. Diatom, desmid and other green algal components of the periphyton mat have decreased as a result of severely shortened hydroperiod. The mat is lost entirely and replaced by non-mat-forming bluegreen algae as a result of nutrient additions in pumped inflow water.

2) The American alligator has been mostly eliminated, due to severely shortened hydroperiod and lowered water table, from the landscape where it was once most abundant. Alligator holes in depressions in the limestone bedrock have silted in with organic debris and no longer function as dry season refugia for aquatic fauna. Their loss has decreased the heterogeneity of vegetation habitat and micro-topography.

3) The marsh fishes, herpetofauna and probably other aquatic fauna of the marl prairies and rocky glades can maintain only diminished population density and secondary production given the shortened hydroperiod and lowered water table, the altered periphyton mat, the loss of dry season refugia in alligator and solution holes, and the physiological stress due to wet season water level reversals.

4) The vegetation community mosaic has lost heterogeneity and changed in species composition due to community shift due to shortened hydroperiod and lowered water table, the loss of alligator holes, tropical hammock tree island burn-out due to altered fire regime, woody plant invasion, and the spread of exotic plants.

5) The Cape Sable sparrow is limited in reproductive success and population size by drying pattern reversals from upstream water releases to the west of Shark River Slough. To the east of the Slough, the sparrow is threatened by shortened hydroperiod and lowered water table, which result either in increased fire frequency and severity, or in woody plant invasion in the absence of fire.

D-A.6.5 ECOLOGICAL VALUES / ATTRIBUTES AND MEASURES

Periphyton mat. The periphyton mat of attached algae plays a key role as a food chain base (Browder et al., 1994), as habitat structure (Loftus, personal communication), and as the source of marl sediments (Gleason, 1972) in the marl prairies and rocky glades. Species composition of the periphyton is a sensitive indicator of both hydrologic conditions and water quality (Browder et al., 1994). Severely reduced hydroperiod in the marl prairies and rocky glades results in a decrease in the diatom, desmid and other green algal species in the periphyton mat, leaving mostly mat-forming blue-green algae that are less valuable as food sources for consumers (Browder et al., 1994). Nutrient enrichment, that may accompany the inflow of canal water, results in the loss of mat-forming species altogether and replacement by non-mat-forming blue-green algae (Browder et al., 1994). Measures of periphyton communities that indicate recovery due to lengthened hydroperiod and potential impacts of nutrient enrichment include aerial coverage, species composition, biomass, and primary productivity rates of periphyton mats of the marl prairies and rocky glades.

Marl substrate. Mat-forming calcitic algae deposit the marl substrate that is characteristic of the marl prairies (Gleason, 1972; Browder et al., 1994), where hydroperiod is too short for the accretion of peat soils. Most of the plant communities described by Olmstead and Loope (1984) and Gunderson (1994) for this region are supported by the marl soils. The dependence of marl deposition on the productivity of the calcitic periphyton mat indicates that the negative impacts of shortened hydroperiod and nutrient enrichment that are noted above for the periphyton mat would also adversely affect the rate of marl accretion. Measures of the marl substrate that should reflect responses to hydroperiod, and nutrients and restoration efforts include marl distribution and depth and marl accretion rate.

Vegetation mosaic and diversity. A unique feature of the marl prairies and rocky glades is the extremely high species richness of their flora. Within the mosaic of low-stature graminoid communities, sawgrass and muhly grass dominate, although more than 100 species of mostly herbaceous plants have been reported (Olmstead and Loope, 1984). The higher-elevation tropical hammock and pine forests that occur as islands within the prairie landscape support flora of West Indian origin that are unique to south Florida, other than the Keys, and that contain the highest number of rare and threatened plant species in south Florida (Gunderson, 1994). The plant communities of the marl prairies and rocky glades have been impacted by man through drainage, exotic invasion and burning practices. Tree island burn-out (Loope and Urban, 1980), shifts to more terrestrial plant associations in the graminoid communities (Hofstetter and Hilsenbeck, 1980; Hilsenbeck et al., 1979), loss of the vegetation heterogeneity associated with the micro-topography of alligator holes (Craighead, 1968), and woody plant invasion of the graminoid communities (Armentano, et al., 1995) have accompanied shortened hydroperiods and lowered water tables. These effects are exacerbated by the spread of exotic trees (Olmstead and Loope, 1984; Armentano et al., 1995; Jones and Doren, 1997) and by dry season burning practices (Gunderson and Snyder, 1994), particularly from illegally-set fires. Measures of vegetation responses to stressors and restoration efforts in the marl prairies and rocky glades include the spatial cover and species composition of graminoid and tree island communities .

Cape Sable sparrow. The Cape Sable seaside sparrow is endemic to the marl marshes of the southern Everglades, where it is listed as an endangered species. The three major breeding colonies of the sparrow include the western sub-population in marl marshes to the west of Shark River Slough, the eastern sub-population to the east of mid Shark River Slough, and the central sub-population to the east of the southwest Slough (Pimm, 1995). The sparrow nests during the dry season months, mostly during April–June, in sites free of standing shrubs or trees. The construction of nests approximately 10 cm above the ground at the bases of tussocks of muhly grass and other marsh graminoids makes the sparrow vulnerable both to spring wildfires and unseasonable water depth increases (dry season water level reversals). Successful nesting requires approximately 45 days of nearly dry conditions without fire. Dry season water level reversals have been a particular problem to the nesting success of the western sub-population, where regulatory water releases through the S-12 A and B outflow gates of Water Conservation Area 3A contribute to the reversals and subsequent nest drowning (Pimm, 1995). The eastern sub-population occupies an over-drained region of marl prairie subject to spring wildfires or to invasion of woody vegetation. The central population is the most stable because of its remote location, although it is vulnerable to infrequent, naturally-occurring dry season fires. Measures of sparrow populations that reflect responses to stressors and restoration measures include nesting distribution, density and success.

Aquatic fauna. The aquatic fauna of freshwater Everglades marshes include the myriad of small fishes, amphibians, reptiles, crayfish, grass shrimp, snails, amphipods and other invertebrates that must play enormously important roles in food webs, nutrient cycles and energy transfers from primary consumers to the highest trophic levels in the ecosystem. Considering their prevalence, little is known about the life histories, population dynamics and ecosystem roles of the aquatic fauna, particularly regarding their ecology in the marl prairies and rocky glades.

Population density of small marsh fishes in the Everglades is directly related to the duration of uninterrupted flooding, and maximum densities are reached only after several years of continual surface water (Loftus and Eklund, 1994; Loftus et al., 1990; Turner et al., 1999 in press). The herpetofauna of the short-hydroperiod wetlands reach higher abundance in habitats with longer hydroperiods and higher water tables (Diffendorfer et al., in preparation.;Dalrymple, 1987; Dalrymple, personal communication). These studies provide evidence that the marl prairies and rocky glades represent stressful environments for aquatic fauna. These marshes typically dried for an average of three months each year under pre-drainage conditions, and extensive areas of this landscape are only wet for an average of three months each year under present conditions (Van Lent et al., 1993; Fennema et al., 1994; VanZee, in preparation). Survival of aquatic fauna during dry periods in the marl marshes and rocky glades depends in the availability of refugia in solution holes, alligator holes, and under periphyton mats which may retain aquatic or moist environments during times when surface water is absent (Loftus et al., 1990; Loftus et al., 1992; Dalrymple, 1987; Diffendorfer et al., in preparation; Loftus, personnal communication; Dalrymple, personal communication).

The small marsh fishes provide the major prey base for the wading birds, wood storks and roseate spoonbills that forage and nest in the Everglades (Ogden, 1994; Bjork and Powell, 1994). Crayfish are particularly important in the diets of white ibis. The marl marshes may provide foraging opportunities for wading birds early in the dry season when deeper water depths in the lower-elevation sloughs are unsuitable for efficient feeding (Fleming, personal communication in Ogden, 1994).

However, the relationship of such foraging opportunities to the advent of nesting and the subsequent reproductive success of wading birds is still hypothetical.

Reduced production and altered species composition of fishes and herpetofauna in the marl prairies and rocky glades result from 1) the direct impact of shortened hydroperiod (Loftus and Eklund, 1994; Turner et al., 1999 in press; Diffendorfer et al., in preparation; Dalrymple, 1987; Dalrymple, personnal communication), 2) indirect impacts of shortened hydroperiod via the loss of the periphyton mat and a reduced primary production food base (Browder et al., 1994), 3) the prolongation of dry conditions and reduction in dry season minimum water levels via the diminished dry season refugium function of solution holes, alligator holes and periphyton mats (Loftus et al., 1992; Diffendorfer et al, in preparation; Dalrymple, 1987; Loftus, personal communication; Dalrymple, personal communication), 4) reduction in spatial extent of wetland habitat (Davis et al. 1994), 5) increased nutrient inputs via the loss of the periphyton mat and a resulting reduction in the primary production food base (Browder et al., 1994), and 6) compartmentalization via levees as potential genetic barriers (Trexler et al., in review) and via canals as corridors for the spread of exotic and higher trophic level fishes (Howard et al., 1995). Measures of aquatic fauna populations that reflect responses to the above stressors include density and species composition of fishes and density of representative herpetofauna and invertebrate species.

American alligator. Prior to drainage, the American alligator was more abundant in the marl marshes and rocky glades than in the deeper central marshes of the Everglades(Craighead, 1968; Mazzotti and Brandt, 1994). By excavating sediments from large solution holes in the limestone bedrock, the alligator created aquatic habitats in which it, and many other groups of aquatic fauna, survived the few months of dry conditions that occurred most years (Craighead, 1968). In the excavation of holes and the creation of nest mounds, the alligator created a micro-topography that supported aquatic as well as terrestrial flora and fauna (Craighead, 1971; Kushlan, 1974). The mounds provided nesting sites not only for the alligator, but also for other marsh reptiles (Deitz and Jackson, 1979; Kushlan and Kushlan, 1980). In these ways, the alligator was a keystone species in the marl prairies and rocky glades because of the aquatic habitats and dry season refugia it created. The high abundance of alligators in the marl marshes and rocky glades, in comparison to lower densities in Shark River Slough, was attributed to high water depths in the Slough that would have been less suitable for alligators prior to drainage (Ogden, 1976; Mazzotti and Brandt, 1994). Given the shortened hydroperiods and lowered water tables in the Everglades due to drainage (Van Lent et al., 1993;Fennema et al., 1994; VanZee, in preparation), the alligator has mostly abandoned the marl marshes and rocky glades, and today the distribution of the alligator in the southern Everglades has shifted to Shark River Slough (Craighead, 1968; Mazzotti and Brandt, 1994). With the loss of alligators from the marl prairies and rocky glades, the habitats and dry season refugia that were provided by its holes and nest mounds have also diminished.

Abandonment by the alligator of the marl prairie/rocky glades has resulted from shortened hydroperiod and increased drought duration and severity, in that the alligator does not occupy habitat that is predominantly dry. Cumulative effects leading to the reduced production of aquatic fauna at all trophic levels probably have also contributed to the demise of the alligator in the mark prairies, since the alligator depends upon these organisms for food during various stages of its life history. The reduced population of alligators has in turn allowed depressions that were previously alligator holes to fill in, further diminishing the populations of aquatic fauna upon which upon which the alligator fed. The restoration of hydroperiods and water tables to those approaching pre-drainage conditions in the marl prairies and rocky glades is anticipated to allow the alligator to re-colonize this region, as measured by <u>density and distribution by age class</u> and <u>density and distribution of alligator holes</u>.

<u>Wading bird and wood stork early dry season foraging</u>. Prior to drainage, the marl prairie/rocky glades may have provided shallow-water foraging opportunities for wading birds and wood storks early in the dry season, at a time when water was too deep to allow successful foraging in Shark River Slough (Fleming, personal communication in Ogden, 1994). The early dry season foraging opportunities may have contributed to the early formation of nesting colonies, and thereby the nesting success of the birds, but this would have been dependent upon an adequate prey base of aquatic fauna in the marl prairie/rocky glades. The relationship of such foraging opportunities to the advent of nesting and subsequent reporductive success of wading birds and wood storks is hypothetical. Under present conditions, both shortened hydroperiod (Van Lent et al.,1993; Fennema et al., 1994; VanZee, in preparation)and loss of spatial extent Davis et al., 1994) have directly reduced the area of feeding habitat and the range of feeding options available to the wading birds and wood storks in the marl prairie/rocky glades (Ogden 1994). Cumulative effects leading to the reduced production of fish and other aquatic fauna, as noted above, have further reduced the prey base for wading birds and wood storks. As a result, the value of the marl prairies and rocky glades for wading bird and wood stork foraging appears to be very limited today in comparison to pre-drainage conditions (Fleming, personal communication in Ogden, 1994) . Measures of wading bird and wood stork utilization of the marl prairie/rocky glades that reflect responses to the above stressors include the <u>seasonal distribution and abundance of foraging birds</u>.

D-A.6.6 HYDROLOGIC PERFORMANCE CRITERIA FOR RESTORATION

Recovery of the ecological values of the marl prairie/rocky glades is dependent upon the reversal of the cumulative effects of decades of drainage, detrimental fire regimes, and exotic plant invasion. The key role of the C&SF Comprehensive plan in the restoration of the marl prairie/rocky glades ecosystem is to provide for the quantity, timing, and distribution of water deliveries that contain low levels of nutrients and toxins. Three priority hydrologic performance measures for the ecological restoration of the marl prairie/rocky glades, in order of priority, are the duration of uninterrupted flooding, drought severity as measured by the duration of dry conditions, and the number of wet season depth reversals.

The duration of a uninterrupted flood events is the highest priority hydrologic performance measure for ecological restoration in the marl prairie/rocky glades. It is identified as the single hydrologic parameter that affects all the ecological values of that region. Only flood events when the mean water depth equals or exceeds 0.2 feet are measured because depths less than 0.2 feet have been observed to impair the establishment of populations of aquatic organisms. The mean duration of all such flood events during the 31-year period of record is the performance measure. The target is the mean duration of flooding indicated by NSM45F. Duration of uninterrupted flooding given a weighting of 3 when averaged with the other performance measures.

Drought severity is the second most important hydrologic variable for ecological restoration in the marl prairie/rocky glades. Drought severity is most clearly indicated by 2X2 model output as the duration of dry conditions. Dry events are defined as times when the water level drops either to zero or a negative value below the ground surface. Two dry events that are separated by a flood event when the water level rises to less than 0.2 feet above the ground surface are grouped as one dry event because such a minor flood event has been observed to not support the establishment of populations of aquatic organisms. In that case, the duration of the dry event is calculated as the sum of the two dry events and the intermittent flood event. The performance measure is the mean duration of all dry events during the 31-year period of record. The target is the mean duration of dry events indicated by NSM45F. The mean duration of dry events is given a weighting of two when averaged with the other performance measures.

Wet season water level reversal is the third most important hydrologic variable for ecological restoration in the marl prairie/rocky glades. A wet season water level reversal is defined as an incident during a period of flooding when water depth recedes to less than 0.2 feet, but then rebounds to greater than 0.2 feet, without the marsh drying completely. A reversal is distinguished from a dry period in that during a reversal, water depth does not drop to or below the ground surface. The performance measure is the total number of reversals during the 31-year period of record. The target is not to exceed the number of reversals indicated by NSM45F.

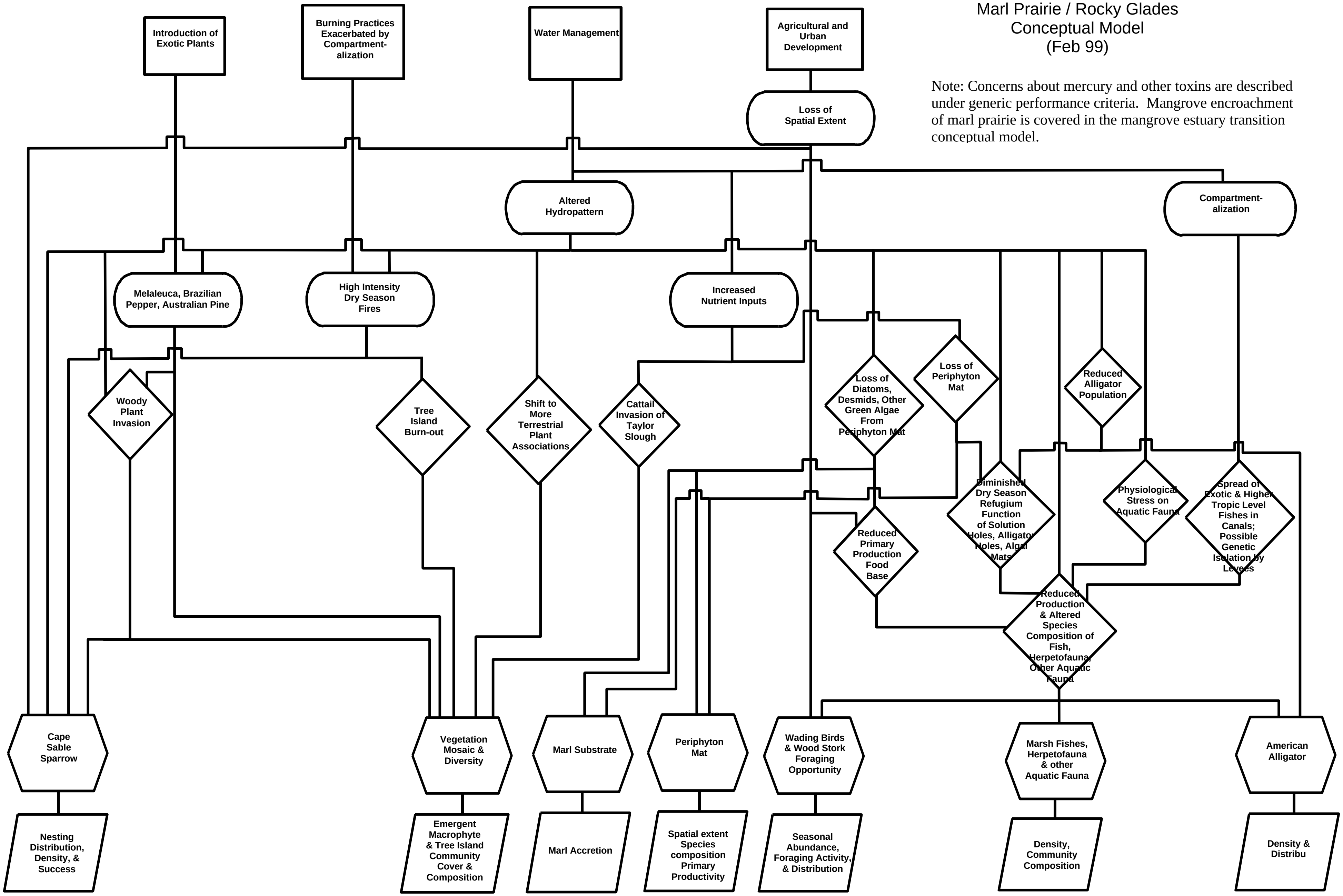
The number of wet season reversals is given a weighting of one when averaged with the other performance measures.

Ecological values and indicators of restoration success in the rockland marl marsh that are linked to the above hydrologic performance measures in the conceptual model include 1) re-colonization and population resurgence by American alligators and a subsequent increase in the number of occupied alligator holes to serve as dry season refugia for aquatic fauna and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased seasonal abundance and foraging activity of wading birds and wood storks, 4) enhanced production and community composition of periphyton, 5) accelerated accretion of marl substrate, 6) increased nesting success and population size of Cape Sable seaside sparrows, and 7) persistence and resilience of highly diverse macrophyte and tree island plant communities.

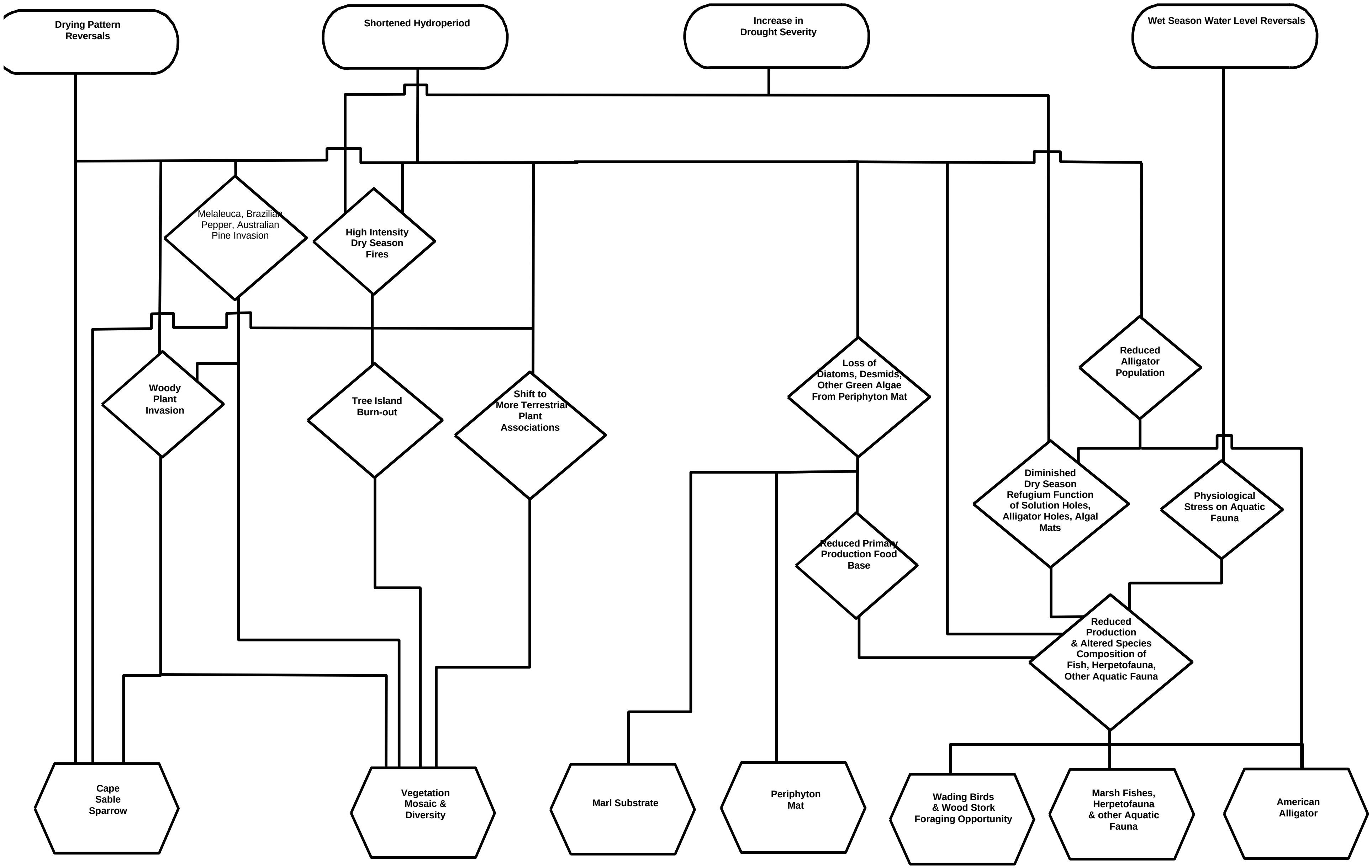
A performance criterion that is generic to the conceptual models of all physiographic regions of south Florida is the input and bio-accumulation of mercury and other toxins. Potential inputs of mercury and pesticides in agricultural and urban runoff water that may be needed for hydropattern restoration in the marl prairie/rocky glades might result in reduced health, behavioral and physical abnormalities, and loss of reproductive vigor of the fauna unless measures are taken to restrict loads of these toxins in inflow water. Measures of faunal health that reflect responses to the mercury and pesticide inputs include body burdens of mercury and other toxins in representative species of fauna and the incidence of physical and behavioral abnormalities in fauna.

Marl Prairie / Rocky Glades
Conceptual Model
(Feb 99)

Note: Concerns about mercury and other toxins are described under generic performance criteria. Mangrove encroachment of marl prairie is covered in the mangrove estuary transition conceptual model.



Marl Prairie / Rocky Glades
Effects of Altered Hydropattern
Conceptual Model
(Feb 99)



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D-A.7 DRAFT MANGROVE ESTUARY TRANSITION CONCEPTUAL MODEL

D-A.7.1 PREPARER

Steven M. Davis, South Florida Water Management District, West Palm Beach, Fl.

D-A.7.2 INTRODUCTION

A brackish water ecotone of coastal bays and lakes, mangrove and buttonwood forests, salt marshes, and tidal creeks separates Florida Bay from the freshwater Everglades. The 24 km-wide ecotone adjoins the north shoreline of Florida Bay between Highway Creek (US1) and Whitewater Bay, which delineate the eastern and western boundaries of the mangrove estuary transition model. Whitewater Bay is included in the model because it is influenced by the Shark River drainage basin originating in the Everglades. The mangrove estuary transition is characterized by a salinity gradient and mosaic that vary spatially with topography and that vary seasonally and inter-annually with rainfall and freshwater flow from the Everglades. Because of its location at the lower end of the Everglades drainage basin, the mangrove estuary transition zone is potentially affected by upstream water management practices that alter the freshwater heads and flows that drive salinity gradients.

D-A.7.3 ECOLOGICAL STRESSORS

Stressors on the mangrove estuary transition ecosystem and the drivers that create them fall into five categories (refer to figures on pages D-A-87& 88). Sea level rise is an important non-societal driver (Wanless et al., 1994) that is causing the inland movement of marine conditions into the estuary transition zone (Meeder et al., 1996). The inland movement of marine conditions due to sea level rise is happening independent from other societal-driven stressors. The societal-driven water management operations of the C&SF Project stress the transition zone through reductions in the volume and duration of freshwater flow entering the zone (McIvor et al., 1994) The introductions of exotic fishes and plants are other societal-driven drivers that have resulted in the dominance of the Mayan cichlid east of Taylor Slough (Trexler et al., in prep.) and the invasion of *Schinus* and *Colubrina* into mangrove forests (Armentano et al., 1995). The societal input and bioaccumulation of mercury and other toxins pose a threat to faunal health at all trophic levels in all south Florida ecosystems, including the mangrove estuary transition, as discussed under generic issues.

D-A.7.4 ECOLOGICAL EFFECTS: CRITICAL LINKAGES BETWEEN STRESSORS AND ECOLOGICAL VALUES

The inland movement of marine conditions due to sea level rise and the reduced input of freshwater due to water management work together to alter and compress the salinity gradient of the mangrove estuary transition (Browder and Moore, 1981). They both result in the landward movement of salinity, the loss of a seasonal shift from moderate saline to oligohaline conditions, and occurrence of hypersalinity within the transition zone during dry years. Both directly change habitat structure by contributing to the siltation and mangrove encroachment of tidal creeks (Meeder et al., 1996), to the extent that open water courses that were described earlier this century are no longer recognizable (Glen Simmons, personal communication).

The alteration and compression of the salinity gradient results in the loss of the spatial overlap of salinity zones with shoreline habitat and nursery grounds (Browder and Moore, 1981). Ecological values of the mangrove estuary transition that depend on the overlap of salinity and habitat include the mangrove/salt marsh vegetation mosaic, the resident mangrove fish assemblage, the wood stork and roseate spoonbill, the American crocodile, spotted seatrout nursery grounds, pink shrimp nursery grounds, and coastal lake vegetation and waterfowl.

D-A.7.5 ECOLOGICAL VALUES / ATTRIBUTES AND MEASURES

Mangrove/salt marsh vegetation mosaic. The alteration and compression of the salinity gradient potentially can affect the community cover, distribution, and production of the mangrove forests (*Rhizophora*, *Avicennia*, *Laguncularia*, and *Conocarpus*), salt marshes and tidal creeks of the mangrove estuary transition that are documented by Welsh et al. (1995). Some mangrove forests in the transition zone have experienced invasion by the exotic trees *Schinus* and *Colubrina* (Armentano et al., 1995). Tidal creeks and adjacent salt marshes have been encroached by red mangrove as described above. The invasion of the freshwater marl marshes at the upstream end of the salinity gradient by red mangrove (Meeder et al., 1996) corresponds to an accelerated rate of sea level rise The vegetation mosaic defines the habitats of the mangrove estuary transition zone. The spatial distribution of those habitats, in combination with the salinity gradient that overlays them, may determine the suitability of this region to sustain its ecological values (Browder and Moore, 1981). The importance of this habitat mosaic warrants the monitoring of the distribution and cover of vegetation communities and tidal creeks in the mangrove estuary transition zone as efforts proceed to restore freshwater inputs and salinity regimes.

Resident mangrove fish community. The resident fish community of sheepshead, sailfin mollies, topminnows, rainwater killifish, and sunfish thrives under low salinity, decreasing in production and increasing in mortality when salinity exceeds 5-8 ppt (Lorenz, 1997 and in press). The exotic Mayan cichlid has become established in this fish community to the extent that it presently is the dominant species from Taylor River east to Highway Creek (Trexler et al., in prep.). Lowered salinity regimes due to increased freshwater inputs are expected to result in community recovery as measured by increased production and abundance of resident mangrove fishes. The dependence of wood storks on larger resident mangrove fishes above approximately 10 cm in length (Ogden et al., 1978) provides an additional measure of increased survival of topminnows and sunfish to year class one (into their second year of life). Consistently lower salinities at the upstream end of the salinity zonation are expected to reduce mortality and allow survivorship of these species to the larger size classes that are available to wood storks.

Wood stork and roseate spoonbill. The collapse of the coastal nesting colonies of wood storks and great egrets is attributed largely to a decline in the production and density of the resident mangrove fishes (Ogden, 1994), particularly topminnows and sunfish that survive past their first year to a size that wood storks can capture (Ogden et al., 1978). The decline in roseate spoonbill nesting and the shift of nesting distribution from eastern to western Florida Bay (Powell et al., 1989) are also attributed to the reduction in populations of resident mangrove fishes upon which they feed (Bjork and Powell, 1994). Small fishes have been reported to be the primary part of the diet of roseate spoonbills in Florida Bay (Allen, 1942; Powell and Bjork, 1990). Increased density of resident mangrove fishes and increased fish survival to year class one, as a result of consistently lower salinity patterns at the upstream end of the gradient, are expected to contribute to the re-establishment of wood stork coastal nesting colonies, the re-establishment of roseate spoonbill Florida Bay nesting colonies east of Seven Palm Lake, and an increase in number of nesting pairs and nesting success of both species.

American crocodile. The American crocodile dwells in the ponds and creeks of the mangrove estuaries of Florida Bay (Ogden, 1976; Mazzotti, 1983). American crocodiles are tolerant of a wide salinity range as adults because of their ability to osmoregulate (Mazzotti, 1989). Juvenile crocodiles lack this ability, however, (Mazzotti, 1989) and their growth and survival decline at salinities exceeding 20 ppt (Mazzotti et al., 1988; Mazzotti and Dunson, 1984; Moler, 1991). Juvenile crocodiles tend to seek freshwater pockets such as black mangrove stands when those choices are available. Re-establishment of a salinity gradient with levels below 20 ppt in shoreline and tidal creek habitats, which would indicate a gradient and mosaic of lower salinities upstream, is expected to benefit the crocodile as measured by increased growth and survival of juveniles.

Spotted seatrout nursery grounds. Post larval spotted seatrout utilize the coastal basins of the Florida Bay mangrove estuary as nursery grounds from Terrapin Bay west to Whitewater Bay. Densities of post larvae in those basins are highest at an intermediate salinity range of 20-30 ppt, and densities drop when salinity exceeds that of seawater (35 ppt) (Thayer et al., 1998; Schmidt, 1993). Restoration of a salinity gradient with a persistent zone of <35 ppt in the coastal basins, as a result of freshwater input from upstream, is expected to result in an increase in the post larval density and thereby an enhancement of the nursery ground value for spotted seatrout and possibly other sport fish species in the coastal basins.

Pink shrimp. Mangrove estuaries in Everglades National Park, along with Florida Bay, are nursery grounds for pink shrimp, an ecologically and economically important species in south Florida. Pink shrimp are harvested commercially on the Tortugas grounds, and the pink shrimp fishery is one of south Florida's most valuable fisheries in terms of ex-vessel value. Pink shrimp are also a food source for many recreationally and commercially important estuarine and marine species such as mangrove snapper and spotted seatrout (Higher Trophic Levels Working Group, 1998).

Pink Shrimp spawning occurs in the Dry Tortugas area, and eggs and larvae are carried inshore by currents and tides (Jones et al., 1970; Hughes, 1969). Browder (1985) and Sheridan (1996) have found positive relationships between indices of freshwater inflow to the coast and Tortugas pink shrimp landings. Sheridan's annually updated statistical model based on various freshwater inflow indices has successfully predicted annual pink shrimp landings in most of the past decade (Sheridan 1996 and unpublished). The salinity gradient associated with coastal runoff may provide navigational directions to immigrating young pink shrimp (Hughes, 1969). Survival rates of juvenile pink shrimp are sensitive to salinity and decrease markedly under extreme hypersaline conditions (Browder, in press). Optimal salinities for survival are not fully determined, but probably are somewhat below that of seawater (35 ppt). Tabb et al. (1962), Rice (1997), and others have documented that the mangrove estuaries in the Whitewater Bay system of Everglades National Park are pink shrimp nursery grounds.

Coastal lake vegetation and waterfowl. Compression of the salinity gradient has changed the coastal lakes and basins of the mangrove ecotone from estuarine to predominantly marine systems. Coastal lakes such as Seven Palm Lake, Cuthburt Lake, Long Lake, West Lake, Lake Monroe and the Taylor River ponds are contained within the mangrove forest and are connected to Florida Bay only by tidal creeks. Coastal basins such as Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight,and Whitewater Bay open directly to Florida Bay or the Gulf of Mexico. The coastal lake and basin estuary ecosystems require seasonal salinity variations from oligohaline (wet season) to mesohaline (dry season) conditions, in contrast to the mesohaline to marine conditions that presently occur during most years. Prolonged periods of salinity concentrations near that of seawater (35 ppt) in the coastal lakes and basins appear to have contributed to the near-elimination the once-abundant beds of the submerged aquatic plants *Ruppia*, *Chara*, and *Utricularia* (Ogden, personnal communication) which require oligohaline to mesohaline conditions (Morrison and Bean, 1997). *Utricularia* tolerates only oligohaline salinities with an upper limit of 5-8 ppt. *Chara* also thrives under freshwater conditions but tolerates mesohaline salinities up to 15-20 ppt. *Ruppia* grows under a mesohaline salinity range of 10-25 ppt. Waterfowl species including coot, scaup, widgeon and pintail feed on the *Ruppia*, *Chara*, and *Utricularia*. The reduction in beds of these plants apparently has contributed to the precipitous decline in numbers of seasonally abundant waterfowl that formerly utilized the coastal lakes and basins (Kushlan et al., 1982). Recent high-rainfall years have witnessed an increase in coot numbers on the West Lake to approximately 2000 during winter 96-97 (Bass, personal communication), but not to the population size of approximately 50,000 that over-wintered there until the 1960's (Kushlan et al., 1982). Re-establishment of a salinity gradient that restores seasonal variation from oligohaline to mesohaline conditions in the coastal lakes and basins is expected to result in an increase in the aerial cover of *Ruppia*, *Chara*, and *Utricularia* and the return of winter waterfowl populations of coot, scaup, widgeon and pintail to the lakes and basins.

D-A.7.6 HYDROLOGIC PERFORMANCE CRITERIA FOR RESTORATION

Ecological restoration of the mangrove estuary transition requires a reduction in the frequency of high salinity events that have been identified for each coastal basin through the conceptual model process. Another restoration criterion is to increase the frequency of low salinity events that have been identified for each coastal basin. The high and low salinity levels represent the best professional judgement of those scientists working in the mangrove estuary, based on the existing information on the biological requirements and distributions of the estuarine organisms that are described above, available salinity data, and field observation.

Table 1 displays the lower and upper salinity levels identified for coastal basins. It is desirable to decrease the frequency that salinity exceeds upper levels, and to increase the frequency that salinity drops below lower levels.

Table 1
Salinity Values

Basin	Lower Level	Upper Level
Joe bay	5 ppt	15 ppt
Little Madeira Bay	15 ppt	25 ppt
Terrapin Bay	25 ppt	35 ppt
Garfield Bight	25 ppt	35 ppt
North River Mouth	5 ppt	15 ppt

The strategy for ecological restoration of the mangrove estuary transition is to maintain freshwater heads and flows in the Everglades at the upstream end of the salinity gradient in order to achieve desirable salinity regimes in the Florida Bay coastal basins at the downstream end of the salinity gradient. Regression analyses demonstrated inverse relationships of salinity in the coastal basins to water level upstream in the Everglades (Davis, 1997). The regressions indicated that stages of 7.3 and 6.3 feet msl at the P33 gage in central Shark River Slough produce the lower and upper salinity levels for Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight, and North River Mouth. Four performance measures for the ecological restoration of the Florida Bay mangrove estuary and coastal basins are derived from the simulated stages at the P33 gage and salinity levels in the coastal basins.

The frequency of stages of 6.3+ at P33 is applied as a performance measure for the Florida Bay coastal basins. The performance measure is the number of months during the 31-year period of record when stages at P33 rose to, or above, 6.3. The target is the number of months that NSM45F provided stages of 6.3 or above. A reduced frequency of high salinity events is given a high priority in the ecological restoration of the coastal basins, thus the frequency of 6.3+ stages is given a weighting of two when averaged with the other performance measures.

The frequency of stages of 7.3+ at P33 is applied as a performance measure to the Florida Bay coastal basins. The performance measure is the number of months during the 31-year period of record when stages at P33 rose to, or above, 7.3. The target is the number of months that NSM45F provided stages of 7.3 or above. An increased frequency of low salinity events is given a lower priority than a reduced frequency of high events, thus the frequency of 7.3+ stages is given a weighting of one when averaged with the other performance measures for the coastal basins.

The transition from the late dry season to the early wet season during March through June is a critical period to estuarine organisms in the Florida Bay coastal basins regarding the frequency and duration of high salinity events. Salinity is estimated based on relationships between mean monthly salinity in the coastal basins and water stage at the P33 gage in mid Shark River Slough. The cumulative salinity difference (ppt) from the high salinity levels that have been identified for Florida Bay coastal basins is summed during the dry/wet season transition months of March-June. Differences are summed over five coastal basins (Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight and North River Mouth) and over the 31-year period of record. Differences above the specified high salinity levels are given a positive value, and differences below the high salinity levels are given a negative value. The target is to reduce the cumulative salinity difference to a value that does not exceed the cumulative difference produced by NSM45F. The cumulative March-June salinity difference from high levels is given a weighting of one when averaged with the other performance measures for the coastal basins

During the August-October transition from the late wet season to the early dry season, it is important to achieve low salinity levels in the Florida Bay coastal basins to provide the seasonal environment for low-salinity estuarine organisms and to postpone the onset of high salinity events further into the dry season. Salinity is estimated based on relationships between mean monthly salinity in the coastal basins and water stage at the P33 gage in mid Shark River Slough. The cumulative salinity difference (ppt) from the low salinity levels that have been identified for the Florida Bay coastal basins is summed during the wet/dry season transition months of August-October. Differences are summed over the five coastal basins and over the 31-year period of record. Differences above the specified low salinity levels are given a positive value, and differences below the low salinity levels are given a negative value. The target is to reduce the cumulative salinity difference to a value that does not exceed the cumulative difference produced by NSM45F. The cumulative August-October salinity difference is given a weighting of one when averaged with the other performance measures for the coastal basins.

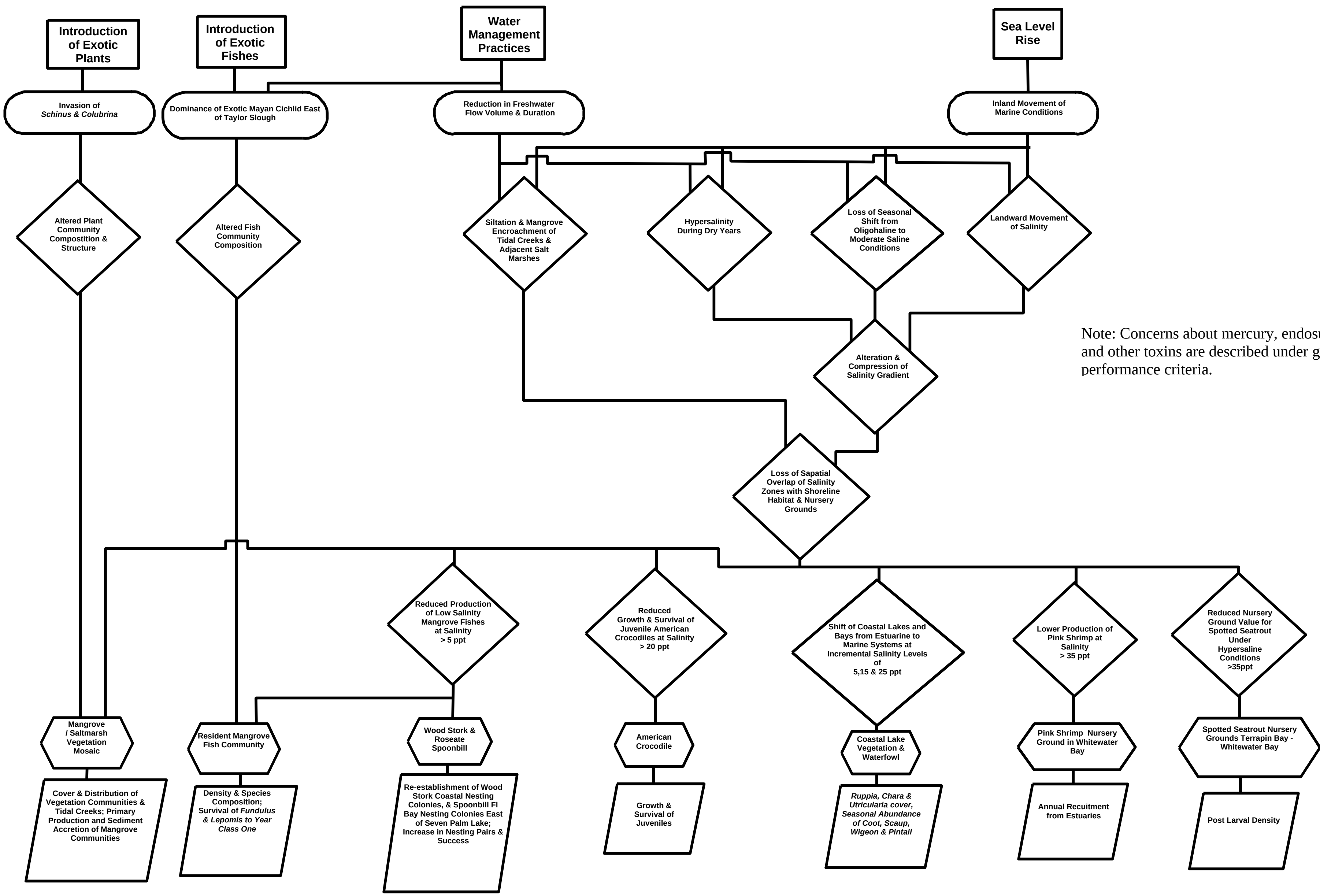
Ecological values and indicators of restoration success in the Florida Bay mangrove estuary and coastal basins that are linked to the above hydrology/salinity performance measures in the conceptual model include 1) increased production of low-salinity mangrove fishes, 2) re-establishment of coastal nesting colonies of wood storks/great egrets and eastern Florida Bay colonies of roseate spoonbill, 3) earlier timing of coastal colony formation by wood storks/great egrets and of Florida Bay colony formation by roseate spoonbills, 4) increased growth and survival of juvenile American crocodiles, 5) increased cover of low-to-moderate salinity aquatic macrophyte communities in coastal lakes and basins, 6) return of seasonal waterfowl aggregations to coastal lakes and basins, 7) enhanced nursery ground value for spotted seatrout and pink shrimp in coastal basins, and 8) persistence and resilience of the mangrove, salt marsh and tidal creek vegetation mosaic.

A performance criterion that is generic to the conceptual models of all physiographic regions of south Florida is the input and bio-accumulation of mercury and other toxins. Potential inputs of mercury and pesticides in agricultural and urban runoff water that may be needed for freshwater input into the mangrove estuary transition might result in reduced health, behavioral and physical abnormalities, and loss of reproductive vigor of the fauna unless measures are taken to restrict loads of these toxins in inflow water. Measures of faunal health that reflect responses to mercury and pesticide inputs include body burdens and the incidence of physical and behavioral abnormalities in representative species.

D-A.7.7 MOVING TARGET

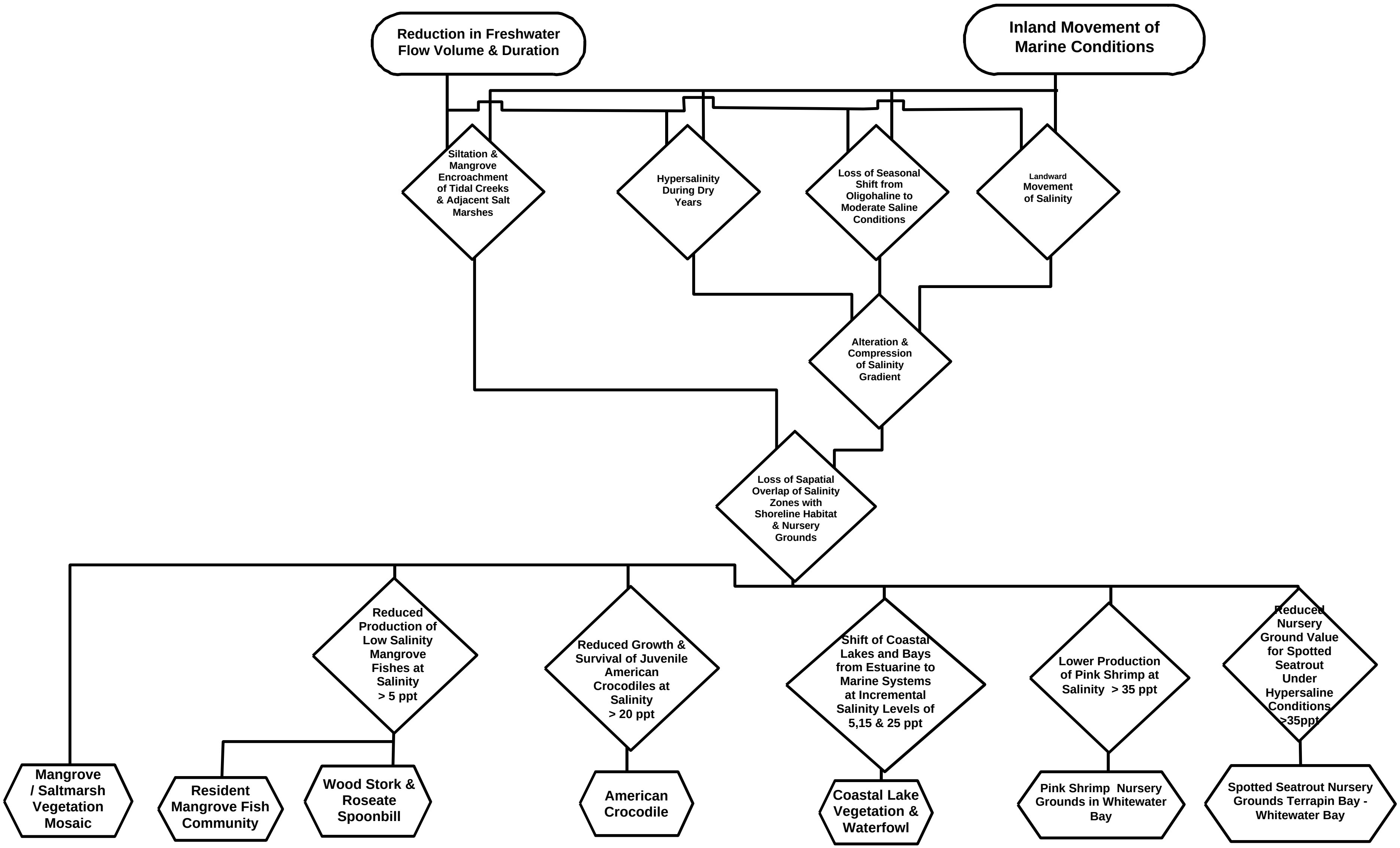
Predicted rises in sea level require re-evaluation of relationships between Everglades stage and mangrove estuary transition salinity during the next century. However, the strategy for the maintenance of salinity at the lower end of the gradient by adjusting upstream water stage at key Everglades gages will continue to apply. Maintaining Everglades stages based on presently derived stage/salinity relationships provides one potential strategy to support a salinity gradient, but with a landward shift in response to rising sea level. Raising Everglades stages based upon revised stage/salinity relationships provides another potential strategy to offset sea level rise and maintain the mangrove estuary transition in its present location. Regardless of rising sea level, however, a salinity gradient supportive of an ecologically functional mangrove estuary transition zone will be required to maintain the integrity of the south Florida ecosystem.

Mangrove Estuary Transition Conceptual Model (Feb 99)



Note: Concerns about mercury, endosulfan and other toxins are described under generic performance criteria.

Mangrove Estuary Transition
Combined Effects of Freshwater Inputs and Sea Level Rise
Conceptual Model
(Feb 99)



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D-A.8 DRAFT BISCAYNE BAY CONCEPTUAL ECOLOGICAL MODEL

D-A.8.1 PREPARERS

Diego Lirman, Elizabeth A. Irlandi, and Wendell P. Cropper, Jr., Center for Marine and Environmental Analyses, University of Miami, Miami, Florida.

D-A.8.2 INTRODUCTION

Biscayne Bay is a subtropical lagoon located on the southeast coast of Florida. The Bay is generally subdivided into three sections with unique biological and physical characteristics: a) North Bay, north of the Rickenbacker Causeway, b) Central Bay, from the Rickenbacker Causeway to Card Sound, and 3) South Bay, an area that includes Card Sound and Barnes Sound (VanArman et al., 1989).

The North Bay, an area heavily influenced by urban development activities, has reduced water clarity, high concentrations of toxicants and nutrients, and chronic sewage pollution (e.g., Wanless, 1976; Harlem, 1979; Judge et al., 1979; Wanless et al., 1984; Corcoran et al., 1987). The main sources of pollution for this heavily urbanized watershed are the Miami River, the Port of Miami, and various canals (e.g., Buck, 1976; Corcoran et al., 1984; Dade County , 1987; Markley et al., 1990). High levels of toxic metals, organic contaminants and pesticides have been found in the water and sediments of discharge sites. Altered salinity regimes, increased nutrient and contaminant loadings, and high water turbidity have all contributed to the decreased health and extent of biological communities within the northern section of Biscayne Bay.

The central portion of the Bay is better flushed than the North Bay and has extensive, healthy seagrass beds and other benthic communities. Nevertheless, industrial and agricultural discharges, as well as leachete from the South Dade landfill, are important sources of pollution to this area (McKenzie, 1983; Shinn and Corcoran, 1987). A salinity gradient is found in the Central Bay, with lower, variable salinity occurring on the western margin of the Bay due to freshwater inflow from canal discharge and runoff, and higher, more stable salinities in the eastern margin, where oceanic influences prevail (Wang et al., 1978; Chin Fatt and Wang, 1987).

The southern portion of the Bay (Card Sound and Barnes Sound) is influenced primarily by agricultural development. Freshwater inflow into the area is mostly through canal discharge, and flushing is limited as there are no direct connections to the ocean. Accordingly, salinity can vary from relatively low values during the wet season (10-20 ppt) to potentially hypersaline values (40-45 ppt.) during the dry season (Lee and Rooth, 1975). Southern Biscayne Bay has extensive, healthy seagrass beds, and is critical habitat for a number of threatened species such as the Cape Sable seaside sparrow, roseate spoonbills, as well as crocodiles, manatees, and snail kites (Kushlan and White, 1977; Kushlan and Mazzotti, 1989).

The benthic habitats of Biscayne Bay are dominated by extensive beds of seagrass that cover most of the Bay bottom (Thorhaug, 1976). *Thalassia testudinum* is the dominant seagrass species, but *Halodule wrightii* and *Syringodium filiforme* are also present and may dominate locally. The seagrass beds also have associated rhizophytic (e.g., *Halimeda* spp., *Penicillus* spp., *and Udotea* spp.) and drift-algal (e.g., *Laurencia* spp., *Polysiphonia* spp.) components. Hardbottom areas with sponges, soft corals, hard corals, and macroalgae are less extensive and occur primarily in the eastern and central portions of the Bay (DiResta et al., 1995; Cropper and DiResta, 1999).

Both commercial and recreational fishing are important activities within Biscayne Bay (Berkeley et al., 1985). Sport-fishing activities are concentrated mainly on fish species such as tarpon, snook, bonefish, and permit (deSylva, 1969). The groups of organisms harvested commercially within the Bay include: spotted seatrout, the snapper-grouper fish complex, bait fish, bait shrimp, stone and blue crabs, lobsters and sponges (Ault et al., 1997).

D-A.8.3 DRIVERS AND STESSORS

The anthropogenic and natural drivers creating potential stressors to the Biscayne Bay ecosystem include urban, industrial, and agricultural development, water management (C&SF project), commercial and recreational fishing and boating activities, and natural disturbances such as storms (refer to figure on page D-A-99).

Prior to the extensive human development in the area, inputs of fresh water into Biscayne Bay were mainly from the Miami River, Little River, Arch Creek, and Snapper Creek. Sheet flow from the adjacent Everglades system, artesian flow from the underlying limestone bedrock, and runoff after storms or heavy rains were important additional sources of fresh water before development (Harlem, 1979; Wanless et al., 1984).

However, since the early 1900s, the hydrology of the Bay has been significantly modified due to coastal construction and the development of the extensive water management system now in place (Wanless et al., 1984). Fresh water input patterns have been highly modified from pre-development patterns, limiting both surface and groundwater inflow into the Bay. At present, the main sources of fresh water are local rainfall and runoff, as well as canal discharges (Wanless et al., 1984).

During the rainy season, tremendous volumes of water can be released through flood control structures creating large and rapid fluctuations in salinity in the vicinity of canal mouths and over-all reduced salinity on the western fringe of the Bay (Wang et al., 1978). Increases in freshwater inflow from runoff as well as from point sources have also contributed to a significant decrease in water quality within Biscayne Bay. Major issues of concern include increased sedimentation and turbidity as well as increased nutrient loading and chemical pollution (VanArman et al., 1989).

Both commercial and recreational boating activities can cause significant physical damage to seagrass beds, hardbottom communities, and manatees (O'Shea et al., 1985; Sargent et al., 1995; Ault et al., 1997). Major storms can also have significant effects on water quality and benthic habitats. After Hurricane Andrew, high turbidity, increased nutrient and pollutant loading, high dissolved organic carbon, and persistent plankton blooms were observed within Biscayne Bay (Tilmant et al., 1994). Benthic communities also experienced high erosion, and burial and removal of organisms during Andrew and previous hurricanes (Thomas et al., 1962; Tilmant et al., 1994).

D-A.8.4 EFFECTS

<u>Salinity</u>: Alterations in salinity can impact species composition and productivity of seagrass communities. Of the three most abundant seagrass species that occur in the Bay, *Halodule* is the most tolerant of low-salinities, and tends to be dominant in areas adjacent to canal discharge sites. *Thalassia* and *Syringodium* are also found near canals, but growth and productivity of these species is reduced at sites influenced by freshwater discharge (Conover, 1964; Lewis et al., 1985; Montague, 1989). Salinity also affects other benthic primary producers associated with seagrass communities. Pulses of reduced-salinity water can have negative effects on the growth of the drift alga *Laurencia* and rhizophytic algae such as *Penicillus* spp., *Udotea* spp., and *Halimeda* spp. (Conover, 1964; Irlandi et al., unpublished data).

Similarly, salinity fluctuations can affect faunal composition and abundance as some species are more tolerant to low salinity than others (Serafy et al., 1997). Salinity effects on the distribution of grazers (both fish and invertebrate) may influence the abundance of phytoplankton, epiphytes and macroalgae that can potentially shade seagrasses (Irlandi et al., 1997). Negative effects of low salinity have also been detected in sponges (Smith, 1973; Storr, 1976).

<u>Pollution</u>: Urban and agricultural development, as well as boating activities in the Bay, contribute to the introduction of contaminants and toxins into the environment. The use of herbicides in farming may potentially influence seagrass growth and production while heavy metals, mercury, and other toxic materials can be detrimental to the health and survival of fish populations and higher trophic levels that feed on them (e.g. bioaccumulation of toxins). Several studies have detected a high number of abnormalities in several fish species within Biscayne Bay, specially around heavily polluted areas such as marinas and canal outflows (e.g., Browder et al., 1993; Gassman et al., 1994)

<u>Nutrients</u>: Agricultural runoff, urban runoff, and stormwater release can result in an increase in both water-column and sediment nutrients, promoting growth of

phytoplankton, seagrass epiphytes, and macroalgae (e.g., Lapointe and Clark, 1992; Frankovich and Fourqurean, 1997). Phytoplankton blooms, epiphyte growth, and growth of attached and drift macroalgae can reduce light availability to seagrasses and reduce their growth and production. Similarly, high concentrations of phytoplankton may be deleterious to filter-feeding sponges in hardbottom habitats due to a potential clogging effect.

Nutrient gradients caused by point sources may have a major influence on the abundance, composition, and distribution of benthic communities. Mats of drift algae are common along the western boundary of the Bay where several canals drain agricultural fields, and their growth and distribution may be the direct result of the increased nutrients. Changes in nutrient levels can also affect the community composition of seagrass meadows by influencing the competitive interactions among the dominant seagrass species (Williams, 1987; Harwell and Fong, 1994; Fong et al., 1997), producing shifts in dominance from *Thalassia* to *Halodule* (Fourqurean et al., 1995) as well as influencing competitive interactions between seagrasses and algae (Williams, 1990; Holmquist, 1992).

Sedimentation: Increased sediment loads associated with canal discharge, runoff, and resuspension due to storms and boating activities can increase water turbidity, shading benthic plants and decreasing productivity (Hall et al., 1991; Onuf, 1991; Tilmant et al., 1994; Sargent et al., 1995). If sediment concentrations are high, there is also the potential for burial and smothering of benthic-communities components.

Harvesting and Poaching: Commercial and recreational fishing can influence the biotic communities of Biscayne Bay. Fishing pressure, species targeted, and size of fish captured can alter the species composition and trophic structure of fish communities. For example, the removal of omnivorous bait fish in large quantities (e.g., pinfish) may result in decreased grazing rates that may facilitate algal and epiphyte overgrowth of seagrasses and hardbottom-community components.

Poaching can also have significant impacts on the populations targeted. The removal of undersized lobsters as well as the removal of large, reproductive sponges can have significant long-term effects on the survival of these populations (Cropper and DiResta, 1999).

Many of the commercially and recreationally important fish and macroinvertebrates found in the Bay rely on seagrass and hardbottom habitats for food and/or shelter, therefore, factors influencing the distribution, productivity, and abundance of these benthic habitats will have an effect on the distribution and abundance of fishery resources in the Bay.

Physical Damage: Direct physical damage to the biotic communities of Biscayne Bay can be caused by boating and harvesting activities as well as by intense storms.

Shrimp trawlers actively target seagrass habitats but may venture into hardbottom areas removing and damaging sponges and gorgonians with their gear. Ault et al. (1997) found that considerable damage to both seagrass and hardbottom communities can result from trawl and trap fishing practices. Significant by-catch of juvenile fish that suffer physical damage and/or mortality can also occur.

Most of the seagrass beds within Biscayne bay show some signs of boat scarring. Boat scars result in the loss of essential habitat for associated fauna, sediment erosion, and increased water turbidity (Sargent et al., 1995). Furthermore, several studies have shown that the recovery of deep scars by seagrasses can be a slow process taking anywhere from a few months to several years to recuperate original seagrass shoot densities (Zieman, 1976; Durako et al., 1992). Lastly, the scouring effects of sediments suspended during intense storms may cause significant mortality of benthic organisms and affect their distribution within the Bay (Tedesco et al., 1995).

D-A.8.5 ATTRIBUTES AND MEASURES

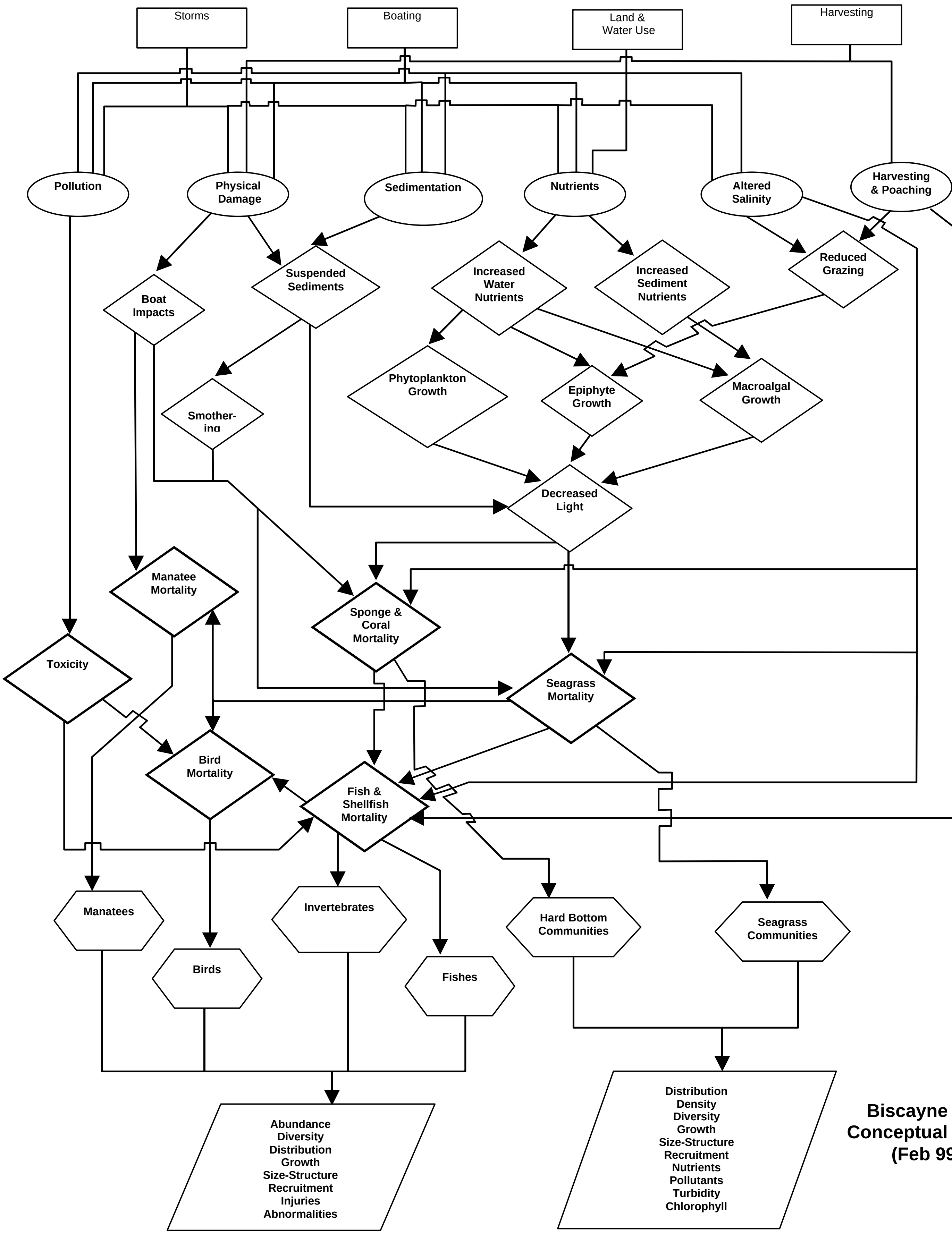
A set of endpoints or attributes can serve as indicators of the health of the Biscayne Bay ecosystem. Most of these attributes are biological components of the system such as the health of birds, macroinvertebrates (e.g., lobsters, shrimp, scallops), fishes, manatees, and seagrass and hardbottom communities.

<u>Faunal Communities</u>: This endpoint considers the abundance, size, and health of Bay species or species groups that are of commercial or recreational importance such as bait shrimp, crabs, lobsters, tarpons, bonefish, snappers and groupers, birds, dolphins, crocodiles and manatees. Measurements and indicators for this endpoint include distribution, abundance, growth, recruitment, and population size structure of these organisms, nest distribution, as well as incidence of disease and abnormalities. Information about the health of commercial stocks could be obtained from landings and fishing effort statistics.

<u>Seagrass Communities:</u> Seagrasses compose a keystone community within Biscayne Bay; they not only dominate spatially but also serve as essential habitat (e.g., food and refuge) for a productive food web. Their presence also plays a role in maintaining water quality (e.g., sediment stabilization, nutrient uptake), another major endpoint for the Bay. The spatial extent, density, and productivity of seagrass beds are key attributes of these communities and can be estimated directly.

<u>Hardbottom Communities:</u> Hardbottom communities within Biscayne Bay contain high densities of sponges, soft corals, and macroalgae. Hard corals can also be important components locally. Just like seagrass communities, hardbottom communities provide essential habitat for a large number of organisms. Juvenile lobsters are often found within sponges (Butler et al., 1994) and large stands of the attached alga *Sargassum* provide both food and shelter to juvenile fishes seasonally.

Also, water and sediment quality are important attributes of the system as the health of the biological components is often tightly linked to them. Direct indicators and measurements of water and sediment quality include turbidity, salinity, dissolved oxygen, bacterial counts, chlorophyll concentrations, and the concentration of nutrients and pollutants. Secondary indicators of reduced water and sediment quality may be the distribution and composition of invertebrate communities (e.g., meiofauna) that respond differently to different environmental conditions.



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D-A.9 DRAFT FLORIDA BAY CONCEPTUAL MODEL

D-A.9.1 PREPARERS

David T. Rudnick, South Florida Water Management District, West Palm Beach Florida.

D-A.9.1.1 Contributors

Christos Anastasiou	University of Florida
Tom Armentano	Everglades National Park
G. Ronnie Best	Biological Resources Div., USGS
Robert Brock	Everglades National Park
Joan Browder	National Marine Fisheries Service, NOAA
Paul Carlson	Florida Marine Research Institute, FDEP
Evan Chipouras	University of Florida
Jim Colvocoresses	Florida Marine Research Institute, FDEP
Wendell Cropper	University of Miami
Steve Davis	Executive Office, SFWMD
Mike Durako	Florida Marine Research Institute, FDEP
Susan Gray	Planning Dept., SFWMD
Lance Gunderson	University of Florida
Beth Irlandi	University of Miami
Bill Kruczynski	U.S. EPA
Jerry Lorenz	National Audubon Society
Christopher Madden	Ecosystem Restoration Dept., SFWMD
Doug Morrison	National Audubon Society
John Ogden	Executive Office, SFWMD
Susan Olson	Ecosystem Restoration Dept., SFWMD
Peter Ortner	Atmospheric and Meteorological Laboratory, NOAA
Casie Regan	Everglades National Park
Mike Robblee	Biological Resources Div., USGS
Steve Traxler	Jacksonville District, USACE
DawnMarie Welcher	Atmospheric and Meteorological Laboratory, NOAA

D-A.9.2 INTRODUCTION

A simple conceptual model of the Florida Bay ecosystem is presented here. This model is consistent with our effort to assess the current understanding of south Florida's ecosystems, identify the most important human effects on these ecosystems, identify restoration goals and success criteria, and identify the minimum measurements required to determine whether these criteria are being met. The structure of the model is largely based on the expert opinions of scientists who have focused their attention on Florida Bay during the past several years. During this time, detailed reviews of our understanding of the Florida Bay have been presented (Boesch et al. 1993, Boesch et al. 1995, Boesch et al. 1997, Fourqurean and Robblee 1999). Detailed plans that identify quantitative information needs for environmental management decision making, as well as strategies to provide this information, have also been presented (Armentano et al. 1994, Armentano et al. 1997). While the conceptual model presented here is largely consistent with the body of knowledge described in the reviews and plans noted above, some details or omissions of this model may not be consistent will the opinions of every contributor listed above or every contributor to the larger Florida Bay research effort.

Florida Bay primer. Florida Bay is a triangularly shaped estuary, with an area of about 850 square miles, that lies between the southern tip of the Florida mainland and the Florida Keys. About 80% of this estuary is within the boundaries of Everglades National Park. A defining feature of the bay is it's shallow depth, with a mean depth of about 1 meter (Schomer and Drew 1981). This shallowness allows light to penetrate through the water to the sediment surface in almost all areas of the bay and results in the potential for the bay to sustain seagrass beds as a dominant habitat and source of productivity. The shallowness of the bay also affects the circulation and salinity regime of the bay; with a complex network of shallow mud banks, water exchange among the bay's basins and between these basins and the Gulf of Mexico is restricted (Smith 1994, Wang et al. 1994). With a long residence time and shallow depth, the salinity of Florida Bay water can rapidly rise during drought periods. Salinity levels as high as twice that of seawater have been measured (McIvor et al. 1994). Another defining feature of the bay is that the sediments are primarily composed of carbonate mud, which can scavenge inorganic phosphorus from bay waters (DeKanel and Morse 1978).

Until the 1980s, Florida Bay was perceived by the public and environmental managers as being a healthy estuary, with clear water, lush seagrass beds, and productive fish and shrimp populations. By the mid 1980s, however, catches of pink shrimp had declined dramatically (Browder et al. 1999) and in 1987, the mass mortality of turtle grass (Thalassia) beds began (Robblee et al. 1991). By 1992, the ecosystem appeared to shift from a clear water system, dominated by primary production on the sediment (benthic production) to a turbid water system, dominated by algae blooms in the water column and resuspended sediment. The conceptual model focuses on these changes in seagrasses and water quality as the central issues to be considered by environmental managers.

Reality check. The simple model presented below does not address the spatial complexity of Florida Bay. Florida Bay is, indeed, not so much a singular estuary, but a complex array of basins, banks, and islands that differ across a set of regions. The mosaic of seagrass habitat and mangrove habitat, as well as water quality and ecosystem processes, vary distinctly with this spatial variation. Nevertheless, only a single, generic model is described and this model is intended to summarize the main characteristics and trends of the bay. While the structure of this model is appropriate for most areas of the bay, the relative importance of the model's components differ considerably among the bay's sub-regions. Any application of this model (for example, recommendations for a specific set of monitoring parameters and guidelines) must take the spatial variability of the bay into account.

D-A.9.3 STRESSORS AND SOURCES OF STRESS

It has often been assumed that a direct cause of Florida Bay's ecological changes is a long-term increase in the Bay's salinity that resulted from the diversion of freshwater away from Florida Bay via SFWMD canals. However, recent research has indicated that the Bay's changes are not attributable to a single cause - while decreased freshwater inflow and resultant increased salinity have been part of the problem, it appears that other human activities, as well as natural forces, have also contributed to the problem (Armentano et al. 1997, Boesch et al. 1993, Boesch et al. 1995, Boesch et al. 1997, Fourqurean and Robblee 1999). The conceptual model thus includes both natural and human derived sources of stress (refer to figure on page D-A-116).

Altered salinity regime. The salinity regime of an estuary is a primary determinant of the species composition of communities, as well as strongly influencing functions of these communities (Sklar and Browder 1998). Salinity is a direct stress on biota; all estuarine biota have adapted to a given salinity range and a given degree of salinity variability. For a given organism, changing salinity beyond this range or too quickly within this range can result in poor health or death. Thus long-term changes in salinity *level or variability* are detrimental to some species, but favorable for other species.

Florida Bay's salinity regime varies greatly over time and space. This variation ranges from coastal areas that can be nearly fresh during the wet season, to large areas of the central bay that can have salinity levels near 70 ppt during prolonged droughts, to nearly stable marine conditions (about 35 ppt) on the western boundary of the bay. The main forces that determine salinity regime in the bay are the inflow of freshwater from the Everglades, rainfall over the bay, evaporation from the bay, and exchange with seawater from the Gulf of Mexico and the Atlantic Ocean. Both freshwater inflow and seawater exchange have changed drastically in the past hundred years, resulting in an alteration of the bay's salinity regime.

Freshwater inflow to Florida Bay decreased in volume and changed in timing and distribution during this century because of water management. Hydrologic alteration began in the late 1800s, but accelerated with the construction of drainage canals by 1920, the Tamiami Trail by 1930, and the C&SF Project and South Dade Conveyance System from the early 1950s through 1980 (Light and Dineen 1994). With the diversion of freshwater to the Atlantic coast and Gulf of Mexico coast, the bay's mean salinity inevitably increased. The extent of this increase and how the variability of salinity changed is not known, but is the subject of current research.

Results from this research indicate that another important development that altered the salinity regime of Florida Bay was construction of the Flagler railway across the Keys from 1905 to 1912 (Swart et al. 1996, Swart et al. 1999). It appears that in the last century, prior to railway construction and water management, Florida Bay had a lower mean salinity and more frequent periods of low (10 ppt - 20 ppt) salinity than during this century. The extent and frequency of high salinity events does not appear to have changed between centuries. The bay's salinity regime changed abruptly around 1910 because passes between the Keys were filled to support the railway. Thus, water exchange between Florida Bay and the Atlantic Ocean was decreased and water circulation throughout the bay was probably altered.

Two important natural controls of salinity, sea level rise and the frequency of major hurricanes must also be considered. Florida Bay is a very young estuary, the product of sea level rising over the shallow slope of the Everglades during the past 4000 years. With rising sea level, the bay not only became larger but also became deeper. With greater depth, exchange of water between the sea and the bay probably increased, resulting in a more stable salinity regime with salinity levels increasingly similar to the sea. However, a factor that has counteracted the rising sea is the accumulation of sediment, which makes the bay more shallow. Most sediment that accumulates in Florida Bay is carbonate that is precipitated from water by organisms that live in the Bay. The extent to which these sediments accumulate is a function of the biology of these organisms, the chemistry of the water, and the physical energy available to transport these sediments from the Bay. Major hurricanes are thought to be important high energy events that can flush the bay of these sediments. However, since 1965, no major hurricane has directly affected Florida Bay. Florida Bay's ecological changes during the past decade may thus be indirectly influenced by changing circulation patterns and resultant changing salinity regimes because of changing water depth in the bay.

Nitrogen and phosphorus inputs. The productivity and food web structure of all ecosystems is strongly influenced by patterns of nutrient cycling and the import and export of these nutrients. Throughout the world, estuarine ecosystems have undergone dramatic ecological changes because they have been enriched by nutrients derived from human activity. These changes have often been catastrophic, with the loss of seagrasses and the occurrence of algal blooms and lethal low oxygen or anoxic events. The input of nitrogen and phosphorus (N and P) to estuaries is thus a potentially important stressor of estuaries.

The importance of N and P as stressors in Florida Bay is unclear. In general, the bay is rich in N and poor in P, especially towards the eastern region of the bay

(Boyer et al. 1997). There is little evidence that nutrient inputs to the bay have increased during this century, but with expanding agriculture and residential development in south Florida through this century, and particularly development of the Keys, nutrient enrichment almost certainly has occurred (Lapointe and Clark 1992, Orem et al. 1998). Anthropogenic nutrients that enter Florida Bay are derived not only from such local sources (fertilizer and wastes from agriculture and residential areas), but also from remote sources. It is likely that remote contributions to the Gulf of Mexico, such as from the phosphate fertilizer industry of the Tampa-Port Charlotte area and residential development from Tampa to Naples, are the most important external sources of nutients (Rudnick et al. 1999). This enrichment from external sources, however, may not less important to the bay's ecology than it's own internal sources and cycling. It is, nevertheless, a reasonable hypothesis that a chronic increase in nutrient inputs has occurred in Florida Bay in this century and this increase has contributed to ecological changes. Ongoing research will provide information to test this hypothesis. Development of a water quality model will also help us understand the effects of past nutrient inputs and predict the effects of future management scenarios.

In the conceptual model, water management is listed as a source of stress because the canal system can transport nutrients through the wetlands toward the bay, decreasing nutrient retention by the wetlands and possibly increasing nutrient inputs to the bay. Nutrient inputs from the Everglades and the Gulf of Mexico are affected not only by changes of freshwater flowing from Taylor Slough and Shark River Slough, but also by changes in bay circulation. Nutrient retention within the Bay is certainly sensitive to these changes in circulation, which have been caused by Flagler railway construction and the balance of sea level rise and sedimentation or sediment removal by major hurricanes. The influence of hurricanes may be particularly important, as nutrients (particularly P) accumulate in the bay's carbonate sediment and the absence of major hurricanes may have resulted in an accumulation of nutrients during the past few decades.

Pesticides and mercury. With the widespread agriculture and residential development of south Florida, the application and release of pesticides and other toxic materials has increased. Mercury is of particular concern because of high concentrations of methylmercury in upper trophic level species. However, it is unclear whether anthropogenic mercury inputs to the Everglades or Florida Bay have increased or whether mercury cycling and methylation rates have changed. Pesticides and mercury are of concern because they can affect human health after the consumption of fish or other biota with high concentrations of these toxins, and because other species may be adversely affected by these compounds. To date, there is no evidence the main ecological changes in Florida Bay are in any way linked to inputs of toxic compounds. Water management affects the distribution of these toxic materials and potentially their transport to Florida Bay. Controlling water levels in wetlands may also influence the decomposition of pesticides and mercury methylation rates because both of these processes are sensitive to the presence of oxygen in soils, which is affected by water levels.

Fishing pressure. For any species that is the target of recreational or commercial fisherman, fishing pressure directly affects population dynamics and community structure. Within Everglades National Park, commercial fishing has been prohibited since 1985, but populations that live outside of ENP boundaries for at least part of their life cycle, which includes most of Florida Bay's sport fish species, are nevertheless affected by fisheries (Tilmant 1989).

D-A.9.4 ESSENTIAL ECOSYSTEM ATTRIBUTES AND LINKS TO STRESSORS

A set of Florida Bay's attributes that are either indicators of the health of the ecosystem or intrinsically important to society are given in the conceptual model. These attributes in most cases are biological components of the ecosystem, including seagrass, molluscs, shrimp, fish and birds, but also an aggregated attribute of the chemical and physical condition of the bay, termed "water quality condition." While the list of biological components is broad, it is clear from the links to stressors that are presented that these attributes are not equally weighted within the model; the central attribute of this conceptual model of Florida Bay is the seagrass community. Details of each attribute and linkage are given below.

Seagrass community. The keystone of the Florida Bay ecosystem is its seagrasses (Zieman et al. 1989, Fourqurean and Robblee 1999). These plants are not only a highly productive foundation of the food web, but are also the main habitat of higher trophic levels and a controller of the bay's water quality. Understanding how seagrasses affect water quality is essential for understanding the current status and fate of the bay.

Seagrasses affect water quality by three mechanisms: nutrient uptake and storage, binding of sediments by their roots, and trapping of particles within their leaf canopy. With the growth of lush seagrass beds, these mechanisms drive the bay towards a condition of clear water, with low nutrients for algae growth in the water and low concentrations of suspended sediment in the water. During the 1970s through the mid-1980s, lush *Thalassia* beds grew throughout central and western Florida Bay and the water was reported to be crystal clear. We hypothesize that with the onset of a *Thalassia* mass-mortality event in 1987 (Robblee et al. 1991), these mechanisms reversed, initiating a cycle that causes continued <u>seagrass habitat loss</u> and propagates persistent turbid water with algae blooms (Stumpf et al. 1999).

The cause of the 1987 mass-mortality event is not known, but thought to be related to earlier changes in two stressors, the salinity regime and nutrient availability. These changes caused *Thalassia* beds to grow to an unsustainable density by the mid 1980s. It is also likely that a decrease in shoal grass and widgeon grass (*Halodule* and *Ruppia*) occurred with the *Thalassia* increase. *Thalassia* "overgrowth" may have occurred because the species thrived when the salinity regime of the bay was stabilized, with few periods of low salinity. Nutrient enrichment also may have played a role, with a chronic accumulation of nutrients caused by increased inputs over decades or decreased outputs because of the absence of major hurricanes or closure of Keys' passes. The factors that conspired to initiate the mass-mortality event in 1987 are also unknown, but thought to be related to the high respiratory demands of the dense grass beds and accumulated organic matter. During the summer of 1987, with high temperatures, sulfide levels may risen to lethal concentrations.

Regardless of the cause of the mass-mortality event, once this event was initiated, the ecology of Florida Bay changed. The cycle causing continued seagrass habitat loss, which characterizes the present Florida Bay, is illustrated in the model. Continued seagrass mortality results in increased sediment suspension and increased nutrient release from the sediments (>N & P), stimulating the growth of algae in the water column. The presence of both these algae and suspended sediment result in decreased light penetration to the seagrass bed. In this cycle, it is this decreased light that stresses the seagrasses and sustains the feedback loop. Light penetration is thus an essential aspect of the attribute, water quality.

The dynamics of this feedback loop are probably not independent of the salinity regime. A disease of seagrass, caused by a slime mold infection, seems to be more common at salinities near or greater than seawater (35 ppt) than at low (15 to 20 ppt) salinities (Landsberg et al. 1996). This may have played a role in either the initial seagrass mass mortality event, but more likely has served to continue seagrass mortality since that event. The incidence of this disease may be directly affected by water management actions.

If the state of the seagrass community is to be used as a criterion to decide the success of environmental restoration efforts, environmental managers must specify the desirability of alternative states. The consensus among scientists is that the Florida Bay of the 1970s and early 1980s, with lush *Thalassia* and clear water, was probably a temporary and atypical condition. From an ecological perspective, restoration should probably strive for a more diverse seagrass community, less dominated by *Thalassia* than during that period.

Water quality condition. Water quality condition reflects not only obvious characteristics, such as salinity, but also the light field, algae in the water column, and the availability of nutrients in the ecosystem. All of these characteristics are closely related to the condition of seagrasses and the food web structure and dynamics of the bay. While these characteristics have been monitored and researched since the early 1990s, earlier information is scarce for salinity and even less available for other characteristics. Thus, at the present time, we do not know whether nutrient inputs to the bay have actually increased in recent decades or whether periods with sustained algal blooms and high turbidity occurred in the past.

Salinity has frequently been suggested as a primary restoration target. However, establishing salinity success criteria, such as those used in the Restudy's evaluation of the effects of hydrological alternatives on coastal salinity, depends on the development of a model of the "natural" salinity distribution of Florida Bay in time and space. This requires a both a water budget for the bay (monitoring rainfall, evaporation, and freshwater flow, water level, and salinity) and a hydrodynamic model, which is now under development. With modeled salinity variability for a wide variety of target sites in the bay, the fit of observed salinity fields to modeled fields could serve as the basis of deciding levels of success.

The magnitude of nutrient inputs to the bay, and their relationship to freshwater inputs is under investigation. Success criteria based on water column nutrient concentrations are probably less meaningful than criteria based on nutrient loading. Preliminary results indicate that phosphorus loads to the bay do not greatly increase with increased freshwater inputs (Rudnick et al. 1999), but Florida Bay is probably very sensitive to any increase in P availability. Unlike phosphorus, nitrogen loads probably do increase with more freshwater flow and algae blooms in western and central Florida Bay appear to be stimulated by increased N (Tomas 1996).

Finally, as emphasized earlier, the penetration of light through Florida Bay waters is a key to the health of seagrasses. An important success criterion should be light penetration, which is largely a function of turbidity from algae and suspended sediment. Light penetration should be sufficient to support a viable seagrass habitat. Such light-based criteria have been used successfully in other estuaries.

Molluscs. Because of our ability to assess historical community structure, molluscs are a good indicators for the entire ecosystem. The composition and activity of the molluscan community is a function of salinity, seagrass and other habitat availability, and food supply. Studies of long-term changes in the composition of this community (by analyzing shells in the sediment) have indeed found changes that reflect the large-scale changes of the bay's salinity regime. Furthermore, molluscs are likely to be important as grazers of algae in bay waters; the trophic status of the bay is reflected by molluscan community composition.

Pink shrimp. Pink shrimp are intrinsically important to society as an economic asset. They are also ecologically important, serving as a major component of the diet of game fish and wading birds; pink shrimp are an indicator of the bay's productivity. Florida Bay and nearby coastal areas are a primary nursery ground for pink shrimp - a nursery that supports the shrimp fishery of the Tortugas Grounds (Costello and Allen 1966). Hydrological and ecological changes in the Everglades and Florida Bay may have impacted this fishery, which experienced a decline in annual harvest from about 10 million pounds per year in the 1960s and 1970s to as little as 2 million pounds per year in the late 1980s (Ehrhardt and Legault 1999). This decline may have been associated with seagrass habitat loss or high salinity (50 to 70 ppt) during the 1989-1990 drought; experiments have shown that pink shrimp mortality rates increase with salinities above 40 ppt (Browder et al. 1999). Shrimp harvest statistics indicate that shrimp productivity increases with increasing freshwater flow from the Everglades (Browder 1985).

Fish populations. The health of Florida Bay's fish populations is of great importance to the public; the sport fishing is a major economic asset to the region. It is clear from recent studies that seagrass beds and the mangrove zone are important habitats for fish, but no dramatic bay-wide decreases in total fish abundance have been observed along with seagrass mass-mortality (Thayer et al. 1999). Rather, a shift in the species composition of this upper trophic level has occurred as a result of the cycle of seagrass habitat loss and sustained algae blooms. While some fish species have declined, fish that eat algae in the water, such as the bay anchovy, are thriving. Thus the stressors, such as altered salinity, not only affect upper trophic level animals directly, but also affect them indirectly through food web changes.

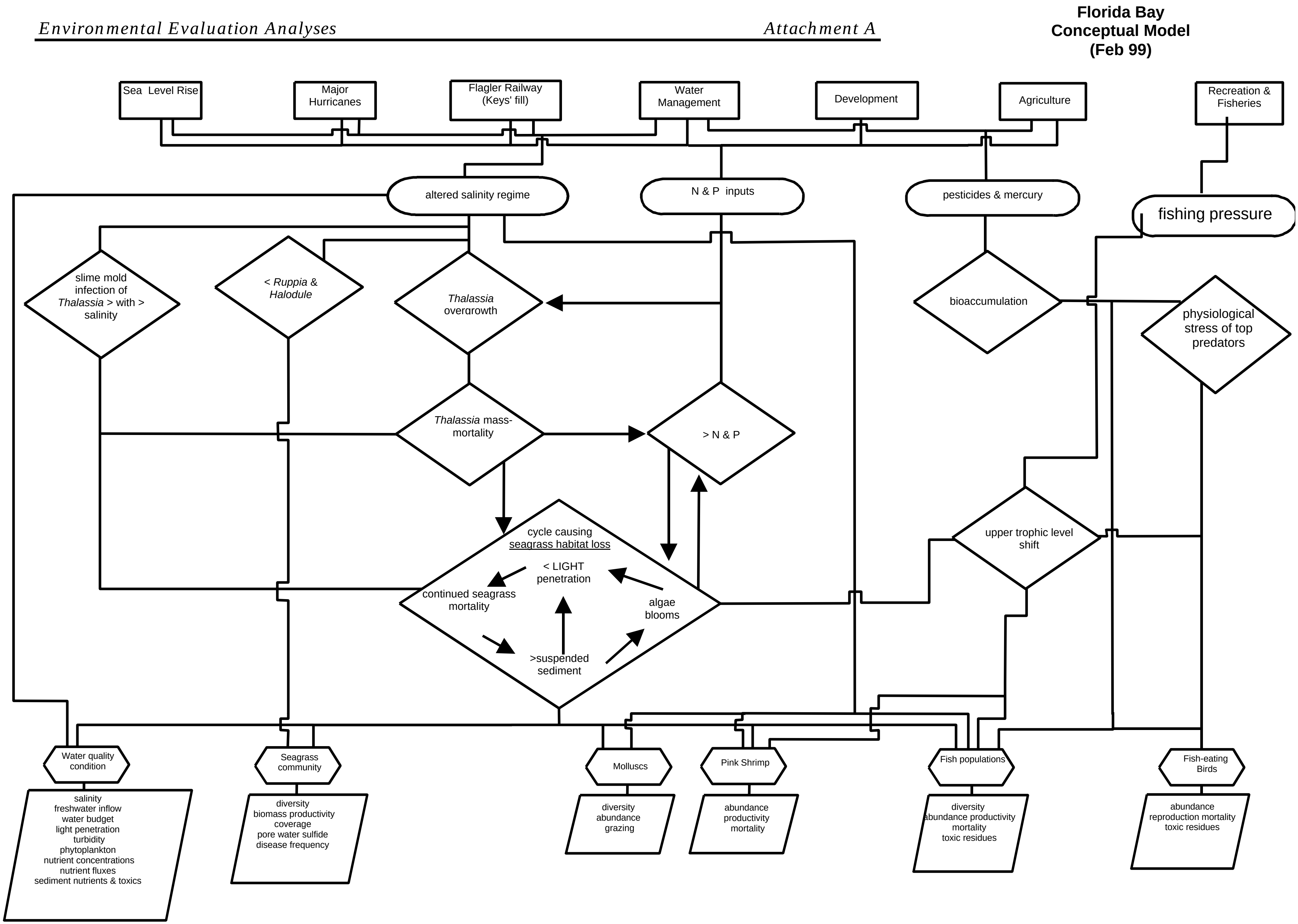
Another important stressor that needs to be considered with regard to fish populations is the impact of pesticides and mercury. As concentrations of mercury and some pesticides greatly increase in upper trophic level animals, such as sport fish, (via the process of bioaccumulation), and people eat such fish, a human health issue potentially exists. Pesticides and mercury can also have ecological impacts by physiologically stressing organisms (particularly reproductive functions). The extent of any existing problem with these toxic compounds in Florida Bay is being investigated, but they currently do not appear to significantly impact human health or ecological health in the bay. The possible impact of future restoration efforts on these issues, however, must still be considered.

Among the many fish species that could be used as indicators of the health of the ecosystem's upper trophic level, there is consensus among scientists that spotted sea trout is a key species. This is the only major sport fish species that spends its entire life-span in the bay. Population changes and toxic residues in this species thus reflect the specific problems of the bay and should also reflect the restoration actions that we take. For northeastern Florida Bay, the abundance of snook, tarpon, and crevalle jack should also be considered.

Birds. Florida Bay and its mangrove coastline is an important feeding ground and breeding ground for water fowl and wading birds. Conceptual models for other regions of the Everglades, particularly the mangrove - estuarine transition zone conceptual model, present more detailed descriptions of the use of bird populations as ecological indicators and consider a wide variety of birds. For the Florida Bay conceptual model, we consider only fish-eating birds, such as osprey, brown pelicans, and cormorants. These birds are important predators of fish in the bay and are potentially impacted by any stressors that affect their prey base, including salinity changes, nutrient inputs, toxic compounds, and fishing pressure. As with other top predators, these bird species are the most vulnerable members of the ecosystem with regard to pesticide and mercury effects.

D-A.9.5 MEASURES

A list of fundamental measures associated with each of the model's ecosystem attributes is given. This list should be considered minimal; interpretation of many of these measures requires a set of associated measures. The list includes not only "structural" variables (for example, pink shrimp abundance), but also dynamic, process variables (for example nutrient fluxes). Note that this list does not reflect the temporal or spatial time scale at which measurements are necessary, but temporal patterns, such as seasonality and interannual variability, and spatial patterns are a central aspect of ecological dynamics. Also note that the power to predict the fate of any ecosystem requires more than monitoring; research and modeling are also essential components of sound environmental management.


Florida Bay
Conceptual Model
(Feb 99)
Sea Level Rise
Major Hurricanes
Flagler Railway (Keys' fill)
Water Management
Development
Agriculture
Recreation & Fisheries
altered salinity regime
N & P inputs
pesticides & mercury
fishing pressure
slime mold infection of Thalassia > with > salinity
< Ruppia & Halodule
Thalassia overgrowth
bioaccumulation
physiological stress of top predators
Thalassia mass-mortality
> N & P
cycle causing seagrass habitat loss
< LIGHT penetration
continued seagrass mortality
algae blooms
>suspended sediment
upper trophic level shift
Water quality condition
Seagrass community
Molluscs
Pink Shrimp
Fish populations
Fish-eating Birds
salinity
freshwater inflow
water budget
light penetration
turbidity
phytoplankton
nutrient concentrations
nutrient fluxes
sediment nutrients & toxics
diversity
biomass productivity
coverage
pore water sulfide
disease frequency
diversity
abundance
grazing
abundance
productivity
mortality
diversity
abundance productivity
mortality
toxic residues
abundance
reproduction mortality
toxic residues

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ATTACHMENT B

DRAFT PERFORMANCE MEASURE DOCUMENTATION

Attachment B
Performance Measure Documentation

Category
Ecological

Performance Measure
Seasonal Distribution of Overland Flow Volume, Mid Shark River Slough

Date Submitted/Revised
June 1988

General Planning Objective

This performance measure is linked to the Everglades Sloughs Conceptual Model developed by the SERA Natural Systems Team, and addresses several hydrologic and ecologic planning objectives identified by the Governors's Commission for a Sustainable South Florida in the C&SF Project Restudy Conceptual Plan.

Region

The seasonal distribution of overland flow volume is applied as a performance measure only to the cross section in mid Shark River Slough.

Restoration Goal

The re-distribution of flow into Shark River Slough, with subsequent restoration of extended duration of uninterrupted flooding, brief duration of dry conditions, water depth pattern, and overland flow volume and **timing characteristic** of the pre-drainage system is among the highest priorities of ecosystem restoration in the southern Everglades.

Problem Addressed

Restoration of the seasonal timing of flow down Shark River Slough is important to extend the duration of flooding in the Slough and to provide seasonal salinity patterns in the estuaries as they would have occurred in the natural system

Model Target

The target is a cumulative deviation that does not exceed that indicated by NSM45F.

Model Output Format

The overland flow volume across the cross-section in mid Shark River Slough that occurs each month of the year is calculated as the percent of the annual flow volume and is averaged over the 31-year period of record. The performance measure is the cumulative deviation of the monthly percent of annual flow under a given alternative from the monthly percent of flow under NSM45F, summed over the 12 months of the year. It is given a weighting of one when averaged with the other performance measures for Shark River Slough because of the higher level of uncertainty in NSM45F simulations of flow compared to other parameters.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate a cross section evaluate a cross-section taken across the entire width and depth of flow in mid Shark River Slough.

Literature Cited

Authors & Contributors

Author: Steve Davis
Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Performance Measure

Florida Bay Performance Measure Suite:
Frequency of Stages of 6.3+ feet MSL at Gage P33
Frequency of Stages of 7.3+ feet NSM at Gage P33
Cumulative Salinity Differences from High Levels, March-June
Cumulative Salinity Differences from Low Leves, August-October

Date Submitted/Revised

June 1998

General Planning Objective

These performance measures are linked to the Florida Bay Mangrove/Estuarine Conceptual Model developed by the SERA Natural Systems Team.

Region

All four measures target Florida Bay coastal basins.

Restoration Goal

Ecological values and indicators of restoration success in the Florida Bay mangrove estuary and coastal basins that are linked to the above hydrology/salinity performance measures in the conceptual model include 1) increased production of low-salinity mangrove fish and invertebrates, 2) re-establishment of coastal nesting colonies of wading birds and wood storks and eastern Florida Bay colonies of roseate spoonbill, 3) delay (syn) in coastal colony formation by wading birds and wood storks, 4) resumption of the return frequency of wading bird and white ibis super colonies, 5) increased growth and survival of juvenile American crocodiles, 6) increased cover of low-to-moderate salinity aquatic macrophyte communities in coastal lakes and basins, 7) return of seasonal waterfowl aggregations to coastal lakes and basins, 8) enhanced nursery ground value for sport fishes and pink shrimp in coastal basins, and 9) persistence and resilience of the mangrove, salt marsh and tidal creek vegetation mosaic.

Problem Addressed

Ecological restoration of the estuary requires a reduction in the frequency of high salinity events that have been identified for each coastal basin through the conceptual model process. Another restoration criterion is to increase the frequency of low salinity events that have been identified for each coastal basin.

Table 1. Lower and upper salinity levels identified for coastal basins. It is desirable to decrease the frequency that salinity exceeds upper levels, and to increase the frequency that salinity drops below lower levels.

Basin	Lower Level	Upper Level
Joe bay	5 ppt	15 ppt
Little Madeira Bay	15 ppt	25 ppt
Terrapin Bay	25 ppt	35 ppt
Garfield Bight	25 ppt	35 ppt
North River Mouth	5 ppt	15 ppt

The strategy for ecological restoration of the estuary is to maintain freshwater heads and flows in the Everglades at the upstream end of the salinity gradient in order to achieve desirable salinity regimes in the Florida Bay coastal basins at the downstream end of the salinity gradient. Regression analyses demonstrated inverse relationships of salinity in the coastal basins to water level upstream in the Everglades. The regressions indicated that stages of 7.3 and 6.3 feet msl at the P33 gage in central Shark River Slough produce the lower and upper salinity levels for Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight, and North River Mouth.

Model Target

Number of months NSM4.5F provided stages of 6.3 or above
Number of months NSM4.5F provided stages of 7.3 or above
Reduce the cumulative salinity difference to a value that does not exceed the cumulative difference produced by NSM4.5F.
Reduce the cumulative salinity difference to a value that does not exceed the cumulative difference produced by NSM4.5F.

Model Output Format

The Florida Bay Mangrove/Estuarine Conceptual Model identifies high salinity concentrations for the coastal basins of Florida Bay which should not be exceeded more frequently than NSM45F would indicate. Stages equaling or exceeding 6.3 feet msl at the P33 gage in mid Shark River Slough correspond to a reduced frequency of those high salinity events in the the Florida Bay coastal basins from Joe Bay to North River Mouth. This performance measure is the number of months during the 31-year period of record when stages at P33 rose to, or above, 6.3. A reduced frequency of high salinity events is given a high priority in the ecological restoration of the coastal basins, thus the frequency of 6.3+ stages is given a weighting of two when averaged with the other performance measures.

The Florida Bay Mangrove Estuarine Transition Conceptual Model identifies low salinity concentrations for the coastal basins of Florida Bay which should be attained as frequently as NSM45F would indicate. Stages equaling or exceeding 7.3 feet msl at the P33 gage in mid Shark River slough corresponded to an increased frequency of those low salinity events in the coastal basins of Florida Bay. The performance measure is the number of months during the 31-year period of record when stages at P33 rose to, or above, 7.3. An increased frequency of low salinity events is given a lower priority than a reduced frequency of high events, thus the frequency of 7.3+ stages is given a weighting of one when averaged with the other performance measures for the coastal basins.

The transition from the late dry season to the early wet season during March through June is a critical period to estuarine organisms in the Florida Bay coastal basins regarding the frequency and duration of high salinity events. Salinity is estimated based on relationships between mean monthly salinity in the coastal basins and water stage at the P33 gage in mid Shark River Slough. The cumulative salinity difference (ppt) from the high salinity levels that have been identified for Florida Bay coastal basins is summed during the dry/wet season transition months of March-June. Differences are summed over five coastal basins (Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight and North River Mouth) and over the 31-year period of record. Differences above the specified high salinity levels are given a positive value, and differences below the high salinity levels are given a negative value. This measure is given a weighting of two when averaged with the other performance measures for the coastal basins because the avoidance of high salinity events is considered more important than the attainment of low salinity events.

During the August-October transition from the late wet season to the early dry season, it is important to achieve low salinity levels in the Florida Bay coastal basins to provide the seasonal environment for low-salinity estuarine organisms and to postpone the onset of high salinity events further into the dry season.

Salinity is estimated based on relationships between mean monthly salinity in the coastal basins and water stage at the P33 gage in mid Shark River Slough. The cumulative salinity difference (ppt) from the low salinity levels that have been identified for the Florida Bay coastal basins is summed during the wet/dry season transition months of August-October. Differences are summed over the five coastal basins and over the 31-year period of record. Differences above the specified low salinity levels are given a positive value, and differences below the low salinity levels are given a negative value. This measure is given a weighting of one when averaged with the other performance measures for the coastal basins because the attainment of low salinity events is considered less important than the avoidance of high salinity events.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate P33 stages. Priority is given to the P33 stage of 6.3 and the March-June cumulative salinity difference, which pertain to the avoidance of high salinity levels, over the P33 stage of 7.3 and the August-October cumulative salinity difference, which pertain to the achievement of low salinity levels

Literature Cited

Authors & Contributors

Author: Steve Davis

Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category

Ecological

Performance Measure

Model Lands/C-111 Performance Measure Suite
High Water
Low Water
Extreme Low Water
Relative Dry Period Slope
Wet Season Inundation Pattern
Late Wet Season Inundation

Date Submitted/Revised

March 1998/July 1998

General Planning Objective

Meets planning objective criteria identified by the SERA Natural System Team and by the Governor's Commission for a Sustainable South Florida.

Region

The term Model Lands, for C&SF Restudy planning purposes, applies to three areas: (1) wetlands immediately north of the C111 Canal, (2) the land between U.S. 1 and Card Sound Road, and (3) land east of Card Sound Road and south of the Mowry Canal (C-103). These areas correspond to Indicator Regions 4 (C-111 Perrine Marl Marsh), 5 (Model Lands South), 6 (Model Lands North), and 47 (North C-111).

Restoration Goal

Reduce artificial hydrological barriers between indicator regions, minimize the amount of time exceedingly high and low water levels stress natural vegetation communities, and restore more natural hydropatterns.

Problem Addressed

The Model Lands/C-111 region encompasses freshwater (predoninantly marl prairie) wetlands, a transition zone, and coastal wetlands. This area has been subdivided and hydrologically isolated from the regional system by primary and secondary canals and major and minor roads. The result has been widespread overdrainage and a reduction in the amount of freshwater reaching the coastal mangroves and nearshore estuarine waters as overland flow.

A study by Meeder et al. (1996) compared recent vegetation to vegetation mapped during the 1940's by Egler (1952). Their work indicated that a zone of low plant cover and low primary productivity, which is observable as a "white zone" on aerial photographs, has expanded inland by as much as 300 meters since 1940. Meeder et al. (1996) associated the inland expansion of this zone with saltwater intrusion.

Surface water connection between the vast freshwater wetlands in this region has been disrupted and runoff to the coastal bays and sounds have been blocked or diverted by U.S. 1, Card Sound Road and borrow ditches, canal levees, and other man-made structures. Ishman's (1998) paleoecologic study of Manatee Bay suggests that the bay supported a lower salinity fauna in the early part of this century than it does today. Although large quantities of fresh water are sometimes flushed to Manatee Bay through the C-111 Canal (S-197), the point source delivery and pulsed manner in which this water moves into Manatee Bay has proved harmful to marine and estuarine life. Most of the time Manatee Bay receives little freshwater inflow.

Model Target

The Natural System Model (NSM) was not used to set performance targets for this region. NSM is not a good indicator of pre-drainage hydrologic conditions in the Model Lands area, as evidenced by NSM predictions of lower dry-season water levels than the 1995 Base. If current water levels were higher than pre-drainage water levels, it is unlikely that the "white zone" would have expanded to the degree that it has since 1940. Additionally, there had to have been sufficient freshwater flows to Manatee Bay at most times of the year to support a brackish water fauna, which does not exist in modern times. Four indicator regions in the Model Lands area were established for the study of alternative management scenarios. Specific target water levels and hydroperiods were defined for these indicator regions based on known topography and projections of future restored vegetation. Vegetation zones adapted from Meeder et al. (1996) were the basis for establishing target water levels. The collective professional experience of a team of biologists from federal, state, and local agencies and businesses was the basis for setting desired maximum ponding depths, minimum water levels, and hydroperiods for each vegetation zone. Indicator regions and the projected desired hydrologic parameters are shown below, followed by the vegetation zones applicable to each indicator region. Maximum and minimum water levels are relative to ground level.

Indicator Region	Region Name	SFWMM Cells	Max Ponding Depth - Wet Season	Min Water Level - Dry Season	Average Hydroperiod	Vegetation Zones Included
4	C-111 Perrine Marl Marsh	R8, C26-27 R7, C26-27	< 2.0 ft	> 0.5 ft	10 - 12 months	3
5	Model Lands South	R8, C29-30	< 2.0 ft	> 0.5 ft	10 - 12 months	3
6	Model Lands North	R10, C29-30	< 1.75 ft	> 0.25 ft	8 - 12 months	2 + 3
47	North C-111	R9, C26-27	< 1.5 ft	> 0 ft	6 - 9 months	2

Vegetation zones used as the basis for establishing targets

Zone	Descriptive Name	Desired Wet Season Maximum Water (relative to ground elevation)	Desired Dry Season Minimum Water (relative to ground elevation)	Desired Average Hydroperiod
0	Agriculture/Open Land Buffer	N/A	N/A	N/A
1	Shrub-dominated Freshwater Marshes	< 0.5 ft	> -0.5 ft	Driven by downstream hydrology
2	Muhly/Sawgrass or Sawgrass Mosaic with Tree Islands	< 1.5 ft	> 0 ft	6 - 9 months, no wet season reversals
3	Sawgrass Marsh with Freshwater Swamp Forests	< 2.0 ft	> 0.5 ft	10 - 12 months, no wet season reversals
4	Mixed Graminoid with Dwarf Mangroves	Driven by upstream maxima	> 0.5 ft	12 months
5	Ecotone - "White Zone"	*	*	12 months
6	Fringing (aka Coastal) Mangroves	**	**	12 months
7	Downstream Marine Areas	N/A	N/A	N/A

Water level not a useful indicator; 0 - 3 ppt salinity desired. year round.

** Water level not a useful indicator; 0 - 5 ppt salinity desired. year round.

Model Output Format

High Water: The proportion of time that water levels are below the high water level which has been specified for the indicator region.

Low Water: The proportion of time that water levels are below the low water level which has been specified for the indicator region.

Extreme Low Water: The proportion of time that water levels stay above one foot below the low water target.

Relative Dry Period Slope: Relative measure of the steepness of the slope for the stage duration curve during dry periods.

Wet Season Inundation Pattern: Proportional measure of how many times during the 31 year simulation that water levels drop below surface elevation during the July-October portion of the wet season.

Late Wet Season Inundation: Proportional measure of how many times during the 31-yr simulation that autumn periods of inundation ended during the months of November and December.

This was applied only to Indicator Region 5 (Model Lands South), which includes habitat critical for Roseate Spoonbill feeding.

Evaluation Tools

South Florida Water Management Model

Literature Cited

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Authors & Contributors

Authors: Joan Browder and Gwen M. Burzycki

Contributors: South Dade Wetlands Team: Individuals will be listed

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Category

Ecological

Performance Measure

Wood Stork Nesting Patterns

Date Submitted/Revised

May 1998

General Planning Objective

Meets SERA objectives to (1) Restore the natural annual and multi-year patterns of native plant and animal distribution, abundance, seasonality and richness to the natural areas of the southern Everglades region, and (2) Provide for self-sustaining and self-regulating populations of native plant and animal species with special attention to threatened, endangered and species of special concern (includes both state and federally listed species).

Meets general planning objectives of the Conceptual Plan for the C&SF Restudy Project, of the Governor's Commission for a Sustainable South Florida, to (1) Improve and protect habitat quality, heterogeneity, and biodiversity in coastal and associated marine ecosystems, and (2) Provide for sustainable populations of native plant and animal species with special attention to threatened, endangered, or species of special concern.

Region

Southern Everglades & Big Cypress Subregions

Restoration Goal

Recover healthy, sustainable Wood Stork nesting colonies to the Everglades basin.

Problem Addressed

The number of Wood Storks nesting in colonies in the central and southern Everglades has declined from 5,000-8,000 birds prior to the C&SF Project (numbers are for 1931-1946) to 250-1,000 birds since 1986 (Ogden 1991, 1994, Gawlik & Ogden 1996). During this same spread of years (1931-1996) the timing of colony formation (initiation of nesting) by storks has shifted from November & December for most years prior to 1970, to February & March for most recent years (Ogden 1994). Earlier forming colonies were larger and more successful than late forming colonies (e.g., means of 2,250 pairs in November colonies, and 450 pairs in March colonies; successful in 7 of 9 years between 1953-1961, but successful only 6 of 28 years between 1962-1989. Early forming colonies were located almost entirely within the mainland, mangrove forest zone downstream from the freshwater Everglades drainage, or along the mangrove-freshwater ecotone in the southern Everglades. Recent stork colonies mostly have been located on willow and pond apple islands in the south-central Everglades.

The hypothesis which best explains the changes in nesting patterns by storks is that, as a result of substantial reductions in freshwater flow into the mainland estuaries, the production and availability of the size classes of fishes which are essential prey for nesting storks has deteriorated to the point where the mangrove zone can no longer support nesting by storks (Ogden 1994). Storks now "wait" until water levels in the later-drying interior sloughs drop low enough for fish to be adequately concentrated to support nesting activity. Interior, late-forming colonies often fail because, (a) fish stocks also are relatively low because of increased frequencies of slough dry-outs in the managed system, (b) interior colonies lack the range of foraging habitat conditions found in estuarine systems, and (c) late colonies are still active when summer rains disperse local prey concentrations.

Model Target

To recover healthy, sustainable nesting colonies of Wood Storks in the Everglades basin, storks must return to nesting in the area of the mainland estuaries, with colonies forming no later than January. The historical pattern was for storks to forage primarily in the mainland estuarine region during the early dry season at the time of colony formation, and to forage in the drying freshwater sloughs during the later dry season during the nestling and fledging stages of reproduction.

In addition to recovery of traditional location and timing patterns, the Science Sub-Group of the South Florida Ecosystem Restoration Task Force and Working Group set a ecosystem restoration target of 3,000 - 5,000 nesting storks for the Everglades and Big Cypress colonies combined (Ogden et al. 1997). This numerical target is consistent with the target set in the revised Wood Stork Recovery Plan for delisting the stork: 2,500 pairs (5,000 birds) nesting in south Florida in a total population of 10,000 pairs (U.S. Fish and Wildlife Service, 1996).

Model Output Format

The two hydrological indicators which best measure the recovery of optimum foraging conditions for storks for the restoration targets described above, are, (a) the measures of the volume of flow into the mainland estuaries downstream from the southern Everglades and Big Cypress (three flow lines; one across the southern

Shark Slough; one across the southern Taylor Slough/Craighead Basin; and one across the Lostman's Slough), and (b) the measure of mean duration of uninterrupted surface hydroperiod in the central and southern Shark Slough (indicator regions 10 and 11). The target is to meet NSM 4.5 predicted flow volumes and hydroperiod durations, respectively. The "score" for each alternative plan and base condition will be the simple mean of the percentages of NSM targets for the five hydrological parameters (3 flow lines and 2 indicator regions). This calculation results in greater weight for the estuarine target, because three of the five values are for measures of flow into the estuaries. Greater weight for the estuarine target is appropriate because achievement of the desired colony timing and location patterns may be dependent of estuarine conditions.

Evaluation Tools

Uses output from the South Florida Water Management Model and the Natural Systems Model (4.5), for Indicator Regions 10 and 11 in the central and southern Shark Slough, and 3 Flow Lines at the freshwater/estuarine ecotone (Taylor Slough, Shark Slough, Lostmans Slough).

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Authors & Contributors

Submitted by: John C. Ogden, South Florida Water Management District

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Category
Ecological

Performance Measure
Viable Populations of the Endangered Cape Sable Sparrow

Date Submitted/Revised
November, 1998

General Planning Objective

Meets Governor's Commission planning objective in the C&SF Project Restudy Conceptual Plan; to provide for sustainable populations of native plant and animal species with special attention to threatened, endangered, or species of special concern.

Region

Everglades National Park and Big Cypress National Preserve

Restoration Goal

For the sparrow to survive in the long-term, there must be three healthy sub-populations, each averaging at least 2000 birds.

Problem Addressed

The Cape Sable sparrow is a Federally listed endangered species found only within the southern Everglades. First found early in this century, its exact range was not known completely until an extensive survey was completed in 1981. Approximately 6500 existed at that time, grouped into three areas. The one west of Shark River Slough (A) was the most numerous, followed by a slightly smaller population east of the Slough and west of Taylor Slough (B). The remaining birds were scattered in populations to the north and east of these two areas (C through E). In 1992, the second annual survey found similar numbers, though the northeastern birds had declined. In 1993, the western population declined precipitously and has remained at low levels since. Population B has remained more or less constant. The remaining populations have been marked by declines and local extinction (Curnutt et al.,l998)

Analysis of the causes of these declines rule out chance fluctuations in numbers (which can be large for similar grassland sparrows) and Hurricane Andrew, which passed over some of the populations in 1992 (Curnutt et al., l998) Persistent high water levels during the bird's breeding season (mid-March to mid-June) are the cause of the decline in the western part of the range. High water levels - caused principally by discharges across the S12 structures during the early months of the year - prevented breeding in 1993 and 1995 and allowed only limited breeding in 1994, 1996, and 1997 (Nott et al., l998). Rainfall during the breeding season has a much smaller effect on the water levels in this area. In the north and east of the sparrow's range, frequent fires caused the decline in sparrow densities. Fires as often as once a year preclude breeding, and sparrow numbers increase as fire frequencies decline to once in seven years. This frequency is the limit of the data. It seems possible that the diversion of water flows from northeast Shark Slough is partly responsible for the drier conditions there, which could result in more frequent fires and, in turn, the decline of the sparrow population.

Model Target

An area of 30 square kilometers in the west should remain dry (water level at or below ground level) for a least 40 days during the period mid-March to mid June. This will allow the birds to complete one clutch. This is a minimum safe standard for wet years, not an average value. Under average conditions, an area of approximately 100 square kilometers would be dry and part of this area would be dry for at least 80 days - the time taken to complete two clutches.

In the northeast part of the sparrow's range, the water levels need to be raised during the pre-breeding season in a way necessary to reduce fire frequencies across the area to a safe minimum standard of no more than one dry season fire in three years.

The first requirement is that the water level at NP205 should be at or below ground level on April 1st of each year. This will ensure that sufficient breeding habitat is available for the population west of Shark River Slough.

The second requirement is that water levels in the marl prairies to the east of Shark River Slough and north of Long Pine Key should be raised at the end of the rainy season by about 12 cm (= 5 inches) above recent averages.

Model Output Format

Evaluation Tools

ATLSS

Literature Cited

Curnutt, J.L., A.L. Mayer, T.M. Brooks, L. Manne, O.L. Bass, Jr., D.M. Fleming, and S.L. Pimm. (in press). Population dynamics of the endangered Cape Sable Seaside-Sparrow. Animal Conservation.

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Authors & Contributors
Stuart L. Pimm
Department of Ecology and Evolutionary Biology
The University of Tennessee
Knoxville, TN 37996

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Category
Ecological

Performance Measure

Inundation Pattern (number and mean duration of inundation periods)

Date Submitted/Revised
September 1997/June 1998

General Planning Objective

Recovery of historical hydroperiods was identified by the SERA Natural Systems Team as the highest priority for the ecological restoration of the slough/peat system, and was identified as one of the general planning objectives established by the Governor's Commission for a Sustainable South Florida in the Conceptual Plan for the C&SF Restudy Project.

Region
Northern and Central Everglades:
Loxahatchee National Wildlife Refuge (WCA-1)
Holey Land and Rotenberger WMAs
WCA-2A and 2B, WCA-3A and 3B
Pennsuco Wetland

Restoration Goal

A functionally restored system should mimic natural system inundation frequencies and duration.

Problem Addressed

Inundation patterns in the managed Everglades system have been substantially altered from pre-drainage patterns due to water management practices. The ecological impacts of this are detailed in one of the four critical ecological pathways suggested by the Everglades slough conceptual model. This pathway links reduction in water storage capacity and shortened hydroperiods (hydrologic stressors) with ecological responses that include reduced production and survival of aquatic animals, degraded plant community structure and composition, and the spread of exotic vegetation.

Model Target

Target values for duration of inundation and number of events were those predicted by NSM 4.5 Final with two exceptions: (1) Indicator Region 17's performance was evaluated by comparing values to the average of NSM values for Indicator Regions 14 and 18; this was because the NSM depths in this Indicator Region had been identified during evaluation of Alternatives 1-3 as being lower than desirable for this relatively pristine marsh area; (2) in LNWR, the targets were 1995 Base values, in keeping with the refuge's current regulation schedule.

Model Output Format

The average depth during a given week in a given year is calculated for each 2x2 grid cell, and these values are averaged over the set of grid cells within an indicator region to obtain an average depth for the indicator region for that week. The duration of inundation for a year is then calculated as the maximum number of sequential weeks in that year during which water depths averaged above zero for the indicator region. Note that this PM differs from the "hydroperiod" measure used in previous planning efforts, in that here only continuous sequences of inundation are scored, whereas the previous measure calculated percent of the year during which water levels were greater than zero, regardless of whether or not the inundation period was interrupted by a dry out. Results are presented in tabular form and also as the two-part graphic "Inundation Pattern 1965-1980, and 1981-1995".

Evaluation Tools

Output from the South Florida Water Management Model and the Natural System Model 4.5 should be used for the following indicator regions: (groupings correspond to areas with distinct hydrologic performance.)

Loxahatchee NWR (Indicator Regions 26 & 27)
Holey Land & Rotenberger WMAs (Indicator Regions 28 & 29)
WCA-2A (Indicator Regions 24 & 25)
WCA-2B (Indicator Region 23)
NW WCA-3A (N of Alligator Alley & W of Miami Canal; Indicator Regions 20 & 22)

Northeastern WCA-3A (N of Alligator Alley & E of Miami Canal; Indicator Region 21)
Eastern WCA-3A (S of Alligator Alley, E of Miami Canal; Indicator Region 19)
Central & Southern WCA-3A (S of A. Alley, W of Miami Canal; Indicator Regions 14, 17 & 18)
WCA-3B(Indicator Regions 15 & 16)
Pennsuco Wetlands (Indicator Regions 52 & 53)

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Authors & Contributors

Originated by SERA Natural Systems Team
Drafted by J. Ogden
Revised by L. Heisler and W. Park

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Category

Water Supply/Resource Protection

Performance Measure

Preventing Salt-Water Intrusion of the Biscayne Aquifer: Percent Time Canal Stage <Salt-Water Intrusions Criteria> 1 Week for Primary Coastal Canal at Selected Structure

Date Submitted/Revised

September 1997

General Planning Objective

Minimum Flows and Levels – SFWMD; Control salt-water intrusion into freshwater aquifers – GCSSFL; Ensure adequate water supply and flood protection for urban, natural and agricultural needs – GCSSFL

Region

Lower East Coast Service Area – Eastern portions of Palm Beach, Broward and Miami-Dade Counties

Restoration Goal

Prevent further encroachment of salt-water interface into the Biscayne aquifer

Problem Addressed

The principal threat to the maintaining the long-term functions of the Biscayne aquifer is salt-water intrusion, i.e. contamination of the aquifer by saltwater. The Biscayne aquifer is located along the eastern edge of Palm Beach County, underlies the majority of Broward County and almost all of Miami-Dade County. Along the aquifer's eastern edge, its fresh water is in contact with the salt water originating from the ocean. The constant westerly flow of fresh water from the Everglades helps to keep the salt water stationary. However, when groundwater levels adjacent to the fresh water/salt water interface are lowered, salt water can potentially move inland replacing the fresh water (Swift *et al*. 1998). The higher density salt water tends to remain inland for long periods of time causing a permanent loss of that portion of the aquifer. Along the Lower East Coast, lowering of the groundwater table due to overdrainage and increased well field withdrawals has allowed salt water to invade and contaminate the Biscayne aquifer during periods of drought (Parker *et al*. 1955). Salt water intrusion of the Biscayne aquifer is considered one of the greatest threats to the long-term water supply of South Florida.

In order to minimize the inland migration of the saline interface, a sufficient head of fresh water must be maintained within the aquifer. Loss of the fresh water head that previously existed west of the Atlantic Coastal Ridge is considered the primary cause of the inland migration of salt water in South Florida (Parker et al. 1955; Fish and Stewart, 1991). The groundwater hydrology of South Florida's Lower East Coast has been permanently altered by urban and agricultural development and construction of the Central and Southern Florida Project. Construction of a series of canals has drained both the upper layer of the Biscayne aquifer and the fresh water mound west of the Atlantic Coastal Ridge. This drainage has reduced the volume of groundwater flowing east and has resulted in the inland migration of saline interface along the entire edge of the aquifer during dry periods. Localized saltwater intrusion has resulted from large coastal wellfields, five of which were partially lost in1939 while others are still threatened today. Construction of coastal canal water control structures, beginning in the 1940s, has helped to stabilize or slow the advance of the saline interface.

Water levels in the coastal canals largely govern the expected inland migration of the saline interface. Managing coastal canals at appropriate water levels during drought periods is a viable option for stabilizing the salt water interface and preventing further inland migration (Swift et al. 1998). The control elevations have been set for the primary canals that receive water from the regional system and have sufficient canal conveyance capacity to receive water from outside their drainage basins.

Model Target

Maintain elevations of primary coastal canals at control structure

Canal - Structure	Canal Stages (ft NGVD)
North New River @ G-54	3.50
Hillsboro Canal @ G-56	6.75
C-51 @ S-155	7.75
C-18 @ S-46	5.00
C-2 @ S-22	2.00
C-4 @ S-25B	2.00
C-6 @ S-26	2.00
C-14 @ S-37B	6.50
C-15 @ S-40	7.75
C-16 @ S-41	7.75
C-9 @ S-29	2.00
C-13 @ S-36	4.00

Model Output Format

Table indicating the target and the number of times and percentage of time the target was not met.

Evaluation Tools

Use output from the south Florida Water Management Model

Literature Cited

Literature Cited: Swift, David, et al. 1998. Draft Proposed Minimum Water Level Criteria for Lake Okeechobee, the Everglades, and the Biscayne Aquifer within the South Florida Water Management District. West Palm Beach, FL

Authors & Contributors

Originated by LEC Subteam of the AET. Drafted by Brenda Mills; Revised by Jeff Giddings

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Category

Ecological

Performance Measure
Extreme Events:
High Water Extremes
Low Water Extremes

Date Submitted/Revised
September 1997/June 1998

General Planning Objective

The extreme events performance measures address the priority criteria submitted by the SERA Natural Systems Team; the elimination of regulatory operational schedules which cause unnatural depth and duration of flooding patterns. These measures also address several planning objectives identified by the Governor's Commission for a Sustainable South Florida in the C&SF Project Restudy Conceptual Plan; to restore more natural organic and marl soil formation processes and arrest soil subsidence, to provide for sustainable populations of native plant and animal species, to restore and, where appropriate improve, functional quality of natural systems, and to restore more natural hydropatterns.

Region
Northern and Central Everglades:
Loxahatchee National Wildlife Refuge (WCA-1)
Holey Land and Rotenberger WMAs, WCA-2A and 2B, WCA-3A and 3B
Pennsuco Wetland

Restoration Goal

Prevention of peat loss resulting from extreme low water events and protection and recovery of tree-island communities that are degraded during extreme high water events.

Problem Addressed

As illustrated in the Everglades sloughs conceptual model, water management practices have generated hydrologic stress on the system in the form of regulatory releases and shortened hydroperiods. The ecologic response to this stress includes flooded tree islands and alligator nests, soil subsidence, spread of exotic vegetation, and ultimately the degredation of plant community structure and the reduction in numbers of native fauna. The extreme events performance measures assess the frequency and duration of water levels that exceed values associated with two major sources of ecological damage in the slough/sawgrass/peat system, namely, muck fires and microbial oxidation during extreme low-water events, and death of tree-island organisms during prolonged high water.

Model Target

Target values for extreme events in LNWR were 1995 Base values, in keeping with the refuge's current regulation schedule. The high water performance target for all other indicator regions in the Northern and Central Everglades was that the number and duration of events be less than or equal to NSM values. For low water extremes, the performance target was to minimize frequencies and duration of events.

Model Output Format

The extreme events measures assess the frequency and duration, for different alternatives, of periods of extreme high and low water. The basic variable calculated is the number of weeks during the period of record during which water levels exceeded a criterion high or low, and the average duration of these events. These counts are obtained for each cell within an indicator region, and then averaged over the cells in the region to obtain an average number of extreme events and an average duration of these events for the entire period of record for that indicator region. Results are presented in tabular form.

Evaluation Tools

Output from the South Florida Water Management Model and the Natural System Model 4.5 for the following indicator regions is used: (groupings correspond to areas with distinct hydrologic performance.)
Loxahatchee NWR (Indicator Regions 26 & 27)
Holey Land & Rotenberger WMAs (Indicator Regions 28 & 29)
WCA-2A (Indicator Regions 24 & 25)
WCA-2B (Indicator Region 23)
NW WCA-3A (N of Alligator Alley & W of Miami Canal; Indicator Regions 20 & 22)
Northeastern WCA-3A (N of Alligator Alley & E of Miami Canal; Indicator Region 21)
Eastern WCA-3A (S of Alligator Alley, E of Miami Canal; Indicator Region 19)
Central & Southern WCA-3A (S of A. Alley, W of Miami Canal; Indicator Regions 14, 17 & 18)
9. WCA-3B(Indicator Regions 15 & 16)
10. Pennsuco Wetlands (Indicator Regions 52 & 53)

Literature Cited

Dineen, J. W. 1974. Examination of water management alternatives in Conservation Area 2A. Central and Southern Florida Flood Control District In Depth Report, Vol. 2, No. 3. (July-August, 1974).

McPherson, B. J. 1973. Vegetation in relations to water depth in Conservation Area 3, Florida. Open File Report No. 73025. US Geological Survey.
Southern Everglades Restoration Alliance (SERA). July 30, 1997. Final Draft:

Final Draft: Natural Systems Team Report to the Southern Everglades Restoration Alliance. July 30, 1997.

South Florida Water Management District. August 14, 1997. Draft minimum water level criteria for Lake Okeechobee, the Everglades Protection Area, and the Biscayne aquifer within the South Florida Water Management District.

Authors & Contributors

Originated by SERA Natural Systems Team

Drafted by J. Ogden; revised by L. Heisler and W. Park

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Category

Water Supply/Resource Protection

Performance Measure

Preventing Salt-Water Intrusion of the Biscayne Aquifer: Stage Duration Curves for selected control structures

Date Submitted/Revised

May 1998

General Planning Objective

Minimum Flows and Levels – SFWMD; Control salt-water intrusion into freshwater aquifers – GCSSFL; Ensure adequate water supply and flood protection for urban, natural and agricultural needs – GCSSFL

Region

Lower East Coast Service Area 3– Eastern portions Miami-Dade County

Restoration Goal

Prevent further encroachment of salt-water interface into the Biscayne aquifer in South Miami-Dade County. Evaluation methodology described herein is to facilitate evaluation and comparison of alternatives and not to supplant the research and analysis necessary to determine the control elevations to slow salt-water intrusion.

Problem Addressed

The principal threat to the maintaining the long-term functions of the Biscayne aquifer is salt-water intrusion, i.e. contamination of the aquifer by saltwater. The Biscayne aquifer is located along the eastern edge of Palm Beach County, underlies the majority of Broward County and almost all of Miami-Dade

County. Along the aquifer's eastern edge, its fresh water is in contact with the salt water originating from the ocean. The constant westerly flow of fresh water from the Everglades helps to keep the salt water stationary. However, when groundwater levels adjacent to the fresh water/salt water interface are lowered, salt water can potentially move inland replacing the fresh water (Swift *et al*. 1998). The higher density salt water tends to remain inland for long periods of time causing a permanent loss of that portion of the aquifer. Along the Lower East Coast, lowering of the groundwater table due to overdrainage and increased well field withdrawals has allowed salt water to invade and contaminate the Biscayne aquifer during periods of drought (Parker *et al*. 1955). Salt water intrusion of the Biscayne aquifer is considered one of the greatest threats to the long-term water supply of South Florida.

In order to minimize the inland migration of the saline interface, a sufficient head of fresh water must be maintained within the aquifer. Loss of the fresh water head that previously existed west of the Atlantic Coastal Ridge is considered the primary cause of the inland migration of salt water in South Florida (Parker et al. 1955; Fish and Stewart, 1991). The groundwater hydrology of South Florida's Lower East Coast has been permanently altered by urban and agricultural development and construction of the Central and Southern Florida Project. Construction of a series of canals has drained both the upper layer of the Biscayne aquifer and the fresh water mound west of the Atlantic Coastal Ridge. This drainage has reduced the volume of groundwater flowing east and has resulted in the inland migration of saline interface along the entire edge of the aquifer during dry periods. Localized saltwater intrusion has resulted from large coastal wellfields, five of which were partially lost in1939 while others are still threatened today. Construction of coastal canal water control structures, beginning in the 1940s, has helped to stabilize or slow the advance of the saline interface.

Water levels in the coastal canals largely govern the expected inland migration of the saline interface. Managing coastal canals at appropriate water levels during drought periods is a viable option for stabilizing the salt water interface and preventing further inland migration (Swift et al. 1998). The control elevations have been set for the primary canals that receive water from the regional system and have sufficient canal conveyance capacity to receive water from outside their drainage basins.

At this time, salt-water intrusion criteria do not exist for the major canals in southern Miami-Dade County. Generally the canals are cut directly into the most pereable portions of the Biscayne aquifer. It is difficult to maintain canal stages for extended periods of time without using significant volumes of water from regional storage. However, it is important to evaluate water levels in these canals because encroachment of the salt front into the Biscayne aquifer has occurred previously in this area. Plus, major public water supply wellfields are located in southern

Miami-Dade County. This area was evaluated by using the stage duration curves for the following structures: C-100A @ S-123, C-1 @ S-21, C-102 @ S-21A, and C-103 @ S-20F. The stage duration curves were used to evaluate the alternatives in two ways: 1) the distance by which an alternative's water level fails to reach two feet NGVD at the 90th percentile of the stage duration curve; and 2) the percentile at which an Alternative's stage duration curve meets the 50th percentile of the 1995 Base's stage duration curve.

In the first scenario, two feet NGVD was used for comparison in keeping with the Ghyben-Herzberg relationship which estimates that one foot of freshwater head is required to protect forty feet of aquifer. The aquifer along the coast in southern Miami-Dade is approximately eighty feet that would require two feet of freshwater head. The 90th percentile of the stage duration curve was used since that percentile reflects lower stages of the dry season when the risk of salt-water intrusion is increased. The score is calculated from the distance of the base conditions and alternatives to the two feet NGVD on the stage duration curve. Alternatives that equaled or exceeded the target scored 100% (no extra credit was given for exceeding the target).

Score = [(2 - Distance/2)] x 100 = % of meeting 2 foot target

The second scenario used the 50th percentile of the 1995 Base to evaluate performance since it represents approximately the midpoint between the wet and dry seasons and can be viewed as "average conditions" for the 1995 Base. The score reflects the percentile at which a base condition or alternative meets or exceeds the water level at the 50th percentile of the 1995 Base. Salt-water encroachment has occurred in the period of record and, therefore, exceeding the 50th percentile is considered an improvement but may not prevent further encroachment.

Model Target

Maintain elevations of primary coastal canals at control structures. These targets are the current operational criteria. The canal stages need to be examined further to develop appropriate targets and operation criteria to prevent encroachment of the salt water into the surficial aquifer.

Canal - Structure	Canal Stages (ft NGVD)
C-100A@ S-123	2.00
C-1@ S-21	2.00
C-102 @ S-21A	2.00
C-103 @ S-20F	2.00

Model Output Format

Model Output Format: Stage Duration Curves for four control structures: C-100A@S-123, C-1@S-21, C102@S21A and C-103@20F

Evaluation Tools

Use output from the south Florida Water Management Model

Literature Cited

Swift, David, et al. 1998. Draft Proposed Minimum Water Level Criteria for Lake Okeechobee, the Everglades, and the Biscayne Aquifer within the South Florida Water Management District. West Palm Beach, FL.

Authors & Contributors

Originated by Sue Alspach, Miami-Dade County, DERM of the LEC Subteam. Drafted by Brenda Mills; Revised by Jeff Giddings

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Category

Ecological

Performance Measure

Seasonal Distribution of Overland Flow Volume, Mid Shark River Slough

Date Submitted/Revised

June 1988

General Planning Objective

This performance measure is linked to the Everglades Sloughs Conceptual Model developed by the SERA Natural Systems Team, and addresses several hydrologic and ecologic planning objectives identified by the Governors's Commission for a Sustainable South Florida in the C&SF Project Restudy Conceptual Plan.

Region

The seasonal distribution of overland flow volume is applied as a performance measure only to the cross section in mid Shark River Slough.

Restoration Goal

The re-distribution of flow into Shark River Slough, with subsequent restoration of extended duration of uninterrupted flooding, brief duration of dry conditions, water depth pattern, and overland flow volume and **timing characteristic** of the pre-drainage system is among the highest priorities of ecosystem restoration in the southern Everglades.

Problem Addressed

Restoration of the seasonal timing of flow down Shark River Slough is important to extend the duration of flooding in the Slough and to provide seasonal salinity patterns in the estuaries as they would have occurred in the natural system

Model Target

The target is a cumulative deviation that does not exceed that indicated by NSM45F.

Model Output Format

The overland flow volume across the cross-section in mid Shark River Slough that occurs each month of the year is calculated as the percent of the annual flow volume and is averaged over the 31-year period of record. The performance measure is the cumulative deviation of the monthly percent of annual flow under a given alternative from the monthly percent of flow under NSM45F, summed over the 12 months of the year. It is given a weighting of one when averaged with the other performance measures for Shark River Slough because of the higher level of uncertainty in NSM45F simulations of flow compared to other parameters.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate a cross section evaluate a cross-section taken across the entire width and depth of flow in mid Shark River Slough.

Literature Cited

Authors & Contributors

Author: Steve Davis
Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category

Ecological

Performance Measure

Duration of Uninterrupted Flooding

Date Submitted/Revised

June 1998

General Planning Objective

The duration of uninterrupted flood events is the highest priority hydrologic performance measure for ecological restoration in the Everglades. Conceptual models of both the ridge and slough landscapes and the marl prairie/rocky glades landscapes identify duration of uninterrupted flooding as the single hydrologic parameter that affects all the plant and animal attributes that are considered to be indicators of ecological health in the Everglades.

Region

Duration of uninterrupted flooding is applied as a performance measure to the Shark River Slough. and Rockland Marl Marsh (Indicator regions 8, 9, 10, and 11).

Restoration Goal

Increased nesting success and abundance of American alligators and a corresponding increase in the number of occupied alligator holes to serve as drought refugia and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased abundance of wading birds and wood storks, 4) re-establishment of coastal nesting colonies of wading birds and wood storks, 5) delay (syn) in timing of colony formation by wading birds and wood storks, 6) resumption of the return frequency of wading bird and white ibis super colonies, 7) enhanced production and community composition of periphyton, 8) accelerated accretion of marl and peat soils, 9) persistence and resilience of macrophyte and tree island plant communities including the cessation of sawgrass expansion into wet prairies and sloughs, and 10) increased nesting success and population size of Cape Sable seaside sparrows.

Problem Addressed

Due to water management practices, inundation frequency and duration in Shark River Slough and the Rockland Marl Marsh landscapes have been altered from pre-drainage patterns. The re-distribution of flow into Shark River Slough, with subsequent restoration of extended duration of **uninterrupted flooding**, brief duration of dry conditions, water depth pattern, and overland flow volume and timing characteristic of the pre-drainage system is among the highest priorities of ecosystem restoration in the southern Everglades.

Model Target

The target is the mean duration of flooding indicated by NSM45F.

Model Output Format

Only flood events when the mean water depth equals or exceeds 0.2 feet are measured because depths less than 0.2 feet have been observed to impair the establishment of populations of aquatic organisms. The mean duration of all such flood events during the 31-year period of record is the performance measure. It is given a weighting of 3 when averaged with the other performance measures for these regions.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate Indicator Regions:

Rockland Marl Marsh
SW Shark Slough
Mid Shark Slough
NE Shark Slough

Literature Cited

Authors & Contributors

Author: Steve Davis
Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category

Ecological

Performance Measure

Duration of Dry Conditions

Date Submitted/Revised

June 1998

General Planning Objective

The re-distribution of flow into Shark River Slough, with subsequent restoration of extended duration of uninterrupted flooding, **brief duration of dry conditions**, water depth pattern, and overland flow volume and timing characteristic of the pre-drainage system, is among the highest priorities for ecosystem restoration in the southern Everglades. The conceptual models identify drought severity as the second most important hydrologic variable for ecological restoration in the Everglades.

Region

The mean duration of dry events is applied as a performance measure to the Shark River Slough and Rockland Marl Marsh indicator regions.

Restoration Goal

Increased nesting success and abundance of American alligators and a corresponding increase in the number of occupied alligator holes to serve as drought refugia and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased abundance of wading birds and wood storks, 4) re-establishment of coastal nesting colonies of wading birds and wood storks, 5) delay (syn) in timing of colony formation by wading birds and wood storks, 6) resumption of the return frequency of wading bird and white ibis super colonies, 7) enhanced production and community composition of periphyton, 8) accelerated accretion of marl and peat soils, 9) persistence and resilience of macrophyte and tree island plant communities including the cessation of sawgrass expansion into wet prairies and sloughs, and 10) increased nesting success and population size of Cape Sable seaside sparrows.

Problem Addressed

Drought severity affects the ability of aquatic fauna to survive dry conditions in alligator holes and solution holes, the intensity of wild fires, and the loss of peat soil in the Everglades.

Model Target

Mean duration of dry events indicated by NSM45F

Model Output Format

Drought severity is most clearly indicated by 2X2 model output as the duration of dry conditions. Dry events are defined as times when the water level drops either to zero or a negative value below the ground surface. Two dry events that are separated by a flood event when the water level rises to less than 0.2 feet above the ground surface are grouped as one dry event because such a minor flood event has been observed to impair the establishment of populations of aquatic organisms. In that case, the duration of the dry event is calculated as the sum of the two dry events and the intermittent flood event. The performance measure is the mean duration of all dry events during the 31-year period of record. It is given a weighting of two when averaged with the other performance measures for these regions.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate Indicator Regions:

Rockland Marl Marsh
SW Shark Slough
Mid Shark Slough
NE Shark Slough

Literature Cited

Authors & Contributors
Author: Steve Davis
Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category
Ecological

Performance Measure
Number of Dry Events
Note: Since reduction in the number of dry events became a priority in the modeling leading to Alternative D13, it was added as a performance measure to replace mean duration of flooding.

Date Submitted/Revised
June 1998

General Planning Objective
The conceptual models identify drought severity as the second most important hydrologic variable for ecological restoration in the Everglades

Region
Number of dry events is applied as a performance measure to the Shark River Slough..

Restoration Goal
Increased nesting success and abundance of American alligators and a corresponding increase in the number of occupied alligator holes to serve as drought refugia and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased abundance of wading birds and wood storks, 4) re-establishment of coastal nesting colonies of wading birds and wood storks, 5) delay (syn) in timing of colony formation by wading birds and wood storks, 6) resumption of the return frequency of wading bird and white ibis super colonies, 7) enhanced production and community composition of periphyton, 8) accelerated accretion of peat soils, 9) persistence and resilience of macrophyte and tree island plant communities including the cessation of sawgrass expansion into wet prairies and sloughs.

Problem Addressed

Drought severity affects the ability of aquatic fauna to survive dry conditions in alligator holes and solution holes, the intensity of wild fires, and the loss of peat soil in the Everglades.

Model Target

The target is not to exceed the number of dry events indicated by NSM45F.

Model Output Format

Dry events are defined as times when the water level drops either to zero or a negative value below the ground surface. Two dry events that are separated by a flood event when the water level rises to less than 0.2 feet above the ground surface are grouped as one dry event because such a minor flood event has been observed to impair the establishment of populations of aquatic organisms. In that case, the duration of the dry event is calculated as the sum of the two dry events and the intermittent flood event. This performance measure calculates the number of dry events during the 31-year period of record.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate Indicator Regions:

SW Shark Slough
Mid Shark Slough
NE Shark Slough

Literature Cited

Authors & Contributors

Author: Steve Davis
Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category

Ecological

Performance Measure

Mean Depth During Flooding

Date Submitted/Revised

June 1998

General Planning Objective

The water mean depth during periods of flooding was identified in the Everglades Sloughs Conceptual Model as relevant to the community composition of wetland vegetation, to the establishment, survival and community composition of aquatic fauna, and to the freshwater head driving flows toward Florida Bay. While the mean depth during flooding is important in these regards, it is not considered to be as high a priority in the restoration of ecological values as duration of flooding or drought severity in the southern Everglades

Region

The mean depth during flooding is applied as a performance measure only to Shark River Slough (Indicator Regions 9, 10 and 11).

Restoration Goal

Increased nesting success and abundance of American alligators and a corresponding increase in the number of occupied alligator holes to serve as drought refugia and to increase habitat heterogeneity, 2) increased population density of aquatic fauna, 3) increased abundance of wading birds and wood storks, 4) re-establishment of coastal nesting colonies of wading birds and wood storks, 5) delay (syn) in timing of colony formation by wading birds and wood storks, 6) resumption of the return frequency of wading bird and white ibis super colonies, 7) enhanced production and community composition of periphyton, 8) accelerated accretion of peat soils, 9) persistence and resilience of macrophyte and tree island plant communities including the cessation of sawgrass expansion into wet prairies and sloughs.

Problem Addressed

Shark River Slough represents the largest drainage basin in the southern Everglades and contains most of the ridge and slough peatland landscape within Everglades National Park. Pre-drainage Shark River Slough was the classic river of grass, a nearly continuously flowing and flooded peatland. Multi-year periods of flooding in Shark River Slough, punctuated by infrequent and brief dry conditions, provided a year-round aquatic ecosystem that produced peat deposits, drove the hydrology of adjacent rockland and marl marshes, provided a drought refugium for aquatic organisms from the adjacent shorter-hydroperiod wetlands, and influenced the salinity regimes in the coastal basins of Florida Bay. The re-distribution of flow into Shark River Slough, with subsequent restoration of extended duration of uninterrupted flooding, brief duration of dry conditions, **water depth pattern**, and overland flow volume and timing characteristic of the pre-drainage system, is among the highest priorities for ecosystem restoration in the southern Everglades.

Model Target

The target is the mean depth indicated by NSM45F.

Model Output Format

To be consistent with the definition for the duration of flooding, only events when the water depth averaged at least 0.2 feet are included in the calculation. The performance measure is the mean depth of all flood events during the 31-year period of record. It is given a weighting of one when averaged with the other performance measures for Shark River Slough.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate Indicator Regions:

SW Shark Slough
Mid Shark Slough
NE Shark Slough

Literature Cited

Authors & Contributors

Author: Steve Davis
Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category

Ecological

Performance Measure

Wet Season Water Level Reversals

Date Submitted/Revised

June 1998

General Planning Objective

This performance measure is linked to the Marl Prairie/Rocky Marl Marsh Conceptual Model developed by the SERA Natural Systems Team, and addresses several hydrologic and ecologic planning objectives identified by the Governors's Commission for a Sustainable South Florida in the C&SF Project Restudy Conceptual Plan.

Region

The number of wet season reversals is applied as a performance measure only to the Rockland Marl Marsh, since reversals were not found to apply to Shark River Slough in the model outputs

Restoration Goal

Recover natural system pattern of wet season reversals.

Problem Addressed

A wet season water level reversal is defined as an incident during a period of flooding when water depth recedes to less than 0.2 feet, but then rebounds to greater than 0.2 feet, without the marsh drying completely. A reversal is distinguished from a dry period in that during a reversal, water depth does not drop to or below the ground surface The Marl Prairie/Rocky Glades Conceptual Model identifies a critical ecological pathway triggered when water depth drops to less than 0.2 feet during a period of flooding; aquatic fauna population densities decline, survivors retreat to refugia in solution holes or alligator holes, and population recovery is slowed

Model Target

The target is not to exceed the number of reversals indicated by NSM45F.

Model Output Format

The performance measure is the total number of reversals during the 31-year period of record. It is given a weighting of one when averaged with the other performance measures for the Rockland Marl Marsh.

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate the Rockland Marl Marsh (Indicator region 8)

Literature Cited

Authors & Contributors

Author: Steve Davis

Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category

Ecological

Performance Measure

Total Annual Overland Flow Volume, Mid Shark River Slough

Date Submitted/Revised

June 1998

General Planning Objective

This performance measure is linked to the Everglades Sloughs Conceptual Model developed by the SERA Natural Systems Team, and addresses several hydrologic and ecologic planning objectives identified by the Governors's Commission for a Sustainable South Florida in the C&SF Project Restudy Conceptual Plan.

Region

The total annual overland flow volume is applied as a performance measure only to a cross section in mid Shark River Slough.

Restoration Goal

The re-distribution of flow into Shark River Slough, with subsequent restoration of extended duration of uninterrupted flooding, brief duration of dry conditions, water depth pattern, and **overland flow volume** and timing characteristic of the pre-drainage system.

Problem Addressed

The annual overland flow volume down Shark River Slough provides a measure of the total contribution of the Slough to freshwater inputs to the Gulf of Mexico and Florida Bay estuaries. Flow volume also relates to duration of flooding and water depth within the Slough..

Model Target

The target is the annual overland flow volume indicated by NSM45F.

Model Output Format

The monthly volumetric flow rate is simulated as the volume passing a section perpendicular to the direction of flow. The cross-section is taken across the entire width and depth of flow in mid Shark River Slough. The total annual flow volume is determined by summing the monthly flow values. The total annual flow volume is averaged over the 31-year period of record. The performance measure is the mean annual flow volume expressed as percent of the NSM45F flow volume. It is given a weighting of one when averaged with the other performance measures for Shark River Slough because of the higher level of uncertainty in NSM45F simulations of flow compared to other parameters

Evaluation Tools

The South Florida Water Management Model and Natural System Model should be used to evaluate a cross-section taken across the entire width and depth of flow in mid Shark River Slough.

Literature Cited

Authors & Contributors
Author: Steve Davis
Contributors: South Florida Water Management District and Everglades National Park staff (Final document will identify individual contributers)

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Category
Ecological

Performance Measure
Salt Intrusion Front Movement and Groundwater Flows to Biscayne Bay

Date Submitted/Revised
August, 1998

General Planning Objective

This measure addresses Governor's Commission for a Sustainable South Florida general planning objectives: 1) Restore more natural hydropatterns, including associated sheetflow, and 2) Provide more natural quality and quantity, timing and distrubutuion of freshwater flow to and through the natural Everglades

Region

This performance measure addresses groundwater flows into Biscayne Bay and affects LEC Service Area 3

Restoration Goal

The restoration target is to restore, to the extent possible, the hydraulic head which drives groundwater flows to Biscayne Bay. Preliminary analysis of the existing Miami-Dade County water quality database for Biscayne Bay indicates that some groundwater flows may occur during periods of high rainfall or during wet years. This is an indication that it may be possible to increase groundwater flows to the bay by raising watershed groundwater levels to the extent possible without triggering flood control measures.

Problem Addressed

Biscayne Bay historically received a large portion of its freshwater inputs from groundwater. Groundwater seeps and springs were/are located throughout the bay and historically, freshwater entered the bay in a more or less distributed manner. Drainage of the watershed for flood control lowered regional groundwater levels and reduced the hydraulic head west of the Atlantic Coastal Ridge which drove these flows. The result has been a reduction in the freshwater inputs from groundwater and an increase in the proportion of the freshwater budget which is provided through surface water flows from the canals. The current surface water flows constitute a point source discharge and although the freshwater is required to maintain estuarine conditions, the distribution and timing of the point source discharges cause large local variations in salinity which are harmful to marine and estuarine biota.

Model Target

The following target groundwater levels, which are based on the Ghyben-Herzberg relationship, would therefore represent the direction in which groundwater levels need to be raised in order to create a more desirable hydraulic head for driving increased groundwater flows to Biscayne Bay. Alternatives that improve conditions over base or future base (i.e. where the groundwater levels more closely approach the Ghyben-Herzberg relationship) are preferable to those where conditions are equal to or worse than base or future base. It should be noted that direct comparisons of target groundwater levels calculated with the Ghyben-Herzberg relationship and the LEC Minimum Levels should not be made. The LEC Minimum Levels are for canal stages at the specified structures; the groundwater levels for the surrounding land will be higher.

Cell Cluster	Approximate Depth to the Base of the Biscayne Aquifer *	Target Groundwater Levels based on the Ghyben-Herzberg Relationship	Average Topography for Cell Cluster (from Topography for SFWMM)	LEC Minimum Flows and Levels - Canal/Structure
North Bay #1	180 ft. between G-3300 and the Snake Creek (C-9) Canal	4.5 NGVD	9.61 NGVD	2.00 - C-9/S-29
North Bay #2	130 ft. at mouth of the Miami Canal	3.25 NGVD	8.25 NGVD	2.50 - C-6/S-26
Central Bay	110 ft. at Snapper Creek	2.75 NGVD	10.26 NGVD	2.50 - C-2/S-22
South Bay	85 ft. at G-3316	2.13 NGVD	5.1 NGVD	None Set

Source: Fish, J.E. and M. Stewart 1991. Hydrogeology of the Surficial Aquifer System, Dade County, Florida. U.S. Geological Survey Water Resources Investigations Report 90-4108, 50 pp.

Model Output Format

Area of Interest: Four blocks of WMM model cells distributed along the western shoreline of Biscayne Bay. The cell clusters are as follows:
North Bay Block #1: R28, C36; R27, C36; R27, C35; R26, C35
North Bay Block #2: R24, C34; R23, C34

Central Bay Block: R21, C33; R20, C33; R20, C32; R19, C32; R19, C31
South Bay Block: R14, C30; R13, C30; R12, C30; R12, C29

North Bay #1 is centered over the Atlantic Coastal Ridge, is bisected by the Biscayne (C-8) Canal, and is composed predominantly of higher elevation uplands. North Bay #2 is centered over the Miami River but intersects the Atlantic Coastal Ridge at the extreme north and south ends, and therefore is composed predominantly of moderate to low-lying uplands. Central Bay Block is centered over the Snapper Creek (C-6) Canal and is composed predominantly of higher elevation uplands. South Bay Block is located between Cutler Ridge and the north end of the Model Lands Basin and is composed almost entirely of low-lying uplands and wetlands.

Groundwater stage hydrographs (weekly averages) and groundwater stage duration curves over the period of record, averaged for each of the cell blocks. Average elevation for each cluster and the Ghyben-Herzberg relationship for that location (based on the aquifer depth at that location - provided below) should be displayed as horizontal lines superimposed on the hydrographs and stage duration curves. Although similar to the salt intrusion performance measures for the LEC, this measure is different because it looks at area groundwater levels rather than canal stages.

Bar graph showing the number of times weekly average groundwater levels equal or exceed the Ghyben-Herzberg relationship for that cell block over the period of record. Alternatives with higher numbers of events would provide higher groundwater flows to Biscayne Bay than alternatives with lower numbers or no events.

Although more appropriate for a static aquifer, the Ghyben-Herzberg relationship (depth to the saltwater interface (below sea level) in a coastal aquifer is 40 times the elevation of the water table above sea level at the same location) can be used as a first approximation for the groundwater levels necessary to maintain freshwater conditions to the base of the aquifer. The LEC Water Supply Plan Committee proposed minimum canal stages for the C-9, C-6, and C-2 to prevent salt intrusion to the Biscayne Aquifer, but modified the levels projected by this relationship based on information that the equation would overestimate the head needed in a flowing system (SFWMD 1997).

Evaluation Tools
SFWMM

Literature Cited

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Parker, G.G., G.E. Ferguson, S.K. Love, and others. 1955. Water Resources of Southeastern Florida. Water Supply Paper 1255. U.S. Geological Survey, Washington, D.C. 965 Pp.

Authors & Contributors

Gwen Burzycki (DERM)
Contributors: Kevin Kotun (DERM)

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Category

Flood Control

Performance Measure

End of Month Stage Duration Curve1983-1993

Date Submitted/Revised

February, 1998

General Planning Objective

This performance measure addresses the general planning objective identified by the Governor's Commission for a Sustainable South Florida in the Conceptual Plan for the C&SF Project; establish levels of provided flood protection in terms of frequency, depth, and duration

Region

C-111 Basin

Restoration Goal

Provide flood protection to the area east of the L-31N and C-11 canals and south of Richmond Drive.

Problem Addressed

The property east of the L-31N and C-111 canals, south of Richmond Drive, was provided a beneficial level of flood protection during the 1983 to 1993 period by the way those two canals were operated. During that period, water levels were raised during the dry months without causing increased water levels during the wet periods. Limited data from 1994-1996 indicate that Experimental Water Deliveries

Program tests 6 and 7 have not achieved this objective. Farmers in the area have experienced a decreased ability to eliminate excess stormwater from their fields.

An occurrence of ground water stage within two (2) feet of the ground surface for a duration of greater than 24 hours is considered a flood event with the potential for causing agircultural crop loss. The SFWMM has no capability to directly measure flood control on individual fields or during relatively short events. Peak stage difference maps have been developed to provide a general indication of the estimated changes in simulated peak stages that result from an alternative scenario. They cannot be used as a performance measure for changes in flooding risk at a particular location for a specific storm event.

Model Target

The 1983-93 portion of the stage duration curve taken from the model calibration and validation runs for each of the five (5) indicator cells in the southern Dade area.

Model Output Format

Stage duration curve described above.

Evaluation Tools

SFWMM

Literature Cited

Authors & Contributors

Tom MacVicar, Carol Drungil, Linda McCarthy, SFWMD's Agricultural Advisory Committee, Lorraine Heisler, Cal Neidrauer.

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Category

Ecological

Performance Measure

Daily Hydrograph with Spring Water Recession Windows

Date Submitted/Revised

January 14, 1998

General Planning Objective

This performance measure addresses one of the preferred options for ecosystem restoration of the Lake Okeechobee Area identified by the Governor's Commission for a Sustainable South Florida; to restore more natural fluctuations of lake levels with no significant impacts to the littoral zone. It also addresses several general planning objectives identified in the conceptual plan for the C&SF Project Restudy; improve habitat quality and heterogeneity, and restore more natural hydropatterns.

Region

Lake Okeechobee

Restoration Goal

Optimize intra-year variation in lake levels to provide a healthy ecosystem for wading birds and other wildlife.

Problem Addressed

Research conducted in the comprehensive Lake Okeechobee Ecosystem Study (LOES) indicated that a certain degree of seasonal variation in lake levels is necessary to maintain a healthy ecosystem (Aumen and Wetzel 1995). In particular, studies dealing with wading bird nesting and food resource (forage fish) utilization indicated that a spring (January through May) recession in lake levels from near 15 ft to below 12 ft, with no reversal greater than 0.5 ft during that period, would optimize the health of those animal populations (Smith et al. 1995, Smith and Callopy 1995). Receding lake levels in spring serve to concentrate prey resources at a time when birds are searching for food for their offspring. Avoiding reversals during that time period is critical, because birds select nesting sites on the basis of current lake levels, and their sense of where lake levels are going in the future. Reversals (sudden increases in lake level following a period of decline) are unexpected events that can flood out and destroy nests. Reversals also can interfere with the reproductive cycle of other animals (e.g., the apple snail) which lay eggs on emergent plant stems. Spring lake level recessions to below 12 ft also benefit the ecosystem by invigorating willow stands (a critical nesting habitat for wood stork) and allowing fires to burn away cattail thatch.

Model Target

The general goal is to achieve a hydropattern for the lake that results in as many years as possible with spring lake level recessions falling within the "windows" of the performance indicator graph. However, it is unclear how many total years out of 30 would be the ideal case.

Model Output Format

A 30-year daily stage hydrograph for the 1995 and 2050 base conditions and each water supply Alternative, overlaid by "windows" spanning the 12-15 ft depth and Jan-May seasonal ranges.

Evaluation Tools

SFWMM

Literature Cited

Aumen, N.G. and R.G. Wetzel. 1995. Ecological studies on the littoral and pelagic systems of Lake Okeechobee, Florida (USA). Archiv fur Hydrobiologie, Advances in Limnology, Volume 45. 356 pp.

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Smith, J.P., J.R. Richardson and M.W. Callopy. 1995. Foraging habitat selection among wading birds at Lake Okeechobee, Florida, in relation to hydrology and vegetative cover. Archiv fur Hydrobiologie, Advances in Limnology 45: 247-285.

Authors & Contributors

Karl E. Havens and Barry H. Rosen, South Florida Water Management District
Contributors: Robert Pace (USFWS), Lorraine Heisler (GFC)

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Category

Ecological

Performance Measure

Similarity in Duration of Lake Stages >15 ft

Date Submitted/Revised

January 14, 1998

General Planning Objective

This performance measure is linked to the Lake Okeechobee Conceptual Model.

It addresses the general planning objective, improve habitat quality and heterogeneity, identified in the conceptual plan for the C&SF Project Restudy.

Region

Lake Okeechobee

Restoration Goal

Minimize the frequency of prolonged events (lake stages exceed 15 ft for more than 12 continuous months) that may limit light penetration to the lake bottom .

Problem Addressed

Prolonged moderate high lake levels (>15 ft) are harmful to the lake's ecological and societal values, including the recreational fishery, birds and other wildlife, the native vegetation mosaic, recreation, ecotourism and water quality (Havens and Rosen 1997). Such events result in loss of submerged plant communities due to light limitation (Steinman et al. 1998), increase the lake-wide phosphorus concentrations (Havens 1998), and may cause an increased frequency of algal blooms in near-shore areas (Maceina 1993).

Model Target

The objective is to avoid prolonged high water level conditions that result in the adverse impacts described above, in order to protect the lake's ecological and societal values. From the standpoint of these objectives, the optimal output would be a "box" spanning the range from approximately 0 to 90 days (3 months), and "whiskers" not reaching beyond 180 days (6 months).

Model Output Format

"Box-whisker" plots showing duration statistics (median, maximum, minimum, 25 and 75th percentile duration in days) for lake stages in excess of 15 ft for a historic period, the 1995 and 2050 base cases, and each proposed water supply Alternative for the 30 year period of record. Each lake regulation schedule alternative will be compared to the period of historical record (1950-1972).

Evaluation Tools

SFWMM

Literature Cited

Havens, K.E. 1997. Water levels and total phosphorus in Lake Okeechobee. Lake and Reservoir Management 13: 16-25.

Havens, K.E. and B.H. Rosen. 1997. A conceptual model for Lake Okeechobee. Society for Ecological Restoration Conference, Ft. Lauderdale, Florida.

Maceina, M.J. 1993. Summer fluctuations in planktonic chlorophyll a concentrations in Lake Okeechobee, Florida: the influence of lake levels. Lake and Reservoir Management 8:1-11.

Steinman, A.D., R.H. Meeker, A.J. Rodusky, W.P. Davis and S-J. Hwang. 1998. Ecological properties of Charophytes in a large subtropical lake. Journal of the North American Benthological Society, in press.

Authors & Contributors

Karl E. Havens and Barry H. Rosen, South Florida Water Management District
Contributors: Robert Pace (USFWS), Lorraine Heisler (GFC)

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Category
Ecological

Performance Measure
Similarity in Duration of Lake Stages <12 ft.

Date Submitted/Revised
January 14, 1998

General Planning Objective

This performance measure is linked to the Lake Okeechobee Conceptual Model.

It addresses the general planning objective, improve habitat quality and heterogeneity, identified in the conceptual plan for the C&SF Project Restudy.

Region
Lake Okeechobee

Restoration Goal

Minimize the frequency of prolonged events (lake stage falls below 12 feet for longer than 12 continuous months) that substantially reduce the littoral area available as wildlife habitat, and promote exotic plant expansion.

Problem Addressed

Prolonged moderate low (<12 ft) lake levels are harmful to the lake's ecological and societal values, including the recreational fishery, birds and other wildlife, the native vegetation mosaic, recreation, ecotourism and water quality (Havens and Rosen 1997). At lake levels below 12 ft, over 70% of the marsh is dry, and cannot function as a habitat for fish, birds or other wildlife (SFWMD 1997). These conditions also are favorable for expansion of exotic plants into native plant-dominated regions of the marsh (Thayer and Haller 1990, Lockhart 1995).

Model Target

The objective is to avoid prolonged low water level conditions that result in the adverse impacts described above, in order to protect the lake's ecological and societal values. From the standpoint of these objectives, the optimal output would be a "box" spanning the range from approximately 0 to 90 days (3 months), and "whiskers" not reaching beyond 180 days (6 months).

Model Output Format

"Box-whisker" plots showing duration statistics (median, maximum, minimum, 25 and 75th percentile durations in days) for lake stages below 12 ft for a historic period, the 1995 and 2050 base cases, and each proposed water supply Alternative for the 30 year period of record. of each lake regulation schedule alternative will be compared to the period of historical record (1950-1972).

Evaluation Tools
SFWMM

Literature Cited
Havens, K.E. and B.H. Rosen. 1997. A conceptual model for Lake Okeechobee. Society for Ecological Restoration Conference, Ft. Lauderdale, Florida.

Lockhart, C.S. 1995. The effect of water level variation on the growth of *Melaleuca* seedlings from the Lake Okeechobee littoral zone. MS Thesis, Florida Atlantic University, Boca Raton, Florida.

SFWMD. 1997. Surface water improvement and management (SWIM) plan – update for Lake Okeechobee. South Florida Water Management District, West Palm Beach, Florida.

Thayer, P.L. and W.T. Haller. 1990. Fungal pathogens, *Phoma* and *Fusarium*, associated with declining populations of torpedo grass growing under high water stress. Proceedings of the European Water Research Society, 8th Symposium on Aquatic Weeds, pp. 209-214.

Authors & Contributors
Karl E. Havens and Barry H. Rosen, South Florida Water Management District
Contributors: Robert Pace (USFWS), Lorraine Heisler (GFC)

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Category
Ecological

Performance Measure
Similarity in Duration of Lake Stages <11 ft

Date Submitted/Revised
January 14, 1998

General Planning Objective
This performance measure is linked to the Lake Okeechobee Conceptual Model.

It addresses the general planning objective, improve habitat quality and heterogeneity, identified in the conceptual plan for the C&SF Project Restudy.

Region
Lake Okeechobee

Restoration Goal
Minimize the frequency of extremely low lake stages (<11 ft) that result in a loss of the littoral zone as habitat for aquatic biota, and promote expansion of exotic plants into pristine native-plant dominated regions of the lake.

Problem Addressed
Extreme low lake levels (<11 ft), of any duration, are harmful to the lake's ecological and societal values, including the recreational fishery, birds and other wildlife, the native vegetation mosaic, recreation, ecotourism and water quality (Havens and Rosen 1997). Low lake levels dry out critical marsh habitat, and may permit the more rapid expansion of exotic plants (*Meleleuca* and torpedo grass) into regions still occupied by native plant communities (Thayer and Haller 1990, Lockhart 1995). At lake levels 11 ft, nearly 95% of the littoral zone is dry, including the Mooneshine Bay region. This region is of particular concern, since it is a prime habitat for snail kite, and a last refuge for these federally-endangered birds (as well as other species) during regional droughts (Bennetts and Kitchens 1997). At present, Moonshine Bay is an excellent habitat because it is dominated by spike rush (*Eleocharis*) and bladderwort (*Utricularia*), which provide considerable open-water habitat for forage fish, and substrates for apple snail eggs. If the region should be overtaken by torpedo grass, whose expansion into new areas appears to be hindered by standing water (Thayer and Haller 1990), these habitat values could be lost.

Model Target
The objective is to avoid the extreme low water level conditions that result in the adverse impacts described above, in order to protect the lake's ecological and societal values. From the standpoint of these objectives, the optimal output would be no such events; i.e., all attributes of the box-whisker plot below zero.

Model Output Format
"Box-whisker" plots showing duration statistics (median, maximum, minimum, 25 and 75th percentile durations in days) for a historic period, the 1995 and 2050 base cases, and each proposed water supply Alternative for the 30 year period of record. of each lake regulation schedule alternative will be compared to the period of historical record (1950-1972).

Evaluation Tools
SFWMM

Literature Cited

Bennett, R.E. and W.M. Kitchens. The demography and movements of snail kites in Florida. Technical Report 56, United States Geological Survey, Biological Resources Division, Talahassee, Florida.

Havens, K.E. and B.H. Rosen. 1997. A conceptual model for Lake Okeechobee. Society for Ecological Restoration Conference, Ft. Lauderdale, Florida.

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Thayer, P.L. and W.T. Haller. 1990. Fungal pathogens, *Phoma* and *Fusarium*, associated with declining populations of torpedo grass growing under high water stress. Proceedings of the European Water Research Society, 8th Symposium on Aquatic Weeds, pp. 209-214

Authors & Contributors

Karl E. Havens and Barry H. Rosen, South Florida Water Management District
Contributors: Robert Pace (USFWS), Lorraine Heisler (GFC)

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Category

Ecological

Performance Measure

Similarity in Duration of Lake Stages >17ft

Date Submitted/Revised

January 14, 1998

General Planning Objective

This performance measure is linked to the Lake Okeechobee Conceptual Model.

It addresses the general planning objective, improve habitat quality and heterogeneity, identified in the conceptual plan for the C&SF Project Restudy.

Region

Lake Okeechobee

Restoration Goal

Minimize the frequency of extreme high lake stage events (>17ft) that may cause wind and wave damage to the shoreline plant communities, and transport phosphorus-laden pelagic water into pristine interior regions of the littoral zone.

Problem Addressed

When lake levels reach this extreme high, the following impacts can be expected, in addition to those occurring when lake levels exceed 15 ft; damage to bulrush and other shoreline plant communities by wind and waves, and transport of nutrients into the pristine littoral marsh, with nutrient-induced changes in periphyton, plant, and animal communities

Model Target

The goal is to have zero events.

Model Output Format

"Box-whisker" plots showing duration statistics (median, maximum, minimum, 25 and 75th percentile durations in days) for a historic period, the 1995 and 2050 base cases, and each proposed water supply Alternative for the 30 year period of record. Each lake regulation schedule alternative will be compared to the period of historical record (1950-1972).

Evaluation Tools

SFWMM

Literature Cited

Bennett, R.E. and W.M. Kitchens. The demography and movements of snail kites in Florida. Technical Report 56, United States Geological Survey, Biological Resources Division, Talahassee, Florida.

Fry, B., P.L. Mumford, F. Tam, D.D. Fox, G.L. Warren, K.E. Havens and A.D. Steinman. 1998. Trophic position and individual feeding histories of fish from Lake Okeechobee, Florida. Canadian Journal of Fisheries and Aquatic Sciences, in review.

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Algal responses to nutrients in a littoral mesocosm experiment. Oikos, in review.

Lockhart, C.S. 1995. The effect of water level variation on the growth of *Melaleuca* seedlings from the Lake Okeechobee littoral zone. MS Thesis, Florida Atlantic University, Boca Raton, Florida.

Maceina, M.J. 1993. Summer fluctuations in planktonic chlorophyll a concentrations in Lake Okeechobee, Florida: the influence of lake levels. Lake and Reservoir Management 8:1-11.

Steinman, A.D., R.H. Meeker, A.J. Rodusky, W.P. Davis and S-J. Hwang. 1998. Ecological properties of Charophytes in a large subtropical lake. Journal of the North American Benthological Society, in press.

Thayer, P.L. and W.T. Haller. 1990. Fungal pathogens, *Phoma* and *Fusarium*, associated with declining populations of torpedo grass growing under high water stress. Proceedings of the European Water Research Society, 8th Symposium on Aquatic Weeds, pp. 209-214.

Authors & Contributors

Karl E. Havens and Barry H. Rosen, South Florida Water Management District
Contributors: Robert Pace (USFWS), Lorraine Heisler (GFC)

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Category

Water Supply

Performance Measure

Agricultural and urban water supply using the Monthly Supply-Side Management Report and Simulated Annual Demands not Met per Year (for each coastal service area).

Date Submitted/Revised

January 1998

General Planning Objective

Soon after the C&SF Comprehensive Review Study (Restudy) process was initiated, SFWMD's Lower East Coast Regional Water Supply Plan staff made a decision to defer planning and making recommendations on phase 2 water supply projects due to potential conflicts with the Restudy results. The phase 2 projects are needed primarily to address environmental goals and agricultural water supply needs that were not met by the LEC WSP projects proposed in phase 1 of the plan. Subsequent to that decision, WRDA 1996 shortened the time period in which the Restudy would be conducted. In 1997, the Florida Legislature modified Florida law

(HB 715) and included some clarification of how the Water Management Districts were to do water supply planning. The Districts' regional water supply plans now must contain a "level-of-certainty planning goal associated with identifying the water supply needs of existing and future reasonable-beneficial uses shall be based upon meeting those needs for a 1-in-10 year drought event" (Chapter 373.0361(2)(a)(1), F. S.). Since a portion of SFWMD's water supply planning was deferred and is now taking place in the Restudy process, it's expected that the goal stated in Florida law be adopted as the Restudy goal.

Region

The Lake Okeechobee Service Area includes the Everglades Agricultural Area, the Caloosahatchee Basin, the St. Lucie Basin, the S-4 Basin, the L-8 Basin and the Seminole Indian (Brighton and Big Cypress) Reservations

Restoration Goal

Water shortage restrictions for the Lake Okeechobee Service Area should be limited to not more than three in the 31-year simulation period.

Problem Addressed

Chapter 373.246, F.S., requires that the Water Management Districts develop a water shortage plan to protect the water resources from serious harm during droughts, and to restore them to their previous condition. In the present water shortage rule, cutbacks in water usage are triggered by either a saltwater intrusion event (well triggers) or by a low-Lake-Okeechobee event. The regional system is operated so that deliveries to the coast are made to either halt or slow down saltwater intrusion. Deliveries are made first from the Water Conservation Areas, then from Lake Okeechobee, depending on what their respective water levels are and on what basin is experiencing the shortage. Under the water shortage plan, provisions for variances and alternative measures to prevent undue hardship and ensure equitable distribution of water resources may be included.

With the present configuration of the C&SF System, Lake Okeechobee is the only reliable water supply source of significance during extended droughts. The Lake Okeecheebee Supply-Side Management Plan was designed to establish a procedure for supply allocation during periods of shortage. The allocation method that was developed recognized the need to hold water in reserve for anticipated high-demand periods, and recognized the actual physical limitations of the delivery system. Water supply releases during dry periods are determined by a set of water shortage management zones. Each of the zones represents storage levels with assigned probabilities of shortage. Some of the assumptions of the original methodology are: 1) that a stage of 13.5 ft on October 1 as being the level which must be exceeded to defer supply-side management; and 2) water deliveries from the Lake would be based on a weekly formula that allocated the available water in the Lake above a stage of 11 feet. The Governing Board would decide each month on additional steps necessary to manage available supplies during the shortage.

The volume of water between 11 ft and 10 ft. is reserved for the purpose of preventing saltwater intrusion in the Lower East Coast wellfields. Because of downstream physical limitations, water cannot be removed from the lake when it falls below 9.5 ft. These operational rules are being used in the SFWMM model runs for the Restudy alternatives.

A second issue that adds to the difficulty of defining “1 in 10” is deciding what to assume the effect of implementing minimum flows and levels (MF&Ls) will be on how the regional system will be operated. There is potential the water shortage plan and supply-side management plan could be modified, depending on how future policy and legal decisions are made. If the outcome of future minimum flow and level-related rule development, lawsuits, changes to current law, require the operational rules of the regional system to be changed from what is assumed in the Restudy, the “1-in-10” definition used for this phase of the Restudy also could change.

The Alternatives Evaluation Team (AET) formed a subcommittee to discuss approaches and make a recommendation on how to define a “1 in 10” year LOC performance measure for the purposes of the Restudy. During the development of SFWMD s Upper East Coast Regional Water Supply Plan, a statistical “1 in 10 year drought” year, based on rainfall, was constructed for use using basin models. The SFWMM cannot be used in the same manner, so one of the goals of the subcommittee was to try to decide how to describe an equivalent LOC for the Lake Okeechobee Service Area and the Lower East Coast. Discussions are still occurring on potential ways to run the SFWMM to try to determine if it’s possible to calculate the volume of water that would be needed from the regional system by each basin to meet water supply needs during a “1-in-10 year drought”. The District’s modeling staff does not have time to design and run the SFWMM for this purpose before April 1998. Discussions are also continuing on if or how to describe a “1 in 10 year drought event”. In the interim, the subcommittee agreed to use the frequency and severity of entering into supply-side management events for the agricultural basins in calculating a 1-in-10 year drought LOC. For the Lower East Coast Service Areas, the number of years the lake triggers a water shortage will be used in addition to the number of locally triggered events in calculating a 1-in-10 year drought LOC.

Model Target

To meet all demands (or needs). Recognizing that this may not be feasible, to meet a “1 in 10 year drought” level of certainty; measured by using the frequency of entering into supply-side management operations. An event should not last longer than 7 consecutive months.

Defining the "1-in-10 year drought event" level-of-certainty (LOC) is problematic because of the distribution capability of the regional system, and could be done in any number of ways. Different areas/basins of the District could be in a 1-in-10 year drought event as defined by rainfall at different times, but could receive sufficient water supply via deliveries through the regional system. Assuming that all service areas are experiencing a 1-in-10 year drought at the same time would in fact be an event that would occur less frequently than 1 in 10 years.

Model Output Format

Using the supply-side management reports, count the number of SSM with cutback events that occur. Months with days in SSM without cutbacks are not included. If the total percent cutback for any month is less than 10%, or the number of days with cutbacks is less than 7, the event is not counted. A water year, beginning October and ending September, is used to count events. An event is defined as any year that has a cutback occurrence as described above. For the coastal service areas: use the "simulated annual demands not met due to water restrictions per year" performance indicator, and count the number of events where demands were not met due to Lake Okeechobee. The target would be no more than three events over the simulated period. (Note: Demands not met caused by local well triggers are not considered in the LOSA.)

EAA and LOSA demands – dry years; C43 and C44 Basin Regional irrigation supply and demand not met; Other LOSA supplemental irrigation supply and demands not met; Total irrigation supply and shortages for Seminole Tribe, Big Cypress Reservation; Mean annual EAA/LOSA irrigation demands and demands not met; Report Cumulative total demand, cut-back volume, and cut-back over period of simulation; Lake Okeechobee daily stage hydrograph; Stage hydrographs and depth duration curves for reservoirs

Evaluation Tools

SFWMM

Literature Cited

Authors & Contributors

Linda McCarthy, Jeff Giddings, Steve Lamb, Fred Rapach, Pat Gleason, Brenda Mills, Carl Woehlcke, Roy Reynolds.

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Category

Ecological

Performance Measure
Flows to Lake Worth Lagoon

Date Submitted/Revised
January, 1998

General Planning Objective

This measure addresses several general planning objective identified by the Governor's Commission for a Sustainable South Florida in the Conceptual Plan for the C&SF Project Restudy; provide more natural quality and quantity, timing, and distribution of freshwater flow to estuaries and coral reef ecosystems, and improve and protect habitat quality, heterogeneity, and biodiversity in coastal and associated marine ecosystems

Region
Lake Worth Lagoon, C-51

Restoration Goal

The restoration target is to create estuarine conditions, to the extent possible, in the Lake Worth Lagoon.

Problem Addressed

Lake Worth lagoon historically was a predominately freshwater system that became estuarine periodically through ephemeral inlets opened by hurricanes. The salinity range in the Lake worth Lagoon varies from 0 parts per thousand (ppt) to approximately marine conditions (36 ppt). This is not normally an estuary that becomes hypersaline.

Model Target

An estuarine salinity envelop of 23 ppt to 35 ppt has been chosen as the target salinity range. This is a viable salinity range for a number of organisms many of that are commercially and recreationally important. To attain this salinity a maximum flow needed to be developed. Previous hydrodynamic modeling displayed that 500 cfs creates a steady state salinity of 23 ppt. For the low flow part of the salinity envelop, 0 cfs is the target. Enough groundwater occurs that should still allow estuarine conditions. Based on past modeling, this flow range of 0-500 cfs should create the salinity range of 23 ppt - 35 ppt.

Model Output Format

Mean wet/dry season flows to Lake Worth through S40, S41 & S155 for the 31 year simulation period.
Number of times salinity envelope criteria were not met for the Lake Worth Lagoon (mean monthly flows 1965-1995)

Evaluation Tools
SFWMM

Literature Cited
Day, J.W. 1989. Estuarine Ecology.

Indian River Lagoon SWIM Plan.

Lake Worth lagoon Draft SWIM PLan.

Haunert, D.E., and R. Chamberlain. 1994. St. Lucie and Caloosahatchee estuary performance measures for alternative Lake Okeechobee Regulation Schedules. SFWMD Memorandum.

Authors & Contributors
The Water Quality subcommittee for the Lake Worth Lagoon
Steve Traxler, Dave Swift, Allen Treffry, Harvey Rudolf, Dick Tomosello, Dawn Whitehead, Jim Barry, Brian Gentry

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Category
Ecological

Performance Measure
Continuity: Water Surface Elevations across Barriers

Date Submitted/Revised
January, 1998

General Planning Objective
This performance measure addresses several general planning objectives for the restudy identified by the Governor's Commission for a Sustainable South Florida; improve connectivity and fragmentation of habitats and restore more natural hydropatterns.

Region
Total System

Restoration Goal
Recover spatial and temporal continuity in water depth patterns, across any levees remaining internal to the natural system, consistent with NSM predictions of regional hydropatterns.

Problem Addressed

Canals and levees are widely used to manage the flow of water in south Florida and it is highly unlikely that they will all be removed. Unfortunately, they have several negative effects on wildlife. The deep-water habitat in canals favors larger, predatory fish over smaller, prey species, canals allow exotic fish to reach the Everglades interior easily, and the warmth of the deep water allows these tropical exotics to overwinter farther north than in the past. Both canals and levees physically restrict the movement of smaller species of wildlife, and levees attract terrestrial predators into the marsh interior. More wide-ranging species took advantage of the fluid range of opportunities presented by the wetting and drying cycles in the natural system. Suitable habitat could usually be found somewhere within the system regardless of the season or amount of rain. In the managed system, however, artificial barriers have disrupted these patterns.

Artificial barriers tend to create markedly different water regimes on their upstream and downstream sides. Water usually pools on the upstream side causing the area downstream to become drier. Water quality parameters also may differ widely. Smaller species that do manage to cross a barrier may find inhospitable conditions on the other side. Larger species such as wading birds that feed at particular depths for example, may have to travel much further to feed.

This performance measure addresses the differences in water surface elevations on either side of major artificial barriers in the remaining Everglades.

Model Target

The target condition is water elevation differences across each barrier similar to that predicted by the NSM. Differences of more than one depth class from NSM predictions are considered poor.

Model Output Format

By selecting groups of SFWMM grids on either side of a barrier and comparing the mean water surface elevation classes of the two groups, an indicator of continuity of landscape can be derived. Groups of cells were used to avoid the pitfalls inherent in single cell comparisons. Many of the barriers in the SFWMM are artificially located on the boundary between cells. In those cases, adjacent cells on either side were used. In other cases, cells containing barriers were excluded to avoid the anomalous elevation values resulting from the influence of the barrier. Adjacent cells were selected so they would have similar soils, vegetation and hydrology. Of course, cells across boundaries may naturally differ in soil, vegetation and hydrology. This measure seeks to evaluate not whether differences exist, which they undoubtedly do, but whether those differences are consistent with NSM predictions.

Comparisons are made to sets of cells on either side of the following barriers: Tamiami Trail (east), Tamiami Trail (west), L-67, and L-28, Alligator Alley, the levee/canal between WCA-2 and WCA3 and the divide between WCA1 and WCA-2A. Cells within the groups are pooled on either side of the barrier by determining the time series of mean weekly water elevations for each set of cells. The difference between these values for the two groups is then compared to the difference between the same groups of cells predicted by the NSM. Water surface elevations are used instead of depth estimates because depth estimates inherently have more error than water elevations, especially across levees where there may have been differential soil loss or accretion and where the collection of topographic data may not be similarly accurate on either side. Comparing water surface elevations instead eliminates this source of error. Additionally, the model is calibrated to water surface elevations and not to depths.

The Performance Measure is a list of mean weekly water surface elevations, upstream minus downstream for each barrier for each alternative next to those predicted by the NSM and a histogram showing the total number of weeks in which the upstream-downstream water elevation differences were: 1) within 0.0 to 0.249 feet of NSM, 2) greater than 0.25-0.49 feet different, 3) less than 0.25-0.49 feet different, etc. using whatever increment best illustrates the range of data for the model runs.

Selected cells are listed below. Superscript G = gauge, IR*n* = Indicator Region Cell

Divide between Loxahatchee NWR (WCA-1) and WCA-2A.

<u>Upstream:</u>
NSM: Ridge and Slough
1995 Land Use: Modified Ridge and Slough I. Cattails along the barrier, nearby Sawgrass Plains
Projected 2050 Land Use: Same as 1995
Cells: R46C29, R45C29^{G}, R45C30^{IR26}, R44C30 ^{IR26}, R44C31

<u>Downstream:</u>
NSM: Ridge and Slough
1995 Land Use: Mixed Cattail/Sawgrass, Cattails along barrier, and nearby Sawgrass Plains
Projected 2050 Land Use: Same as 1995 but with expanded cattails and irrigated pasture and row crops at the south end.
Cells: R45C28^{G,IR25}, R44C28 ^{IR25}, R44C29^{IR25}, R43C29, R43C30

Levee and canal between WCA-2A and WCA-3A

Upstream

NSM: Sawgrass (north), Ridge and Slough (south).

1995 Land Use: Modified Ridge and Slough I, Sawgrass, Mixed Cattail/Sawgrass, Cattail

Projected 2050 Land Use: Sawgrass Plains (north), Modified Ridge and Slough I (south), Cattails along barrier

Cells: R41C26, R41C27, R40C27, R39C27, R39C28, R38C28

Downstream:

NSM: Sawgrass (north), Ridge and Slough (south)

1995 Land Use: Sawgrass Plains, Mixed Cattail/Sawgrass, Cattails along barrier

Projected 2050 Land Use: Same as 1995

Cells: R41C25, R40C25[IR21], R40C26, R39C26, R38C26, R38C27[G]

L-67 WCA-3A to WCA-3B

Upstream:

NSM: Ridge and Slough system.

1995 Land Use: Sawgrass plains (northeast), Modified Ridge and Slough I (southwest)

Projected 2050 Land use: Same as 1995

Cells: R29C25, R28C24, R27C24[G,IR15], R27C23[G], R26C23, R25C22, R24C22

Downstream:

NSM: Ridge and Slough

1995 Land Use: Wet Prairie

Projected 2050 Land use: Same as 1995

Cells: R29C26, R28C25, R27C25[IR15], R26C24[G] , R25C24[IR15], R25C23, R24C23[IR15]

Miami Canal

Upstream:

NSM: Ridge and Slough system.

1995 Land Use: Sawgrass plains, Cattails, Modified Ridge and Slough I near L-67

Projected 2050 Land use: Same as 1995

Cells: R41C19, R40C20, R39C20, R38C21, R34C24, R33C25, R32C26

Downstream:

NSM: Ridge and Slough

1995 Land Use: Sawgrass Plains, Wet Prairie, a few Cattails at Alligator Alley

Projected 2050 Land use: Same as 1995

Cells: R41C17 [IR22], R40C18[G,IR22], R39C18[IR20], R38C19[IR20], R33C23, R32C23, R31C24

L-28
Upstream (WCA-3A):
NSM: Predominantly Ridge and Slough
1995 Land Use: Predominantly Modified Ridge and Slough I
Projected 2050 Land use: Same as 1995
Cells: R29C17[IR17], R28C17 [IR17], R27C17, R26C17, R25C17 [IR14],

Downstream (BICY):
NSM: Forested wetlands (north), Wet Prairie (south)
1995 Land Use: Same as NSM
Projected 2050 Land use: Same as NSM
Cells: R29C15, R28C15, R27C15, R26C15, R25C15,

Alligator Alley West of L-28 Interceptor:
Upstream
NSM: Forested Wetlands.
1995 Land Use: Same as NSM
Projected 2050 Land use: Same as NSM
Cells: R37C10, R37C11, R37C12, R37C13

Downstream:
NSM: Forested Wetlands
1995 Land Use: Same as NSM
Projected 2050 Land use: Same as NSM
Cells: R35C10, R35C11, R35C12, R35C13

Alligator Alley East of L-28 Interceptor, north of WCA-3A:
Upstream
NSM: Ridge and Slough
1995 Land Use: Some Wet Prairie, Mostly Sawgrass Plains
Projected 2050 Land use: Same as 1995
Cells: R36C18[G,IR20], R36C19, R36C20 and R36C24, R36C25, R36C26

Downstream:
NSM: Ridge and Slough
1995 Land Use: Wet Prairie west of Miami Canal, Sawgrass to the east, cattails at intersection of canal and road
Projected 2050 Land use: Same as 1995
Cells: R34C18[IR18], R34C20 [IR18] R34C20 [IR18], R34C24[IR19], R34C25 [IR19], R34C26 [IR19]

East Tamiami Trail - WCA-3B to ENP
Upstream
NSM: Ridge and Slough system.

1995 Land Use: Wet Prairie (west), Modified Ridge and Slough I (east)
Projected 2050 Land use: Same as 1995
Cells: R23C23[IR15], R23C24[G,IR16,] R23C25[IR16], R23C26[G,IR16]

Downstream:
NSM: Ridge and Slough
1995 Land Use: Modified Ridge and Slough II
Projected 2050 Land use: Same as 199 5
Cells: R22C23[G], R22C24, R22C25, R22C26 [G]

Tamiami Trail WCA-3A to ENP
Upstream:
NSM: Ridge and Slough system.
1995 Land Use: Modified Ridge and Slough I
Projected 2050 Land use: Same as 1995
Cells: R23C17[IR14], R23C18 [IR14], R23C19 [IR14], R23C20 [IR14]

Downstream:
NSM: Marl Marsh.
1995 Land Use: Some Marl Prairie (west), mostly Modified Ridge and Slough II
Projected 2050 Land use: Same as 1995
Cells: R22C17, R22C18[G], R22C19[G], R22C20

Tamiami Trail west of L-28
Upstream:
NSM: Forested Wetlands, Wet Prairie between levee and 50-Mile Bend
1995 Land Use: Same as NSM
Projected 2050 Land use: Same as NSM
Cells: R26C11, R26C12[IR37], R26C13

Downstream:
NSM: Forested Wetlands, Wet Prairie between levee and 50-Mile Bend
1995 Land Use: Same as NSM
Projected 2050 Land use: Same as NSM
Cells: R24C11[IR40], R24C12, R24C13

Evaluation Tools
SFWMM

Literature Cited

Authors & Contributors
Drafted by Cheryl Buckingham (USFWS)

Contributors: John Ogden (SFWMD), Lorraine Heisler (FGFWFC), Winifred Park (SFWMD)

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Category
Ecological

Performance Measure
Fragmentation: Miles of Canals and Levees Affecting Natural Areas

Date Submitted/Revised
February, 1998

General Planning Objective

This performance measure addresses several general planning objectives for the restudy identified by the Governor's Commission for a Sustainable South Florida; improve connectivity and fragmentation of habitats and restore more natural hydropatterns.

Region
Total System

Restoration Goal

Fill in artificial water features, remove barriers or otherwise make these structures biologically invisible to the surrounding landscape.

Problem Addressed

In its effort to control floodwaters and provide water supply, the C&SF Project created miles of canals, levees, and water control structures with associated deep pools. Canals and levees usually coexist; construction of a canal usually means a spoil levee exists alongside it just as a levee requires a borrow canal. Roadway construction usually involves combinations of levees and canals, sometimes with culverts to allow water to flow underneath. Water control structures are usually even more complex, involving combinations of levees, canals and deep pools. In some places, multiple canals, levees and water control structure form intricate patterns - and formidable barriers to wildlife.

When levees block the flow of water, they also restrict the movement of aquatic and semi-aquatic life forms in the water. Land-based predators use the levees to invade the marsh interior, preying upon animals that try to cross the intrusive fingers of terrestrial habitat. Levees also act as conduits, allowing terrestrial plants to invade. Canals act as corridors particularly for non-native animals and plants that can extend their ranges rapidly from points of introduction and can move into wetlands where they can alter habitats and affect food webs (Loftus and Kushlan 1987; Loftus 1986). Artificial, deep-water habitats provide thermal and spatial refuge to large numbers of both non-native and native aquatic predators in the dry season, enhancing their survival and ultimate population sizes. During the dry season, these predators prey heavily on small marsh fishes and invertebrates moving in from the adjacent wetlands (Howard et al. 1995). Alternatives that accomplish their purpose without adding to the present array of levees, canals, culvert pools, and borrow ponds in the system are considered to do no further harm but do not “restore” connectivity. Alternatives that fill in artificial water features, remove barriers or otherwise make these structures biologically invisible to the surrounding landscape are considered a positive step towards restoration. Alternatives that require a net addition of structures are detrimental.

Model Target

Minimize the extent of canals and levees internal to the remaining natural system.

Model Output Format

Outputis a table showing the number of miles of canals and, levees bordering or bisecting natural areas for each alternative.

Evaluation Tools

SFWMM

Literature Cited

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Authors & Contributors

Drafted by Cheryl Buckingham (USFWS)
Contributors: Joan Browder, NFMS/NOAA, Cheryl Buckingham, USFWS, William F. Loftus, NPS, John Ogden (SFWMD), Agnes McLean (SFWMD)
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Category
Ecological

Performance Measure
Sheetflow: Volumes Across Transects in the WCAs and Everglades National Park

Date Submitted/Revised
February, 1998

General Planning Objective

This performance measure addresses several general planning objectives for the restudy identified by the Governor's Commission for a Sustainable South Florida; restore more natural hydropatterns, including associated sheetflow, and improve connectivity and reduce fragmentation of habitats.

Region
Total System

Restoration Goal

Restoring the appropriate volume and direction of sheet flow to large areas of the freshwater marshes will allow the system to once again naturally shape tree islands, take up nutrients, precipitate phosphorus and calcium carbonate into the substrate, and retain water into the dry season. Restoring volumes of flow to Shark River Slough (the largest drainage in the system) and across the marl prairies of southern Everglades and through the system of creeks ringing Florida Bay will increase freshwater inputs into the Bay. Restoring freshwater flows into the Bay, particularly during the dry season, is badly needed to recreate the proper salinity patterns and circulation needed to restore the ecology of the system.

Problem Addressed

Sheet flow is one of the defining characteristics of the pre-drainage Everglades. Water once continuously flowed from the shore of Lake Okeechobee through the Everglades to Shark River Slough and on into Florida Bay. In the managed system, the Lake and the Water Conservation Areas have been impounded. Flow patterns out of Lake Okeechobee have shifted from primarily wet season flows in response to rainfall to dry season flows in response to urban and agricultural water supply demands.

While depths may be similar to the pre-drainage system, the River of Grass is now stagnated. The Water Conservation Areas, divided by levees and canals, are now a series of pools where water travels with less velocity and in different directions of flow. "Ponded systems favor certain species and flowing systems favor others. There are many physicochemical differences in the two systems: food types and sources, migration of macroinvertibrates, dispersion of nutrients, aeration and diffusion of gases in water, particulate suspension, and thermal stratification are some examples. Ponding in the WCAs amounts to regulation for certain species—the zoo approach that is not an ecosystem approach. From a water conservation perspective, ponding may be wise; and in a water-limited system, ponded water for fish is a real improvement over no water for fish. Is would be possible to match regulated hydroperiods month to month with natural hydroperiods and still have a completely different ecosystem due to the difference in water movement. This is another reason why a hydroperiod analysis is singularly insufficient to create the intended biological conditions." (U. S. Corps of Engineers, 1994).

System-wide, there has also been a loss of dry season lag flows from the dense sawgrass plain that formerly covered the present Everglades Agricultural Area. "Impoundment of water in the Water Conservation Areas and diversion of surface water flows to the east, combined with groundwater and levee seepage loses eastward in the modified system, have significantly contributed to reduced flows and the resultant loss of persistent hydroperiods in the southern Everglades flows and the resultant loss of persistent hydroperiods in the southern Everglades." (Davis and Ogden 1994).

The overall flow pattern has changed, too, now that the deepest part of the system, east of the Dade-Broward levee, has become an urban landscape. More water is forced through the remaining area, creating excessive depths in the impounded areas. In Florida Bay, decreased freshwater flow and increased salinity have contributed to the deterioration of estuarine productivity in Florida Bay. Pink shrimp, snook, redfish and recruitment have been reduced. Reproductive success of ospreys, great white herons, and many wading birds that nested in the estuarine ecotonal areas have been lowered. Wading bird colonies have collapsed as once-persistent pools in lower Shark River Slough have dried. Mortality in seagrass beds and mangroves has also been linked to reduced freshwater flows.

Model Target

Flow volumes across selected groups of transects predicted by NSM version 4.5 Final.

Model Output Format

A relative value for improvement in sheetflow in the Everglades marshes was obtained by comparing flow volumes across a number of transects in the north, central and southern Everglades and Big Cypress with those predicted by the NSM version 4.5 Final. Twenty-six transects were chosen throughout the Water Conservation Areas, Big Cypress, and Everglades National Park. The average annual volumes of flow for the wet season and dry season for each alternative were compared to the wet season and dry season volumes from NSM version 4.5 Final. Dry season volumes were considered more important. The 26 transects were grouped into five categories representing their general area: Big Cypress Group

(T24, T25, T26), Central Everglades (WCA-3A) Group (T7, T8, T12), Southern Everglades Group (T21, T23A, B, &C), Tamiami Trail Group (T17, T18) and the L-67 Group (T13, T14). Then for each group, an index was calculated for each transect based on the wet season and dry season average annual overland flows. For each base condition and plan, the flow value was divided by the NSM value to obtain wet season and dry season proportions, which were then scaled. Scaling, using the same curve formula described above was used to obtain values between 0.0 and 1.0. In cases where the proportion of wet season flows exceeded NSM, they received a value of 1.0. For dry season flows, excess flows were treated the same as insufficient flows.

Evaluation Tools
SFWMM

Literature Cited

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Authors & Contributors
Drafted by Cheryl Buckingham (USFWS)
Contributors: Ken Tarbotton (SFWMD), John Ogden (SFWMD), Agnes McLean (SFWMD)

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Category
Ecological

Performance Measure
Maintenance of desirable salinity conditions within the St. Lucie Estuary
# of months with mean monthly flow < 300 cfs
# of months with mean monthly flows > 2,800 cfs
# of months with mean monthly flows were > 4,500 cfs
# of months with mean monthly flows > 2,800 cfs (local basin runoff)
additional # of months with mean monthly flows > 2,800 cfs (Lake Okeechobee regulatory releases)

Date Submitted/Revised
June, 1998

General Planning Objective

This performance measure suite is linked to the St. Lucie and Caloosahatchee conceptual model (Grey and Haunert). It addresses several general planning objective identified by the Governor's Commission for a Sustainable South Florida in the Conceptual Plan for the C&SF Project Restudy; provide more natural quality and quantity, timing, and distribution of freshwater flow to estuaries and coral reef ecosystems, and improve and protect habitat quality, heterogeneity, and biodiversity in coastal and associated marine ecosystems

Region
Caloosahatchee Estuary

Restoration Goal

Reduce high volume and minimum discharge events to the estuary to improve estuarine water quality and protect and enhance estuarine habitat and biota.

Problem Addressed

The Caloosahatchee Estuary is located on the southwest coast of Florida, and discharges into Charlotte harbor, and then into the Gulf of Mexico. The Caloosahatchee is also connected to Lake Okeechobee through the C-43 canal (Caloosahatchee River), and there are a series of smaller drainage works in association with substantial agriculture development in the watershed. The construction of a water control structure (Franklin Lock and Dam) downstream of Lake Okeechobee has decreased the tidally influenced portion of the estuary, allowing for a convenient use of the C-43 as a potable water supply.

To determine appropriate water quantity inflows to the estuary, biological indicators with definable salinity preferences were chosen. A favorable range of salinities for the estuary were determined (referred to as the salinity envelope) based on the requirements of SAV (*Vallisneria*). The favorable ranges of salinity (salinity envelope) have been related to volumes of freshwater flow to the estuary and a target range of flows was determined. In order to meet the salinity envelope criteria the surface water flows coming from the watershed as well as from ground water should be in the range of 300cfs - 2800cfs.

Model Target

The performance measures have targets based on flow that would support optimum hydrologic conditions conducive of optimum quality habitat for fish, wildlife, and other aquatic resources. The targets are based on optimization model outputs, natural variation that would occur during the period 1965-1995, and desirable salinity conditions for existing and potential aquatic resources within the Caloosahatchee Estuary.

# of months with mean monthly flow < 300 cfs : Target minimum mean monthly flows to the estuary are 300 cfs to protect *Vallisneria*, tape grass and support juvenile fish populations. This flow could come from the watershed (including groundwater), Lake Okeechobee (via S-79), or a combination of the two. The results of hydrologic modeling indicate that the optimum scenario would have no more than 60 months of mean monthly flows of <300 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

b. High Discharge Criteria, # of months with total mean monthly flows > 2,800 cfs : The results of hydrologic modeling indicate that the optimum scenario would have no more than 22 months of mean monthly flows of >2,800 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

High Discharge Criteria, # of months with total mean monthly flows were > 4,500 cfs : The results of hydrologic modeling indicate that the optimum scenario would have no more than 6 months of mean monthly flows of >4,500 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

# of months with mean monthly flows > 2,800 cfs (C-43 basin runoff) : The results of hydrologic modeling indicate that the optimum scenario would have no more than 22 months of mean monthly flows of >2,800 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

additional # of months with mean monthly flows > 2,800 cfs (Lake Okeechobee regulatory releases, Zone A discharges) : The results of hydrologic modeling indicate that the optimum scenario would have no additional months of mean monthly flows of >2,800 cfs (from Lake Okeechobee). The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

Model Output Format

# of months with mean monthly flow < 350 cfs
# of times the 14-day moving average flow is > 2800 cfs (local basin runoff)
additional # of times the 14-day moving average flow is > 2800 cfs (Lake Okeechobee releases)

High Discharge Criteria, # of times mean monthly flow is > 2800 cfs
High Discharge Criteria, # of times mean monthly flow is > 4500 cfs

Evaluation Tools
SFWMM

Literature Cited
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Authors & Contributors
Dan Haunert, Susan Grey, Liz Manners

Coordinator: Steve Traxler, Winnie Park

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Category
Ecological

Performance Measure
Maintenance of desirable salinity conditions within the St. Lucie Estuary
# of months with mean monthly flow < 350 cfs
# of months with mean monthly flows > 1,600 cfs
# of months with mean monthly flows were > 2,500 cfs
# of times the 14-day moving average flow is > 1600 cfs (local basin runoff)
additional # of times the 14-day moving average flow is > 1600 cfs (Lake Okeechobee regulatory releases)

Date Submitted/Revised
January, 1998

General Planning Objective

This performance measure suite is linked to the St. Lucie and Caloosahatchee conceptual model (Grey and Haunert). It addresses several general planning objective identified by the Governor's Commission for a Sustainable South Florida in the Conceptual Plan for the C&SF Project Restudy; provide more natural quality and quantity, timing, and distribution of freshwater flow to estuaries and coral reef ecosystems, and improve and protect habitat quality, heterogeneity, and biodiversity in coastal and associated marine ecosystems

Region
St. Lucie Estuary

Restoration Goal

Reduce high volume discharge events to the estuary to improve estuarine water quality and protect and enhance estuarine habitat and biota.

Problem Addressed

The St. Lucie Estuary is located on the southeast coast of Florida, and discharges into the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. The estuary encompasses about eight square miles, and the historic watershed was estimated to be about 1/3 the size of its present configuration. Due to extensive agricultural and urban drainage projects beginning in the 1910s, the present day watershed area has been expanded to almost 775 square miles. Major canals in the watershed include the C-23 and C-24 canals, part of the Central and South Florida Flood Control Project. In addition, the estuary is linked to Lake Okeechobee by the

C-44 canal that is utilized for both navigation and the release of floodwaters from Lake Okeechobee.

To determine appropriate water quantity inflows to the estuary, biological indicators with definable salinity preferences were chosen. A favorable range of salinities for the estuary were determined (referred to as the salinity envelope) based on the requirements of SAV and oysters. Woodward-Clyde, in a literature review report developed for the District in 1998, summarizes the approximate salinity tolerances for selected SAV and American oyster. A report on the abundance and type of SAV species by Phillips and Ingle (1960), provided the most complete source of information on SAV occurrence and abundance in the St. Lucie Estuary. This survey of SAV which was conducted from September 1957 to March 1959 revealed that the three most commonly found species of SAV in the estuary at the time were shoal grass (outer and middle estuary), manatee grass (outer estuary), and widgeon grass (north fork). They also reported on the salinity tolerance, normal, common and optimum range for all species. The normal tolerance range for shoal grass is 5-55 ppt; for manatee grass, 17-44 ppt; and for widgeon grass, 0-45 ppt. These numbers were based on reviewed literature, and all species can withstand even greater salinity fluctuations for short periods of time. The salinity tolerance ranges were also summarized for the different life cycle stages of the American oyster. The optimum range for adults and juveniles is 10-20 ppt, 20-23 for spat, 23-27 for larvae and embryos and 15-20 ppt for a sustainable population (Woodward-Clyde 1998). These favorable ranges of salinity (salinity envelope) have been related to volumes of freshwater flow to the estuary and a target range of flows was determined. In order to meet the salinity envelope criteria the surface water flows coming from the watershed as well as from ground water should be in the range of 350cfs - 1600cfs

Model Target

The performance measures have targets based on flow that would support optimum hydrologic conditions conducive of optimum quality habitat for fish, wildlife, and other aquatic resources. The targets are based on optimization model outputs, natural variation that would occur during the period 1965-1995, and desirable salinity conditions for existing and potential aquatic resources within the St. Lucie Estuary. The target salinity gradients in St. Lucie Estuary were determined by a hydrodynamic salinity model (Morris 1987) combined with estimates of salinity requirements for two indicator species in the estuary, *Halodule wrightii* (shoal grass) *and Crassostrea virginica* (American oyster).

# of months with mean monthly flow < 350 cfs : Target minimum mean monthly flows to the estuary are 350 cfs to protect oysters near the Roosevelt Bridge, promote brackish aquatic plant growth, and support juvenile fish populations. This flow could come from the watershed (including groundwater), Lake Okeechobee (via S-80), or a combination of the two. The results of hydrologic

modeling indicate that the optimum scenario would have no more than 50 months of mean monthly flows of <350 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

# of times the 14-day moving average flow is > 1600 cfs (local basin runoff) : Historically, the high flow events have been the most destructive. The results of hydrologic modeling indicate that the optimum scenario would have no more than 13 events of 14-day moving average flows of >1600 cfs. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

# of times the 14-day moving average flow is > 1600 cfs (Lake Okeechobee releases) : The results of hydrologic modeling indicate that the optimum scenario would have no months of 14-day moving average flows >1600 cfs from Lake Okeechobee releases. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

# of times mean monthly flow is > 1600 cfs : The results of hydrologic modeling indicate that the optimum target would have no more than 9 months of mean monthly flows of >1600 cfs. This target dictates a maximum flow that will provide suitable habitat for important benthic communities. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

# of times mean monthly flow is > 2500 cfs : The results of hydrologic modeling indicate that the preferred scenario would have no more than 3 months of mean monthly flows of >2500 cfs. Mean monthly flows above 2500 cfs result in freshwater conditions throughout the estuary causing severe impacts to estuarine communities. The estuary data for the alternatives is taken from the performance measures bar graphs and tables.

Model Output Format

# of months with mean monthly flow < 350 cfs
# of times the 14-day moving average flow is > 1600 cfs (local basin runoff)
additional # of times the 14-day moving average flow is > 1600 cfs (Lake Okeechobee releases)
# of times mean monthly flow is > 1600 cfs
# of times mean monthly flow is > 2500 cfs

Evaluation Tools

SFWMM, optimization modeling for the S. Lucie basins

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Authors & Contributors
Dan Haunert, Susan Grey, Liz Manners

Coordinator: Steve Traxler, Winnie Park

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Category
Ecological

Performance Measure
Canal Discharges to Biscayne Bay

Date Submitted/Revised
May, 1998

General Planning Objective

This performance measure addresses several planning objectives identified by the Governor's Commission for a Sustainable South Florida in the Conceptual Plan for the C&SF Project Restudy; Improve habitat quality and heterogeneity, Provide more natural quality and quantity, timing and distribution of freshwater flow to estuaries, and improve and protect habitat quality, heterogeneity, and biodiversity in coastal and associated marine ecosystems.

Region

For this performance measure, Biscayne Bay is considered to be bounded by Snake Creek to the north (Oleta River State Park) and the southern border of Biscayne National Park to the south.

Based on historical accounts and scientific studies, Biscayne Bay has been classed as a positive, shallow, tidal, bar-built estuary (Kohout and Kolipinski 1967). The term positive refers to the condition of salinity being less than seawater (Hela et al. 1957). The salinity gradient that established estuarine habitat in Biscayne Bay is dependent on both surface and ground water flows (Fatt and Wang 1987). The effect of regional drainage projects on these flows has been to disrupt salinity patterns and impair coastal ecosystem function by altering the timing and amounts of freshwater input to the bay.

Restoration Goal

Reduce excessive canal discharges to the bay, provide a stable brackish water habitat during the wet season, and provide more water during dry periods to prevent hypersaline conditions from impacting important marginal wetlands and nearshore habitats.

Problem Addressed

Based on historical accounts and scientific studies, Biscayne Bay has been classed as a positive, shallow, tidal, bar-built estuary (Kohout and Kolipinski 1967). The term positive refers to the condition of salinity being less than seawater (Hela et al. 1957). The salinity gradient that established estuarine habitat in Biscayne Bay is dependent on both surface and ground water flows (Fatt and Wang 1987). The effect of regional drainage projects on these flows has been to disrupt salinity patterns and impair coastal ecosystem function by altering the timing and amounts of freshwater input to the bay.

While accomplishing the goal of flood control, the presence and operation of the canals has had profound hydrological and ecological consequences on Biscayne Bay (Teas et al. 1976, Thorhaug et al. 1976, Hoffmeister 1974). The temporal and spatial pattern of freshwater inflow to the bay was fundamentally altered to one of point source discharges (canal mouths) that are characterized by abrupt periods of high discharge and minimal or no discharge to the bay. Although the general pattern of wet and dry seasons still persist, operation of coastal water control structures results in rapid changes in local salinity gradients that may occur on a daily basis and over several months, particularly during the rainy season (Fatt 1986). During the dry season, hypersalinity has been observed as a result of evaporation, retention of canal flow, and bay circulation (Lee 1975). While abrupt changes in salinity can occur naturally in nearshore habitats, they usually result from infrequent events such as hurricanes and tropical storms. The effects of salinity changes have been documented for fish (e.g. Davenport & Vahl 1975, Provencher et al. 1993, Serafy et al. in press) and for invertebrates (e.g. Brook 1982, Montegue and Ley 1993, Irlandi et al. in press). The presence and operation of the canals and construction of permanent oceanic inlets has resulted in a loss of estuarine function and shifted Biscayne Bay to more of a lagoon, adversely impacted from freshwater pulses and highly variable salinities. These conditions have been at least partly responsible for the loss of historically abundant estuarine species, such as red drum, black drum, and eastern oyster, the loss of juvenile fish habitat, and the significant increase in stress-tolerant fish species such as the gulf toadfish (Serafy et al., in press).

Model Target

Model results were compared to surface water budget targets that were considered appropriate to achieving restoration of the Biscayne Bay ecosystem. These targets consist primarily of the existing average annual inflow to Biscayne Bay as defined by the 1995 Base hydrologic period, with a 2% increase in total inflow budget to be applied in the dry season to the Central and South Bay regions.

A separate target for Snake Creek (S29) was also developed based on canal discharge that would maintain salinities for oyster survival. average salinity (measured at one meter depth) near the mouth has averaged less than 20 ppt. since 1988. Viable oyster communities appear to thrive in the area forming the headwaters of the Oleta River. By use of linear regression modeling, a total monthly volume of 13,300 acre-feet equates to 20 ppt. salinity concentration. This should be viewed as a minimum monthly flow. Excessive flow does not seem to be problem in general.

Model Output Format

Based on SFWMM hydrologic model output, the bay was divided into five regions from north to south, based on the mean monthly discharge from water control structures in these regions. The regions were Snake Creek (S29), North Bay (G58, S28, S27), Miami River (S25, S25B, S26), Central Bay (G97, S22, S123), and South Bay (S21, S21A, S20F, S20G). Model output for each alternative provides results as the sum of discharge from the structures in each region in terms of a mean annual wet season and dry season volume.

Evaluation Tools

SFWMM

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ATTACHMENT C

ACROSS TROPHIC LEVEL SYSTEM SIMULATION

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ATTACMENT C
ATLSS
(Across Trophic Level System Simulation)

D-C.1 INTRODUCTION

README File for Across Trophic Level System Simulation (ATLSS) Model Outputs for the Central and Southern Florida Comprehensive Study Review (Restudy) FTP Site (Address: ftp://ftp.tiem.utk.edu/pub/atlss/)

Prepared by The Institute for Environmental Modeling
University of Tennessee, Knoxville
Knoxville, TN 37996-1610

With Financial Support from The University of Tennessee, the U.S. Geological Survey (through Cooperative Agreement #1445-CA09-95-0094), and the U.S. Army Corps of Engineers, and a partial Software grant from O2 Technology Incorporated.

A complete description of the ATLSS modeling and the results can be accessed at either the U.S. Army Corps of Enginers, Jacksonville District, ATLSS home page (http//www.restudy.org/atlss/) or as appendix D of the CD version of this report. The following sections presents a description of the individual models used in the ATLSS assessment for each alternative scenario and the results of the scenario. Except for examples this report does not contain output files referred to in the write ups. The out put files are avalibe at http//www.restudy.org/atlss/ or as appendix D of the CD version of this report. A detailed description of the hydrologic components for each modeled alternative can be found in Section 9 of the Feasibility Report/PEIS.

D-C.1.1 Disclaimer

All information, files, and intellectual property contained in this Report are copyright by The Institute for Environmental Modeling, The University of Tennessee, Knoxville (hereafter TIEM/UTK). These materials may be used by all U.S. and State government agencies and non-profit organizations to aid evaluation of the Central and Southern Florida Comprehensive Study Review (hereafter the RESTUDY). Use for any other purpose, including all commercial use involving monetary payment for the materials, is prohibited without express written consent of the copyright holders.

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The results included on the ATLSS website (http://www.restudy.org/atlss/index/html) have been obtained with the assistance of a financial support from a variety of organizations. The statements, findings, conclusions, recommendations, and other data located on this Site are solely those of the authors and do not necessarily reflect the views of The University of Tennessee, the U.S. Geological Survey, the US Army Corps of Engineers, O2 Technology Incorporated, or any other organization providing support for the work included.

D-C.1.2 ATLSS Objectives

The Everglades and Big Cypress Swamp of South Florida are characterized by complex patterns of spatial heterogeneity and temporal variability, with water flow being the major factor controlling the trophic dynamics of the system. A key objective of modeling studies for these systems is to compare the future effects of alternative hydrologic scenarios on the biotic components of the systems. Due to the varying scales at which trophic interactions occur, and the importance of population structure and individual behavior for population prediction in higher trophic level organisms, use of a single modeling approach is not appropriate.

A large group of collaborators has been developing a set of models (the linked collection of these is called a multimodel) designed to integrate several approaches for different trophic levels of the system including: (1) process models for lower trophic levels (including benthic insects, periphyton and zooplankton), (2) structured population models for functional groups of fish, macroinvertebrates, amphibians and reptiles and (3) individual-based models for consumers (including Cape Sable Seaside Sparrow, Snail Kite, wood storks, white-tailed deer, and Florida panther). The models (together called ATLSS for Across Trophic Level System Simulation) are still evolving. The current collection of models being applied to the Restudy with outputs included on this Site have all been produced at TIEM/UTK, and will be added to as additional model components are completed. ATLSS is integrated across the freshwater landscape of South Florida, coupled to a variety of GIS maps, and involves spatial scales of resolution as small as 28 m. ATLSS makes use of input hydrology data obtained at a 2 mile by 2 mile resolution, links this with a model for fine-resolution topographic differences called the pseudotopography, and produces from this estimates of hydrology at 500 m or finer resolution. This fine-resolution hydrology is then utilized throughout the collection of ATLSS components.

The overall ATLSS project is coordinated by Dr. Donald DeAngelis of the Biological Resources Division of the U.S. Geological Survey.

D-C.1.3 Subdivisions of S. Florida for Analysis of ATLSS Model Output

The large size of the area being evaluated for the Central and South Florida Project Restudy requires that it be broken down into subregions for assessing the impacts of alternative hydrologic restoration plans. Some of the subregions, such as the Water Conservation Areas, are clearly delineated by physical boundaries such as canals and levees. Other subdivisions, such as resource management units within Everglades National Park and Big Cypress National Preserve, may have no physical features associated with them. In order to meet the information needs of the many professional disciplines involved in the restudy, the ATLSS Project has developed a set of subdivisions of the region that include both physical and administrative boundaries.

The physically bounded subregions used by ATLSS are defined to correspond to the internal structure of the South Florida Water Management Model (SFWMM), which is being used to generate the hydrological predictions for the various restoration alternatives. These regions are EAA, WCA-1, WCA-2A, WCA-2B, WCA-3A, and WCA-3B. Another subregion, ENP-East, is further divided into smaller subregions for natural resource management reasons. Each of these regions corresponds to hydrologic basins that are defined within the structure of the SFWMM. Because the SFWMM is based on a rectilinear grid of connected cells, each of which is 2 miles x 2 miles in size, these basins are defined within the SFWMM as groups of 2 x 2 mile squares. Thus, although in reality these basins are physically defined by a continuous series of canals and levees, in the model their boundaries are represented as "steps" that are 2 miles on a side. As a result, the boundaries of these areas do not correspond directly to the linear features on the landscape. For example, around the boundaries of the Water Conservation Areas, the perimeter canals and levees may either be inside or outside the boundaries of the WCAs as they are represented in the SFWMM. These approximations result in portions of the landscape being modeled with water that does not correspond to that actually experience by that area (e.g., the "downstream" side of a levee being modeled with water appropriate to the "upstream" side of the levee). To address these boundary discrepancies, ATLSS model output is "trimmed" to exclude the areas where these discrepancies occur. This assures that the potentially distinct hydrologic dynamics of one basin are not inadvertently included in the output for another basin.

One basin boundary illustrates this issue particularly clearly. On the actual landscape, the southern boundary of the WCA-3A basin corresponds to the northern boundary of the Everglades National Park-East basin, which is the Tamiami Trail levee and canal. However, because of the 2 x 2 mile grid structure of the SFWMM, the actual boundary (the Tamiami Trail) runs through the center of the 2 x 2 mile cell that lies south of the model's internal boundary for the two basins. As a result, the one mile wide strip that lies to the north of the Tamiami Trail, which in reality is in WCA-3A and 3B, is modeled by the SFWMM as if its hydrologic conditions were identical to the area south of the trail, in Everglades National Park. For this reason, the ATLSS subdivisions bordering this area are defined to exclude this 1-mile-wide strip where the water does not correspond to the actual location. Thus, the northern boundary of the Everglades National Park is set at the Tamiami Trail, while the southern boundary of WCA-3 is set 1 mile to the north, at a position that corresponds to the internal boundary of the SFWMM. To some degree, this same boundary discrepancy occurs at all the internal boundaries of the SFWMM. All subdivisions for ATLSS model output are defined to exclude areas where water is modeled inappropriately because of a mismatch between the positions of internal SFWMM basin boundaries and the actual physical boundaries on the landscape. Exclusion of these boundary areas results in the area described in ATLSS model output being slightly smaller than the actual physical size of certain subregions, particularly the Water Conservation Areas.

Away from the boundaries of the SFWMM boundaries, either inside the basins, or outside them (i.e., Big Cypress National Preserve), boundaries for ATLSS output subdivisions are defined to correspond to either actual physical features (e.g., roads where appropriate) or to administrative boundaries.

D-C.1.4 Listing of ATLSS Models Applied to Restudy

The ATLSS modeling system includes a wide range of model types, ranging from relatively simple physically-based deterministic models, such as the high resolution landscape hydrology model that processes the output of the South Florida Water Management Model (SFWMM) to produce the hydrology for ATLSS, to the individual-based models of the highest trophic levels, which include animal energetics, behavior, and movement. Because the ATLSS modeling system is based on the premise that higher trophic levels (such as wading birds and panthers) are strongly influenced by the food resources on which they depend, ATLSS model output can be summarized at any level in the trophic system, from the physical conditions that influence plants and animals, through the growth of plants and algae, to the population dynamics of herbivores and the predators that eat them.

The different types of models can be characterized in terms of their temporal and spatial complexity and the detail with which they represent biological and ecological processes. Different levels of model output can serve different objectives within the framework of the Central and South Florida Restudy. The basic components of ATLSS being utilized in the initial phases of the Restudy are below:

Pseudotopography

High Resolution Hydrology

Hydroperiods Associated with Vegetation Types

Cape Sable Seaside Sparrow Breeding Potential Index

Wading Bird Foraging Condition Index

White-tailed Deer Breeding Potential Index

Landscape Fish Model

Cape Sable Seaside Sparrow Individual Based Model

Snail Kite Breeding Potential Index

D-C.1.5 Output Formats for ATLSS Models

D-C.1.5.1 Maps

All standard maps cover the entire region of the SFWMM, with high resolution data summarized into 500 x 500 meter cells (each of which could represent as many as 300 high resolution pixels). These maps are produced using either time-averaged data (e.g., means, sums) for specified time intervals, or correspond to specific time points during the 31-year simulation period. All maps are produced for a Set of comparisons with 3 maps on an 8.5 x 11 inch page. The right map is for the new alternative scenario, the left map is for the base case (e.g., the Future without project condition), and the middle map shows the differences between the scenario and the base case (i.e., the scenario data minus the base case data). Most comparison maps are accompanied by tables with quantitative analysis of the data summarized by the above described spatial subdivisions.

D-C.1.5.2 Data Tables

Quantitative analyses of changes in the spatial distribution of properties such as hydroperiod, maximum water depth, as well as the surface area with a particular hydroperiod or vegetation type, are presented as data tables summarized by the above described spatial subdivisions. For each analysis of interest (e.g., average hydroperiod for each vegetation type during the 5 wettest years) there is a separate table entry for each subdivision. In addition to the values for each scenario being compared (e.g., total area in a given hydroperiod range) the table also presents the absolute difference between the scenarios, as well as the percentage change attributable to the alternative being evaluated.

D-C.1.5.3 Time-series Graphs

Population size estimates that are produced by ATLSS models are presented as graphs that show the projected changes in population size over the 31-year time period. These graphs show the population projections for an alternative scenario and the base case, plus the difference between the two. Multiple graphs are included on a single page, with each graph corresponding to the population dynamics in one of the drainage basin/management units (or other subunits appropriate to the species being considered). Particular models include specialized forms of this, such as the time series of size histograms for the fish model.

D-C.1.6 Sources of Uncertainty for ATLSS Models

All model outputs contain uncertainty or variability (defined as deviations from actual or expected values of predicted parameters) that results from a number of different sources. While this uncertainty should be considered when evaluating model output for assessment and policy decisions, it is also true that the actual uncertainty of model predictions is extremely difficult to quantify without a very large effort in statistical evaluation and "error analysis." Understanding the different sources of this uncertainty helps clarify the appropriate use of model output. There are four primary sources of uncertainty that must be considered in assessing the potential impacts of wetland restoration activities in South Florida:

1) Uncertainty resulting from lack of knowledge about future climate and weather. The planned use of the 1965-1995 historical climate as the basis for scenario evaluation means that model output cannot be considered a prediction of the future hydrologic conditions or the future condition of plant and animal populations. Scenario evaluations compare the relative performance of different hydrologic management plans under the same climatic conditions, but cannot be considered to be a prediction of the ecological conditions that will occur after the restoration measures are implemented. Any changes in climate or climatic variability, including increased hurricane frequency or intensity, may result in major differences between model projections based on 1965-1995 climate and the conditions that actually occur in the future.

2) Uncertainty resulting from imperfect understanding and representation of major processes in physical and biological models. This source of uncertainty can be reduced by research that leads to better representation of physical and biological

processes in models, which can also help to identify the most important parameters and the spatial and temporal scales at which they should be measured and modeled.

3) Uncertainty resulting from imprecise measurements of important physical and biological parameters used in equations that describe processes or initial conditions. This source of uncertainty can be quantified using methods known as "sensitivity analysis" and can be reduced by improved parameter estimates based on more accurate measurements in the field, better representation of physical and biological processes, and use of appropriate temporal and spatial resolutions for measuring and modeling physical and biological processes.

4) Uncertainty resulting from randomness in models with stochastic components (such as the probability of a predator encountering its prey during a particular time interval). This source of uncertainty can be reduced by increasing the number of "replicate" computer simulations, among which the only differences will be those that result from random processes included in the models. An increased number of replicates will result in more accurate "confidence intervals" and means.

For complex models such as those included as components of ATLSS, issues of model validation and error propagation are difficult to address. The basis of ATLSS use for this Restudy is that what we wish to produce are relative assessments of different scenarios, rather than exact quantitative predictions for any particular scenario. Under the assumption that the uncertainties mentioned above do not interact differentially with changes in scenarios (a reasonable assumption for scenarios produced by methods external to the models being used to assess them, in this case ATLSS), it is reasonable to hypothesize that errors propagate similarly in model runs on different scenarios. This is a hypothesis however that would require considerable additional testing to evaluate.

D-C.1.7 File Formats and Performance Set File Naming Conventions

ATLSS FTP Performance Set File Naming Conventions

File Name:

```
XX XX XXXX . XXX
-- -- ---- ---
|  |  |  |
|  |  |  |=> File Type
|  |  |
|  |  |=> Content Descriptor
|  |
|  |=> Model Code
```

|
|=> Input(s) Identifier

Input(s) Identifier:

1st Character = E -> Base with Existing Project Conditions (C1995-Base) F -> Base without Existing Project Conditions (F2050-Base)
2cnd Character = [0-9, A->Z] -> Scenario or Base Identifier _ (underbar) -> No Scenario, a run of a Base Condition only
Examples: F_ = File is associated with a run of the F2050 base with only. No comparison with another scenario are represented.
F0 = File is associated with a run of the first scenario received. File will contain a comparison of the first scenario (alt0) and the F2050 base.

Model Code: Code for the model that generated the output characterized by the file.

Examples:

HY = Hydrology
VG = Vegetation
BC = Cape Sable Seaside Sparrow Breeding Potential Index
BD = White-tailed deer Breeding Potential Index
FC = Wading bird Foraging Condition Index
FI = Fish
SP = Sparrow
DR = Deer
PN = Panther

Content Descriptor:

Set by the modeler to describe the contents of the file.

Examples:

69 = Performance set represents the year 1969
CR = Model was executed at a Coarse (2 mile) Resolution
FR = Model was executed at a Fine (500 meter) Resolution

File Type:

Indicates the format of the file and the type of contents.

Examples:

PDF = ADOBE's PDF (maps, time series charts).
TXT = Plain ASCII text file (tables, listings).
DOC = Metadata file describing the contents of the file(s) indicated by the base file name.

IX. Listing of ATLSS Model Files Included on FTP Site

Directory ftp://ftp.tiem.utk.edu/pub/atlss

README - High level ATLSS description and discussion of files and their naming conventions (this file).

00Index.DOC - Description and transaction log of files in the ATLSS ftp directory

CSSSBPI_.DOC - Description of the Cape Sable Seaside Sparrow Breeding Potential Index Model and it's performance set output files.

FISHREUN.PDF - Map showing the reporting units or areas used in the performance set output files for the Landscape Fish Model.

FISH____.DOC - Description of the Landscape Fish Model and it's performance set output files.

HYDRO___.DOC - Description of the High Resolution Hydrology Model and it's performance set output files.

SPARROW_.DOC - Description of the SIMSPAR Individual-based Cape Sable Seaside Sparrow Model and it's performance set output files.

REPUNITS.PDF - Map showing the reporting units or areas used in the performance set output files for all models except the Landscape Fish Model.

WBBPI___.DOC - Description of the Wading Bird Breeding Potential Index Model and it's performance set output files. NOTE: This model is not utilized after Alternative 3 scenario comparisons. Please see the Wading Bird Foraging Condition Model (files WBFCI___.DOC and WB_MOD__.DOC) for more information.

WBFCI___.DOC - Description of the Wading Bird Foraging Condition Model and it's performance set output files.

WTDBPI__.DOC - Description of the White-tailed Deer Breeding Potential Index Model and it's performance set output files.

Subdirectories:

alt0.to.F2050 - Performance sets for the original September 27 release of Alternative 0 to 2050Base

alt1.to.F2050 - Performance sets for the November 3 release of Alternative 1 to 2050Base

C1995.to.F2050 - Performance sets for the November 3 release of 1995Base to 2050Base

alt2.to.F2050 - Performance sets for the December 19 release of Alternative 2 to 2050Base

alt3.to.F2050 - Performance sets for the February 2 release of Alternative 3 to 2050Base

alt4.to.F2050 - Performance sets for the March 2 release of Alternative 4 to 2050Base

alt5.to.F2050 - Performance sets for the March 30 release of Alternative 5 to 2050Base

D-C.2 HIGH RESOLUTION HYDROLOGY

Calculation of High Resolution Hydrology in the ATLSS Modeling System

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Michael Huston and Scott Sylvester
The Institute for Environmental Modeling
University of Tennessee - Knoxville

One of the key features of the ATLSS models is the use of a high resolution hydrology model based on vegetation maps to convert the low resolution hydrologic output of the South Florida Water Management Model (1 water value per 2 x 2 mile cell) to the higher resolution needed to model ecological processes and the distribution of wildlife species. The ATLSS High Resolution Hydrology Model post-processes the output of the South Florida Water Management Model (SFWMM) using an algorithm based on conservation of water volume, and redistributes the water volume over a surface of high resolution topography (ATLSS "pseudotopography") to produce a high resolution map of water depth. This process is repeated on daily timesteps (corresponding to the daily output of the SFWMM) to create a map of water depth across the wetlands of South Florida with over 3000 separate values within each 2 x 2 mile cell (using topography based on the 28.5 meter resolution of a LandSat image).

The first step in calculating high resolution hydrology is processing the output of the SFWMM. This output is provided as daily values of water level for each of the approximately 1700 2 x 2 mile cells of the SFWMM. For the simulation period of 1965-1995 this output is an 88 megabyte file. These data are provided as distance of the water surface from the ground surface (+ or -) and so require a separate file of surface elevations to be converted to absolute elevation above mean sea level. These water surface data are converted to water volume per 2 x 2 mile cell by setting the basal surface of the volume occupied by water in each cell at an elevation 20 meters below the ground surface elevation. This elevation was selected because analysis of SFWMM output for the 31-year simulation period showed that in no cell did the water level ever exceed 20 meters below ground surface, nor 20 meters above ground surface. Thus, each cell has a base elevation for calculation of water volume that is set in relation to its surface elevation. This base elevation is constant throughout the 31 year period. The 40 meter range allows water surface elevations to be stored at 1 millimeter resolution using a "short integer" format in C++.

Because the water surface elevation can be either above or below the ground surface in any cell, water volume calculations must be subdivided into below and aboveground components. Above the ground surface, standing water occupies 100% of the volume defined by the following equation: volume = (water level - ground surface) x the surface area of the cell. Below the ground surface, ground water occupies only a fraction of the total volume, since sediment or bedrock occupy most of the volume (that is, if the ground is "solid"). In the SFWMM, the "water storage capacity" of the bedrock is modeled as varying from region to region across South Florida, but most values are close to 0.2. Thus, ground water is 20% of the volume defined by the following equation: volume = (groundwater level - basal elevation) x the surface area of the cell. When the water level is above the ground surface, calculation of total water volume has both an aboveground and a belowground component.

The ATLSS High Resolution Hydrology Model calculates the volume of water predicted by the SFWMM for each 2 x 2 mile cell for each day of the 31-year simulation period. The primary SFWMM output file used is: daily_stg_minus_lsel.bin. The SFWMM input file from which the bedrock water storage capacities are obtained is: statdta.int95_2. SFWMM data values in feet are converted to metric for use in ATLSS. Thus, the 31 year file of daily water level output is converted to a 31 year file of daily water volume in each of the 1700 cells of the SFWMM "Map" of South Florida.

The second step in calculating high resolution hydrology is redistributing the water volume for each 2 x 2 mile cell over the irregular topographic surface of the ATLSS pseudotopography. Pseudotopography is used to replace the completely flat surface of the SFWMM 2 x 2 mile cell with an undulating surface that corresponds to the topography underlying the vegetation (i.e., the highest areas are hardwood hammocks or pine stands, and the lowest are open water or deep marsh vegetation). The same basic subdivision of volume calculations by surface and subsurface water that was used to calculate water volume from the water surface elevations of the SFWMM is used to convert the water volumes back into surface elevations of water on the undulating landsurface of the pseudotopography. The water surface is assumed to be level across each 2 x 2 mile square of pseudotopography landscape. Consequently, for any particular water surface elevation, some fraction of the total water volume will be surface water (assuming the water level is above the lowest point on the land surface) and the rest will be subsurface water. The ATLSS High Resolution Hydrology Model calculates the water surface elevation for any specific water volume by "balancing" the surface and subsurface volumes to equal the total water volume produced by the SFWMM. This "high resolution hydrology" can potentially estimate water depths for each 28.5 x 28.5 meter area within the region covered by the SFWMM, rather than a single water depth for each 2 x 2 mile area. Thus, the ATLSS High Resolution Hydrology Model converts a low resolution map of 1700 surface water elevation values into a high resolution map with as many as 5.5 million surface water elevation values within the same total area.

The ATLSS High Resolution Hydrology Model provides water depth estimates at spatial scales that are relevant to the vegetation and wildlife species of the Everglades and Big Cypress. Nonetheless, this level of resolution (28.5 m) is not fine enough to detect certain biologically important features, such as alligator holes. For other purposes, such a high resolution is not necessary. Consequently, some of the ATLSS animal models use water data that has been aggregated to 100m or 500m cells, which are based on averages of the 28.5 meter data.

D-C.2.1 Potential Errors in High Resolution Hydrology Calculations

There are three primary sources of error in the daily water depths calculated by the ATLSS High Resolution Hydrology model: 1) Errors in the pseudotopography base map used to calculate water depth; 2) Errors in the daily stage height output of the SFWMM; and 3) Discrepancies between the structure of the SFWMM and the actual physical structure of the South Florida Landscape, as reflected in the vegetation map and the derived pseudotopography. Errors in the base pseudotopography can result from several sources. Obviously, errors in the satellite-based vegetation map will result in errors in any products derived from that map. However, while this map certainly contains a number of misclassified 28.5 x 28.5 m cells, the overall pattern of vegetation is consistent with other maps of South Florida vegetation. So these errors should have relatively little impact on the overall validity of pseudotopography. A second source of error is the hydroperiod parameters used to generate pseudotopography from the vegetation map. These parameters are based on values reported in the literature, and are consistent with the general topographic positions of the major vegetation types found throughout the South Florida wetlands.

More serious sources of error for both pseudotopography, and all water calculations are 2) and 3), listed above. Wherever the output of the SFWMM does not closely match the actual hydrograph that occurs (or would occur) in a particular location, both pseudotopography (based on the "calibration-validation" runs of the SFWMM) and high resolution hydrology may be incorrect at that location.

It is important to note that there is a possibility that high resolution hydrology (HRH) may in some situations actually decrease the errors present in SFWMM output. This occurs because HRH, specifically the underlying pseudotopography, force the shape of the landscape to create hydroperiods appropriate for the vegetation types that are present, while it preserves the water volume predicted by the SFWMM. For example, where the SFWMM predicts a long hydroperiod in an area where the vegetation maps shows only short hydroperiod vegetation types (such as pine and Muhlenbergia), the HRH pseudotopography algorithm will raise the surface of the landscape sufficiently that the appropriate hydroperiods will be experienced by the vegetation. In such a case, the bulk of the water volume will be stored as subsurface water.

Errors in SFWMM output are particularly critical where they result in predicting more favorable conditions than those that would actually occur. This would cause all derivative model runs to overpredict the population density of affected species. In critical habitats, it is important that SFWMM output (specifically the calibration-validation runs on which all empirical model validation will be conducted) be checked against measured stage height data.

The third major source of error results from the inevitable mismatch between a relatively coarse scale model (the 2 x 2 mile grid structure of the SFWMM) and the actual fine-scale patterns of vegetation and control structures on the landscape. The grid structure of the SFWMM requires that physical structures, such as levees, be represented as occurring along the edges of the 2 x 2 mile cells, which produces a "stair-step" approximation of the actual linear structure in the wetlands. This creates a problem for HRH when vegetation on the "down-gradient" side of a levee within a 2 x 2 mile cell is modeled as having water based on the "up-gradient" side of the levee. This problem occurs primarily along the boundaries of the Water Conservation Areas (and is discussed in the Boundaries of the Reporting Units used by ATLSS). This problem results in HRH being incorrect in those areas where SFWMM boundaries do not coincide with actual levees and/or canals. To some degree, HRH and pseudotopography adjust for this type of misalignment by alterning the topographic surface of the landscape so the vegetation experiences the appropriate hydroperiod under calibration conditions. However, this results in a discrepancy between the water depth and hydroperiod predictions of the SFWMM raw output and the water depth and hydroperiods predicted by the High Resolution Hydrology. In such areas of discrepancy, there is a good probability that the HRH results are more accurate that the raw SFWMM output, but this should be checked against actual measurements of topography and hydrographs wherever possible.

One potential solution to the problem of the mismatch between SFWMM model boundaries and the actual boundaries on the landscape is to post-process the SFWMM output into the irregularly shaped cells that correspond to the areas of discrepancy. This would be a substantial programming effort, but would solve this major source of error for all future model runs.

D-C.2.2 Performance measures associated with the ATLSS Hydrology model

In accordance with the ATLSS file naming conventions, each file name will consist of the characters:

"X" or "_" => the Base, typically F for the F2050 base or E for the C1995 base
"X" or "_" => the alternative scenario or base
"HY" => the ATLSS Hydrology Model
"XXXX" => 4 character mnemonic
"."
"PDF" or "TXT" or "DOC" => PDF, tabular text or documentation

Maps

The comparison maps for the ATLSS Hydrology model reflect a graphical representation of the hydroperiod data found in the accompaning tables. For a detailed discussion of the hydroperiod data, see the description of the comparison tables below.

The comparison maps associated with the ATLSS Hydrology model consist of the following files:

File Name	Description
XXHYHCM1.TXT	Comparison map set showing the total area by hydroperiod classes averaged over the years 1985 to 1995 grouped by subregion.
XXHYHCM2.TXT	Comparison map set showing the total area by hydroperiod classes averaged over the five driest years grouped by subregion.
XXHYHCM3.TXT	Comparison map set showing the total area by hydroperiod classes for the driest year grouped by subregion.
XXHYHCM4.TXT	Comparison map set showing the total area by hydroperiod classes averaged over the five wettest years grouped by subregion.
XXHYHCM5.TXT	Comparison map set showing the total area by hydroperiod classes for the wettest year grouped by subregion.
XXHYHCM6.TXT	Comparison map set showing the total area by hydroperiod classes for the average year grouped by subregion.

Time Series Charts None.

Histograms None.

Tables

The high resolution hydrology analysis for the Across Trophic Level System Simulation (ATLSS) consists of a set of tables which compare two hydrology scenarios as provided to our research group by the South Florida Water Management District (SFWMD). The comparisons are broken down into two basic types of files. The first type contains hydroperiod analysis for the vegetation types. The other contains an report on the area in each of 10 hydroperiod classes. These analyses are repeated for each of several regions in South Florida (SF) and for a variety of years or combinations of years.

The comparisons are carried out on a variety of subregions of SF. These regions represent major control and management areas of SF, such as Loxahatchee, the water management areas, and management regions with in The Everglades National Park (ENP) and Big Cypress National Preserve (BCNP).

The comparisons are also broken in to a number of temporal units. The current time groupings are a ten year average from 1985 to 1994, an average of five years which had the highest rain fall (currently 1966, 1968, 1969, 1982, 1983) an average of five years which had the lowest rain fall (currently 1971, 1981, 1988, 1989, 1990), the year with the highest rain fall (1969) the year with the lowest rain fall (1990) and the year with an average rain fall (1977).

The first type of file provides hydroperiod comparison for the vegetation type. Within each region the average hydroperiod is computed for each vegetation type which covers at least 10% of the area of that region. At the top of each table is the name of the region and the total area of that region. Each row of a tables represents the values for a single vegetation type. The columns of each row are defined as follows: The vegetation type index and description, the area of the region covered in that vegetation type, the hydroperiods for the vegetation type under the two scenarios, the difference between the hydroperiods and the percentage difference. The indices represent those used in the Pearlstine vegetation cover map to represent the vegetation types. The vegetation type descriptions are those used by The Nature Conservancy (TNC) for the South Eastern United States. Hydroperiods have units of days, and the areas are listed in Km.

The second type of table gives the area covered in each region by each of twelve hydroperiod classes. The top of the table gives the region name and the total area of the region. Each row of the tables contains the information about a single hydroperiod class. The columns of each row are defined as follows: The first column contains the range of hydroperiod which defines the hydroperiod class, the next two are give the area of the listed region which has a hydroperiod with in the range of values for that class for each of the scenarios being compared and the last column gives the difference between these two values.

The mnemonic section of the file names are composed as follows:

"XX" = P1, P2, P3, P4, P5 => the Time Period
"XX" = HC, VT => Hydrology Class, Vegetation Type

The performance measure tables associated with the ATLSS Hydrology model consist of the following files:

File Name	Description
XXHYVTP1.TXT	Comparison tables set showing the total area of significant vegetation types averaged over the years 1985 to 1994 grouped by subregion.
XXHYVTP2.TXT	Comparison tables set showing the total area of significant vegetation types averaged over the five driest years grouped by subregion.
XXHYVTP3.TXT	Comparison tables set showing the total area of significant vegetation types for the driest year grouped by subregion.
XXHYVTP4.TXT	Comparison tables set showing the total area of significant vegetation types averaged over the five wettest years grouped by subregion.
XXHYVTP5.TXT	Comparison tables set showing the total area of significant vegetation types for the wettest year grouped by subregion.
XXHYVTP6.TXT	Comparison tables set showing the total area of significant vegetation types for the average year grouped by subregion.
XXHYHCP1.TXT	Comparison tables set showing the total area by hydroperiod classes averaged over the years 1985 to 1995 grouped by subregion.
XXHYHCP2.TXT	Comparison tables set showing the total area by hydroperiod classes averaged over the five driest years grouped by subregion.
XXHYHCP3.TXT	Comparison tables set showing the total area by hydroperiod classes for the driest year grouped by subregion.
XXHYHCP4.TXT	Comparison tables set showing the total area by hydroperiod classes averaged over the five wettest years grouped by subregion.

XXHYHCP5.TXT	Comparison tables set showing the total area by hydroperiod classes for the wettest year grouped by subregion.
XXHYHCP6.TXT	Comparison tables set showing the total area by hydroperiod classes for the average year grouped by subregion.

D-C.2.3 F2050 (Revised) vs. C1995 (Revised)

The ATLSS models and breeding potential indices are driven by input data from the South Florida Water Management Model (SFWMM). These data, which are provided as daily water depth for each 2 x 2 mile area in the region covered by the model, are processed by the ATLSS landscape model into high resolution hydrology that is based on a high resolution topographic map created from a high resolution vegetation map (see section 1.1 above or HYDRO___.DOC for a more detailed description of high resolution hydrology and pseudotopography). The ATLSS landscape model redistributes the water from the SFWMM across the landscape in a way that produces hydroperiods that are appropriate for the vegetation types that occur in a specific area. The high resolution hydrology patterns may appear quite different from the output of the SFWMM, since the high resolution hydrology produces a mosaic of wet and dry areas (or deep and shallow water) within each 2 x 2 mile area that is represented in the SFWMM output as a uniform water depth (or completely dry) over the entire 2 x 2 mile area.

D-C.2.3.1 SFWMM Output Comparisons

In the raw output from the SFWMM for the C1995 and F2050 scenarios the differences in water depth form clear and stable patterns. C1995 generates increased water depth relative to F2050 in WCA-1, most of WCA-3A South, and a small region located along the boundary between the East Panhandle and South Taylor Slough. C1995 generates decreased water depth relative to F2050 in WCA-2A, WCA-2B, WCA-3B, the Rotenberger-Holeyland area, the north end of WCA-3A and through the remnant water way including Shark River Slough, East Slough, the northern portion of Taylor Slough and the area surrounding these sloughs. The region in WCA-1 experiences increased water depth under C1995 relative to F2050 in all years except the first year of simulation, 1969. In this year the water depth in WCA-1 is deeper under F2050. The differences in water depth in WCA-1 between C1995 and F2050 shows a smoothly graded pattern from large differences along the southern boundary of WCA-1 and smallest difference in the northern most corner. This pattern is present in all years with year to year variations in the range of differences. In WCA-3A, C1995 generates a region of increased water depth relative to F2050 which forms a band from the south west corner to the north east corner and is parallel to the L-67 levies. This pattern of increased water depth is present during the entire 31 year simulation time period. During some years WCA-3B and the Dwarf Cypress/Lostmans Pines area, which are adjacent to WCA-3A, experience increased water depths under C1995 relative to F2050, though typically these areas have lower water depths under C1995. The southern region of increased water depth under C1995 in the East Panhandle boundary is present in all years with variations in extent and peak value from year to year. C1995 also predicts a number of regions of lower water depths relative to F2050. The Rotenberger-Holeyland area and the northern portion of WCA-3A experience decreased water depth under C1995 relative to F2050 over the entire 31 year time frame. In most years the differences between C1995 and F2050 in these areas are significant. However, in years such as 1990, the spatial extent of these areas of lower C1995 water depths are contracted and cover only the Rotenberger-Holeyland area and a small portion of the north east corner of WCA-3A. WCA-2A and WCA-2B experience decreased water depths under C1995 relative to F2050 over most of the 31 years. Within WCA- 2A the greatest differences between the scenarios occurs most commonly along the south and south west borders, and the smallest differences appear along the border shared with WCA-1 in the north east. Between these boundaries the differences generally form a smooth gradient from south west to north east. In a very few years, such as 1971 and 1973, there is a departure from this pattern. During these years, the northern third of WCA-2A has decreased water depths under C1995 relative to F2050, while the lower two-thirds experiences an increase in water depth under C1995. During other years, such as 1979 and 1988 the pattern of gradation in WCA-2A described earlier is still present, however, in these years the water depth along the north east border of WCA-2A is deeper and the south west border is given less water under C1995 as compared to F2050. Except for a three year run from 1988 to 1990, the water depths in WCA-2B are significantly lower under C1995 as compared to F2050. During this three year run, the difference between C1995 and F2050 do not form any strong patterns. While the region still experiences slightly decreased water depth under C1995, some cells have increased water depth during some of the years. Water depths in WCA-3B are lower under C1995 relative to F2050 for most of the years of the scenario run. For most of these years of decreased water depth there are larger differences in the northern portion and smaller difference in the southern portion, though during several years the differences are consistent over the entire area. WCA-3B has regions of increased water depths under C1995 during a few years. For some of the years the locations of increase are small and appear along the border formed by the L-67 levies. During some years, such as 1979, all of WCA-3B experiences increased water depths under C1995 relative to F2050. Through most of the area within the Everglades National Park (ENP), including all of Shark River Slough, the northern portion of Taylor Slough and most of East Slough, C1995 generates decreased water depths as compared to F2050 over all of the 31 year time period. The largest difference is water depth within this region typically occur through the center of Shark River Slough, with differences becoming smaller as distance from the center of the Slough increases. During some years, such as 1995, the largest difference between C1995 and F2050 are found along the eastern edge of the ENP.

Additionally there is a small region between the East and West Panhandle which experience decreased water depth under C1995 relative to F2050 during many of the years of the scenario. Over most of Big Cypress National Preserve (BCNP) the differences between C1995 and F2050 are small and scattered through the region. C1995 is slightly dryer that F2050 within this region over all the years of the scenario, but the dryer locations are scattered through the area, are not consistent from year to year, and do not form a clear pattern of drying.

D-C.2.3.2 ATLSS High Resolution Hydrology Output Comparison

The 1985-1994 10-year average hydroperiod analysis (Figure FEHYHPM1.PDF) shows a pattern of longer hydroperiod created by C1995 in WCA-1, most of WCA-2A, most of WCA-3A, WCA-3B, the Dwarf Cypress/Lostmans Pines area and in a region which lies along the border between South Taylor Slough and the Western Panhandle. Hydroperiods in these regions are lengthened between 1 to 14 weeks relative to F2050. The pattern of increased hydroperiod in WCA-2A occurs throughout most of the region except for a small patch in the northern corner. In this corner the hydroperiod generated by C1995 is shorter than the hydroperiod generated by F2050. The region of increased hydroperiod in WCA-3A is present across most of the region except two small regions in the north east and north west corners. In these small regions the hydroperiod generated by C1995 is shorter than the hydroperiod generated by F2050. The range of lengthened hydroperiods generated by C1995 in WCA- 1 is consistent across the entire region. The range of lengthened hydroperiod generated by C1995 in WCA-2A has only small variations. The regions of lengthened hydroperiod which covers most of WCA-3A, WCA-3B and the Dwarf Cypress/Lostmans Pines area contains a great deal of variability in the hydroperiod differences generated. There are regions of varying size located throughout the region which have significantly lengthened hydroperiod under C1995 relative to F2050. These sub-regions correspond to various structures within WCA-3A. Some sub-regions reflect tree islands within WCA-3A, while others reflect the presence of the C-304 canal. There is also a region parallel to the L-67 levies of hydroperiods which are moderately lengthened by C1995 relative to F2050. A small region of C1995 lengthened hydroperiod is centered approximately mid-way long the boundary between the South Taylor Slough and the West Panhandle with difference in hydroperiods between C1995 and F2050 becoming smaller as distance from the center of the pattern increases. Over the 10-year average there area several regions where the hydroperiod generated my C1995 is shorter than the hydroperiod generated by F2050. A small region in the northern section of WCA-2A and two regions in the north east and north west corners of WCA-3A all have shorter hydroperiods under C1995 relative to F2050. Additionally WCA-2B is also given a shorter hydroperiod under C1995 relative to F2050, though the differences in the predicted hydroperiods are not as large in this region as in other locations. There is also a large region in the southern portion of the study area, including Shark River Slough, North Taylor Slough and East

Slough, where the hydroperiod predicted by C1995 is shorter than the hydroperiod predicted by F2050. In this southern region the differences through Shark River Slough are relatively small, representing a difference of only 1-2 weeks. In the regions directly to the north and south of Shark River Slough, the differences are much larger. Of all the regions for which C1995 predicts shortened hydroperiod relative to F2050, the two in the north of WCA-3A show the largest differences with the north east corner displaying a moderately size region of consistently large differences. In addition to these regions of shortened hydroperiod, there is a small region in the eastern section of the East Panhandle which show a modest shortening of hydroperiod under C1995 as compared to F2050.

The basic pattern of long and short hydroperiod predicted by C1995 relative to F2050 seen in the 10-year average is consistent across each of the rain fall year conditions used in this analysis. During all the rain fall conditions, C1995 predicts lengthened hydroperiod in WCA-1, most of WCA-3A, and the small region along the common border between South Taylor Slough and the West Panhandle. In WCA-1 under low and average rain fall conditions (Figures FEHYHPM2.PDF, FEHYHPM3.PDF and FEHYHPM6.PDF), C1995 generates hydroperiods which are not only longer than those generated by F2050, but the difference in the hydroperiods is greater than the differences shown in the 10-year average. During the wet conditions (FEHYHPM4.PDF and FEHYHPM5.PDF) the hydroperiods predicted by C1995 are still longer than those of F2050 but the differences for WCA-1 are diminished, and in fact show sections where there are no perceivable difference in hydroperiod. The pattern of lengthened hydroperiod generated by C1995 relative to F2050 in WCA-3A South is also present under all rain fall conditions. Under the lowest rain fall conditions, 1990, (Figure FEHYHPM3.PDF) the patterns is reduced both in extent and in maximum difference. The region which was predicted as having longer hydroperiod under C1995 relative to F2050 is broken in to two pieces, divided by a band, showing no difference in hydroperiod, which cuts across the center of WCA-3A and is parallel to the L-67 levies. The small region of C1995 lengthened hydroperiod along the border between South Taylor Slough and the West Panhandle is also present under all rain fall conditions with some variation in extent, exact location and peak value during the different rain fall conditions. In WCA-2A the pattern of differences between C1995 and F2050 predicted hydroperiods changes under varying rain fall conditions. Under the low rain fall conditions (Figure FEHYHPM2.PDF and FEHYHPM3.PDF) the pattern of differences is similar to the pattern seen in the 10-year average rain fall. Most of the region is given a longer hydroperiod under C1995 relative to F2050, with a small section in the north where C1995 generates shorter hydroperiods. Under low rain fall conditions the difference between C1995 and F2050 are larger than those seen in the 10-year average. Under high rain fall conditions (Figure FEHYHPM4.PDF and FEHYHPM5.PDF) the pattern of hydroperiod differences between C1995 and F2050 almost disappears in WCA-2A and WCA-2B. Under average rain fall conditions (Figure FEHYHPM6.PDF) C1995 predicts a region of significantly lengthened hydroperiod within WCA-2A along the boundary separating WCA-2A and WCA-1. Immediately to the south of this structure, extending to the border between WCA-2A and WCA-2B, there is a region where C1995 generates shorter hydroperiods relative to F2050. Along the north west border shared with the Everglades Agricultural Area (EAA) C1995 and F2050 generate hydroperiods which are identical. Within WCA-2B the two scenarios generate similar hydroperiod, with C1995 predicting slightly shorter hydroperiods along the eastern border under some conditions. Only under the lowest rain fall conditions (Figure FEHYHPM3.PDF) does C1995 predict longer hydroperiod relative to F2050 for WCA-2B. Shark River Slough, North Taylor Slough, the Ten Mile Marl and the surrounding areas tend to have shorter hydroperiods under C1995 relative to F2050. Under the highest rain fall conditions (Figures FEHYHPM4.PDF and FEHYHPM5.PDF) the two scenarios predict nearly identical hydroperiod for most of Shark River Slough, though the surrounding areas still have a shorter hydroperiod under C1995 relative to F2050. Under low and average rain fall conditions (Figures FEHYHPM2.PDF, FEHYHPM3.PDF and FEHYHPM6.PDF) small patches appear within Shark River Slough for which C1995 predicts a longer hydroperiod relative F2050. The two areas in north WCA-3A for which C1995 predicts shorter hydroperiods relative to F2050 are also present under all rain fall conditions. Under low rain fall conditions (Figure FEHYHPM2.PDF and FEHYHPM3.PDF) the western of these two areas is diminished in spatial extent and peak value, nearly disappearing during the lowest rain fall year, 1990. During the years of highest rain fall become larger and more intense filling most of WCA-3A north of I-75. Additionally, there is a small regions along the border between the East and West Panhandle where C1995 predicts shorter hydroperiods on average than F2050. This region is present under the 10-year average, 5 lowest rain fall average and the wettest rain fall conditions (Figures FEHYHPM1.PDF, FEHYHPM2.PDF, FEHYHPM4.PDF and FEHYHPM6.PDF). This small region disappears during the lowest rain fall year, 1990 (Figure FEHYHPM3.PDF) and is enhanced during the highest rain fall years.

Overall the pattern of difference in hydroperiod predicted by C1995 and F2050 is consistent across all rain fall conditions. A pattern of hydroperiod lengthened under C1995 relative to F2050 is present throughout much of the northern portion of the study area. WCA-1, most of WCA-2A and most of WCA-3A are given lengthened hydroperiod under C1995 relative to F2050. Two regions in the northern portions of WCA-3A are given shortened hydroperiods by C1995 relative to F2050 under all rain fall conditions. WCA-2B is given shorter hydroperiods under C1995 under most rain fall conditions. WCA-2A is given longer or equal hydroperiods by C1995 under most rainfall conditions. An additional region in the southern section of the study area along the border between the West Panhandle and South Taylor Slough is given a longer hydroperiod by C1995 under all rain fall conditions. The pattern of C1995 shortened hydroperiod in the periphery of Shark River Slough of the study area is also consistent across all rainfall conditions.

D-C.2.4 Alternative A vs. F2050 (Revised)

D-C.2.4.1 SFWMM Output Comparisons

In the raw output from the SFWMM the differences between ALT-A and F2050 form patterns of increased and decreased water depth which are consistent over the most of the 1965 to 1995, 31-year time period. For part of the study area including WCA-1, WCA-2A, WCA-2B, Shark River Slough, Taylor Slough, Long Pine Key, West Panhandle, and in several areas surrounding those, ALT-A predicts higher water depths relative to F2050 in almost every year of the simulation time period. These differences are most pronounced in the central portion of Shark River Slough. There are some years (1965, 1981, 1984, 1986, 1993, 1994) for which the pattern for most of WCA-2A and WCA-2B is reversed, with lower water depths predicted by ALT-A. In a few other years (1966, 1968, 1976, 1977, 1995), portions of WCA-2A have a higher predicted water for ALT-A, while other portions have lower predicted water. In several areas including most of the Rotenberger/Holeyland area, WCA-3A South along the L-67 levees, the eastern portion of WCA-3A north of I-75 (WCA-3A North), most of the East Slough, the East Panhandle, and portions of BCNP, ALT-A predicts water depths which are lower for most or all of the 31-year time period. In some years (1965, 1972, 1973, 1981, 1982, 1986, 1994, 1995) the lower water depths predicted by ALT-A expand to cover essentially all of WCA-3A and 3B, while in other years the region of ALT-A lowered water is restricted to the southern portions of WCA-3A South and the eastern portions of WCA-3A North. The pattern in WCA-3B is complex, with some years having ALT-A increased water depths, other years decreases in these depths relative to F2050, and other years having a mixer pattern. ALT-A predicts lower water depths in the eastern half of the Rotenberger/Holeyland area for every year except 1984 when most of the area is given higher water depths by ALT-A relative to F2050. In approximately one-third of the years, the western most portion of the Rotenberger/Holeyland area is given higher water depths under ALT-A relative to F2050. The pattern predicted for WCA-3A North is quite variable from year to year, with some years (1967, 1970, 1974, 1979, 1989, 1992) having ALT-A increased water depths, other years (1971, 1972, 1986, 1994, 1995) having mostly ALT-A decreased water depths, and the remaining having a mixed pattern throughout the area. The pattern of decreased water depth ALT-A predicts as compared to F2050 along the L-67 levees through the East Slough and Dwarf Cypress/Lostmans Pine areas is present during most every year (not in 1967, 1970, 1974, 1978, 1989) of the simulation time period. In the years when this pattern is broken East Slough and the surrounding area still have shorter hydroperiods under ALT-A relative to F2050, but the southern end of WCA-3A South is given longer hydroperiods. Over time changes in the pattern of lowered water in the East Slough and surrounding areas show up as an increase in the spatial extent of ALT-A lowered water depths from the south eastern portion of the pattern into southern BCNP. The pattern in BCNP is a complex intermingling of small areas with increased water depths in ALT-A relative to F2050 and small areas with decreases.

D-C.2.4.2 ATLSS High Resolution Hydrology Output Comparison

In the 1985 to 1994, 10-year average, hydroperiod analysis (Figure FAHYHPM1.PDF) most of the study area is given either an increased hydroperiod by ALT-A relative to F2050, or there is no significant difference. WCA-1, WCA-2A, WCA-2B, WCA-3B, Shark River Slough, Taylor Slough, and Long Pine Key are given longer hydroperiods by ALT-A relative to F2050 during the 10-year average rain fall condition. Of these areas the eastern border of the study area from WCA-3B south through Northern Taylor Slough shows the largest increase in hydroperiod under ALT-A relative to F2050. The only regions with shortened hydroperiods predicted for ALT-A are the East Slough area, small portions of WCA-3A North, and portions of the Western Panhandle. Most of WCA-3A South, and BCNP are assigned equivalent hydroperiods by ALT-A and F2050. A few of the above described patterns of lengthened and shortened hydroperiod are present under most or all of the other rain fall conditions. Under all rain fall conditions the regions in North Taylor Slough and most of WCA-3B are given longer hydroperiods under ALT-A relative to F2050. The only exception within these areas is in a small region in the south east corner of WCA-3B where, during the high rain fall condition (Figures FAHYHPM4.PDF and FAHYHPM5.PDF), the two scenarios predict similar hydroperiods. Under all but the high rain fall conditions (Figures FAHYHPM4.PDF and FAHYHPM5.PDF) all of Shark River Slough is given longer hydroperiods by ALT-A relative to F2050. During the high rain fall conditions, Shark River Slough along with much of WCA-1, WCA-2A, and WCA-2B are all given similar hydroperiods by both ALT-A and F2050. For all rain fall conditions in the central portion of WCA-3A South, ALT-A and F2050 predict similar hydroperiods. Around the periphery of this region there is no difference or an increase in hydroperiod under ALT-A for most rain fall conditions. Only during the average rain fall year, 1977, (Figure FAHYHPM6.PDF) does ALT-A predict shorter hydroperiods relative to F2050 around the perimeter of WCA-3A South. BCNP receives equivalent predicted hydroperiods by the two scenarios for all rain fall conditions. During all but the average rain fall conditions most of East Slough, the northern part of the 10-Mile Marl and small portions of the surrounding areas receive shorter hydroperiods under ALT-A relative to F2050. For the average rain fall year, 1977, (Figure FAHYHPM6.PDF) most of East Slough has the same hydroperiod under ALT-A and F2050. The small region of ALT-A shortened hydroperiod in the West Panhandle persists under all rain fall conditions, though there are small changes in the spatial extent and the character of the immediately surrounding areas during the various rain fall conditions. The patterns of long and short hydroperiod predicted by ALT-A relative to F2050 for WCA-2A and WCA-3A North are not consistent across the various rain fall conditions. For most of WCA-

2A, ALT-A predicts long hydroperiods during the 10-year average and the average of the five lowest rain fall conditions. During the lowest rain fall year, 1990, (Figure FAHYHPM3.PDF) ALT-A predicts longer hydroperiods around the perimeter of WCA-2A relative to F2050 and similar hydroperiods in the center of the conservation area. For the high rain fall conditions (Figure FAHYHPM4.PDF and FAHYHPM5.PDF) most of WCA-2A is given equivalent hydroperiods by both scenarios with only a small region of ALT-A lengthened hydroperiod along the north eastern border shared with WCA-1. For the average rain fall year, 1977, (Figure FAHYHPM6.PDF) most of WCA-2A is given shorter hydroperiods by ALT-A with a few scattered areas of equal or longer hydroperiod. The hydroperiod patterns within WCA-3A North are variable both in location and under what rain fall conditions the patterns arise. A thin band within WCA-3A North which follows the C-304 canal is given shorter hydroperiods under all of the rain fall conditions though there is a great deal of variability in the extent and intensity of the values along this band. During the other rain fall conditions hydroperiods within this region are variable. For the average of the five highest rain fall conditions (Figure FAHYHPM4.PDF) much of WCA-1 is still given longer hydroperiods by ALTA relative to F2050. Under the highest rain fall conditions, 1969, (Figure FAHYHPM5.PDF) the two scenarios predict similar hydroperiods over most of WCA-1, leaving only a small area in the north for which ALT-A predicts longer hydroperiods relative to F2050.

Overall the general patterns predicted for ALT-A hydroperiods relative to F2050 are consistent spatially with lengthened hydroperiod predicted by ALT-A for Taylor Slough, much of Shark River Slough, WCA- 3B, and WCA-1. ALT-A predicts shortened hydroperiods in East Slough and portions of the Western Panhandle and WCA-3A North. For most of BCNP and WCA-3A South, ALT-A and F2050 have similar predicted hydroperiods. The above patterns have some spatial variation based upon rain fall conditions.

D-C.2.5 Alternative B vs. F2050 (Revised)

D-C.2.5.1 SFWMM Output Comparisons

In the raw output from the SFWMM the differences between ALT-B and F2050 form patterns of increased and decreased water depth which are consistent over the most of the 1965 to 1995, 31-year time period. For most of the study area including WCA-1, WCA-3B, most of WCA-3A south of I-75 (WCA-3A South), most of WCA-2A, Shark River Slough, Taylor Slough, Long Pine Key, East and West Panhandle, part of eastern Big Cypress National Preserve (BCNP) and in several areas surrounding those named ALT-B predicts higher water depths relative to F2050 in almost every year of the simulation time period. In a small region along the border between East and West Panhandle ALT-B predicts higher water levels relative to F2050 which are significantly greater than those in the immediately surrounding areas. In WCA-3A South ALT-B predicts higher water depths relative to F2050 for most of the northern portion of the conservation area during all of the 31-year time period except 1995. A region within WCA-3A South lying along the L-67 levees and the southern border of the conservation area is predicted by ALT-B as having lower water depths relative to F2050. This band of lowered ALT-B water depths is connected to a region of lower water depths in the East Slough area. The pattern of difference between the two scenarios is less distinctive and less consistent in WCA-2A. Most frequently the southern half of WCA-2A is given lower water depths and the northern half higher water depths by ALT-B relative to F2050. However, during several years all or most of WCA- 2A is given higher water depths under ALT-B as in 1968, 1973 and 1982. Occasionally all of WCA-2A is given lower water depths by ALT-B relative to F2050 as in 1965 and 1983. In several areas including WCA-2B, the eastern half of the Rotenberger/Holeyland area, WCA-3A South along the L-67 levees, most of WCA-3A north of I-75 (WCA-3A North), most of the Dwarf Cypress/Lostmans Pine area, East Slough and a small region south of the Panhandle areas ALT-B predicts water depths which are lower for most or all of the 31-year time period. All of WCA-2B is given lower water depths by ALT-B relative to F2050 during every year except 1974, 1975 and 1988 to 1990 inclusive. During these years ALT-B predicts higher water depths relative to F2050 over the most or all of WCA-2B. ALT-B predicts lower water depths in the eastern half of the Rotenberger/Holeyland area for every year except 1984 when most of the area is given higher water depths by ALT-B relative to F2050. The western most portion of the Rotenberger/Holeyland area is most frequently given higher water depths under ALT-B relative to F2050. Relative to F2050, ALT-B predicts lower water depths in the north east corner of WCA-3A North. During many years this area of lower ALT-B water covers most or all of WCA-3A North. Under some conditions, such as those experienced in 1980 through 1982 the region of lowered water depths in WCA-3A North extends southward along the eastern border of the conservation area and connects with the area of lower ALT-B water depths along the L-67 levees. For only a few years, such as 1970, ALT-B predicts higher water depths relative to F2050 over most of WCA- 3A North. The pattern of decreased water depth ALT-B predicts as compared to F2050 along the L-67 levees through the East Slough and Dwarf Cypress/Lostmans Pine areas is present during every year of the simulation time period. Over time this pattern demonstrates very small changes in character which mostly show up as an increase in the spatial extent of ALT-B lowered water depths from the south eastern portion of the pattern into southern BCNP. The only region within the study area for which ALT-B and F2050 predict similar water depths is in the western portion of BCNP. This region of equal water depths is present at this location for most or all of the 31-year time period.

D-C.2.5.2 ATLSS High Resolution Hydrology Output Comparison

In the 1985 to 1994, 10-year average, hydroperiod analysis (Figure FBHYHPM1.PDF) most of the study area is given an increased hydroperiod by

ALT-B relative to F2050. WCA-1, WCA-2A, west central WCA-3A, WCA-3B, Shark River Slough, Taylor Slough, Long Pine Key and the West Panhandle area are given longer hydroperiods by ALT-B relative to F2050 during the 10-year average rain fall condition. Of these areas the region within WCA-3A, the eastern border of the study area from WCA-3B south through Northern Taylor Slough and a small region in the West Panhandle show the largest increase in hydroperiod under ALT-B relative to F2050. A nearly continuous band from the north east corner of WCA-3A, along the eastern border of WCA-3A, the L-67 levees, the southern border of WCA-3A and through the East Slough area is given shorter hydroperiods by ALT-B relative to F2050 during the 10- year average rain fall conditions. Over most of it's length the band is separated from the region of lengthened hydroperiod in central WCA- 3A by an area for which ALT-B and F2050 predict equivalent hydroperiods. The northern most part of the band, in the north east corner of WCA-3A, covers most of WCA-3A North, and shows the largest decrease in hydroperiod predicted by ALT-B relative to F2050. Two small additional areas in the eastern most portion of WCA-2B and in the southern part of the West Panhandle area are also given shorter hydroperiods under ALT-B relative to F2050. A few of the above described patterns of lengthened and shortened hydroperiod are present under most or all of the other rain fall conditions. Under all rain fall conditions the regions in west central WCA-3A, most of WCA-3B, North Taylor Slough and in the West Panhandle are given longer hydroperiods under ALT-B relative to F2050. Under all but the high rain fall conditions (Figures FBHYHPM4.PDF and FBHYHPM5.PDF) all of WCA-1 is given longer hydroperiods by ALT-B relative to F2050. Under the high rain fall conditions parts of WCA-1 are given similar hydroperiods by both ALT-B and F2050. For the average of the five highest rain fall conditions (Figure FBHYHPM4.PDF) most of the WCA-1 is still given longer hydroperiods by ALT-B relative to F2050 with only a small region along the south western border where the two scenarios predict similar hydroperiods. Under the highest rain fall conditions, 1969, (Figure FBHYHPM5.PDF) the two scenarios predict similar hydroperiods over most of WCA-1, leaving only a small area in the north for which ALT-B predicts longer hydroperiods relative to F2050. All of WCA-3B is given longer hydroperiods by ALT-B relative to F2050 under all but the highest rain fall conditions. During the highest rain fall conditions, 1969, (Figure FBHYHPM5.PDF) a small part of WCA-3B in the south east corner is given similar hydroperiods by both ALT-B and F2050. Under all rain fall conditions ALT-B predicts shortened hydroperiod in the north eastern portion WCA-3A North. There is some variation in this pattern under the various rain fall conditions, most notably during the high rain fall conditions (Figures FBHYHPM4.PDF and FBHYHPM5.PDF) when the spatial extend and peak value of the pattern of ALT-B lowered hydroperiod is decreased. The reduction becomes most extreme during the highest rain fall year, 1969, (Figure FBHYHPM5.PDF) when only a small area in the center of WCA-3A North is predicted by ALT-B as having shorter hydroperiods relative to F2050, the rest of the conservation area being given the same hydroperiods by both scenarios. For all but the lowest rain fall conditions ALT-B predicts lower hydroperiods in the East Slough area. During the lowest rain fall conditions, 1990, (Figure FBHYHPM3.PDF) ALT-B and F2050 predict similar hydroperiod in East Slough with a few scattered locations throughout the area for which ALT-B still predicts shorter hydroperiods. Under all but the highest rain fall conditions, 1969, (Figure FBHYHPM5.PDF) ALT-B predicts shorter hydroperiods relative to F2050 along the L-67 levees.

Under all but the low rain fall conditions ALT-B predicts shorter hydroperiods than those predicted by F2050 for most or all of WCA-2B. During the low rain fall conditions (Figures FBHYHPM2.PDF and FBHYHPM3.PDF) ALT-B predicts longer hydroperiods within WCA-2B. Under the average rain fall conditions, 1977, (Figure FBHYHPM6.PDF) ALT-B predicts shorter hydroperiods for almost all of WCA-2B relative to F2050. In WCA-2A ALT-B predicts longer or equivalent hydroperiods relative to F2050 during the various rain fall conditions. For the 10- year average, and the average of the five lowest rain fall conditions (Figures FBHYHPM1.PDF and FBHYHPM2.PDF) ALT-B predicts longer hydroperiod for most of WCA-2A relative to F2050 with a small region in the south central portion of the area for which the two scenarios predict equivalent hydroperiods. During the lowest, the high and average rain fall conditions (Figures FBHYHPM3.PDF through FBHYHPM6.PDF) the two scenarios predict similar hydroperiods for most of WCA-2A. Under these rain fall conditions a few areas near the borders of the conservation area are still predicted has having longer hydroperiod by ALT-B relative to F2050. Through Shark River Slough the pattern of long and short hydroperiod is not consistent over the various rain fall conditions. For the 10-year average, the five lowest and the average rain fall conditions (Figures FBHYHPM1.PDF, FBHYHPM2.PDF, FBHYHPM6.PDF) most of Shark River Slough is given longer hydroperiods by ALTB as compared to F2050. During the high rain fall conditions (Figures FBHYHPM4.PDF, FBHYHPM5.PDF) most of the slough is given equivalent hydroperiods by both scenarios. Finally under the lowest rain fall conditions (Figure FBHYHPM3.PDF) the northern end of the slough is given equal hydroperiod by the two scenarios, the central portion is given lower hydroperiod by ALT-B and the southern end is given longer hydroperiod by ALT-B as compared to F2050. In the Long Pine Key area and in South Taylor Slough ALT-B gives equal or longer hydroperiods under all rain fall conditions relative to F2050. Under the low rain fall conditions (Figures FBHYHPM2.PDF, FBHYHPM3.PDF) Long Pine Key, South Taylor Slough and parts of the surrounding areas are given equivalent hydroperiods by both scenarios. During the high and average rain fall conditions (Figures FBHYHPM4.PDF though FBHYHPM6.PDF) only part of Long Pine Key is given longer hydroperiods by ALT-B as compared to F2050, with the central portion of Long Pine Key and most of South Taylor Slough area still given similar hydroperiods by the scenarios.

Overall the general patterns predicted for ALT-B hydroperiods relative to F2050 are consistent spatially with lengthened hydroperiod predicted by ALT-B for central Shark River Slough, WCA-3B, central western portion of WCA-3A South, and WCA-1. ALT-B predicts shortened hydroperiods along a band from northeastern portion of WCA-3A North, along the L-67 levees, and through the southern portion of WCA-3A South into East Slough. For most of BCNP ALT-B and F2050 have similar predicted hydroperiods. The above patterns have some spatial variation based upon rainfall conditions.

D-C.2.6 Alternative C vs. F2050 (Revised)

D-C.2.6.1 SFWMM Output Comparisons

In the raw output from the SFWMM for the ALT-C and F2050 scenarios the differences in water depth show clear and stable patterns. ALT-C generates increased water levels relative to F2050 in WCA-1, most of WCA-3A south of I-75, WCA-3B, and most of the Everglades National Park (ENP) including Shark River Slough, Taylor Slough, Long Pine Key, and the East and West Panhandle areas. ALT-C predicts lower water levels in parts of the Rotenberger-Holeyland area, a portion of WCA-3A north of I-75, most of the southern end of WCA-2A, WCA-2B, East Slough and a small region south of East and West Panhandle areas. In Big Cypress National Preserve (BCNP) the differences between ALT-C and F2050 show only nominal differences in water depth between the two scenarios. For most of BCNP ALT-C predicts deeper water with scattered areas of decreased water depth relative to F2050. These differences in BCNP do not form a consistent pattern of wetting or drying over the 31-year time period. These patterns of increased and decreased water depth within the study area are consistent across the entire 1965-1995 time period with some year to year variation. In almost all years simulated by the SFWMM ALT-C predicts lower water depths relative to F2050 in a contiguous region which includes the eastern half of the Rotenberger-Holeyland area, a band in WCA-3A north of I-75, the southern end of WCA-2A and WCA-2B. During all years the largest decrease in water depths between ALT-C and F2050 occur in the Rotenberger-Holeyland area and WCA-2B. The band of decreased water depths predicted by ALT-C relative to F2050 in WCA-3A north of I-75, which extends from the north east corner of WCA-3A south west into the conservation area, is present in almost every year. In some years, such as 1970, the band disappears and ALT-C predicts increased water depths relative to F2050 for most of WCA-3A north of I-75. In other years the spatial extent of the band increases and ALT-C predicts deeper water relative to F2050 for most of WCA-3A north of I-75. Relative to F2050, ALT-C predicts lower water depths in the eastern portion of the Rotenberger-Holeyland area for almost all of the 31-year time period. For several of these years ALT-C predicts lower water depths for all of the Rotenberger-Holeyland area and for two years, 1983 and 1984, ALT-C predicts high water depths relative to F2050 for most of the area. In most years ALT-C predicts lower water levels in the southern part of WCA-2A and higher water levels in the northern part. Though the pattern within WCA-2A is present in almost every year, there are large variations in the extent of increased and decreased water depths produced by ALT-C relative to F2050.

During some years, such as 1983, nearly all of WCA-2A has decreased water depths under ALT-C relative to F2050; while in 1988 ALT-C predicts higher water depths for the entire area. Over most the 31-year simulation period WCA-2B is given lower water depths under ALT-C relative to F2050 and remains a region in which ALT-C predicts the greatest deficit of water relative to F2050. Only during 1974, 1975 and 1988-1990 do the ALT-C predictions for WCA-2B change, giving the region lower water depths relative to F2050. ALT-C also predicts lower water depths in the East Slough area and south of East and West Panhandle for most of the 31-year simulation time period. The area of decreased water depth in East Slough predicted by ALT-C relative to F2050 is present in every year from 1965 to 1995. During this time the surrounding areas to the north in the Dwarf Cypress/Lostmans Pine area, to the south in the 10-Mile Marl area, and to the north east in the southern end of WCA-3A all experience episodes of lowered water depth under ALT-C relative to F2050. In the southern most end of the ENP a small area south of the East and West Panhandle areas is predicted by ALT-C to have lower water depths relative to F2050 for every year of the simulation time period. Occasionally, ALT-C predicts additional surrounding areas to the west and north as having lower water depths relative to F2050. The increased water levels predicted by ALT-C relative to F2050 for WCA-1, WCA-3A south of I-75, WCA-3B, and the ENP are present over most of the 31-year simulation period. During the simulation period, almost all of WCA-1 is given deeper water depths under ALT-C relative to F2050. During a few, very rare occasions a small area in the northern end of the conservation area is given lower water depths relative to F0205. From 1965 to 1995 the largest areas of increase under ALT-C occur along Shark River Slough and in the eastern portion of WCA-3A parallel to the L-67 levies. Most of the ENP is predicted as having deeper water depths under ALT-C relative to F2050, though as times parts of Shark River Slough at the southern reaches of the park are given lower water levels under ALT-C. Occasionally the southern end of WCA-3A experiences an area of decreased water depths under ALT-C relative to F2050, which is contiguous with the decreased water depths ALT-C predicts for East Slough. Additionally there is a small region of increased water under ALT-C relative to F2050 along the border between the East and West Panhandle areas.

D-C.2.6.2 ATLSS High Resolution Hydrology Output Comparison

The 1985-1994 10-year average rain fall hydroperiod analysis (Figure FCHYHPM1.PDF) shows increased hydroperiods under ALT-C relative to F2050 over most of the study area. This area is contiguous and covers WCA-1, WCA-2A, most of WCA-2B, most of WCA-3A south of I-75, WCA-3B, Shark River Slough, North Taylor Slough, and the north eastern portion of BCNP. An additional disjoint region which experiences increased hydroperiod under ALT-C relative to F2050 appears along the border between the East and West Panhandle. Along the southern end of WCA-3A ALT-C and F2050 predict a region of equal hydroperiod which is connected to the region of equal or shortened ALT-C hydroperiod in the

East Slough. In the 10-Mile Marl area, the southern end of East Slough, the north east corner of WCA-3A, the eastern most edge of WCA-2B and a small region in the West Panhandle ALT-C predicts shorter hydroperiods relative to F2050. The area of ALT-C shortened hydroperiod in the East Slough area is surrounded by a region for which ALT-C and F2050 predict equivalent hydroperiods. The largest decrease in hydroperiods predicted by ALT-C relative to F2050 occurs in the north east corner of WCA-3A and in WCA-2B. For most of the central and western portions of BCNP, most of the Long Pine Key area, and South Taylor Slough there are negligible differences between the hydroperiods predicted by ALT-C and F2050. The basic pattern of long and short hydroperiod predicted by ALT-C relative to F2050 under the 10-year average rain fall condition are present during the other rain fall conditions. During the average of the five lowest rain fall conditions (Figure FCHYHPM2.PDF) ALT-C predicts almost no change in the amount of area for which ALT-C predicts increased water depth relative to F2050, but the differences between the two scenarios becomes larger than those seen under the 10-year average rain fall conditions. For the lowest rain fall conditions, 1990, (Figure FCHYHPM3.PDF) there is a decrease in the amount of area for which ALT-C predicts longer hydroperiods relative to F2050. Regions including the center of WCA-2A, the southern end of WCA-3A, northern end of Shark River Slough, South Taylor Slough and Long Pine Key are give equivalent hydroperiods under ALT-C and F2050. The region of shortened hydroperiod in the 10-Mile Marl area and southern East Slough predicted by ALT-C relative to F2050 is diminished in both spatial extent and peak value during the lowest rain fall year, 1990, (Figure FCHYHPM3.PDF). In the north east corner of WCA-3A, the eastern most part of WCA-2B and the area in the West Panhandle ALT-C predicts shorter hydroperiods relative to F2050 under the lowest rain fall conditions (Figures FCHYHPM2.PDF and FCHYHPM3.PDF). During the year of lowest rain fall, 1990, (Figure FCHYHPM3.PDF) the difference in hydroperiods between the two scenarios becomes larger in the north east corner of WCA-3A and in the West Panhandle. The region of decreased hydroperiod in east WCA-2B which appears under other rain fall conditions is not present under the lowest rain fall conditions. Under the lowest rain fall conditions an area along the L-67 levees is given shorter hydroperiods under ALT-C relative to F2050. Under the highest rain fall conditions (Figure FCHYHPM4.PDF and FCHYHPM5.PDF) the region for which ALT-C predicts increased hydroperiod relative to F2050 under the 10-year average is decreased both in spatial extent and peak value. Under the high rain fall conditions portions of WCA-1, most of WCA-2A and Shark River Slough are given comparable hydroperiods by both ALT-C and F2050. Under the highest rain fall year, 1969, (Figure FCHYHPM5.PDF) most of the area within WCA-3A north of I-75, the north east end of Shark River Slough, and a corner of WCA-3B are all given equivalent hydroperiods by both ALT-C and F2050. An area for which ALT-C predicts lower hydroperiod relative to F2050 persists in the center of WCA-3A north of I-75 under the highest rain fall conditions though it is smaller in spatial extent. The northern end of the 10-mile Marl area and East Slough are given shorter hydroperiods under

ALT-C relative to F2050 during the high rain fall conditions (Figures FCHYHPM4.PDF and FCHYHPM5.PDF). In the southern end of the 10-mile Marl area, a region which under other rain fall conditions is given shorter hydroperiod by ALT-C, is given a longer hydroperiod by ALT-C relative to F2050 during the highest rain fall conditions. Under the high rain fall conditions (Figures FCHYHPM4.PDF and FCHYHPM5.PDF) the region of long hydroperiod predicted by ALT-C relative to F2050 along the border between the West and East Panhandle shows smaller difference between the two scenarios. During the average rain fall conditions, 1977, (Figure FCHYHPM6.PDF) most of the study area, including WCA-1, WCA-3A south of I-75, WCA-3B, Shark River Slough, North Taylor Slough, the eastern part of BCNP and the border between the West and East Panhandle area are given a longer hydroperiod by ALT-C relative to F2050 with lower predicted hydroperiods in a large portion of WCA-3A north of I-75, the southern end of the 10-Mile Marl area and East Slough. Most of WCA-2A is given equal or shorter hydroperiods by ALT-C relative to F2050 under the average rain fall conditions with a small region of increased hydroperiod along the north east border shared with WCA-1. An additional area in the south east portion of BCNP is given longer hydroperiods under ALT-C relative to F2050 only during the average rain fall conditions. As in the other years, during the average rain fall year ALT-C and F2050 predicts similar hydroperiods for Long Pine Key, South Taylor Slough, and central and western BCNP. Overall the pattern of differences between ALT-C and F2050 are consistent during all rain fall conditions. Much of the study area is given a longer hydroperiod under ALT-C as compared to F2050 and only the areas in WCA-3A north of I-75, the 10-Mile Marl area, East Slough, and the eastern most portion of WCA-2B have shorter hydroperiods under ALT-C relative to F2050. A few areas including the South Taylor Slough, part of the West Panhandle and central to western BCNP experience equivalent hydroperiods under both ALT-C and F2050. The general pattern of hydroperiods predicted by ALT-C are very similar to those predicted by ALT-D. The only major differences appear in the Dwarf Cypress/Lostmans Pine area. Within this region ALT-D predicts longer hydroperiod relative to F2050 while ALT-C predicts hydroperiods similar to those predicted by F2050.

D-C.2.7 Alternative D vs. F2050 (Revised)

D-C.2.7.1 SFWMM Output Comparisons

In the raw output from the SFWMM for the ALT-D and F2050 scenarios the differences in water depth show clear and stable patterns. ALT-D generates increased water levels relative to F2050 in WCA-1, most of WCA-3A south of I-75, WCA-3B, and most of the Evergaldes National Park (ENP) including Shark River Slough, Taylor Slough, Long Pine Key, and the East and West Panhandle areas. ALT-D predicts lower water levels in parts of the Rotenberger-Holeyland area, a portion of WCA-3A north of I-75, most of the southern end of WCA-2A, WCA-2B, East Slough and a small region south of East and West Panhandle areas. In Big Cypress National Preserve (BCNP) the differences between ALT-D and F2050 show only nominal differences is water depth between the two scenarios. For most of BCNP ALT-D predicts deeper water with scattered areas of decreased water depth relative to F2050. These differences in BCNP do not form a consistent pattern of wetting or drying over the 31-year time frame. These patterns of increased and decreased water depth within the study area are consistent across the entire 1965-1995 time period with some year to year variation. In almost all years simulated by the SFWMM ALT-D predicts lower water depths relative to F2050 in a contiguous region which includes the eastern half of the Rotenberger-Holeyland area, a band in WCA-3A north of I-75, the southern end of WCA-2A and WCA-2B. During all years the largest decrease in water depths between ALT-D and F2050 occur in the Rotenberger-Holeyland area and WCA-2B. The band of decreased water depths predicted by ALT-D relative to F2050 in WCA-3A north of I-75, which extends from the north east corner of WCA-3A south west into the conservation area, is present in almost every year. In some years, such as 1970, the band disappears and ALT-D predicts increased water depths relative to F2050 for most of WCA-3A north of I-75. In other years the spatial extent of the band increases and ALT-D predicts deeper water relative to F2050 for most of WCA-3A north of I-75. Relative to F2050, ALT-D predicts lower water depths in the eastern half of the Rotenberger-Holeyland area and higher water depths in the western half for almost all of the 31 year time period. For several of these years ALT-D predicts lower water depths for all of the Rotenberger-Holeyland area and for two years, 1983 and 1984, ALT-D predicts high water depths relative to F2050 for most of the area. In most years ALT-D predicts lower water levels in the southern part of WCA-2A and higher water levels in the northern part. Though the pattern within WCA-2A is present in almost every year, there are large variations in the extent of increased and decreased water depths produced by ALT-D relative to F2050. During some years, such as 1983, nearly all of WCA-2A has decreased water depths under ALT-D relative to F2050; while in 1988 ALT-D predicts higher water depths for the entire area. The increased water levels predicted by ALT-D relative to F2050 for WCA-3A south of I-75, WCA-3B, and the ENP are present over all 31 years. Over this time period the largest area of increase under ALT-D occur along Shark River Slough and in the eastern portion of WCA-3A parallel to the L-67 levies. Additionally there is a small region of increased water under ALT-D relative to F2050 along the border between the East and West Panhandle areas. Occasionally the southern end of WCA-3A experiences an area of decreased water depths under ALT-D relative to F2050 which is contiguous with the decreased water depths ALT-D predicts for East Slough.

D-C.2.7.2 ATLSS High Resolution Hydrology Output Comparison

The 1985-1994 10-year average rain fall hydroperiod analysis (Figure FDHYHPM1.PDF) shows increased hydroperiods under ALT-D relative to F2050 over most of the study area. This area is contiguous and covers WCA-1, WCA-2A, most of WCA-2B, most of WCA-3A south of I-75, WCA-3B, Shark River Slough, Taylor Slough, Long Pine Key, and the eastern portion of BCNP. An additional disjoint region which experiences increased hydroperiod under ALT-D relative to F2050 appears along the border between the East and West Panhandle. Along the southern end of WCA-3A ALT-D and F2050 predict a region of equal hydroperiod which is connected to the region of equal or shortened ALT-D hydroperiod in the East Slough. In the East Slough area, the north east corner of WCA-3A, the eastern most edge of WCA-2B and a small region in the West Panhandle ALT-D predicts shortening in hydroperiod relative to F2050. The area of ALT-D shortened hydroperiod in the East Slough area is surrounded by a region for which ALT-D and F2050 predict equivalent hydroperiods. The largest decrease in hydroperiods predicted by ALT-D relative to F2050 occurs in the north east corner of WCA-3A and in WCA-2B. For most of the central and western portions of BCNP and a small swath at the southern end of the study area there are negligible differences between the hydroperiods predicted by ALT-D and F2050. The basic pattern of long and short hydroperiod predicted by ALT-D relative to F2050 under the 10-year average rain fall condition are present during the other rain fall conditions. During the average of the five lowest rain fall conditions (Figure FDHYHPM2.PDF) ALTD predicts almost no change in the amount of area for which ALT-D predicts increased water depth relative to F2050, but the differences between the two scenarios becomes larger than those seen under the 10- year average rain fall conditions. For the lowest rain fall conditions, 1990, (Figure FDHYHPM3.PDF) there is a decrease in the amount of area for which ALT-D predicts longer hydroperiods relative to F2050. Regions including the center of WCA-2A, the southern end of WCA-3A, northern end of Shark River Slough, South Taylor Slough and Long Pine Key are give equivalent hydroperiods under ALT-D and F2050. In East Slough, the north east corner of WCA-3A, the eastern most part of WCA-2B and the area in the West Panhandle ALT-D predicts shorter hydroperiods relative to F2050 under the lowest rain fall conditions (Figures FDHYHPM2.PDF and FDHYHPM3.PDF). During the lowest rain fall condition, 1990, (Figure FDHYHPM3.PDF) the difference in hydroperiods between the two scenarios becomes larger in the north east corner of WCA-3A and in the West Panhandle. Under the same rain fall conditions the differences between ALT-D and F2050 becomes smaller in East Slough both in peak value and spatial extent. The region of decreased hydroperiod in east WCA-2B which appears under other rain fall conditions is not present under the lowest rain fall conditions. Under the lowest rain fall conditions a area along the L-67 levies is given shorter hydroperiods under ALT-D relative to F2050. Under the highest rain fall conditions (Figure FDHYHPM4.PDF and FDHYHPM5.PDF) the region for which ALT-D predicts increased hydroperiod relative to F2050 under the 10-year average is decreased both in spatial extent and peak value. Under these rain fall conditions most of WCA-2A, Shark River Slough, South Taylor Slough are given comparable hydroperiods by both ALT-D and F2050. Under the highest rain fall year, 1969, (Figure FDHYHPM5.PDF) most of the area within WCA-3A north of I-75, the north east end of Shark River Slough, and a corner of WCA-3B are all given equivalent hydroperiods by both ALT-D and F2050. The areas which ALT-D predicts as having shorter hydroperiod relative to F2050 under the 10-year average do not change greatly under the highest rain fall conditions. East Slough is still predicted as having a shorter hydroperiod under ALT-D relative to F2050, thought the differences in predicted hydroperiod becomes larger especially under the highest rain fall conditions, 1969, (Figure FDHYHPM5.PDF). The area in WCA-3A north of I-75 for which ALT-D predicts shorter hydroperiods relative to F2050 becomes smaller under the highest rain fall conditions but also experiences an increase in the difference between the predicted hydroperiods. Under the high rain fall conditions (Figures FDHYHPM4.PDF and FDHYHPM5.PDF) the region of long hydroperiod predicted by ALT-D relative to F2050 along the border between the West and East Panhandle shows a smaller difference between the two scenarios. There is a similar pattern of increased and decreased hydroperiod between ALT-D and F2050 under average rain fall conditions, 1977, (Figure FDHYHPM6.PDF) as is seen under the other rain fall conditions. WCA-1, WCA-3A south of I-75, WCA-3B, Shark River Slough, Taylor Slough, eastern BCNP and the border between East and West Panhandle are all given longer hydroperiods by ALT-D relative to F2050 under average rain fall conditions. The area in the north east corner of WCA-3A and the eastern most part of WCA-2B are still given shorter hydroperiod by ALT-D relative to F2050 under the average rain fall conditions. Along the northern border WCA-2A shares with WCA-1 there is a small region for which ALT-D predicts a longer hydroperiod than F2050 under average rain fall conditions. Over the remaining portion of WCA-2A ALT-D predicted hydroperiod equal to or shorter than those predicted by F2050. Under average rain fall conditions portions of the area of ALT-D shortened hydroperiod in East Slough is replaced by hydroperiods of similar length for both ALT-D and F2050. Immediately to the south in the 10-mile Marl area ALT-D predicts shorter hydroperiod than F2050.

Overall the pattern of differences between ALT-D and F2050 are consistent during all rain fall conditions. Much of the study area is given a longer hydroperiod under ALT-D as compared to F2050 and only the areas in WCA-3A north of I-75, East Slough, and the eastern most portion of WCA-2B have shorter hydroperiods under ALT-D relative to F2050. A few areas including the South Taylor Slough, part of the West Panhandle and central to western BCNP experience equivalent hydroperiods under both ALT-D and F2050.

D-C.3 ATLSS LANDSCAPE FISH MODEL

ATLSS
Landscape Fish Model (ALFISH)
Brief Description
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Donald DeAngelis, Holly Gaff, Louis Gross, Moris Shorrosh
The Institute for Environmental Modeling
University of Tennessee - Knoxville

The ATLSS Landscape Fish model (ALFISH) has as its main objective the ability to compare in a spatially-explicit manner the relative effects of alternative hydrologic scenarios on fresh-water fish densities across South Florida. Another objective is to provide a measure of the dynamic, spatially-explicit food resources available to wading birds.

ALFISH operates by splitting the landscape into spatial grid cells, of size 500 m by 500 m, characterizing the within-cell variability in water depth in a statistical manner. Within each cell, there is a distribution of elevations based upon an average hypsograph obtained by averaging data from a number of locations. Cells also contain permanently wet areas of small size, called ponds, with the remaining cell areas which may be subject to periodic dry down and reflooding called the marsh areas. Fish densities change within cells between areas of various depths as a cell drys down or rewets, since differing fractions of area within cells will be at differing water depths. The spatial cells are coupled in the model by movements of fish density between cells due to differences in relative fish densities or differences in relative water depth between cells. ALFISH is a mostly deterministic model, with the only stochastic component being the size of the pond within each cell.

The main inputs to ALFISH are hydrology data at a 500 m resolution from the pseudotopography model, time of year, and food resources available from lower trophic levels. For the current application of ALFISH to the Restudy, all lower trophic level resources are assumed constant, independent of hydrology. The time step of the model is 5-days, so hydrology data is averaged to produce 5-day average water depths for each 500 m cell across the study area. The study area includes all of the region for which hydrology data are being produced for each scenario, with some outputs being computed only for particular sub-regions within the study area.

ALFISH considers two fish functional groups: Functional Group #1 (small fish) includes all fish species which have a maximum possible length in the system of 7 cm; Functional Group #2 (large fish) includes all fish species with maximum lengths of greater than 7 cm. For example, the model would consider Killifishes or small live-bearers (Poeciliids) to be in functional group #1, while Gar and catfish would be in functional group #2. ALFISH treats the fish functional groups as an age-size structured model. Each age class is 30 days. The Large Fish functional group has 40 age classes, while the Small Fish functional group has 25 age classes. The Large Fish functional group has two stages: the first stage includes the first few age classes when fish are small in size and can be preyed upon by the second stage of larger, older fish. Each age class is divided into 6 size classes with length (in cm) calculated as a function of age from a Von Bertalanffy equation.

The fish in each functional group grow in size every 5-day time step, and move to the next age class every 30 days. Mature fish of each functional group produce a number of viable offspring during their reproductive month. The age of maturity, the fecundity, and the months during the year in which each functional group reproduces are parameters, which can differ for each functional group. Currently, only the age of maturity and the fecundity are unique to each functional group. For both functional groups, it is assumed that they can reproduce at the first time step of every month. There are four causes of mortality in ALFISH: (i) Background mortality, or the natural mortality of an uncrowded population, which is dependent on fish age class, but is independent of population size; (ii) Density-dependent mortality from starvation; (iii) Loss due to predation from other functional groups; and (iv) Death due to dry down in which some fraction of fish density do not successfully reach deeper water as a cell drys.

Movement in ALFISH has two phases. First, within cell movement takes place allowing fish density to move between the pond and the marsh areas of various depths within a particular cell. Secondly, fish density can shift between the marsh areas of adjoining cells, based on differences between water depth and fish densities in these cells. When the fraction of a cell with standing water has dropped too low, it is assumed there is no longer movement of fish into or out of that cell.

While ALFISH is capable of producing very detailed comparisons of changes in fish densities and size structure between scenarios, the outputs being placed on the website (hppt//www.restudy.org/atlss/) for distribution are just a small fraction of what it produces. All of the outputs in this report concern just the Small Fish functional group. The ALFISH outputs for the Restudy posted to the website are:

(1) Maps of the Small Fish functional group total number density (# fish/ m^2) in the marsh areas within cells over the entire region modeled at a 500 m x 500 m cell resolution generated for a single day at two times (model time step dates nearest July 1 and October 15). These maps will be produced for three years over the course of the simulation: a high, average, and low rainfall year.

(2) Maps of the Small Fish functional group total number density (# fish/ m^2) in the marsh areas within cells of fish > 2cm length over the entire region modeled at a 500 m x 500 m cell resolution generated for a single day at three times during wading bird breeding season (January 1, February 15, and April 1) in cells with appropriate water depth for wading bird foraging (10 cm to 30 cm water depth). These maps will be produced for three years over the course of the simulation: a high, average, and low rainfall year.

(3) Maps of average Small Fish functional group total number density (# fish/ m^2) in the marsh areas within cells over the entire 31 year scenario for these dates, with the July 1 and October 15 maps including fish of all size classes, and the January 1, February 15, and April 1 maps including just fish densities for those size classes > 2cm. These maps are all for the entire region, not just portions with certain water depths.

(4) Time series showing the average number density of the Small Fish functional group, averaged over the entire region, with output every 2 model time steps (e.g. every 10 days). Separate time series for fish densities in marsh and in pond areas.

(5) Time series showing the average number density of the Small Fish functional group (# fish/ m^2), for fish between 2 and 7 cm length, associated with each of the wading bird breeding season maps in (2) above. Time step for these series is every 5 days over the breeding season from December 15 to May 15, with separate time series for each of the maps described in (2) and for the 31-year average map described in (3).

(6) Time series showing the average number density of the Small Fish functional group in two subregions of WCA 3A (a long-hydroperiod and a short hydroperiod subregion, derived based upon empirical observations by Joel Trexler), with output every 2 model time steps (e.g. every 10 days), for fish between 2 and 7 cm length.

(7) Time series of histograms of the size distribution of the Small Fish functional group in the marsh areas of the two subregions of WCA 3A described in (6), with output every model step (e.g. every 5 days).

(8) Tables summarizing the total fish number densities broken down by basin area and by year. The entries represent fish per meter squared averaged over the entire year.

Outputs associated with the ATLSS Landscape Fish Model (ALFISH)

In accordance with the ATLSS file naming conventions, each file name consists of the characters:

"F","E", or "_" => F = the Future Without Project Condition (2050 Base)
E = Existing Condition (C1995 Base)
_ = No Base condition, a run of a scenario only
"0-9, A-Z" or "_" => Scenario Identifier (e.g. 0 = Scenario 0)
_ = No Scenario, a run of Base case only
"FI" => the ATLSS Fish Model
"XXXX" => 4 character mnemonic
"."
"PDF" or "TXT" or "DOC" => PDF, tabular text or documentation

Note: For all output, fish means only those in the Small Fish Functional Group (Functional Group #1). In addition, "total fish" means all fish are counted in all water depths. "Fish available for wading birds" means only fish greater than 2 cm in length found in water between 10 and 30 cm deep are counted. "Fish over 2cm long in all water" is used for only for maps which average the model output over several years. The units for all three are numbers of fish per meter squared.

1. Maps

The map outputs used to characterize the results of the ATLSS Fish Model will consist of 20 map images in the PDF file format. Each map shows a "Set" of model results, comparing a Base case to a Scenario, following the conventions for ATLSS comparison of two model runs. Each map has 3 panels. The left panel is the alternative scenario. The right panel is the base scenario - typically the Future without Project Conditions Case. The middle panel is the difference between the two scenarios.

For each of five dates during a high, low and average rainfall year the images provide a spatial display of the density of fish available for wading birds or total fish available upon that day. October 15 and July 1 display the total fish available on the model date closest to these in that year. The outputs for the other dates display only the fish available for wading birds. In addition, there are maps for the five dates averaged over 31 years of the run. These averages are total fish for the October 15 and July 1 dates, and fish over 2cm long in all water depths for the other three dates.

The mnemonic characters are composed according to the convention:

"XX" = Last two digits of the year or "MY" for the Mean value of all years.

"XX" = D1, D2, D3, D4, D5 -> the date designator

Listing of ALFISH map files for 2050 Base compared to Alternative 0:

File Name	Type of Year Closest Model Time Step to Day
XXFI68D1.PDF	High Rainfall Oct.
15XXFI69D2.PDF	High Rainfall Jan.
1XXFI69D3.PDF	High Rainfall Feb.
15 XXFI69D4.PDF	High Rainfall Apr.
1XXFI69D5.PDF	High Rainfall Jul.
1XXFI76D1.PDF	Average Rainfall Oct.
15XXFI77D2.PDF	Average Rainfall Jan.
1XXFI77D3.PDF	Average Rainfall Feb.
15XXFI77D4.PDF	Average Rainfall Apr.
1XXFI77D5.PDF	Average Rainfall Jul.
1XXFI89D1.PDF	Low Rainfall Oct.
15XXFI90D2.PDF	Low Rainfall Jan.
1XXFI90D3.PDF	Low Rainfall Feb.
15XXFI90D4.PDF	Low Rainfall Apr.
1XXFI90D5.PDF	Low Rainfall Jul.
1XXFIMYD1.PDF	Average of all Years Oct.
15XXFIMYD2.PDF	Average of all Years Jan.
1XXFIMYD3.PDF	Average of all Years Feb.
15XXFIMYD4.PDF	Average of all Years Apr.
1XXFIMYD5.PDF	Average of all Years Jul. 1

2. Time Series Charts

The time series charts associated with ALFISH consists of the following files:

File Name	Description
XXFIAVGD.PDF	The total fish density in marsh and pond every 10 days averaged across the entire area.
XXFIBRY1.PDF	The fish available for wading birds in 10-30cm water for Dec 15, 1968 through May 15, 1969.
XXFIBRY2.PDF	The fish available for wading birds in 10-30cm water for Dec 15, 1976 through May 15, 1977.

XXFIBRY3.PDF	The fish available for wading birds in 10-30cm water for Dec 15, 1989 through May 15, 1990.
XXFIAVGB.PDF	The fish longer than 2cm in all water depths averaged for every year for Dec 15 through May 15.
XXFILHAB.PDF	The total fish in a long hydroperiod subregion of WCA 3A across all years. The two subregions together cover all of WCA 3A, are fixed throughout all model runs, and are derived from empirical estimates by Joel Trexler
.XXFISHAB.PDF	The total fish in a short hydroperiod subregion of WCA 3A across all years. The two subregions together cover all of WCA 3A, are fixed throughout all model runs, and are derived from empirical estimates by Joel Trexler.

3. Histograms

The histograms associated with ATLSS Fish Model display the size distribution of fish within two subregions of WCA 3A corresponding to long and short hydroperiods based upon empirical estimates by Joel Trexler, and give the fish size structure dynamics corresponding to the total fish data in file shown in XXFILHAB.PDF. Each image displays the size structure dynamics for half the years of the run. The histograms consist of the following files:

File Name	Description
X_FIBLH1.PDF	A size histogram for fish in the long hydroperiod subregion in WCA 3A in the indicated base scenario and the first half of the years of the run.
X_FIBLH2.PDF	A size histogram for fish in the long hydroperiod subregion in WCA 3A in the indicated base scenario and the second half of the years of the run.
_XFIALH1.PDF	A size histogram for fish in the long hydroperiod subregion in WCA 3A in the indicated alternative scenario for the first half of the years of the run.
_XFIALH2.PDF	A size histogram for fish in a the long hydroperiod subregion in WCA 3A given the indicated alternative scenario for the second half of the years of the run.
X_FIBSH1.PDF	A size histogram for fish in the short hydroperiod subregion in WCA 3A in the indicated base scenario and the first half of the years of the run.
X_FIBSH2.PDF	A size histogram for fish in the short hydroperiod subregion in WCA 3A in the indicated base scenario and the second half of the years of the run.

_XFIASH1.PDF	A size histogram for fish in the short hydroperiod subregion in WCA 3A in the indicated alternative scenario for the first half of the years of the run.
_XFIASH2.PDF	A size histogram for fish in the short hydroperiod subregion in WCA 3A in the indicated alternative scenario for the second half of the years of the run.

4. Tables

The tables associated with the ATLSS fish model consist of the following files:

File Name	Description
F_FIBASE.TXT	Total fish listed by years and basin areas for the Future Without Project Condition scenario.
_XFIBASE.TXT	Total fish listed by years and basin areas for the indicated scenario.
FXFIDIFF.TXT	The difference of the total fish listed by years and basin areas between the Future Without Project Condition and the indicated scenario.

D-C.3.1 F2050 (Revised) vs. C1995 (Revised)

Assessment of the Effects of Proposed Water Regimes C1995 (Revised) vs. F2050 (Revised)on the Fish Prey Base for Wading Birds in South Florida: Output of the ATLSS Fish Model

Figure FEFIAVGD.PDF indicates the same temporal pattern for total fish abundance in both C1995 and F2050; however, the total abundance of fish in the marsh areas in C1995 is higher by a factor of on average 1.15 than in F2050. For fish in pond areas, there is no similar pattern of overall fish abundance difference across the entire region, and average differences between C1995 and F2050 are less than two percent.

Figures FEFIBRY1.PDF, FEFIBRY2.PDF, FEFIBRY3.PDF and FEFIAVGB.PDF show the time series for fish in marsh during the wading bird breeding season assumed to be available to wading birds (e.g. including fish greater than 2 cm in length in water depths between 10 and 30 cm). Except in the low rainfall year (1990), C1995 tends to produce lower fish abundances available to wading birds early in the breeding season relative to F2050, while the reverse pattern holds in the latter part of the breeding season. Thus, for the 31 year average, fish abundance across the marsh is approximately 10% higher late in the breeding season in C1995 relative to F2050. These differences are particularly exaggerated in the high (1969) and average (1977) rainfall years, though there is little difference in the early breeding season. In the low rainfall year (1990), there is a consistent pattern of higher fish abundances available to wading birds in C1995 with more than twice as high fish densities in C1995 after early February.

The pattern of higher fish abundance in C1995 illustrated by the time series results described above do not occur uniformly across the spatial region being modeled. Five figures (FEFIMYD1.PDF through FEFIMYD5.PDF) show the 31 year (1965-1995) average values of total fish densities spatially across the ATLSS model region. Values shown are means for individual days that span the entire seasonal cycle (Oct 15, Jan 1, Feb 15, April 1, and July 1). These results clearly indicate a consistent pattern across all time periods of higher fish densities in C1995 versus F2050 in WCA3B, WCA3A (South), WCA1, So BCNP (N 41), South BCNP (S 41), and along the boundary between Long Pine Key and the Eastern Panhandle. There are significantly lower predicted total fish densities for C1995 as compared to F2050 for East Slough, Shark Slough, North Taylor Slough, the northern part of WCA3A (North), and WCA2B. These differences reflect the different hydroperiods associated with C1995 and F2050 for these regions as illustrated in FEHYHPM1.PDF and the other hydroperiod comparisons.

The spatial dynamics that produce the long-term average results discussed above are illustrated by the seasonal cycle of total fish abundance during October and July and fish availability for wading birds (fish greater than 2 cm in length, in water depths between 10 and 30 cm) for the January through April breeding season. Maps here illustrate these spatial dynamics for a typical rainfall year (1977, figs. FEFI76D1.PDF through FEFI77D5.PDF), a high rainfall year (1969, figs. FEFI68D1.PDF through FEFI69D5.PDF) and a low rainfall year (1990, figs. FEFI89D1.PDF through FEFI90D5.PDF). These maps illustrate the major influence of water depth differences between C1995 and F2050 particularly in WCA3A (South), WCA3B, along the boundary between Long Pine Key and the Eastern Panhandle, and WCA1 in which C1995 has consistently deeper water. They also reflect the consistent pattern of less water for C1995 relative to F2050 in WCA2B, Shark Slough, North Taylor Slough, and the northern and northwest portions of WCA3A (North). Thus, in the typical rainfall year, C1995 has consistently higher fish abundances in WCA3A (South) and WCA3B for all dates with the exception that the fish availability for wading birds in January (and somewhat in February) does not differ in the WCA3A (South) between the scenarios since the predicted water depths are too high for wading bird foraging. The relative fish density differences between C1995 and F2050 throughout the rest of the study area varies considerably through the year. In a low rainfall year (1990), WCA3A (South) is significantly higher in the October and January maps for C1995 compared with F2050 with some additional differences in WCA1 and WCA2A. For most of the low rainfall year (1990) model output shows few if any differences between the two scenarios in predicted fish densities since the overall predicted densities are extremely low in both scenarios. The pattern for a high rainfall year

(1969) shows complex spatial changes throughout the year with C1995 producing generally higher total fish abundances than F2050 in WCA3A (South) and WCA3B in October. The only other pattern for this high rainfall year (1969) is the tendency for C1995 to produce lower fish densities along the northern portion of WCA3A (North). The pattern of fish availability to wading birds in 1969 shows a complex intermingling of relative positive and negative differences between C1995 and F2050 through much of the ATLSS model region. In the very central portion of Shark River Slough in October and April, C1995 produces somewhat lower fish abundances for wading birds than F2050. No consistent pattern is evident throughout the rest of the region during the wading bird breeding season for 1969.

Tables _EFIBASE.TXT, F_FIBASE.TXT and FEFIDIFF.TXT show a breakdown by subregion of total fish density averaged over each year for C1995, F2050 and the difference respectively. These indicate the general pattern of higher fish density for C1995 relative to F2050 in 4 of the modeled subregions as measured by the mean over all years. The largest differences in this mean occur in WCA3B, WCA3A (South), and WCA1 with magnitudes varying from 50% to 75% higher for C1995. C1995 average fish density is significantly lower than that predicted for F2050 in WCA3A (North) and Shark Slough. The magnitudes of these differences relative to F2050 are much smaller however than the positive differences in the other subregions. In some of the above however, the table comparisons average over significant spatial variations in fish densities within subregions, which is particularly evident in WCA3A (North) (figs. FEFIMYD1.PDF through FEFIMYD5.PDF) and in the year to year variations in FEFIDIFF.TXT also for WCA3A (North).

D-C.3.1.1 Conclusion

The ATLSS fish model predicts that C1995 water conditions will produce average fish abundances consistently higher than those that would be expected under the F2050 water conditions in average across the modeled region particularly WCA3B, WCA3A (South), WCA1. However, C1995 provides consistently lower fish densities in WCA2B, the northeastern portion of WCA3A (North), East Slough and Shark Slough compared to F2050. In addition to these major differences in abundance patterns in different regions, the spatial pattern of differences in abundance varies somewhat based upon rainfall conditions in the particular year. Temporal patterns of total fish abundance averaged across the entire model region are similar with higher abundances produced by C1995. This does not holds true for fish availability to wading birds when including only fish greater than 2 cm in length in areas of appropriate depths for wading bird foraging during the early portion of the breeding season.

D-C.3.2 Alternative A vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative A versus F2050 (Revised)on the Fish Prey Base for Wading Birds in South Florida: Output of the ATLSS Fish Model

Figure FAFIAVGD.PDF indicates the same temporal pattern for total fish abundance in both ALT-A and F2050, however the total abundance of fish in the marsh areas in ALT-A is higher by a factor of 1.2 than in F2050 except at the very beginning and very end of the 31 year run. This pattern of higher abundances of fish in ALT-A also occurs for fish abundance in the pond areas though the difference is typically less than two percent.

Figures FAFIBRY1.PDF, FAFIBRY2.PDF, FAFIBRY3.PDF and FAFIAVGB.PDF show the time series for fish in marsh during the wading bird breeding season assumed to be available to wading birds (e.g. including fish greater than 2 cm in length in water depths between 10 and 30 cm). The pattern shows consistently higher fish available in ALT-A with essentially similar patterns of abundance in ALT-A and F2050. As shown by figure FAFIAVGB.PDF there is a consistent trend towards increasing numbers of fish available to wading birds as the breeding season progresses for ALT-A over F2050. The differences reach over a factor of 2 higher in ALT-A through out the breeding season for the high rainfall year (1969) as well as in the average rainfall year (1977). In the low rainfall year (1990), the results indicate a decreasing trend in fish available to wading birds for both ALT-A and F2050; however, ALT-A shows approximately twice the fish density of F2050 in the first half of the breeding season while in the second half, ALT-A maintains fish densities above 0.1 compared with F2050 which approaches extremely low levels.

The pattern of higher fish abundance in ALT-A illustrated by the time series results described above do not occur uniformly across the spatial region being modeled. Five figures (FAFIMYD1.PDF through FAFIMYD5.PDF) show the 31 year (1965-1995) average values of total fish densities spatially across the ATLSS model region. Values shown are means for individual days that span the entire seasonal cycle (Oct 15, Jan 1, Feb 15, April 1, and July 1). These results clearly indicate a consistent pattern across all time periods of higher fish densities in ALT-A versus F2050 in WCA3B, East Shark River Slough, Central Shark Slough, WCA1, WCA2B and North Taylor Slough, as well as in the northwestern portions of WCA2A. There are significantly lower predicted total fish densities for ALT-A as compared to F2050 for East Slough and South Big Cypress (South of 41). These differences reflect the different hydroperiods associated with ALT-A and F2050 for these regions as illustrated in FAHYHPM1.PDF and the other hydroperiod comparisons.

The spatial dynamics that produce the long-term average results discussed above are illustrated by the seasonal cycle of total fish abundance during October and July and fish availability for wading birds (fish greater than 2 cm in length, in water depths between 10 and 30 cm) for the January through April breeding season. Maps here illustrate these spatial dynamics for an typical rainfall year (1977, figs. FAFI76D1.PDF through FAFI77D5.PDF), a high rainfall year (1969, figs. FAFI68D1.PDF through FAFI69D5.PDF) and a low rainfall year (1990, figs. FAFI89D1.PDF through FAFI90D5.PDF). In the typical rainfall year (1977), ALT-A has consistently higher fish abundances in WCA3B and all of Shark Slough in October, April and July. However, the fish availability for wading birds in January does not differ in the Central Shark Slough between the scenarios since the predicted water depths are too high for wading bird foraging, and in February, there is a complex spatially variable pattern of differences between F2050 and ALT-A of fish available to wading birds in the Central Shark Slough. In a low rainfall year (1990), there is a consistent pattern in which ALT-A has consistently higher fish abundances and availability to wading birds but only in selected areas, particularly in the northwestern portions of WCA2A and the area along the boundary between WCA3B and Northeast Shark Slough. The pattern for a high rainfall year (1969) shows complex spatial changes throughout the year. The pattern of fish availability to wading birds in the high rainfall year (1969) shows a complex intermingling of relative positive and negative differences between ALT-A and F2050 through much of the ATLSS model region. No consistent pattern is evident throughout the region during the seasonal cycle for the high rainfall year (1969).

Tables _AFIBASE.TXT, F_FIBASE.TXT and FAFIDIFF.TXT show a breakdown by subregion of total fish density averaged over each year for ALT-A, F2050 and the difference respectively. These indicate the general pattern of higher fish density for ALT-A relative to F2050 when averaged over the entire modeled region by approximately 20%. This difference is not uniform across all regions. ALT-A average fish density is significantly lower than that predicted for F2050 in East Slough and South Big Cypress (South of 41). ALT-A produces higher fish densities when compared with F2050 in WCA1, WCA2A, WCA2B, WCA3B, Northeast Shark Slough, and Shark Slough. In some of the above however, the table comparisons average over significant spatial variations in fish densities within subregions, which is particularly evident in WCA3A North (figs. FAFIMYD1.PDF through FAFIMYD5.PDF) and in the year to year variations in FAFIDIFF.TXT also for WCA3A North.

D-C.3.2.1 Conclusion

The ATLSS fish model predicts that ALT-A water conditions will produce average fish abundances consistently higher than those that would be expected under the F2050 water conditions in most of the modeled region particularly Shark

Slough, WCA3B, WCA1, WCA2A, WCA2B, and northeast Shark Slough. However, ALT-A provides consistently lower fish densities in East Slough and South Big Cypress (South of 41) compared to F2050. In addition to these major differences in abundance patterns in different regions, the spatial pattern of differences in abundance varies somewhat based upon rainfall conditions in the particular year. Temporal patterns of total fish abundance averaged across the entire model region are similar with higher abundances produced by ALT-A. This holds true for both total abundance and fish availability to wading birds when including only fish greater than 2 cm in length in areas of appropriate depths for wading bird foraging.

D-C.3.3 Alternative B vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes ALTB vs. F2050 (Revised) on the Fish Prey Base for Wading Birds in South Florida: Output of the ATLSS Fish Model

Figure FBFIAVGD.PDF indicates the same temporal pattern for total fish abundance in both ALT-B and F2050, however the total abundance of fish in the marsh areas in ALT-B is consistently higher by a factor of 1.3 than in F2050. This pattern of consistently higher abundances of fish in ALT-B also occurs for fish abundance in the pond areas though the difference is typically less than two percent.

Figures FBFIBRY1.PDF, FBFIBRY2.PDF, FBFIBRY3.PDF and FBFIAVGB.PDF show the time series for fish in marsh during the wading bird breeding season assumed to be available to wading birds (e.g. including fish greater than 2 cm in length in water depths between 10 and 30 cm). The pattern shows consistently higher fish available in ALT-B with essentially similar patterns of abundance in ALT-B and F2050. As shown by figure FBFIAVGB.PDF there is a consistent trend towards increasing numbers of fish available to wading birds as the breeding season progresses for ALT-B over F2050. The differences reach over a factor of 2 higher in ALT-B late in the breeding season for the high rainfall year (1969) with ALT-B having a factor of 2.5 more fish in the average rainfall year (1977). In the low rainfall year (1990), the results indicate a decreasing trend in fish available to wading birds for both ALT-B and F2050; however, ALT-B shows approximately twice the fish density of F2050 in the first half of the breeding season while in the second half, ALT-B maintains fish densities above 0.2 compared with F2050 which approaches extremely low levels.

The pattern of higher fish abundance in ALT-B illustrated by the time series results described above do not occur uniformly across the spatial region being modeled. Five figures (FBFIMYD1.PDF through FBFIMYD5.PDF) show the 31 year (1965-1995) average values of total fish densities spatially across the ATLSS model region. Values shown are means for individual days that span the entire seasonal cycle (Oct 15, Jan 1, Feb 15, April 1, and July 1). These results clearly indicate a consistent pattern across all time periods of higher fish densities in ALT-B versus F2050 in WCA3B, East Shark River Slough, Central Shark Slough, WCA1, North Taylor Slough, Eastern Panhandle, as well as in the north western portions of WCA2A and WCA3A (South). There are significantly lower predicted total fish densities for ALT-B as compared to F2050 for WCA2B, the north eastern portion of WCA3A (North), the eastern boundary of WCA3A (South), East Slough and South Big Cypress (South of 41). These differences reflect the different hydroperiods associated with ALT-B and F2050 for these regions as illustrated in FBHYHPM1.PDF and the other hydroperiod comparisons.

The spatial dynamics that produce the long-term average results discussed above are illustrated by the seasonal cycle of total fish abundance during October and July and fish availability for wading birds (fish greater than 2 cm in length, in water depths between 10 and 30 cm) for the January through April breeding season. Maps here illustrate these spatial dynamics for an typical rainfall year (1977, figs. FBFI76D1.PDF through FBFI77D5.PDF), a high rainfall year (1969, figs. FBFI68D1.PDF through FBFI69D5.PDF) and a low rainfall year (1990, figs. FBFI89D1.PDF through FBFI90D5.PDF). In the typical rainfall year (1977), ALT-B has consistently higher fish abundances in Shark Slough in October, April and July. However, the fish availability for wading birds in January does not differ in the Central Shark Slough between the scenarios since the predicted water depths are too high for wading bird foraging, and in February, F2050 produces higher fish available to wading birds in the Central Shark Slough since the predicted water depths in ALT-B are still too high while those in F2050 are within the 10 to 30 cm restriction. In a low rainfall year (1990), there is a consistent pattern in which ALT-B has consistently higher fish abundances and availability to wading birds but only in selected areas, particularly in most of WCA1 and the northwestern portions of WCA2A and WCA3A (South). The pattern for a high rainfall year (1969) shows complex spatial changes throughout the year with ALT-B producing generally higher total fish abundances than F2050 in portions of western WCA3A and northeastern WCA3B in October and July. The pattern of fish availability to wading birds in the high rainfall year (1969) shows a complex intermingling of relative positive and negative differences between ALT-B and F2050 through much of the ATLSS model region. No consistent pattern is evident throughout the region during the wading bird breeding season for the high rainfall year (1969).

Tables _BFIBASE.TXT, F_FIBASE.TXT and FBFIDIFF.TXT show a breakdown by subregion of total fish density averaged over each year for ALT-B, F2050 and the difference respectively. These indicate the general pattern of higher fish density for ALT-B relative to F2050 when averaged over the entire modeled region by approximately 25%. This difference is not uniform across all regions. ALT-B average fish density is higher than that predicted for F2050 in most subregions except WCA2B, WCA3A (North), East Slough, South Big Cypress (North of 41) and South Big Cypress (South of 41). The largest positive differences in this mean occur in WCA1, WCA3A (South), WCA3B, Northeast Shark Slough, Shark Slough, and the Eastern Panhandle. In some of the above however, the table comparisons average over significant spatial variations in fish densities within subregions, which is particularly evident in WCA3A North (figs. FBFIMYD1.PDF through FBFIMYD5.PDF) and in the year to year variations in FBFIDIFF.TXT also for WCA3A North.

D-C.3.3.1 Conclusion

The ATLSS fish model predicts that ALT-B water conditions will produce average fish abundances consistently higher than those that would be expected under the F2050 water conditions in most of the modeled region particularly Shark Slough, WCA3B, WCA1, Eastern Panhandle and the northwestern portions of WCA3A South and WCA2A. However, ALT-B provides consistently lower fish densities in WCA2B, the northeastern corner of WCA3A North, East Slough, South Big Cypress (North of 41) and South Big Cypress (South of 41) compared to F2050. In addition to these major differences in abundance patterns in different regions, the spatial pattern of differences in abundance varies somewhat based upon rainfall conditions in the particular year. Temporal patterns of total fish abundance averaged across the entire model region are similar with higher abundances produced by ALT-B. This holds true for both total abundance and fish availability to wading birds when including only fish greater than 2 cm in length in areas of appropriate depths for wading bird foraging.

D-C.3.4 Alternative C vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes ALTC versus F2050 (Revised) on the Fish Prey Base for Wading Birds in South Florida: Output of the ATLSS Fish Model

Figure FCFIAVGD.PDF indicates the same temporal pattern for total fish abundance in both ALT-C and F2050, however the total abundance of fish in the marsh areas in ALT-C is consistently higher by a factor of on average 1.4 than in F2050. This pattern of consistently higher abundances of fish in ALT-C also occurs for fish abundance in the pond areas though the difference is typically less than two percent.

Figures FCFIBRY1.PDF, FCFIBRY2.PDF, FCFIBRY3.PDF and FCFIAVGB.PDF show the time series for fish in marsh during the wading bird breeding season assumed to be available to wading birds (e.g. including fish greater than 2 cm in length in water depths between 10 and 30 cm). The pattern shows consistently higher fish available in ALT-C with essentially similar patterns of abundance in ALT-C and F2050. As shown by figure FCFIAVGB.PDF there is a consistent trend towards increasing numbers of fish available to wading birds as the breeding season progresses for ALTC over F2050. However, at the end of the breeding season, ALT-C has a factor of 1.4 higher numbers of fish available to wading birds than F2050. The differences reach over a factor of 4 higher in ALT-C during some portions of the breeding season for the high rainfall year (1969) with ALT-C having a factor of 3 to 4 times more fish consistently across the average rainfall year (1977). In the low rainfall year (1990) ALT-C provides higher fish abundance to wading birds relative to F2050 by a factor of 3 to 40 with the largest magnitude differences occurring at the end of the breeding season. In the low rainfall year (1990), the results indicate a decreasing trend in fish available to wading birds for both ALT-C and F2050, with F2050 fish densities approaching extremely low levels while ALT-C densities level out at approximately 0.35 fish per meter squared. In the low rainfall year (1990), the within season variation in fish available to wading birds remains relatively consistent across the breeding season for ALT-C relative to that of F2050 which reaches extremely low levels of fish density by the middle of the breeding season.

The pattern of higher fish abundance in ALT-C illustrated by the time series results described above do not occur uniformly across the spatial region being modeled. Five figures (FCFIMYD1.PDF through FCFIMYD5.PDF) show the 31 year (1965-1995) average values of total fish densities spatially across the ATLSS model region. Values shown are means for individual days that span the entire seasonal cycle (Oct 15, Jan 1, Feb 15, April 1, and July 1). These results clearly indicate a consistent pattern across all time periods of higher fish densities in ALT-C versus F2050 in WCA3B, Northeast Shark River Slough, Central Shark Slough, WCA3A (South), WCA1, and the northwestern portion of WCA2A. There are significantly lower predicted total fish densities for ALT-C as compared to F2050 for the boundary between East Slough and South Big Cypress (South of 41), the northeast corner of WCA3A, and WCA2B. There are relatively minor higher fish densities in the Eastern Panhandle and Mullet Slough for ALT-C relative to F2050. These differences reflect the different hydroperiods associated with ALT-C and F2050 for these regions as illustrated in FCHYHPM1.PDF and the other hydroperiod comparisons.

The spatial dynamics that produce the long-term average results discussed above are illustrated by the seasonal cycle of total fish abundance during October and July and fish availability for wading birds (fish greater than 2 cm in length, in water depths between 10 and 30 cm) for the January through April breeding season. Maps here illustrate these spatial dynamics for a typical rainfall year (1977, figs. FCFI76D1.PDF through FCFI77D5.PDF), a high rainfall year (1969, figs. FCFI68D1.PDF through FCFI69D5.PDF) and a low rainfall year (1990, figs. FCFI89D1.PDF through FCFI90D5.PDF). In the typical rainfall year, ALT-C has higher fish abundances in Shark Slough and WCA3A (South) for October, April and July while in January the fish availability for wading birds does not differ in Shark Slough between the scenarios and in February ALT-C has lower fish available for wading birds in parts of these areas since the predicted water depths may be too high for wading bird foraging. In a low rainfall year (1990), ALT-C compared with F2050 has significantly higher fish abundances in the western region of WCA3A (South) in the October, January and February maps and the northwestern region of WCA2A as well as along the boundary between WCA3A (North) and WCA2B for all maps. The pattern for a high rainfall year (1969) shows complex spatial changes throughout the year with ALT-C producing generally higher total fish abundances than F2050 in portions of WCA3B, Shark Slough, Taylor Slough and WCA3A in October and July. The pattern of fish availability to wading birds in 1969 shows a complex intermingling of relative positive and negative differences between ALT-C and F2050 through much of the ATLSS model region. In the northwestern portion of WCA2A in October, January and February, ALT-C produces somewhat higher fish abundances for wading birds than F2050. No consistent pattern is evident throughout the rest of the region during the wading bird breeding season for 1969.

Tables _CFIBASE.TXT, F_FIBASE.TXT and FCFIDIFF.TXT show a breakdown by subregion of total fish density averaged over each year for ALT-C, F2050 and the difference respectively. These indicate the general pattern of higher fish density for ALT-C relative to F2050 in all but 4 of the modeled subregions as measured by the mean over all years. The largest differences in this mean occur in NE Shark Slough, WCA3B, WCA3A South, Shark Slough, Mullet Slough, WCA1 and WCA2A with magnitudes varying from 10% to 120% higher for ALT-C. ALT-C average fish density is lower than that predicted for F2050 in WCA2B, WCA3A (North) East Slough, and South Big Cypress (S 41). The magnitudes of these differences relative to F2050 are smaller however than the positive differences in the other subregions. In some of the above however, the table comparisons average over significant spatial variations in fish densities within subregions, which is particularly evident in WCA3A North (figs. FCFIMYD1.PDF through FCFIMYD5.PDF) and in the year to year variations in FCFIDIFF.TXT also for WCA3A North.

D-C.3.4.1 Conclusion

The ATLSS fish model predicts that ALT-C water conditions will produce average fish abundances consistently higher than those that would be expected under the F2050 water conditions in most of the modeled region particularly Shark Slough, WCA3B, WCA3A South, WCA1 and in WCA2A. However, ALT-C provides consistently lower fish densities in WCA2B, the northeastern corner of WCA3A North, East Slough and South Big Cypress (South of 41) compared to F2050. In addition to these major differences in abundance patterns in different regions, the spatial pattern of differences in abundance varies somewhat based upon rainfall conditions in the particular year. Temporal patterns of total fish abundance averaged across the entire model region are similar with higher abundances produced by ALT-C. This holds true for both total abundance and fish availability to wading birds when including only fish greater than 2 cm in length in areas of appropriate depths for wading bird foraging. Please note as well that the patterns of fish density produced by ALT-C are very similar to ALT-D although there are differences in the actual fish densities.

D-C.3.5 Alternative D vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative D versus F2050 (Revised) on the Fish Prey Base for Wading Birds in South Florida: Output of the ATLSS Fish Model

Figure FDFIAVGD.PDF indicates the same temporal pattern for total fish abundance in both ALT-D and F2050, however the total abundance of fish in the marsh areas in ALT-D is consistently higher by a factor of on average 1.5 than in F2050. This pattern of consistently higher abundances of fish in ALT-D also occurs for fish abundance in the pond areas though the difference is typically less than two percent.

Figures FDFIBRY1.PDF, FDFIBRY2.PDF, FDFIBRY3.PDF and FDFIAVGB.PDF show the time series for fish in marsh during the wading bird breeding season assumed to be available to wading birds (e.g. including fish greater than 2 cm in length in water depths between 10 and 30 cm). The pattern shows consistently higher fish available in ALT-D with essentially similar patterns of abundance in ALT-D and F2050. As shown by figure FDFIAVGB.PDF there is a consistent trend towards increasing numbers of fish available to wading birds as the breeding season progresses for ALT-D over F2050. However, at the end of the breeding season, ALT-D has a factor of 1.5 higher numbers of fish available to wading birds than F2050. The differences reach over a factor of 4 higher in ALT-D during some portions of the breeding season for the high rainfall year (1969) with ALT-D having a factor of 3 to 10 times more fish in the average rainfall year (1977) and the low rainfall year (1990). In the low rainfall year (1990), the results indicate a decreasing trend in fish available to wading birds for both ALT-D and F2050, with F2050 fish densities approaching extremely low levels while ALT-D densities level out at approximately 0.3 fish per meter squared. In the low rainfall year (1990), the within season variation in fish available to wading birds remains relatively consistent across the breeding season for ALT-D relative to that of F2050 which reaches extremely low levels of fish density by the middle of the breeding season.

The pattern of higher fish abundance in ALT-D illustrated by the time series results described above does not occur uniformly across the spatial region being modeled. Five figures (FDFIMYD1.PDF through FDFIMYD5.PDF) show the 31 year (1965-1995) average values of total fish densities spatially across the ATLSS model region. Values shown are means for individual days that span the entire seasonal cycle (Oct 15, Jan 1, Feb 15, April 1, and July 1). These results clearly indicate a consistent pattern across all time periods of higher fish densities in ALT-D versus F2050 in WCA3B, Northeast Shark River Slough, Central Shark Slough, WCA3A (South), WCA1, Mullet Slough, and the northwestern portion of WCA2A. There are significantly lower predicted total fish densities for ALT-D as compared to F2050 for the boundary between East Slough and South Big Cypress (South of 41), the northeast corner of WCA3A, and WCA2B. There are relatively minor higher fish densities in the Eastern Panhandle for ALT-D relative to F2050. These differences reflect the different hydroperiods associated with ALT-D and F2050 for these regions as illustrated in FDHYHPM1.PDF and the other hydroperiod comparisons.

The spatial dynamics that produce the long-term average results discussed above are illustrated by the seasonal cycle of total fish abundance during October and July and fish availability for wading birds (fish greater than 2 cm in length, in water depths between 10 and 30 cm) for the January through April breeding season. Maps here illustrate these spatial dynamics for a typical rainfall year (1977, figs. FDFI76D1.PDF through FDFI77D5.PDF), a high rainfall year (1969, figs. FDFI68D1.PDF through FDFI69D5.PDF) and a low rainfall year (1990, figs. FDFI89D1.PDF through FDFI90D5.PDF). In the typical rainfall year, ALT-D has consistently higher fish abundances in Shark Slough and WCA3A (South) for all dates with the exception that the fish availability for wading birds in January (and somewhat in February) does not differ in Shark Slough between the scenarios since the predicted water depths are too high for wading bird foraging. In a low rainfall year (1990), the western region of WCA3A (South) and the northwestern region of WCA2A are significantly higher in the October, January and February maps for ALT-D compared with F2050. The pattern for a high rainfall year (1969) shows complex spatial changes throughout the year with ALT-D producing generally higher total fish abundances than F2050 in WCA3B and portions of Shark Slough, Taylor Slough and WCA3A in October and July. In addition, ALT-D produces lower numbers of fish compared to F2050 throughout the year in the northeastern portion of WCA3A (North). The pattern of fish availability to wading birds in 1969 shows a complex intermingling of relative positive and negative differences between ALT-D and F2050 through much of the ATLSS model region. In the northwestern portion of WCA2A in October, January and February, ALT-D produces somewhat higher fish abundances for wading birds than F2050. No consistent pattern is evident throughout the rest of the region during the wading bird breeding season for 1969.

Tables _DFIBASE.TXT, F_FIBASE.TXT and FDFIDIFF.TXT show a breakdown by subregion of total fish density averaged over each year for ALT-D, F2050 and the difference respectively. These indicate the general pattern of higher fish density for ALT-D relative to F2050 in all but 4 of the modeled subregions as measured by the mean over all years. The largest differences in this mean occur in NE Shark Slough, WCA3B, WCA3A South, Shark Slough, Mullet Slough, WCA1 and WCA2A with magnitudes varying from 10% to 120% higher for ALT-D. ALT-D average fish density is lower than that predicted for F2050 in WCA2B, WCA3A (North) East Slough, and South Big Cypress (S 41). The magnitudes of these differences relative to F2050 are smaller however than the positive differences in the other subregions. In some of the above however, the table comparisons average over significant spatial variations in fish densities within subregions, which is particularly evident in WCA3A North (figs. FDFIMYD1.PDF through FDFIMYD5.PDF) and in the year to year variations in FDFIDIFF.TXT also for WCA3A North.

D-C.3.5.1 Conclusion

The ATLSS fish model predicts that ALT-D water conditions will produce average fish abundances consistently higher than those that would be expected under the F2050 water conditions in most of the modeled region particularly Shark Slough, WCA3B, WCA3A South, WCA1 and in WCA2A. However, ALT-D provides consistently lower fish densities in WCA2B, the northeastern corner of WCA3A North, East Slough and South Big Cypress (South of 41) compared to F2050. In addition to these major differences in abundance patterns in different regions, the spatial pattern of differences in abundance varies somewhat based upon rainfall conditions in the particular year. Temporal patterns of total fish abundance averaged across the entire model region are similar with higher abundances produced by ALT-D. This holds true for both total abundance and fish availability to wading birds when including only fish greater than 2 cm in length in areas of appropriate depths for wading bird foraging.

D-C.4 WADING BIRD BREEDING POTENTIAL INDEX

Wading Bird Foraging Conditions Index
Basic Model Description

Michael Huston, John Curnutt and Jane Comiskey
The Institute for Environmental Modeling
University of Tennessee
Knoxville, TN 37996-1610

D-C.4.1 Introduction

Through the 1960's, the Everglades served as a major breeding center for wading birds in the eastern United States. Over the past several decades, wading bird reproduction has declined dramatically, although the area is still an important feeding ground (Robertson and Frederick 1994). Numerous theories have been offered to explain the decline, including reduction in extent of habitat, reduced prey availability, alteration of drying rates, loss of peripheral short-hydroperiod wetlands, increase in frequency of drydowns, mercury toxicity, effects of eutrophication, shift in migratory patterns, and changes in storm frequency (summarized in Fleming, Wolff, and DeAngelis 1994).

Changing water management strategies for south Florida, which have coincided with decreases in colonial wading bird populations, affect many of the processes implicated in these declines. As part of the Central and Southern Florida Comprehensive Study Review (Restudy), the ecological impacts of a series of proposed alternative water management regimes will be evaluated. Each scenario will affect potential breeding activity of wading birds across the landscape.

The ATLSS Wading Bird Breeding Potential Index uses knowledge of how hydrologic factors affect the concentration and availability of food resources during the breeding season to compute a Breeding Potential Index (BPI) for wading birds. ATLSS expresses the effects of proposed scenarios as changes in the spatial pattern of breeding potential over the model area. The ATLSS sub-area reporting units are based on a combination of public area, drainage basin, and management unit subregion maps (see REPUNITS.PDF).

D-C.4.2 Methods

For most wading bird species, small freshwater fish and invertebrates are the primary food brought back to rookeries to feed young birds. Both the amount and timing of prey availability are critical to breeding success during any specific nesting season. SFWMM restoration scenario hydrology output is used to make spatially explicit estimates of surface area with water in the depth range needed for successful feeding for the group-foraging species (10-30 cm covers the range used by species such as ibis and wood storks).

The wading bird breeding cycle consists of courtship, nest-building/ breeding, incubation, feeding, and fledging. A breeding cycle is not initiated unless hydrologic conditions are appropriate. After nesting and feeding have been initiated, successful fledging will not occur unless adequate food is available over the period required for young to attain critical growth. The Breeding Potential Index focuses on food availability during the period from hatching to fledging, when young birds must be fed continuously. If the food supply is interrupted during this period, the young may starve, and most nesting efforts fail to produce fledglings. Such interruptions can occur if water levels fall too rapidly, stranding and killing the fish, or if water levels rise above the optimal depth range, which disperses the high concentrations of fish needed for efficient feeding. The critical feeding period ranges from 45 days for white ibises, snowy egrets, and small herons, to 80 days for wood storks (references in Frederick and Powell 1994, Bancroft et al. 1994).

ATLSS computes the daily average area of water in the optimal depth range (10-30 cm) over 3-day periods for subregions of the model area. If this average area in a subregion decreases by 30% or more from one averaging period to the next, the current nesting cycle is considered a failure, and calculations for a new nesting cycle are initiated. These calculations are made over the period from December 15 to May 15, which contains a maximum of 3 nesting cycles of 45 days each. The Breeding Potential Index is computed as the number of successful breeding cycles, scaled by the maximum potential number of breeding cycles. This calculation is performed for each subregion within the area covered by the SFWMM.

The Wading Bird BPI model is being run on SFWMM calibration/validation data for 1979--1995, and index values for subregions are being compared to reported densities for wading birds for those years (Bancroft et al. 1994, Cramer et al. 1997) to determine optimal settings for cycle length, subregion proportions, and temporal averaging period. A number of related indices and metrics, including cell by cell counts of successful cycles, relative distribution of ponding depth classes in the early dry season, drying rates, and productivity estimates, are initially being computed to aid in calibration and refinement of the model and in interpretation of index values.

The Wading Bird BPI is a composite index of spatial and temporal patterns. Spatial patterns will be computed based on ATLSS High Resolution Hydrology (28.5 x 28.5 meter units). This resolution captures the fine-scale spatial structure of the South Florida wetlands that creates the shallow depressions and ponding areas that are critical for wading bird feeding. However, because the index is based on a spatial average over landscape subregions, index values are reported for the larger spatial areas over which the mean is computed.

Output associated with the ATLSS Wading Bird Breeding Potential Index Model.

In accordance with ATLSS file naming conventions, each file name will consist of the characters:

"X" or "_" => the Base, typically F for the F2050 base or E for the C1995 base
"X" or "_" => the alternative scenario or base
"BD" => the ATLSS Wading Bird Breeding Potential Index Model
"XXXX" => 4 character mnemonic

"."
"PDF" or "TXT" or "DOC" => PDF, tabular text or documentation

ATLSS Wading Bird Breeding Potential Index

1. Maps

Map outputs used to characterize results of the Wading Bird component of the ATLSS Breeding Potential Index Model will consist of eight image files in PDF file format. Each map shows a "Set" of model results, comparing a Base case to a Scenario, following the conventions for ATLSS comparison of two model runs. Each map has 3 panels. The left panel is an alternative or base scenario. The right panel is the base scenario, typically the Future without Project Conditions Case. The middle panel is the difference between the two scenarios.

Each map depicts the model area at either a Fine (500-meter x 500-meter) or Coarse (2 mile) scale of resolution, with each cell color coded to represent either the value of the breeding potential index or the difference between the breeding potential index in the alternative or base scenario and the base scenario.

For each of a list of years, the images will provide a spatial display of breeding potential values during that year. In addition, there is an image file for the mean of all simulated years. The list of years includes years with high, low, and typical rainfall, and several years that serve to highlight the differences between the scenarios.

The mnemonic characters are composed according to the convention:

"XX" = Last two digits of the year

"XX" = CR - Coarse (2 mile) resolution, FR - Fine (500 meter) resolution

Listing of ATLSS Wading Bird Breeding Potential Index map files:

File Name	Time Period
XXBW69XX.PDF	A High Rainfall Year (1969)
XXBW70XX.PDF	Highlight Scenarios (1970)
XXBW77XX.PDF	A Typical Rainfall Year (1977)
XXBW83XX.PDF	Highlight Scenarios (1983)
XXBW90XX.PDF	A Low Rainfall Year (1990)
XXBW95XX.PDF	Highlight Scenarios (1995)
XXBWMYXX.PDF	Mean of All Years (1965->1995)

2. Time Series None

3. Histograms None

4. Tables

The tables associated with the ATLSS Wading Bird Breeding Potential Index Model will display the breeding indices by subregions and years. The tables will also be at either a 500 meter (FR = Fine Resolution) or 2 mile (CR = Coarse Resolution) scale as indicated by the file name.

File Name	Description
X_BWBAXX.TXT	Breeding index listed by subregions and years for the indicated base scenario.
_XBWALXX.TXT	Breeding index listed by subregions and years for the indicated alternative scenario.
XXBWDIXX.TXT	The difference of the breeding indices listed by subregions and years between the alternative and base scenarios.

D-C.4.3 F2050 (Revised) vs. C1995 (Revised)

Assessment of the Effects of Proposed Water Regimes F2050 (Revised) vs. C1995 (Revised) on Foraging Conditions for Wading Birds in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of two hydrological scenarios some regions of the model area will show changes favorable to wading bird foraging for a given year, while other regions for the same year will reflect a deterioration of conditions. The spatial and temporal dynamics of rookery formation involve the interplay of many factors and are not well understood; therefore, it is difficult to ascertain the effects of predicted foraging potentials on breeding activity. For example, suitable wading bird rookery sites are not distributed uniformly across the South Florida landscape, so a direct comparison of the magnitude of suitable foraging area available under alternative scenarios would be misleading. Therefore, we will interpret the current results the same way we have in the past, by limiting our discussion to areas where most birds have traditionally nested. Those areas are: (1) along the eastern part of WCA-3A, WCA-3B, and Northeast Shark River Slough (hereafter referred to as Northeastern Rookeries); and (2) the transition zone between Shark River Slough and the mangrove estuaries (hereafter referred to as the Southwestern Rookeries) (WBROOKS_.PDF).

D-C.4.3.1 Foraging Conditions Indices Results for Short-legged Wading Birds

Figure FEWSMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for short-legged wading birds across the model area. As indicated in the central panel of this set of three maps, C1995 produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FEWSMYFR.PDF) for most of WCA-2A, all of WCA2-B, most of WCA3-B, and most of the potential wading bird foraging habitat east of Shark Slough. For the areas including Northeastern rookeries (WCA-3A, WCA-3B, and Northeast Shark Slough), F-2050 results show slightly higher FCI's in the south while C1995 shows higher values for the north (including nearly all of WCA-3A). For the areas encompassing the Southwestern Rookeries, C1995 produces higher FCI values over most of the area relative to F2050, with the exception of the main Shark Slough drainage and lower Taylor Slough, where F2050 produces higher values.

The long-term average discussed above differs from predicted conditions during a "typical" year (1977, Fig. FEWS77FR.PDF), in that FCI values under the two scenarios are virtually the same across much of the area encompassing the Southwestern Rookeries, again with the exception of the main Shark River Slough drainage, where F2050 produces higher FCI's. In all other areas, the results for a typical year correspond with the 31-year mean.

During a high rainfall year (1969, Fig. FEWS69FR.PDF, which was not an exceptionally high water year), the F2050 scenario is superior to or equivalent to the C1995 scenario in terms of the wading bird feeding conditions throughout the area encompassing the Northeastern Rookeries (gray and blue colors in the central panel of Fig. FEWS69FR.PDF). This is especially pronounced in WCA-3A where foraging is precluded under C1995 while F2050 provides a range of FCI values. For the Southwestern Rookeries, Shark River Slough and southern Big Cypress produce higher FCI's under C1995 relative to F2050, while the East Slough shows higher values under F2050.

For 1983, a year of relatively high water, the pattern of FCI's are similar to those of 1969 (Fig. FEWS83FR.PDF). The higher water levels lead to a spatial constriction of potential foraging, including the loss of Shark River Slough as a foraging area under both scenarios. This leaves the area of the Southwestern Rookeries with higher FCI's under F2050 relative to C1995, although the extent of the areas that show a difference is negligible. For the Northeastern Rookeries, results of the two scenarios for 1983 are similar to those reported above for 1969, with a minor decrease in the spatial extent of potential foraging areas.

Under extremely high surface water conditions (1970 and 1995, Figs. FEWS70FR.PDF and FEWS70FR.PDF), foraging conditions are similar for both scenarios in the Water Conservation Areas and in northeast Shark Slough (i.e., unsuitable), but C1995 results in a higher FCI in small parts of the regions containing the Southwestern Rookeries and in North Taylor Slough, which may fall outside the range of the traditional foraging areas for the Northeastern Rookeries.

In the dry year of 1990 (Fig. FEWS90FR.PDF), F2050 and C1995 produce similar foraging conditions across the model area. FCI values are low for the Southwest Rookeries area and generally higher for the area encompassing the Northeastern Rookeries, where FCI values are slightly higher under C1995.

D-C.4.3.2 Foraging Conditions Indices Results for Long-legged Wading Birds

Figure FEWLMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for long-legged wading birds across the model area. As indicated in the central panel of this set of three maps, C1995 produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FEWLMYFR.PDF) for WCA1, WCA2-A, WCA2-B, WCA3-B and Northeast Shark River Slough. Conversely, F2050 results in a higher FCI for the greater part of WCA3-A. Thus, although one scenario does not result in higher FCI's for the entire area encompassing the Northeastern Rookeries, C1995 does so for the greater part of the area. For the areas encompassing the Southwestern Rookeries sites, F2050 produces slightly higher FCI,s throughout.

For a typical rainfall year (1977, Figure FEWL77FR.PDF) FCI results are similar across most of the model area under the two scenarios. The slight differences that do exist follow the same pattern as described above for the 31-year mean.

During a high rainfall year (1969, Fig. FEWL69FR.PDF, which was not an exceptionally high water year), the most significant differences between the scenarios are in WCA3-A (higher FCI's under F2050) and in southern WCA2-A (higher FCI's under C1995). Northeast Shark River Slough also shows higher FCI's under C1995. Thus, among the areas encompassing the Northeastern Rookeries, there is no clear advantage to either scenario in terms of FCI values. Much the same can be said for the area that includes the Southwestern Rookeries, although here F2050 produces slightly higher FCI's relative to C1995 in East Slough and southern Big Cypress.

For 1983, a relatively high water year, the primary difference between the two scenarios is the retention and consequent deeper water in WCA3-A under C1995 versus the lower WCA3-A water levels and consequent higher levels in

Shark River Slough (Fig. FEWL83FR.PDF). As with the results for 1969, the effects of these scenarios on the Northeastern Rookeries are mixed. For the Southwestern Rookeries, the predominant effect is higher FCI's in Shark River Slough under C1995.

Under high surface water conditions (1970, Fig. FEWL70FR.PDF), foraging conditions are unsuitable across the greater part of the area encompassing the Northeastern Rookeries under both F2050 and C1995. The differences that do exist between the scenarios are minor in extent and magnitude. Throughout the area encompassing the Southwestern Rookeries foraging conditions are suitable, except in the heart of Shark River Slough, under both scenarios. C1995 provides higher FCI's relative to F2050 over a restricted area near the Shark River Slough/mangrove interface. The same patterns are evident for 1995, an extremely high surface water year, except that foraging is even more restricted and under both scenarios the Shark River Slough/mangrove interface is unsuitable for foraging.

In the dry year of 1990 (Fig. FEWS90FR.PDF), long-legged wading bird foraging is restricted primarily to the WCA's and Shark River Slough under both F2050 and C1995. There is virtually no difference between the FCI's produced by the two scenarios in areas associated with the Southwestern Rookeries. Only slight differences occur in the Northeastern Rookeries area, and these can be attributed to higher FCI's under C1995.

D-C.4.3.3 Conclusion

For the area encompassing the Northeastern Rookeries, C1995 generally produces higher FCI's relative to F2050 under dry to "typical" conditions for both short-legged and long-legged wading birds. Under high rainfall and moderately high water conditions, F2050 produces higher FCI's relative to C1995 over parts of the area, most notably in WCA3-A. However, no one scenario dominates in higher FCI values. Under extreme high water conditions, neither scenario provides suitable foraging conditions over even a small fraction of the area.

For the area encompassing the Southwestern Rookeries, there is very little difference in the FCI values produced by C1995 and F2050 under dry conditions for both short-legged and long-legged wading birds. Under both scenarios, the extent of suitable foraging is restricted for long-legged wading birds. During "typical" and high rainfall, C1995 produces higher FCI values for short-legged birds, especially in Shark River Slough. Conversely, F2050 produces higher FCI values under these hydrologic conditions for long-legged wading birds. Under moderately high and high surface water conditions, C1995 produces higher FCI values relative to F2050 for both long- and short-legged wading birds. Under extremely high water conditions, short-legged wading bird foraging is significantly curtailed under both scenarios, but C1995 produces higher FCI values over a very small area. Long-legged birds, under these extremely high surface water conditions, do not experience the same magnitude of foraging area contraction. For these birds, there is virtually no difference between the FCI values produced under F2050 and C1995.

D-C.4.4 Alternative A vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative A versus F2050 (Revised) on Foraging Conditions for Wading Birds in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of an alternative scenario with those of the F2050 base scenario some regions of the model area will show changes favorable to wading bird foraging for a given year, while other regions for the same year will reflect a deterioration of conditions. The spatial and temporal dynamics of rookery formation involve the interplay of many factors and are not well understood; therefore, it is difficult to ascertain the effects of predicted foraging potentials on breeding activity. For example, suitable wading bird rookery sites are not distributed uniformly across the South Florida landscape, so a direct comparison of the magnitude of suitable foraging area available under alternative scenarios would be misleading. Therefore, we will interpret the current results the same way we did in the past, by limiting our discussion to areas where most birds have traditionally nested. Those areas are: (1) along the eastern part of WCA-3A, WCA-3B, and Northeast Shark River Slough and (hereafter referred to as Northeastern Rookeries); and (2) the transition zone between Shark River Slough and the mangrove estuaries (hereafter referred to as the Southwestern Rookeries) (WBROOKS_.PDF).

D-C.4.4.1 Foraging Conditions Indices Results for Short-legged Wading Birds

Figure FAWSMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for short-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative A produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FAWSMYFR.PDF) for the southern half of WCA-2A, eastern and northern WCA-3A, northern WCA-3B, and the prairies from Shark River Slough to the Eastern Panhandle. Alternative A produces significantly higher FCI values, relative to F2050, for far northern WCA-3B and a small area east of WCA-3A. For the area encompassing the Northeastern rookeries (WCA-3A, WCA-3B, and Northeast Shark Slough), F2050 results show slightly higher mean FCI's from middle WCA-3B south to Northeast Shark River Slough. For the areas encompassing the Southwestern Rookeries, F2050 produces higher FCI values over most of the area relative to Alternative A, with the above noted exception of the southern wetlands east of Shark River Slough, where Alternative A produces higher values.

The long-term average discussed above differs from predicted conditions during a "typical" year (1977, Fig. FAWS77FR.PDF), in that FCI values under the two scenarios are virtually the same across much of the area encompassing the Southwestern Rookeries. For the Northeastern Rookeries, Alternative A produces higher or equivalent FCI values over all but Northeast Shark Slough, including significantly higher values in northern WCA-3B and east of the WCA's.

In the dry year of 1990 (Fig. FAWS90FR.PDF), where differences exist between the two scenarios, Alternative A clearly produces higher or equivalent FCI values relative to F2050 in most cases, including the areas encompassing the Northeastern and Southwestern Rookeries.

During a high rainfall year (1969, Fig. FAWS69FR.PDF, which was not an exceptionally high water year), the F2050 scenario provides higher FCI values across most of the model area relative to Alternative A (gray and blue colors in the central panel of Fig. FAWS69FR.PDF). This is especially pronounced in most of WCA-3B, where foraging is precluded under Alternative A while F2050 provides a range of FCI values. For the Northeastern Rookeries the exceptions to the above are two small areas east of the WCA's, a strip of land in far northeastern WCA-3A south, and the northern tip of WCA-3B. For the Southwestern Rookeries, F2050 allows for foraging conditions across a greater extent of Shark River Slough relative to Alternative A, while Alternative A produces slightly higher FCI values relative to F2050 in and around southern Big Cypress. Otherwise, the two scenarios provide equivalent values in the area encompassing the Southwestern Rookeries.

For 1983, a year of relatively high water (Fig. FAWS83FR.PDF), there is a spatial constriction of potential foraging, including the loss of Shark River Slough and southern WCA-3A as a foraging area under both scenarios. The northern part of the Southwestern Rookeries experiences higher FCI values under Alternative A, relative to F2050, solely due to the effect on southern Big Cypress. Across the remaining area of the Southwestern Rookeries, the FCI values produced under the two scenarios are equivalent or slightly higher under F2050. For the Northeastern Rookeries, foraging is greatly reduced under these high water conditions. Alternative A provides low values for the eastern edge of WCA-3A, but in the remaining suitable foraging sites F2050 allows for higher FCI values.

Under extremely high surface water conditions (1970 and 1995, Figs. FAWS70FR.PDF and FAWS95FR.PDF), predicted foraging conditions are similar for both scenarios in the Water Conservation Areas and in northeast Shark Slough (i.e., unsuitable). For the Northeastern Rookeries, F2050 provides a greater spatial extent of suitable foraging relative to Alternative A, although even this advantage is so restricted as to be inconsequential. For the Southwestern Rookeries, F2050 provides higher FCI values in East Slough for the 1970 model year, while to the north Alternative A provides higher or equivalent values. In 1995, the wettest year of record, Alternative A produces higher or equivalent FCI values, relative to F2050, throughout the Southwestern Rookeries area.

D-C.4.4.2 Foraging Conditions Indices Results for Long-legged Wading Birds

Figure FAWLMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for long-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative A produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FAWLMYFR.PDF) for all regions except eastern WCA-3B, southern Big Cypress, Northeast Shark River Slough, the main drainage of Shark River Slough and the Eastern Panhandle. In these areas F2050 results in a higher FCI values. Thus, for the area encompassing the Northeastern Rookeries, Alternative A generally produces higher FCI values relative to F2050. For the areas encompassing the Southwestern Rookeries, neither scenario produces higher FCI values throughout.

For a "typical" rainfall year (1977, Fig. FAWL77FR.PDF), FCI values are similar for both scenarios across most of the model area. For the area encompassing the Northeastern Rookeries, Alternative A produces higher or equivalent values throughout, except for the northeast corner of Northeast Shark Slough and a scattering of sites in eastern WCA-3A. For the Southwestern Rookeries, there is virtually no difference between scenarios in terms of FCI values produced.

For a dry year, (1990 Fig. FAWL90FR.PDF) the spatial extent of suitable foraging conditions for long-legged wading birds is constricted under both scenarios. Alternative A, however, produces higher FCI values relative to F2050 at nearly every location for which a difference exists between the scenarios. Therefore, Alternative A is clearly more conducive to wading bird foraging in both rookery areas relative to F2050.

During a high rainfall year (1969, Fig. FAWL69FR.PDF, which was not an exceptionally high water year), the primary difference between the two scenarios lies in southern WCA-3B and Northeast Shark Slough. Here, suitable foraging conditions are precluded under Alternative A but not under F2050. Even though Alternative A does produce higher FCI values, relative to F2050, in northern WCA-3B and along the eastern edge of WCA-3A, the greater spatial extent of foraging under F2050 suggests that this scenario is more favorable to the Northeastern Rookeries. The same can be said for the Southwestern Rookeries, where Alternative A provides slightly higher FCI values, relative to Alternative A, only in south Big Cypress.

During a relatively high water year (1983, Fig. FAWL83FR.PDF), the main channel of Shark River Slough is unsuitable for long-legged wading bird foraging under both scenarios. The differences that exist between the scenarios are minor. For the Northeastern Rookeries, Alternative A produces higher FCI values, relative to F2050, over a slightly greater area. For the Southwestern Rookeries, F2050 produces slightly higher values. The limited extent of the differences between the two scenarios under these hydrologic conditions are minor in spatial extent and magnitude.

Under high surface water conditions (1970 and 1995, Figs. FAWL70FR.PDF and FAWL95FR.PDF), foraging conditions are unsuitable across the greater part of the area encompassing the Northeastern Rookeries under both F2050 and Alternative A. Alternative A, however, does produce higher FCI values, relative to F2050, except along the eastern edge of WCA-3B and southern Northeast Shark Slough. Throughout the area encompassing the Southwestern Rookeries, foraging conditions are suitable, except in the heart of Shark River Slough, under both scenarios. F2050 provides higher FCI's relative to Alternative A in the area of the Shark River Slough/mangrove interface.

D-C.4.4.3 Conclusion

For the area encompassing the Northeastern Rookeries, Alternative A generally produces higher FCI's relative to F2050 under dry to "typical" conditions for both short-legged and long-legged wading birds. With increasing water depth, F2050 produces higher FCI values over an increasing proportion of the area, first for short-legged wading birds and then for long-legged birds. However, no one scenario dominates in higher FCI values. Under extreme high water conditions, neither scenario provides suitable foraging conditions over even a small fraction of the area.

For the area encompassing the Southwestern Rookeries, Alternative A produces higher FCI values relative to F2050 under dry conditions for both short-legged and long-legged wading birds. Under both scenarios, the extent of suitable foraging is restricted for long-legged wading birds in the driest years. During "typical" and high rainfall years, the differences between the scenarios are minor. Under extremely high water conditions, short-legged wading bird foraging is significantly curtailed under both scenarios. Alternative A produces higher FCI values over a very small area and F2050 produces slightly higher values over a slightly greater area. Under extremely high surface water conditions, long-legged birds do not experience the same magnitude of foraging area contraction. For these birds, there is only a slight difference between FCI values produced under the two scenarios, with F2050 producing higher values relative to Alternative A.

D-C.4.5 Alternative B vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative B versus F2050 on Foraging Conditions for Wading Birds in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of an alternative scenario with those of the F2050 base scenario some regions of the model area will show changes favorable to wading bird foraging for a given year, while other regions for the same year will reflect a deterioration of conditions. The spatial and temporal dynamics of rookery formation involve the interplay of many factors and are not well understood; therefore, it is difficult to ascertain the effects of predicted foraging potentials on breeding activity. For example, suitable wading bird rookery sites are not distributed uniformly across the South Florida landscape, so a direct comparison of the magnitude of suitable foraging area available under alternative scenarios would be misleading. Therefore, we will interpret the current results the same way we did in the past, by limiting our discussion to areas where most birds have traditionally nested. Those areas are: (1) along the eastern part of WCA-3A, WCA-3B, and Northeast Shark River Slough and (hereafter referred to as Northeastern Rookeries); and (2) the transition zone between Shark River Slough and the mangrove estuaries (hereafter referred to as the Southwestern Rookeries) (WBROOKS_.PDF).

D-C.4.5.1 Foraging Conditions Indices Results for Short-legged Wading Birds

Figure FBWSMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for short-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative B produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FBWSMYFR.PDF) for most of WCA-2A, all of WCA-2B, northern and southern WCA-3A and most of the potential wading bird foraging habitat east of Shark Slough. Alternative B also produces higher FCI values east of WCA-3A and B. For the areas including Northeastern rookeries (WCA-3A, WCA-3B, and Northeast Shark Slough), F2050 results show slightly higher mean FCI's in WCA-3B and Northeast Shark River Slough, however, Alternative B shows higher values in potential foraging habitat east of the WCA's. For the areas encompassing the Southwestern Rookeries, F2050 produces higher FCI values over most of the area relative to Alternative B, with the above noted exception of the southern wetlands east of Shark River Slough, where Alternative B produces higher values.

The long-term average discussed above differs from predicted conditions during a "typical" year (1977, Fig. FBWS77FR.PDF), in that FCI values under the two scenarios are virtually the same across much of the area encompassing the

Southwestern Rookeries. For the Northeastern Rookeries, the same pattern can be seen in the "typical" year as described for the 31-year mean, however, differences between the two scenarios are more accentuated.

In the dry year of 1990 (Fig. FBWS90FR.PDF), foraging conditions are suitable across much of the landscape under both scenarios. Alternative B, however, produces higher or equivalent FCI values relative to F2050 throughout the areas encompassing the Northeastern and Southwestern Rookeries.

During a high rainfall year (1969, Fig. FBWS69FR.PDF, which was not an exceptionally high water year), the F2050 scenario provides higher FCI values across most of the model area relative to Alternative B (gray and blue colors in the central panel of Fig. FBWS69FR.PDF). This is especially pronounced in central WCA-3A and all of WCA-3B, where foraging is precluded under Alternative B while F2050 provides a range of FCI values. For the Northeastern Rookeries the exceptions to the above are two small areas east of the WCAs, a strip of land in far eastern WCA-3A, and the northern edge of WCA-2B. For the Southwestern Rookeries, F2050 allows for foraging conditions across a greater extent of Shark River Slough relative to Alternative B while Alternative B produces slightly higher FCI values relative to F2050 in and around East Slough. Otherwise, the two scenarios provide equivalent values in the area encompassing the Southwestern Rookeries.

For 1983, a year of relatively high water (Fig. FBWS83FR.PDF), there is a spatial constriction of potential foraging, including the loss of Shark River Slough as a foraging area under both scenarios. The northern part of the Southwestern Rookeries experiences higher FCI values under Alternative B, relative to F2050, solely due to the effect on East Slough. Across the remaining area of the Southwestern Rookeries the FCI values produced under the two scenarios are equivalent or slightly higher under F2050. For the Northeastern Rookeries, foraging is greatly reduced under these high water conditions. Alternative B provides low values for the eastern edge of WCA-3A, but in the remaining suitable foraging sites F2050 allows for higher FCI values.

Under extremely high surface water conditions (1970 and 1995, Figs. FBWS70FR.PDF and FBWS95FR.PDF) foraging conditions are similar for both scenarios in the Water Conservation Areas and in northeast Shark Slough (i.e., unsuitable). For the Northeastern Rookeries, F2050 provides a greater spatial extent of suitable foraging relative to Alternative D, although even this is so restricted as to be inconsequential. For the Southwestern Rookeries, F2050 provides slightly higher FCI values along the southern edge of the model area, while to the north Alternative B does so, especially in 1995, the wettest year of record.

D-C.4.5.2 Foraging Conditions Indices Results for Long-legged Wading Birds

Figure FBWLMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for long-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative B produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FBWLMYFR.PDF) for all regions except eastern WCA-3A, East Slough/ Big Cypress, and from WCA-3B through Northeast Shark River Slough and the main drainage of Shark River Slough. In these areas F2050 results in a higher FCI values. Thus, neither scenario results in higher FCI's for the entire area encompassing the Northeastern Rookeries. The same can be said for the areas encompassing the Southwestern Rookeries sites.

For dry and typical rainfall years (1990 and 1977, respectively, Figures FBWL90FR.PDF and FBWL77FR.PDF) Alternative B produces higher FCI values relative to F2050 except in Northeast Shark River Slough (only in typical rainfall year) and eastern WCA-3A (only in typical rainfall year), here F2050 produces higher FCI values. Under dry conditions, Alternative B produces higher or equivalent FCI values, relative to F2050, for both the Southwestern and Northeastern rookery areas. Under "typical' rainfall conditions, the differences between the two scenarios for the Southwestern Rookeries area is insignificant and for the Northeastern Rookeries both scenarios produce higher FCI values relative to one another for different parts of the area.

During a high rainfall year (1969, Fig. FBWL69FR.PDF, which was not an exceptionally high water year) and a relatively high water year (1983, Fig. FBWL83FR.PDF), F2050 provides higher FCI values relative to Alternative B in central WCA-3A, all of WCA-3B and Northeast Shark River Slough. Although Alternative B provides higher FCI values for a small area along the eastern edges of WCA-3A and B, the area encompassing the Northeastern Rookeries experiences overall higher FCI's under F2050. For the area that includes the Southwestern Rookeries, the two scenarios produce very similar results; where differences do exist, however, F2050 produces slightly higher FCI values relative to Alternative B across most of the area.

Under high surface water conditions (1970 and 1995, Figs. FBWL70FR.PDF and FBWL95FR.PDF), foraging conditions are unsuitable across the greater part of the area encompassing the Northeastern Rookeries under both F2050 and Alternative B. The differences that do exist between the scenarios are minor in extent. Throughout the area encompassing the Southwestern Rookeries, foraging conditions are suitable, except in the heart of Shark River Slough, under both scenarios. F2050 provides higher FCI's relative to Alternative B in the area of the Shark River Slough/mangrove interface.

D-C.4.5.3 Conclusion

For the area encompassing the Northeastern Rookeries, Alternative B generally produces higher FCI's relative to F2050 under dry to "typical" conditions for both short-legged and long-legged wading birds. Under high rainfall and moderately high water conditions, F2050 produces higher FCI's relative to Alternative B over parts of the area, most notably in WCA-3A. However, no one scenario dominates in higher FCI values. Under extreme high water conditions, neither scenario provides suitable foraging conditions over even a small fraction of the area.

For the area encompassing the Southwestern Rookeries, Alternative B produces higher FCI values relative to F2050 under dry conditions for both short-legged and long-legged wading birds. Under both scenarios, the extent of suitable foraging is restricted for long-legged wading birds in the driest years. During "typical" and high rainfall, the differences between the scenarios are less apparent than under drier conditions. Under extremely high water conditions, short-legged wading bird foraging is significantly curtailed under both scenarios. Alternative B produces higher FCI values over a very small area and F2050 produces slightly higher values over a slightly greater area. Under extremely high surface water conditions, long-legged birds do not experience the same magnitude of foraging area contraction. For these birds, there is only a slight difference between FCI values produced under the two scenarios, with F2050 producing higher values relative to Alternative B.

D-C.4.6 Alternative C vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative C versus F2050 (Revised) on Foraging Conditions for Wading Birds in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of an alternative scenario with those of the F2050 base scenario some regions of the model area will show changes favorable to wading bird foraging for a given year, while other regions for the same year will reflect a deterioration of conditions. The spatial and temporal dynamics of rookery formation involve the interplay of many factors and are not well understood; therefore, it is difficult to ascertain the effects of predicted foraging potentials on breeding activity. For example, suitable wading bird rookery sites are not distributed uniformly across the South Florida landscape, so a direct comparison of the magnitude of suitable foraging area available under alternative scenarios would be misleading. Therefore, we will interpret the current results the same way we did in the past, by limiting our discussion to areas where most birds have traditionally nested. Those areas are: (1) along the eastern part of WCA-3A, WCA-3B, and Northeast Shark River Slough and (hereafter referred to as Northeastern

Rookeries); and (2) the transition zone between Shark River Slough and the mangrove estuaries (hereafter referred to as the Southwestern Rookeries) (WBROOKS_.PDF).

D-C.4.6.1 Foraging Conditions Indices Results for Short-legged Wading Birds

Figure FCWSMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for short-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative C produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FCWSMYFR.PDF) for most of WCA-2A, all of WCA-2B, the northernmost portion of WCA-3A and most of the potential wading bird foraging habitat in and around Shark Slough. Alternative C also produces slightly higher FCI values throughout the Big Cypress National Preserve (BCNP). For the areas including Northeastern rookeries (WCA-3A, WCA-3B, and Northeast Shark Slough), F-2050 results show slightly higher mean FCI's across most of the area. However, Alternative C shows higher values in northern WCA-3B and in potential foraging habitat east of the WCA's. For the areas encompassing the Southwestern Rookeries, F2050 produces higher FCI values over most of the area relative to Alternative C, with the above noted exception of the Big Cypress and the southern wetlands east of Shark River Slough, where F2050 produces higher values.

The long-term average discussed above differs from predicted conditions during a "typical" year (1977, Fig. FCWS77FR.PDF), in that FCI values under the two scenarios are virtually the same across much of the area encompassing the Southwestern Rookeries. For the Northwestern Rookeries, the same pattern can be seen in the "typical" year as described for the 31-year mean, however, differences between the two scenarios are more accentuated.

In the dry year of 1990 (Fig. FCWS90FR.PDF), foraging conditions are suitable across nearly the entire landscape under both scenarios. Alternative C, however, produces higher or equivalent FCI values relative to F2050 throughout the areas encompassing the Northeastern and Southwestern Rookeries.

During a high rainfall year (1969, Fig. FCWS69FR.PDF, which was not an exceptionally high water year), the F2050 scenario is superior to or equivalent to the Alternative C scenario in terms of the wading bird feeding conditions throughout the area encompassing the Northeastern Rookeries (gray and blue colors in the central panel of Fig. FCWS69FR.PDF). This is especially pronounced in WCA-3A, where foraging is precluded under Alternative C while F2050 provides a range of FCI values. The only exceptions are two small areas east of the WCA's and the northern edge of WCA-2B. For the Southwestern Rookeries, F2050 allows for foraging conditions across a greater extent of Shark River Slough relative to

Alternative C while Alternative C produces slightly higher FCI values relative to F2050 over a small area of southern Big Cypress.

For 1983, a year of relatively high water (Fig. FCWS83FR.PDF), there is a spatial constriction of potential foraging, including the loss of Shark River Slough as a foraging area under both scenarios. This leaves the area of the Southwestern Rookeries with overall higher FCI's under Alternative C relative to F2050, although a slightly higher FCI is produced under F2050 just south of Shark River Slough. For the Northeastern Rookeries, F2050 allows foraging conditions over a greater area relative to Alternative C and, consequently, produces higher FCI values.

Under extremely high surface water conditions (1970 and 1995, Figs. FCWS70FR.PDF and FCWS95FR.PDF) foraging conditions are similar for both scenarios in the Water Conservation Areas and in northeast Shark Slough (i.e., unsuitable), but F2050 results in a higher FCI in East Slough near the Southwestern Rookeries in 1970, in 1995 this area is unsuitable for foraging under both scenarios. F2050 produces higher FCI values east of WCA-3A and B, within the area encompassing the Northeastern Rookeries.

D-C.4.6.2 Foraging Conditions Indices Results for Long-legged Wading Birds

Figure FCWLMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for long-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative C produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FCWLMYFR.PDF) for all regions except eastern WCA-3A, East Slough, and from southeastern WCA-3B through Northeast Shark River Slough and the main drainage of Shark River Slough. In these areas F2050 results in a higher FCI values. Thus, neither scenario results in higher FCI's for the entire area encompassing the Northeastern Rookeries. The same can be said for the areas encompassing the Southwestern Rookeries sites, except that F2050 produces slightly higher FCI's relative to Alternative C in East Slough.

For dry and typical rainfall years (1990 and 1977, respectively, Figures FCWL90FR.PDF and FCWL77FR.PDF) Alternative C produces higher FCI values relative to F2050 except in Northeast Shark River Slough (only in typical rainfall year) and a scattering of small areas in the northern third of the model area, here F2050 produces higher FCI values. Therefore, under these hydrologic conditions, Alternative C produces higher FCI values relative to F2050 for both the Northeastern and Southwestern Rookery areas.

During a high rainfall year (1969, Fig. FCWL69FR.PDF, which was not an exceptionally high water year) and a relatively high water year (1983, Fig.

FCWL83FR.PDF), F2050 provides higher FCI values relative to Alternative C in eastern WCA-3A, all of WCA-3B and Northeast Shark River Slough. Although Alternative C provides higher FCI values for a small area along the eastern edges of WCA-3A and B, the area encompassing the Northeastern Rookeries experiences overall higher FCI's under F2050. For the area that includes the Southwestern Rookeries, the two scenarios produce very similar results. However, F2050 produces slightly higher FCI values relative to Alternative C in Shark River Slough and southern Big Cypress, while East Slough shows slightly higher FCI values under Alternative C.

Under high surface water conditions (1970 and 1995, Figs. FCWL70FR.PDF and FCWL95FR.PDF), foraging conditions are unsuitable across the greater part of the area encompassing the Northeastern Rookeries under both F2050 and Alternative C. The differences that do exist between the scenarios are minor in extent. Throughout the area encompassing the Southwestern Rookeries, foraging conditions are suitable, except in the heart of Shark River Slough, under both scenarios. F2050 provides higher FCI's relative to Alternative C in the area of the Shark River Slough/mangrove interface.

D-C.4.6.3 Conclusion

For the area encompassing the Northeastern Rookeries, Alternative C generally produces higher FCI's relative to F2050 under dry to "typical" conditions for both short-legged and long-legged wading birds. Under high rainfall and moderately high water conditions, F2050 produces higher FCI's relative to Alternative C over parts of the area, most notably in WCA-3A. However, no one scenario dominates in higher FCI values. Under extreme high water conditions neither scenario provides suitable foraging conditions over even a small fraction of the area.

For the area encompassing the Southwestern Rookeries, Alternative C produces higher FCI values relative to F2050 under dry conditions for both short-legged and long-legged wading birds. Under both scenarios, the extent of suitable foraging is restricted for long-legged wading birds. During "typical" and high rainfall, Alternative C produces higher FCI values for short-legged birds and, to some extent, for long-legged wading birds as well. Under high and moderately high surface water conditions, Alternative C produces higher FCI values relative to F2050 for short-legged wading birds, while for long-legged birds there is little difference between the two scenarios. Under extremely high water conditions, short-legged wading bird foraging is significantly curtailed under both scenarios, but Alternative C produces higher FCI values over a very small area. Under these extremely high surface water conditions, long-legged birds do not experience the same magnitude of foraging area contraction. For these birds, there is only a slight difference between FCI values produced under the two scenarios, with F2050 producing higher values relative to Alternative C.

D-C.4.7 Alternative D vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative D versus F2050 (Revised) on Foraging Conditions for Wading Birds in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of an alternative scenario with those of the F2050 base scenario some regions of the model area will show changes favorable to wading bird foraging for a given year, while other regions for the same year will reflect a deterioration of conditions. The spatial and temporal dynamics of rookery formation involve the interplay of many factors and are not well understood; therefore, it is difficult to ascertain the effects of predicted foraging potentials on breeding activity. For example, suitable wading bird rookery sites are not distributed uniformly across the South Florida landscape, so a direct comparison of the magnitude of suitable foraging area available under alternative scenarios would be misleading. Therefore, we will interpret the current results the same way we did in the past, by limiting our discussion to areas where most birds have traditionally nested. Those areas are: (1) along the eastern part of WCA-3A, WCA-3B, and Northeast Shark River Slough and (hereafter referred to as Northeastern Rookeries); and (2) the transition zone between Shark River Slough and the mangrove estuaries (hereafter referred to as the Southwestern Rookeries) (WBROOKS_.PDF).

D-C.4.7.1 Foraging Conditions Indices Results for Short-legged Wading Birds

Figure FDWSMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for short-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative D produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FDWSMYFR.PDF) for most of WCA-2A, all of WCA2-B, the northernmost portion of WCA3-A and most of the potential wading bird foraging habitat east and west of Shark Slough. Alternative D also produces slightly higher FCI values throughout the Big Cypress National Preserve (BCNP). For the areas including Northeastern rookeries (WCA-3A, WCA-3B, and Northeast Shark Slough), F-2050 results show slightly higher mean FCI's across most of the area, however, Alternative D shows higher values in northern WCA3-B and in potential foraging habitat east of the WCA's. For the areas encompassing the Southwestern Rookeries, F2050 produces higher FCI values over most of the area relative to Alternative D, with the above noted exception of the Big Cypress and the southern wetlands east of Shark River Slough, where F2050 produces higher values.

The long-term average discussed above differs from predicted conditions during a "typical" year (1977, Fig. FDWS77FR.PDF), in that FCI values under the two scenarios are virtually the same across much of the area encompassing the Southwestern Rookeries. For the Northwestern Rookeries, the same pattern can be seen in the "typical" year as described for the 31-year mean, however, differences between the two scenarios are more accentuated.

In the dry year of 1990 (Fig. FDWS90FR.PDF), foraging conditions are suitable across nearly the entire landscape under both scenarios. Alternative D, however, produces higher or equivalent FCI values relative to F2050 throughout the areas encompassing the Northeastern and Southwestern Rookeries.

During a high rainfall year (1969, Fig. FDWS69FR.PDF, which was not an exceptionally high water year), the F2050 scenario is superior to or equivalent to the Alternative D scenario in terms of the wading bird feeding conditions throughout the area encompassing the Northeastern Rookeries (gray and blue colors in the central panel of Fig. FDWS69FR.PDF). This is especially pronounced in WCA-3A, where foraging is precluded under Alternative D while F2050 provides a range of FCI values. The only exceptions are two small areas east of the WCA's and the northern edge of WCA2-B. For the Southwestern Rookeries, F2050 allows for foraging conditions across a greater extent of Shark River Slough relative to Alternative D while Alternative D produces slightly higher FCI values relative to F2050 over a small area of southern Big Cypress.

For 1983, a year of relatively high water (Fig. FDWS83FR.PDF), there is a spatial constriction of potential foraging, including the loss of Shark River Slough as a foraging area under both scenarios. This leaves the area of the Southwestern Rookeries with overall higher FCI's under Alternative D relative to F2050, although a slightly higher FCI is produced under F2050 just south of Shark River Slough. For the Northeastern Rookeries, F2050 allows foraging conditions over a greater area relative to Alternative D and, consequently, produces higher FCI values.

Under extremely high surface water conditions (1970 and 1995, Figs. FDWS70FR.PDF and FDWS95FR.PDF) foraging conditions are similar for both scenarios in the Water Conservation Areas and in northeast Shark Slough (i.e., unsuitable), but Alternative D results in a higher FCI in East Slough near the Southwestern Rookeries. F2050 produces higher FCI values east of WCA3-A and B, within the area encompassing the Northeastern Rookeries.

D-C.4.7.2 Foraging Conditions Indices Results for Long-legged Wading Birds

Figure FDWLMYFR.PDF shows the 31 year (1965-1995) average values of Foraging Conditions Indices (FCI) for long-legged wading birds across the model area. As indicated in the central panel of this set of three maps, Alternative D produces average FCI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FDWLMYFR.PDF) for all regions except eastern WCA3-A, East Slough, and from southeastern WCA3-B through Northeast Shark River Slough and the main drainage of Shark River Slough. In these areas F2050 results in higher FCI values. Thus, although one scenario does not result in higher FCI's for the entire area encompassing the Northeastern Rookeries, Alternative D does so for the greater part of the area. The same can be said for the areas encompassing the Southwestern Rookeries sites, except that F2050 produces slightly higher FCI's relative to Alternative D in East Slough.

For dry and typical rainfall years (1990 and 1977, respectively, Figures FDWL90FR.PDF and FDWL77FR.PDF), FCI results are similar across much of the model area under the two scenarios. Where differences exist, Alternative D produces higher FCI values relative to F2050 except in Northeast Shark River Slough (only in typical rainfall year) and a scattering of small areas in the northern third of the model area, here F2050 produces higher FCI values.

During a high rainfall year (1969, Fig. FDWL69FR.PDF, which was not an exceptionally high water year) and a relatively high water year (1983, Fig. FDWL83FR.PDF), F2050 provides higher FCI values relative to Alternative D in eastern WCA3-A, all of WCA3-B and Northeast Shark River Slough. Although Alternative D provides higher FCI values for a small area along the eastern edges of WCA3-A and B, the area encompassing the Northeastern Rookeries experiences overall higher FCI's under F2050. For the area that includes the Southwestern Rookeries, F2050 produces slightly higher FCI's relative to Alternative D in Shark River Slough and southern Big Cypress, while East Slough shows slightly higher FCI values under Alternative D.

Under high surface water conditions (1970 and 1995, Figs. FDWL70FR.PDF and FDWL95FR.PDF), foraging conditions are unsuitable across the greater part of the area encompassing the Northeastern Rookeries under both F2050 and Alternative D. The differences that do exist between the scenarios are minor in extent and magnitude. Throughout the area encompassing the Southwestern Rookeries, foraging conditions are suitable, except in the heart of Shark River Slough, under both scenarios. F2050 provides higher FCI's relative to Alternative D in the area of the Shark River Slough/mangrove interface.

D-C.4.7.3 Conclusion

For the area encompassing the Northeastern Rookeries, Alternative D generally produces higher FCI's relative to F2050 under dry to "typical" conditions for both short-legged and long-legged wading birds. Under high rainfall and moderately high water conditions, F2050 produces higher FCI's relative to

Alternative D over parts of the area, most notably in WCA3-A. However, no one scenario dominates in higher FCI values. Under extreme high water conditions neither scenario provides suitable foraging conditions over even a small fraction of the area.

For the area encompassing the Southwestern Rookeries, Alternative D produces higher FCI values relative to F2050 under dry conditions for both short-legged and long-legged wading birds. Under both scenarios, the extent of suitable foraging is restricted for long-legged wading birds. During "typical" and high rainfall, Alternative D produces higher FCI values for short-legged birds and, to some extent, for long-legged wading birds as well. Under high and moderately high surface water conditions, Alternative D produces higher FCI values relative to F2050 for short-legged wading birds, while for long-legged birds there is little difference between the two scenarios. Under extremely high water conditions, short-legged wading bird foraging is significantly curtailed under both scenarios, but Alternative D produces higher FCI values over a very small area. Under these extremely high surface water conditions, long-legged birds do not experience the same magnitude of foraging area contraction. For these birds, there is only a slight difference between FCI values produced under the two scenarios, with F2050 producing higher values relative to Alternative D.

D-C.5 WHITE-TAILED DEER BREEDING POTENTIAL INDEX MODEL

White-tailed Deer Breeding Potential Index
Basic Model Description

Jane Comiskey and Louis Gross
The Institute for Environmental Modeling
University of Tennessee
Knoxville, TN 37996-1610

D-C.5.1 Introduction

The white-tailed deer is the largest herbivore in the Everglades and a major prey source for the endangered Florida panther. Since the early 1960's, when intensive water management began, the Everglades deer population has declined by almost 75%, from a high of 25-30,000 deer. Changing water management strategies for south Florida have impacted deer in several ways, affecting reproductive success and recruitment, movement and foraging, and forage production and availability (Fleming 1997). During wet years, extended periods of inundation with water depths over 2-ft. are common in the impounded marshes of the northern Everglades. During these high water events, deer move to elevated sites such as tree islands, where they often suffer deterioration of physical condition and increased susceptibility to parasites and disease as food stores became depleted. Does and fawns are particularly susceptible to the effects of prolonged high water.

As part of the Central and Southern Florida Comprehensive Study Review (Restudy), the ecological impacts of a series of proposed alternative water management regimes will be evaluated. Each of these scenarios will affect potential breeding and foraging activity of deer across the landscape. The ATLSS White-tailed Deer Breeding Potential Index (BPI) uses knowledge of how hydrologic factors affect the production and availability of food resources and the availability of dry bedding sites during the breeding season to compute a BPI for deer. ATLSS expresses the effects of proposed scenarios as changes in the spatial pattern of breeding potential over the model area. The ATLSS sub-area reporting units are based on a combination of public area, drainage basin, and management unit subregion Maps (see REPUNITS.PDF).

D-C.5.2 Methods

SFWMM restoration scenario hydrology output is used to make spatially explicit estimates of surface area with water in the depth ranges which restrict and preclude deer movement and fawning success.

The deer breeding cycle consists of mating, gestation, birth, lactation/nursing and fawn growth and maturation. Peak fawning occurs during the dry season (February -- March), when uninundated bedding sites are available. Fawns born in late winter to early spring will have grown enough to move about on the landscape when the wet season starts in May-June. The BPI focuses on the depth of ponded water, which would serve as an impediment to fawning, movement and foraging during the breeding season. If the food supply is interrupted during this period, the health of mother and offspring may suffer, and fawns are less likely to be recruited into the herd. Elevated water levels can make beds uninhabitable, and high water can drown young fawns.

For each landscape grid cell in the SFWMM model area, the model computes a daily feedback term, the ratio of the current ponding depth to a threshold depth above which deer movement and foraging is precluded. These daily feedback terms are summed over the time period from January 1 to May 31. The Breeding Potential Index is computed as 1 - ((feedback sum)/(days in summing period)). This results in an index between 0 and 1, with 0 representing no breeding potential, and 1 representing maximum potential (no interference from ponded water). This index is further scaled by a measure of habitat quality, using a metric of hydroperiod for each cell during the previous year as an indication of forage productivity and availability. Deer densities have been reported to be highest in areas with moderate hydroperiods (Fleming 1997.) Overdrained marshes with annual hydroperiods of less than 2-3 months do not support quality forage production, especially for females with young. When the ATLSS high-resolution forage model has been calibrated, the BPI Model will use forage estimates simulated for each grid cell rather than hydroperiod metrics.

The White-tailed Deer BPI model was initially run on SFWMM calibration/validation data for 1979-1995. Index values for subregions were compared to reported densities for deer in those years to determine optimal settings for water depth thresholds and habitat effects. A number of related indices and metrics, including yearly movement potential indices, are being computed to aid in scenario evaluation. Landscape grid cell index values will be represented pictorially as 3-panel difference maps, and spatial averages computed over landscape subregions will be reported in tabular form.

The Deer BPI is a composite index of spatial and temporal patterns. Spatial patterns will be computed based on ATLSS High Resolution Hydrology (28.5 x 28.5 meter units). This resolution captures fine-scale spatial heterogeneity of the South Florida wetlands and permits model representation of the elevated tree island habitats that are critical for deer survival during extended periods of high water.

Output associated with the ATLSS White-tailed Deer Breeding Potential Index Model.

In accordance with ATLSS file naming conventions, each file name will consist of the characters: UVXXYYZZ.EXT

"U" or "_" => the Base, typically F for the F2050 base or E for the C1995 base
"V" or "_" => the alternative scenario or base
"XX" => "BD" for the ATLSS White-tailed Deer BCI Model
"YYZZ" => 4 character mnemonic, described below
"."
"EXT" = "PDF" or "TXT" or "DOC" => PDF, tabular text or documentation

ATLSS White-tailed Deer Breeding Potential Index

1. Maps

Map outputs used to characterize results of the White-tailed Deer Breeding Potential Index Model will consist of eight image files in PDF file format. Each map shows a "Set" of model results, comparing a Base case to a Scenario, following the conventions for ATLSS comparison of two model runs. Each map has three panels. The left panel displays index values for an alternative or base scenario; the right panel displays index values for a base scenario, typically the Future without Project Conditions Case. The middle panel displays the cell-by-cell difference between index values for the two compared scenarios (e.g., ALT-A minus F2050).

Grid cells in the left and right panels are color-coded to represent the (positive) values of the displayed index, which range between 0 and 1. Cell colors in the center panel represent either positive (shades of gold) or negative (shades of blue) differences between index values displayed in the left panel and those in the right panel. Color keys are provided at the bottom of each map. Each map depicts the model area at either a Fine (500-meter x 500-meter) or Coarse (2-mile) scale of resolution.

For each of six selected years, images will provide a spatial display of index values for that year. In addition, an image file is provided for the mean of all simulated years. The selected years include years with high, low, and typical rainfall, and several additional years that serve to highlight differences between the compared scenarios.

The mnemonic characters are composed according to the convention:

"YY" = Last two digits of the year
"ZZ" = CR - Coarse (2 mile) resolution, FR - Fine (500 meter) resolution

Listing of ATLSS White-tailed Deer Breeding Potential Index map files:

File Name	Time Period
UVBD69ZZ.PDF	A High Rainfall Year (1969)
UVBD70ZZ.PDF	Highlight Scenarios (1970)
UVBD77ZZ.PDF	A Typical Rainfall Year (1977)
UVBD83ZZ.PDF	Highlight Scenarios (1983)
UVBD90ZZ.PDF	A Low Rainfall Year (1990)
UVBD95ZZ.PDF	Highlight Scenarios (1995)
UVBDMYZZ.PDF	Mean of All Years (1965->1995)

2. Time Series None.

3. Histograms None.

4. Tables

The tables associated with the ATLSS White-tailed Deer Breeding Potential Index Model will display the breeding indices by subregions and years. The tables will also be at either a 500 meter (FR = Fine Resolution) or 2 mile (CR = Coarse Resolution) scale as indicated by the file name.

File Name	Description
U_BDBASE.TXT	Breeding index listed by subregions and years for the indicated base scenario.
_VBDALTN.TXT	Breeding index listed by subregions and years for the indicated alternative scenario.
UVBDDIFF.TXT	The difference of the breeding indices listed by subregions and years between the alternative and base scenarios.

D-C.5.3 F2050 (Revised) vs. C1995 (Revised)

Assessment of the Effects of Proposed Water Regimes F2050 (Revised) vs. C1995 (Revised) on the Breeding Potential of White-tailed Deer in South Florida

Figure FEBDMYFR.PDF shows mean values over the 31 year simulation period (1965-1995) for the Breeding Potential Index (BPI) for white-tailed deer. As indicated in the central panel of this set of three maps, the C1995 hydrologic regime produces average BPI values which differ only slightly from those of F2050 throughout most of the modeled region, indicated by the gray, yellow and light blue colors, representing no difference or small positive or negative differences, respectively (see also Table FEBDDIFF.TXT, which lists mean BPI values for the various subregions delimited for evaluating ecological responses). The spatial pattern of these differences, however, is distinctive, and this pattern is consistent throughout the simulation period, with intensity and extent of differences varying with relative wetness of individual years. Higher BPI values are seen under C1995 in southern and western WCA-2A and WCA-2B, the Rotenberger and Holey Land WMA's, WCA-3A north of Alligator Alley, and in all of the model area south of the Tamiami Trail with the exception of the southeastern marl prairies of ENP. Values for BCNP are equivalent under the two regimes for all years in all but the easternmost and southernmost portions. For most years, index values for the eastern edge of BCNP are slightly higher under F2050, while the 10-mile Marl and East Slough areas generally show higher values under C1995. Small deteriorations in deer breeding potential values are seen under C1995 relative to F2050 in WCA-1, WCA-3A south and (in all but the wettest years) WCA-3B. Note that in both scenarios, the BPI is quite low throughout the entire region, with higher values limited in all but the driest years to Long Pine Key and portions of BCNP.

The performance of the scenarios during a "typical" year (1977, Fig. FEBD77FR.PDF), is very similar to the long-term average discussed above, although the overall area with high BPI values is reduced from the mean in the single year analysis.

During a high rainfall year (1969, which was not an exceptionally high water year, Fig. FEBD69FR.PDF), the same pattern persists, with the higher relative index values resulting from F2050 in WCA's 1 and 3, as in the long-term average. For this year, the F2050 regime produces higher index values relative to C1995 in the deep water areas of WCA3-A than in wetter years, when BPI's are zero for both scenarios. During these wet conditions, values of the deer breeding potential index were very low throughout most of the region, with high values concentrated in central and northern BCNP and in Long Pine Key. Similar patterns occur in other wet years, including 1970 (Fig. FEBD70FR.PDF), 1983 (Fig. FEBD83FR.PDF), and 1995 (Fig. FEBD95FR.PDF), with an additional area of improvement seen for C1995 for these wetter years in WCA3-B.

In the dry year of 1990, the extent of positive differences (higher values for C1995, indicated by yellow to gold colors in central panel, Fig. FEBD90FR.PDF) is reduced, but the magnitude of these differences increases in northern WCA-3A.

D-C.5.3.1 Conclusion

The current Breeding Potential analyses suggest distinct spatial trends in effects of the F2050 hydrologic scenario compared to C1995.

Advantages under the F2050 scenario are limited to WCA-1 and WCA-3, where deer stranding and deaths may occur during high water events, and the southeastern marl prairies of ENP. This improvement reflects the production under F2050 of somewhat drier conditions in the impounded areas north of Tamiami Trail, providing a longer period of water depths that deer can tolerate. However, somewhat wetter conditions are produced in the natural areas to the south of Tamiami Trail, where C1995 BPI values are generally higher. In the areas with potentially high breeding index values for deer there is either little difference between the BPI values produced by C1995 and F2050 (north and northwestern portions of BCNP), or C1995 values are slightly higher in Long Pine Key and surrounding short hydroperiod marshes.

D-C.5.4 Alternative A vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative A versus F2050 (Revised) on the Breeding Potential of White-tailed Deer in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of an alternative scenario with those of a base scenario some regions of the model area may show changes favorable to deer breeding for a given year, while other regions for the same year may reflect a deterioration of conditions. This is the case when we compare Alternative A with F2050.

Figure FABDMYFR.PDF shows mean values over the 31 year simulation period (1965-1995) for the ATLSS Breeding Potential Index (BPI) for white-tailed deer. As indicated in the central panel of this set of three maps, the Alternative A hydrologic regime produces average BPI values which differ only slightly from those of F2050 throughout most of the modeled region, indicated by the gray, yellow and light blue colors, representing no difference or small positive or negative differences, respectively (see also Table FABDDIFF.TXT, which lists mean BPI values for the various subregions delimited for evaluating ecological responses). The spatial pattern of these differences changes throughout the simulation period, with intensity and extent of differences varying with relative wetness of individual years. In the mean map, higher BPI values are seen under Alternative A in the Holey

Land WMA, a few scattered sites in central WCA-3A north, East Slough, the northern end of 10-Mile Marl, the northwestern portion of Shark River Slough, and a few sites in the southeastern marl prairies of ENP. BPI values are equivalent or slightly higher under F2050 for all other portions of the model area, including WCA-1, WCA-2A, WCA-2B, most of WCA-3A, WCA-3B, central and southern Shark River Slough, and most of Big Cypress National Preserve (BCNP) and Everglades National Park (ENP). Note that in both scenarios, the BPI is quite low throughout the entire region, with higher values limited in all but the driest years to Long Pine Key and portions of BCNP.

Relative performance of the scenarios during a "typical" year (1977, Fig. FABD77FR.PDF) differs from the long-term average discussed above in several respects. The overall area with high BPI values is reduced from the mean in the single year analysis. Positive differences for Alternative A for the Holey Land WMA are higher than in the mean map and extend into the Rotenberger WMA. Additional areas of advantage for Alternative A are seen along L-67 canal in WCA-3A and 3B and in WCA-2B. 1977 is the only simulation year for which Alternative A produces higher values in WCA-2B. BPI values are equivalent for 1977 under the two scenarios for the East Slough/10 Mile Marl/NW Shark River Slough area, where higher BPI's were seen for Alternative A in the mean map.

The pattern seen in wet years is similar to that seen in the long-term average, with the extent of areas of Alternative A advantages expanding as wetness increases. During a high rainfall year (1969, which was not an exceptionally high water year, Fig. FABD69FR.PDF), patterns and extents are very similar to mean patterns, with areas of Alternative A advantage restricted to the Holey Land WMA, north central WCA-3A north, and the East Slough/northern 10-mile Marl/NW Shark River Slough area. In other wet years, including 1970 (Fig. FABD70FR.PDF), 1983 (Fig. FABD83FR.PDF), and 1995 (Fig. FABD95FR.PDF), the area of higher BPI values for Alternative A around East Slough expands into southwestern and central WCA-3A and northern Shark River Slough and parts of WCA-3B. In the very wet year of 1995 Alternative A BPI's are higher in southeastern BCNP and all of WCA-3A and 3B. During these wet conditions, values of the deer breeding potential index are very low throughout most of the region, with high values concentrated in central and northern BCNP and in Long Pine Key. For these wetter years, BPI values become zero under both hydrological regimes in the deeper water portions of WCA-3A south and 3B, and through the central flowway of Shark River Slough. Progressive loss of deer habitat in WCA-3B and Shark River Slough is seen first under Alternative A and then with F2050 also as conditions become wetter, while progressive loss of habitat in WCA-3A south is more extensive under F2050.

In the dry year of 1990, the extent of positive differences (higher values for Alternative A, indicated by yellow to gold colors in the central panel, Fig.

FABD90FR.PDF), is reduced, restricted to the Holey Land/Rotenberger WMA's, and very small scattered sites elsewhere in the model area. The magnitude of relative advantages for F2050 increases in WCA-1 and parts of North Taylor Slough. BPI values are generally much higher overall in dry years such as as 1989 (not shown) and 1990.

D-C.5.4.1 Conclusion

The current Breeding Potential analyses suggest distinct spatial trends in predicted effects of the Alternative A hydrologic scenario compared to F2050. In dry years, predicted foraging conditions for deer are equivalent or more favorable under F2050 in most parts of the model area, with the exception of the Holey Land and Rotenberger WMA's.

As more water is added to the system, BPI's decline overall, the deeper water areas become inhospitable to deer, and areas of more favorable predicted breeding conditions for deer under Alternative A appear in north central WCA-3A, along L-67 in WCA-3A south, and in the East Slough/northern 10-Mile Marl/northwestern Shark River Slough areas. In the very wet year of 1995, these areas coalesce to form a single continuous unit through the central portion of the model area. Elsewhere, BPI's are equivalent or F2050 values are slightly higher. This pattern reflects the production under F2050 of somewhat drier conditions in the central flow-way of Shark River Slough and in the impounded areas of the WCA's (in all but the wettest years), providing a slightly longer period of water depths that deer can tolerate in these areas. Alternative A produces consistently drier conditions in the Holey Land WMA and, as conditions become wetter, in expanding areas around East Slough and portions of WCA-3A south and WCA-3B.

Because Alternative A produces somewhat drier conditions in deep water portions of WCA-3A and 3B in very wet years, fewer deer mortalities could be expected in these impounded areas during high water events. In areas with potentially high breeding index values for deer (northern portions of BCNP and Long Pine Key), there is little difference between the BPI values produced by Alternative A and F2050.

D-C.5.5 Alternative B vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative B versus F2050 on the Breeding Potential of White-tailed Deer in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of an alternative scenario with those of a base scenario some regions of the model area may show changes favorable to deer breeding for a given year, while other regions for the same year may reflect a deterioration of conditions. This is the case when we compare Alternative B with F2050.

Figure FBBDMYFR.PDF shows mean values over the 31 year simulation period (1965-1995) for the ATLSS Breeding Potential Index (BPI) for white-tailed deer. As indicated in the central panel of this set of three maps, the Alternative B hydrologic regime produces average BPI values which differ only slightly from those of F2050 throughout most of the modeled region, indicated by the gray, yellow and light blue colors, representing no difference or small positive or negative differences, respectively (see also Table FBBDDIFF.TXT, which lists mean BPI values for the various subregions delimited for evaluating ecological responses). The spatial pattern of these differences, however, is distinctive, and this pattern is consistent throughout the simulation period, with intensity and extent of differences varying with relative wetness of individual years. Higher BPI values are seen under Alternative B in WCA-2B, the Holey Land WMA, central WCA-3A north deep water portions of WCA-3A south, East Slough, and the northern half of the 10-Mile Marl area. BPI values are equivalent or slightly higher under F2050 for all other portions of the model area, including WCA-1, WCA-2A, WCA-3B, central and southern Shark River Slough, and most of Big Cypress National Preserve (BCNP) and Everglades National Park (ENP). Note that in both scenarios, the BPI is quite low throughout the entire region, with higher values limited in all but the driest years to Long Pine Key and portions of BCNP.

The performance of the scenarios during a "typical" year (1977, Fig. FBBD77FR.PDF) is similar to the long-term average discussed above, although the overall area with high BPI values is reduced from the mean in the single year analysis. The positive differences for ALT-B for the Holey Land WMA are higher than in the mean map and extend into the Rotenberger WMA, while BPI values are equivalent for 1977 under the two scenarios for East Slough and WCA-2A.

During a high rainfall year (1969, which was not an exceptionally high water year, Fig. FBBD69FR.PDF), the same pattern persists, with higher relative index values resulting from F2050 in WCA-1, northern WCA-2A, WCA-3A south (except for the deep water portions along L-67) WCA-3B, and ENP, as in the long-term average. Similar patterns occur in other wet years, including 1970 (Fig. FBBD70FR.PDF), 1983 (Fig. FBBD83FR.PDF), and 1995 (Fig. FBBD95FR.PDF). The area of higher BPI values for Alternative B around East Slough expands in wet years into southwestern WCA-3A and northern Shark River Slough and in the very wet year of 1995 into southeastern BCNP and southwestern WCA-3A. During these wet conditions, values of the deer breeding potential index are very low throughout most of the region, with high values concentrated in central and northern BCNP and in Long Pine Key. For these wetter years, BPI values become zero under both hydrological regimes in the deeper water portions of WCA-3A south and 3-B, and through the central flowway of Shark River Slough. Progressive loss of deer habitat in WCA-3B and Shark River Slough is seen first under Alternative B and then with F2050 also as conditions become wetter while progressive loss of habitat in WCA-3A south is seen first under F2050.

In the dry year of 1990, the extent of positive differences (higher values for Alternative B, indicated by yellow to gold colors in the central panel, Fig. FBBD90FR.PDF), is reduced, restricted to the Holey Land/Rotenberger WMA's, a small area in north central WCA-3A and adjacent to L-67 in WCA-3A south, but the magnitude of these differences increases. The magnitude of relative advantages for F2050 increases in WCA-1, parts of WCA-3, and scattered sites within ENP. BPI values are generally much higher overall in dry years such as 1989 (not shown) and 1990.

D-C.5.5.1 Conclusion

The current Breeding Potential analyses suggest distinct spatial trends in predicted effects of the Alternative B hydrologic scenario compared to F2050. In dry years, predicted foraging conditions for deer are more equivalent or favorable under F2050 in most parts of the model area, with the exception of the Holey Land and Rotenberger WMA's, small areas in north central WCA-3A and along L-67 in WCA-3A south, and scattered sites in southwestern BCNP. As more water is added to the system, BPI's decline overall, the deeper water areas become inhospitable to deer, and areas of more favorable predicted breeding conditions for deer under Alternative B expand in WCA-2A south, WCA-2B, WCA-3A and the East Slough/northern 10-Mile Marl area. In the very wet year of 1995, these areas coalesce to form a single continuous unit through the central portion of the model area. Elsewhere, BPI's are equivalent or F2050 values are slightly higher. This pattern reflects the production under F2050 of somewhat drier conditions in most of ENP and in the impounded areas of WCA-1, WCA-3B, and (in all but the wettest years) west-central WCA-3 south, providing a longer period of water depths that deer can tolerate in these areas. Alternative B produces consistently drier conditions in the Holey Land WMA and in expanding areas of East Slough, WCA-2B and the deep-water portions of WCA-3A south. In areas with potentially high breeding index values for deer (northern portions of BCNP and Long Pine Key), there is little difference between the BPI values produced by Alternative B and F2050.

D-C.5.6 Alternative C vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative C versus F2050 (Revised) on the Breeding Potential of White-tailed Deer in South Florida

Because of differential spatial effects of proposed hydrologic modifications for south Florida, when we compare the results of an alternative scenario with those of a base scenario some regions of the model area may show changes favorable to deer breeding for a given year, while other regions for the same year may reflect a deterioration of conditions. This is the case when we compare Alternative C with F2050.

Figure FCBDMYFR.PDF shows mean values over the 31 year simulation period (1965-1995) for the ATLSS Breeding Potential Index (BPI) for white-tailed deer. As indicated in the central panel of this set of three maps, the Alternative C hydrologic regime produces average BPI values which differ only slightly from those of F2050 throughout most of the modeled region, indicated by the gray, yellow and light blue colors, representing no difference or small positive or negative differences, respectively (see also Table FCBDDIFF.TXT, which lists mean BPI values for the various subregions delimited for evaluating ecological responses). The spatial pattern of these differences, however, is distinctive, and this pattern is consistent throughout the simulation period, with intensity and extent of differences varying with relative wetness of individual years. Higher BPI values are seen under Alternative C in southern WCA-2A and WCA-2B, the Holey Land WMA, central WCA-3A north of Alligator Alley, East Slough, and the northern half of the 10-Mile Marl area. BPI values for most of Big Cypress National Preserve (BCNP) are equivalent for the two water regimes, while values for Everglades National Park (ENP) are slightly higher under F2050 except for a few scattered sites in southeastern ENP. Values are also slightly higher under F2050 for WCA's 1, 3A south, and 3B. Note that in both scenarios, the BPI is quite low throughout the entire region, with higher values limited in all but the driest years to Long Pine Key and portions of BCNP.

The performance of the scenarios during a "typical" year (1977, Fig. FCBD77FR.PDF) is similar to the long-term average discussed above, although the overall area with high BPI values is reduced from the mean in the single year analysis. The positive differences for ALT-C for the Holey Land WMA are higher than in the mean map and extend into the Rotenberger WMA, and BPI values are equivalent for East Slough and WCA-2A.

During a high rainfall year (1969, which was not an exceptionally high water year, Fig. FCBD69FR.PDF), the same pattern persists, with higher relative index values resulting from F2050 in WCA's 1, northern 2A, 3A south and 3B, and in most of ENP, as in the long-term average. Similar patterns occur in other wet years, including 1970 (Fig. FCBD70FR.PDF), 1983 (Fig. FCBD83FR.PDF), and 1995 (Fig. FCBD95FR.PDF). The area of higher BPI values for Alternative C around East Slough expands into southwestern WCA-3A and northern Shark River Slough and in the very wet year of 1995 into southeastern BCNP and southwestern WCA-3A. During these wet conditions, values of the deer breeding potential index are very low throughout most of the region, with high values concentrated in central and northern BCNP and in Long Pine Key. For these wetter years, BPI values become zero under both hydrological regimes in the deeper water portions of WCA-3A south and 3-B, and through the central flowway of Shark River Slough. This progressive loss of deer habitat is seen first under Alternative C and then with F2050 also as conditions become wetter.

In the dry year of 1990, the extent of positive differences (higher values for Alternative C, indicated by yellow to gold colors in the central panel, Fig. FCBD90FR.PDF) is reduced to the Holey Land/ Rotenberger WMA's and a small area in north central WCA-3A. The magnitude of relative advantages for F2050 increases in WCA-1 and parts of WCA-3. BPI values are generally much higher overall in dry years such as 1989 (not shown) and 1990.

D-C.5.6.1 Conclusion

The current Breeding Potential analyses suggest distinct spatial trends in predicted effects of the Alternative C hydrologic scenario compared to F2050. In dry years, foraging conditions for deer are more favorable under F2050 in most parts of the model area, with the exception of the Holey Land and Rotenberger WMA's and a small area in north central WCA-3A. As more water is added to the system, BPI's decline overall, the deeper water areas become inhospitable to deer, and conditions under Alternative C become relatively more favorable in WCA-2A south, WCA-2B, and the East Slough/northern 10-Mile Marl area. Elsewhere, BPI's are equivalent or F2050 values are slightly higher. This pattern reflects the production under F2050 (in all but the wettest years) of somewhat drier conditions in the impounded areas of WCA-1 and WCA-3 and in most of ENP, providing a longer period of water depths that deer can tolerate. In the areas with potentially high breeding index values for deer (northern portions of BCNP and Long Pine Key), there is little difference between the BPI values produced by Alternative C and F2050.

D-C.5.7 Alternative D vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative D versus F2050 (Revised) on the Breeding Potential of White-tailed Deer in South Florida

Figure FDBDMYFR.PDF shows mean values over the 31 year simulation period (1965-1995) for the ATLSS Breeding Potential Index (BPI) for white-tailed deer. As indicated in the central panel of this set of three maps, the Alternative D hydrologic regime produces average BPI values which differ only slightly from those of F2050 throughout most of the modeled region, indicated by the gray, yellow and light blue colors, representing no difference or small positive or negative differences, respectively (see also Table FDBDDIFF.TXT, which lists mean BPI values for the various subregions delimited for evaluating ecological responses). The spatial pattern of these differences, however, is distinctive, and this pattern is consistent throughout the simulation period, with intensity and extent of differences varying with relative wetness of individual years. Higher BPI values are seen under Alternative D in southern WCA-2A and WCA-2B, the Holey Land WMA, central

WCA-3A north of Alligator Alley, East Slough, and the northern half of the 10-Mile Marl area. BPI values for most of Big Cypress National Preserve (BCNP) are equivalent for the two water regimes, while values for Everglades National Park (ENP) are slightly higher under F2050 except for a few scattered sites in southeastern ENP. Values are also slightly higher under F2050 for WCA's 1, 3A south, and 3B. Note that in both scenarios, the BPI is quite low throughout the entire region, with higher values limited in all but the driest years to Long Pine Key and portions of BCNP.

The performance of the scenarios during a "typical" year (1977, Fig. FDBD77FR.PDF) is similar to the long-term average discussed above, although the overall area with high BPI values is reduced from the mean in the single year analysis. The positive differences for ALT-D for the Holey Land WMA are higher than in the mean map and extend into the Rotenberger WMA, and BPI values are equivalent for East Slough and WCA-2A.

During a high rainfall year (1969, which was not an exceptionally high water year, Fig. FDBD69FR.PDF), the same pattern persists, with higher relative index values resulting from F2050 in WCA's 1, northern 2A, 3A south and 3B, and in most of ENP, as in the long-term average. Similar patterns occur in other wet years, including 1970 (Fig. FDBD70FR.PDF), 1983 (Fig. FDBD83FR.PDF), and 1995 (Fig. FDBD95FR.PDF). The area of higher BPI values for Alternative D around East Slough expands into southwestern WCA-3A and northern Shark River Slough. During these wet conditions, values of the deer breeding potential index are very low throughout most of the region, with high values concentrated in central and northern BCNP and in Long Pine Key. For these wetter years, BPI values become zero under both hydrological regimes in the deeper water portions of WCA-3A south and 3-B, and through the central flowway of Shark River Slough. This progressive loss of deer habitat is seen first under Alternative D and then with F2050 also as conditions become wetter.

In the dry year of 1990, the extent of positive differences (higher values for Alternative D, indicated by yellow to gold colors in the central panel, Fig. FDBD90FR.PDF) is reduced to the Holey Land/Rotenberger WMA's and a small area in north central WCA-3A. The magnitude of relative advantages for F2050 increases in WCA-1 and parts of WCA-3. BPI values are generally much higher overall in dry years such as 1989 (not shown) and 1990.

D-C.5.7.1 Conclusion

The current Breeding Potential analyses suggest distinct spatial trends in predicted effects of the Alternative D hydrologic scenario compared to F2050. In dry years, foraging conditions for deer are more favorable under F2050 in most parts of the model area, with the exception of the Holey Land and Rotenberger WMA's and a small area in north central WCA-3A. As more water is added to the system, BPI's decline overall, the deeper water areas become inhospitable to deer, and conditions under Alternative D become relatively more favorable in WCA-2A south, WCA-2B, and the East Slough/northern 10-Mile Marl area. Elsewhere, BPI's are equivalent or F2050 values are slightly higher. This pattern reflects the production under F2050 (in all but the wettest years) of somewhat drier conditions in the impounded areas of WCA-1 and WCA-3 and in most of ENP, providing a longer period of water depths that deer can tolerate. In the areas with potentially high breeding index values for deer (northern portions of BCNP and Long Pine Key), there is little difference between the BPI values produced by Alternative D and F2050.

D-C.6 SNAIL KITE INDEX MODEL

ATLSS
Snail Kite Index Model
Basic Model Description

Jane Comiskey, John Curnutt, and Louis Gross
The Institute for Environmental Modeling
University of Tennessee, Knoxville
Knoxville, TN 37996-1610

D-C.6.1 Statement of Limitations

The ATLSS Snail Kite Index (SKI) Model was developed as a crude indicator of potential habitat quality during the breeding season for snail kites in the Florida Everglades. All evidence suggests that the population dynamics for this species are influenced by environmental conditions occurring throughout its entire range in Florida. This model addresses only relative habitat quality within a limited area, ignoring larger spatial extent population dynamics that may have a much greater effect on this species than habitat quality in part of its range. Consequently, this model should not be interpreted to represent population dynamics or viability. The time scales at which evaluations of alternative scenarios are evaluated also are likely to be too short to encompass some long-term changes in habitat quality.

Particularly, stabilized hydrologic regimes may result in a slow degradation of habitat that may be overlooked at the time scales evaluated with this model. In addition, very little verification of this model's performance has been performed and several of its parameter values are "best guess" approximations, for which data are either currently lacking or have not yet been fully analyzed. A spatially explicit full demographic model for snail kites based on available data is currently under development as part of the ATLSS project.

D-C.6.2 Introduction

The snail kite (*Rostrhamus sociabilis*) is an endangered raptor whose distribution in the United States is restricted to the South Florida Ecosystem, including watersheds of the Everglades, Lake Okeechobee, Kissimmee River, and Upper St. Johns River. Because snail kites feed almost exclusively on one species of aquatic snail (the apple snail, *Pomacea paludosa*), their survival depends directly on the hydrologic functioning of these watersheds. Each of these watersheds has experienced, and continues to experience, substantial degradation, resulting in the current planning for what probably will become the largest ecosystem restoration ever undertaken. Although other endangered species occur within the ecosystem, snail kites are probably the only species restricted to the watersheds within the South Florida Ecosystem and dependent on the entire network of wetlands within this ecosystem. Over half of the wetlands within central and southern Florida have been lost during the past century and those that remain have been highly fragmented and severely degraded (Weaver et al. 1994). This degradation has prompted planning for ambitious restoration efforts (e.g., the Central and South Florida Project Restudy, Kissimmee River Restoration, and the South Florida Ecosystem Restoration initiative). Because of the snail kite's restricted range and because their population is highly dependent on the success of restoration efforts, the snail kite is a key species to monitor throughout the restoration process.

D-C.6.3 Model Development

Temporal Constraints. - Although snail kites in Florida can potentially lay eggs in all months of the year, there is a very distinct seasonal distribution of nest initiations. Nest initiations begin as early as November, but in most years widespread initiations usually do not begin until January or February. During most years nest initiations decrease markedly after June, but may extend through July in some years. For this model we defined the primary breeding season as the period from January-July (reviewed by Bennetts and Kitchens 1997).

Suitable conditions for any given year are required to persist for a minimum of 16 weeks during the primary breeding season (January-July). This is based on the time required to complete one breeding cycle, including nest building (10 days), egg laying (2-day intervals with incubation beginning with the 2nd egg), incubation

(27 days), the nestling period (30 days), and a post-fledgling period (45 days) (Beissinger 1984, Beissinger and Snyder 1987, Snyder et al. 1989).

Relative Habitat Quality - Available evidence suggests that suitable conditions for snail kite breeding are influenced by each of three aspects of hydrology that occur at different temporal scales (Bennetts et al. 1998). Suitable conditions at each scale are necessary, but none is sufficient alone to delimit suitable breeding habitat for snail kites. The hydrology at each of these scales regulates a different aspect of the environment important to snail kites. Thus our Snail Kite Index (SKI) takes on the values of 0 (unsuitable), 1 (marginal), or 2 (suitable) for each landscape grid cell. A value of 0 for any of the hydrologic measures results in a cell BPI value of 0 for that year. Otherwise, the cell is assigned the lowest non-zero factor value.

The first hydrologic factor is daily water level (depth). The empirical relationship between snail kites' use of a given habitat and water depth has been well recognized and has been illustrated by the distribution of nests or foraging birds with respect to water depth (e.g., Stieglitz and Thompson 1967, Sykes 1987, Bennetts et al. 1988). The response of snail kites to changing water depth can be seen in shifts in spatial distribution (Bennetts and Kitchens 1997, Bennetts et al. 1998). For example, the spatial distribution of nesting kites within Water Conservation Area (WCA) 3A, a 237,000 ha impoundment used extensively for nesting during the past three decades, was similar for 1992, 1993, and 1994. During the 1995-breeding season, water depths were at record high levels throughout the Everglades as a result of tropical storm Gordon the previous fall. The distribution of nesting kites within WCA-3A shifted dramatically to the north during 1995 compared to observations for the previous three years. Birds moved from areas that were too deep to areas of higher elevation with correspondingly shallower water (Bennetts and Kitchens 1997). When water levels receded the following year, the distribution of nesting birds shifted back to the south where they had been prior to the high water event.

Water depth is probably important for snail kites because of how it affects apple snail behavior and availability. Water depths that are too shallow (e.g., < 10-cm) may impede the movement of snails, as submergent vegetation is densely compacted within the water column (Darby et al. 1997). Shallow water during certain seasons also may result in water temperatures rising above the tolerance level of snails (Darby et al. 1997). Bennetts et al. (1988) suggested that a minimum of 20-cm at the time of initiation is required for suitable breeding conditions, with some drying expected during the nesting season. Our lower limit for suitable breeding conditions with respect to water depth is 20-cm at the time of initiation (i.e., during the primary breeding season), and depth must remain above 10-cm for at least the time required to successfully raise a brood (110 days).

Water that is too deep may also be unsuitable for breeding snail kites. Water deeper than 1-m may lack sufficient oxygen to support apple snails (Hanning 1978) and/or sufficient vegetation that would enable snails to climb near the surface, where they are available to kites (Darby et al. 1997). The distribution of water depths in the Everglades typically ranges from 10 to 115-cm. Snail kite nests at alligator holes or other depressions are occasionally built over deeper water (Bennetts et al. 1994). Thus, we defined an upper limit of suitable depths to be 115-cm.

The second hydrologic factor considered is the time since dry-down at a given location. This factor contributes both to apple snail population dynamics and to the maintenance of plant communities comprising snail kite habitat. Florida apple snails are aquatic and have a limited capacity to survive dry conditions (Little 1968), although the timing of drying may be more important to the overall population dynamics than just the occurrence of drying (Darby et al. 1997). However, drying events result in periodic reductions in the availability of snail kite food resources regardless of whether snail survival is significantly affected. Based on preliminary comparisons of numbers of kites counted during the annual survey before and after drying events in several wetlands, relative habitat quality on average is about 50% of pre-drying conditions the year following the drying event, 85% two years following and fully recovered by three years. Thus, we consider relative habitat quality to be unsuitable during the year that an area dried, marginal the following year, and suitable after two years. However, recent work by Darby et al. (1997) has indicated that the timing of a drying event may be a critical factor in how it affects the apple snail population. Snails hatched during the previous year undergo an almost complete die-off during May-July following reproduction. Thus the cohort that provides the breeding potential for the next year are those that hatched in the preceding year. Given that the peak of egg laying (for snails) occurs from March-May, a drying event that occurs before May can deplete the cohort of breeders for the following year. Consequently, if a drying event occurs before May, we consider habitat to be marginal for an additional year, while the breeding stock replenishes.

Although the occurrence of drying events may affect apple snail populations, the absence of drying results in changes in plant communities. There is a considerable body of evidence regarding the tolerances to prolonged inundation of the plant species that comprise suitable habitat (e.g., Craighead 1971, U.S. Department of Interior 1972, McPherson 1973, Worth 1983, Dineen 1972, 1974, Gunderson 1994). Observable changes in plant communities in the absence of drying have occurred after 5-6 years (Ager and Kerce 1970, U.S. D.I. 1972), and some plant communities comprising kite habitat can be replaced by other communities in as little as 9-10 years (Milleson 1987). Thus, we consider habitat to be in the process of deterioration after 5 years of continuous flooding; it is considered unsuitable after 10 years of continuous flooding.

The third hydrologic factor is a cumulative effect of the longer temporal pattern of repeated drying events. In particular, the frequency of drying events is expressed as a "hydrologic regime" and is measured as long-term (10-yr) hydroperiod (the proportion of time an area is inundated over a 10-year period). This long-term pattern is the primary hydrologic scale at which plant communities are regulated; although vegetation is also regulated by still slower processes that affect climatic regimes and sea level rise (Gunderson 1994). Although rapid degradation of habitat occurs if a site is continuously inundated, most sites experience drying at intervals less than that which would result in direct transitions of plant communities. Habitat changes often occur slowly and incrementally, with periods of at least partial rejuvenation resulting from periodic drying. Because of the extreme lack of topographic relief across the central and southern Florida wetland landscape, relatively small changes in elevation correspond to relatively large changes in hydrology. Consequently, differences of a few centimeters in elevation can have profound effects on plant communities and ultimately on the quality of the habitat for kites. The response of snail kites at this scale also can be illustrated by changes in their spatial distribution over longer time periods. For this index model, cells which are inundated less than 80% or greater than 98% of the time over a ten-year are considered unsuitable as snail kite habitat; cells with inundation periods of 80-85% and 95-98% are considered marginal; and cells with 85-95% inundations periods are considered suitable.

Acknowledgments

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Output associated with the ATLSS Snail Kite Index Model.

In accordance with ATLSS file naming conventions, each file name will consist of the characters: UVXXYYZZ.EXT

"U" or "_" => the Base, typically F for the F2050 base or E for the C1995 base
"V" or "_" => the alternative scenario or base
"XX" => "SK" for the ATLSS Snail Kite Index Model
"YYZZ" => 4 character mnemonic, described below
"."
"EXT" = "PDF" or "TXT" or "DOC" => PDF, tabular text or documentation

ATLSS Snail Kite Index Model

1. Maps

Map outputs used to characterize results of the Snail Kite Index Model will consist of eight image files in PDF file format. Each map shows a shows a "Set" of model results, comparing one SFWMM hydrologic scenario to another, following the conventions for ATLSS comparisons of two model runs. Each map has three panels. The left panel displays index values for either an alternative or base scenario; the right panel displays index values for a base scenario (e.g., the Future without Project Conditions Case, or F2050). The middle panel displays the cell-by-cell difference between index values for the two compared scenarios (e.g., ALT-5 minus F2050).

Grid cells in the left and right panels are color-coded to represent the (positive) values of the displayed index, which range between 0 and 1. Cell colors in the center panel represent either positive (shades of gold) or negative (shades of blue) differences between index values displayed in the left panel and those in the right panel. Color keys are provided at the bottom of each map. Each map depicts the model area at either a Fine (500-meter x 500-meter) or Coarse (2-mile) scale of resolution.

For each of six selected years, images will provide a spatial display of index values for that year. In addition, an image file is provided for the mean of all simulated years. The selected years include years with high, low, and typical rainfall, and several additional years that serve to highlight differences between the compared scenarios.

The mnemonic characters are composed according to the convention:
"YY" = Last two digits of the year
"ZZ" = CR - Coarse (2 mile) resolution, FR - Fine (500 meter) resolution

Listing of ATLSS Snail Kite Index map files:

File Name	Time Period
UVSK69ZZ.PDF	A High Rainfall Year (1969)
UVSK70ZZ.PDF	Highlight Scenarios (1970)
UVSK77ZZ.PDF	A Typical Rainfall Year (1977)
UVSK83ZZ.PDF	Highlight Scenarios (1983)
UVSK90ZZ.PDF	A Low Rainfall Year (1990)
UVSK95ZZ.PDF	Highlight Scenarios (1995)
UVSKMYZZ.PDF	Mean of All Years (1965->1995)

2. Time Series

Time series sets associated with the ATLSS Snail Kite Index will display index values for five subregions: WCA-1, WCA-2A, WCA-2B, WCA-3A and WCA-3B.

These show percentage of available habitat in which suitable habitat conditions occurred for each simulation year.

File Name	Description
UVSKTSZZ.PDF	Percentage of available habitat in which suitable habitat conditions occurred for each simulation year in each of three subregions.

3. Histograms None.

4. Tables None.

D-C.6.4 F2050 (Revised) vs. C1995 (Revised)

Assessment of the Effects of Proposed Water Regimes F2050 (Revised) vs. C1995 (Revised) on Snail Kites in South Florida

D-C.6.4.1 Caveats

The vagility of the Snail Kite in Florida is evident in both its highly variable breeding distribution and its propensity to disperse great distances between breeding seasons. Our model area incorporates only a part of the Kite's potential breeding range - albeit a very important part. Furthermore, there are many factors affecting the spatial and temporal dynamics of nest placement and breeding success. For Kites, as for most raptors, these include the density and availability of prey, the presence of suitable nesting sites, and the ability to establish and maintain a pair bond. Other factors such as temperature, predation, and water quality may also be important. Our Snail Kite model is driven solely by hydrology and the predicted effects of hydrology on the production and availability of Apple Snails (the Kite's primary prey). Thus, results of the model should be interpreted more as indices of foraging conditions than as breeding potentials. However, since we are interested only in the level of foraging that is sufficient for successful breeding, our output refers only to prey densities and foraging conditions that occur during the Kite breeding season. Thus, if an area has an index value of zero it may still have snails, but not at a sufficient density, or under the correct hydrologic conditions that would allow a successful Kite nesting cycle. Given this caveat, for the sake of simplicity we will refer to the model output as a foraging condition index.

As noted above, Kite breeding distribution is highly variable. However, the Water Conservation areas (WCA-1, WCA-2A, WCA-2B, WCA-3A, and WCA-3B) typically hold a large proportion of breeding Kites in most years. Kites have nested south of the WCAs in Everglades National Park intermittently, but, perhaps because of low habitat suitability, this area has not served as a major Kite breeding ground. Our interpretation of the model results, therefore, will focus on the WCA's.

D-C.6.4.2 Index Results

Figure FESKMYFR.PDF shows the 31-year (1965-1995) average values of Snail Kite Indices (SKI) for foraging conditions across the model area. As indicated in the central panel of this set of three maps, C1995 produces average SKI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FESKMYFR.PDF) for nearly all of WCA-3B, most of WCA-2B, the northern half of WCA-2A and a large part of WCA-3A (south). F2050 results in higher SKI values for northern WCA-3A, the southern half of WCA-2A, and the larger sloughs of Everglades National Park. WCA-1 shows great spatial variation in which scenario has higher SKI values, with higher values under F2050 dominating at the downstream edge of the area.

The long-term average discussed above masks divergent effects of hydrologic conditions for individual years. During a "typical" year (1977, Fig. FESK77FR.PDF) the spatial extent of foraging conditions suitable for Kite breeding is greatly reduced under F2050 - producing higher SKI values relative to C1995 only for portions of WCA-2B. Conversely, under C1995 mid-range SKI values occur over WCA-1, southern WCA-3A, a portion of WCA-3B, and the Holey Land WMA.

During a high rainfall year (1969, Fig. FESK69FR.PDF, which was not an exceptionally high water year) and a high surface water year (1970, Fig. FESK70FR.PDF), Snail Kite SKI's are high across much of the model area under both scenarios. In these years, there are spatial differences in SKI between the two scenarios - C1995 produces equivalent or higher SKI values over all of WCA-1, most of WCA-3A (south), WCA-3B and part of WCA-2B, relative to F2050. F2050 produces higher SKI's over central WCA-2A and northern WCA-3A as well as part of the Holey Lands WMA. In Everglades National Park, central Shark River Slough has higher SKI values under C1995, while in the periphery of the Slough F2050 produces higher SKI's.

During extremely wet years the Snail Kite SKI pattern becomes very complex. Water levels that are too high limit the availability of snails to Kites and the spatial extent of suitable foraging conditions contracts relative to less extreme high water years. During the years of 1983 and 1995 (Figs. FESK83FR.PDF and FESK95FR.PDF), F2050 produces higher SKI values for much of the model area relative to C1995, although there are considerable spatial variations in this. In 1983, WCA-2B, WCA-3B and the west-central portion of WCA-3A exhibit higher SKI values under C1995 relative to F2050. In 1995, F2050 provides predominantly higher SKI's relative to C1995, but C1995 again produces higher SKI's for WCA-2B and WCA-3B.

In the dry year of 1990 (Fig. FESK90FR.PDF), foraging conditions suitable for breeding are practically non-existent across the model area under both F2050 and C1995. F2050 does provide a small area of intermediate SKI values in the Holey Lands WMA, but the overall difference between the two scenarios is negligible.

Figures FESKT1FR.PDF and FESKT2FR.PDF are temporal plots of total foraging potential realized for each of the WCAs and the mean across these selected subregions. Generally, both F2050 and C1995 show the same trajectory over time - increasing and decreasing in step, with index values falling below threshold levels proposed for successful breeding in most drought years. For WCA-2A there is virtually no difference between the two scenarios in total foraging potential realized over the period of record. For the remaining WCA's, C1995 tends to produce higher foraging potential relative to F2050 in most years - and always in wet and high water years (1969, 1970, 1983, 1995) for WCA-2B and WCA-3B.

D-C.6.4.3 Conclusion

Results of the model show clearly the compartmental nature of Snail Kite foraging habitat in southern Florida. In comparing two scenarios with relatively similar overall hydroperiod patterns, such as C1995 and F2050, it is difficult to determine the merits of one versus the other. Often, one scenario produces relatively higher SKI's in some regions while the other scenario gives higher values in other regions in the same year. Overall, C1995 produces higher Snail Kite SKI's under a wide range of hydrologic conditions across all regions relative to F2050, often showing a faster recovery from drought conditions. The differences are not great, and in extreme conditions F2050 can produce higher SKI's (e.g. drought years in WCA-2B).

D-C.6.5 Alternative A vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative A versus F2050 (Revised) on Snail Kites in South Florida

D-C.6.5.1 Index Results

Figure FASKMYFR.PDF shows the 31-year (1965-1995) average values of Snail Kite Indices (SKI) for foraging conditions across the model area. As indicated in the central panel of this set of three maps, Alternative A produces average SKI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FASKMYFR.PDF) for nearly all of WCA-1, central WCA-2A, the eastern edge of WCA-2B, practically all of WCA-3A and most of WCA-3B. F2050 results in higher SKI values for the southern part of WCA-3B, eastern WCA-2A, most of WCA-2B, the Holey Land WMA, East Slough and the central drainage of Northeast Shark Slough and Shark River Slough.

The long-term average discussed above masks divergent effects of hydrologic conditions for individual years. During a "typical" year (1977, Fig. FASK77FR.PDF) the spatial extent of foraging conditions suitable for Kite breeding is greatly reduced under both scenarios. Alternative A provides a significant spatial distribution of relatively high SKI values in southern WCA-1, a small portion of WCA-3B, and central Shark River Slough. F2050 produces a scattering of low SKI values in WCA-2A and 2B, and moderate values in northern WCA-3A and the Holey Land WMA.

In the dry year of 1990 (Fig. FASK90FR.PDF), foraging conditions suitable for breeding are practically non-existent across the model area under both F2050 and Alternative A. F2050 does provide a small area of intermediate SKI values in the Holey Lands WMA. Alternative A does the same for southern WCA-1 and a small area straddling Northeast Shark Slough and Shark Slough. Overall, the difference between the two scenarios under dry conditions is negligible.

During a high rainfall year (1969, Fig. FASK69FR.PDF, which was not an exceptionally high water year), Alternative A provides higher or equivalent SKI values, relative to F2050, in WCA-1, 2A, 2B, and 3B. Alternative A also provides equivalent or higher values across central WCA-3A and along the edges of Shark River Slough. F2050 produces moderately higher SKI values in parts of northern WCA-3A and the Holey Land WMA, and significantly higher values at the southern edge of WCA-3A and the central drainage of Shark River Slough.

During a high surface water year (1970, Fig. FASK70FR.PDF), F2050 again produces significantly higher SKI values, relative to Alternative A for the central Shark Slough drainage from the southern edge of WCA-3B south, and moderately higher values for the Holey Land WMA and northern East Slough. The remaining model area shows moderately higher SKI values under Alternative A, relative to F2050, and significantly higher values in WCA-3B and the edges of Shark River Slough. At even higher surface water conditions (1983, Fig. FASK83FR.PDF), SKI values under both scenarios are lower than those predicted for 1970, except in central Shark River Slough. Under these conditions F2050 produces higher SKI values for most of WCA-1, northwestern WCA-2A, northern WCA-2B, southern WCA-3A and 3B, Northeast Shark River Slough, Shark River Slough and East Slough, relative to Alternative A. Alternative A produces equivalent or higher SKI values, relative to F2050, in northern WCA-3A, the periphery of WCA-3B and Shark River Slough, and the Holey Land WMA.

During extremely wet years (Fig. FASK95FR.PDF), F2050 dominates WCA-1, 2A, 3B, Northeast Shark Slough, Shark River Slough, and East Slough with higher SKI values, relative to Alternative A. Alternative A produces moderately higher SKI values across much of WCA-3A, and significantly higher values in the Holey Land WMA, northern WCA-3B, and the southern edge of the Shark River Slough drainage. SKI values are high across a large proportion of the landscape under both scenarios.

Figures FASKT1FR.PDF and FASKT2FR.PDF are temporal plots of total foraging potential realized for each of the WCA's and the mean across these selected subregions. For WCA-1 Alternative A realizes a larger proportion of potential relative to F2050 in all but the highest water conditions (FASKT1FR.PDF: top). There is no clear pattern in the potential realized under the two scenarios for WCA-2A and WCA-2B (FASKT1FR.PDF: middle and bottom). For WCA-3A, Alternative A generally equals the realized potential produced by F2050 in all but a few years of the model (FASKT2FR.PDF: top). For WCA-3B, Alternative A realizes more potential, relative to F2050, in all years but those where the above mentioned threshold is met (FASKT2FR.PDF: middle). Taken together, Alternative A out-performs F2050 in potential realized, but, when averaged over all regions, the difference is slight (FASKT2FR.PDF: bottom).

D-C.6.5.2 Conclusion

Alternative A produces higher SKI conditions under very dry to typical hydrologic conditions, relative to F2050. As water levels rise, F2050 provides higher SKI values across much of the area. In WCA-3A, an important area for Kites if only by its large size, there is little difference between the scenarios. Thus, each of these scenarios provides a substantial amount of potential kite foraging/breeding area under most conditions. In critical drier years, however, Alternative A provides more than F2050.

D-C.6.6 Alternative B vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative B versus F2050 on Snail Kites in South Florida

D-C.6.6.1 Index Results

Figure FBSKMYFR.PDF shows the 31-year (1965-1995) average values of Snail Kite Indices (SKI) for foraging conditions across the model area. As indicated in the central panel of this set of three maps, Alternative B produces average SKI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FBSKMYFR.PDF) for nearly all of WCA-1, the northern half of WCA-2A, the southern half of WCA-2B, all of WCA-3B and most of WCA-3A. F2050 results in higher SKI values for the far northern and southern parts of WCA-3A, the southern half of WCA-2A and most potential kite foraging habitat south of Tamiami Trail.

The long-term average discussed above masks divergent effects of hydrologic conditions for individual years. During a "typical" year (1977, Fig. FBSK77FR.PDF) the spatial extent of foraging conditions suitable for Kite breeding is greatly reduced under both scenarios. Alternative B provides a significant spatial distribution of relatively high SKI values in southern WCA-1, south and east WCA-3A and a small portion of WCA-3B. Alternative B also produces low to moderate SKI values in the Holey Land WMA. Conversely, F2050 produces very little in the way of SKI values. Under the "typical" hydrologic conditions, F2050 produces a scattering of low SKI values in WCA-2A and B, and moderate values in the Holey Land WMA.

In the dry year of 1990 (Fig. FBSK90FR.PDF), foraging conditions suitable for breeding are practically non-existent across the model area under both F2050 and Alternative B. F2050 does provide a small area of intermediate SKI values in the Holey Lands WMA, as does Alternative B (but to a lesser extent). Overall difference between the two scenarios under dry conditions is negligible.

During a high rainfall year (1969, Fig. FBSK69FR.PDF, which was not an exceptionally high water year), Alternative B is clearly more advantageous to producing high SKI values across most of the model area, relative to F2050. Alternative B provides higher SKI values across all of southern WCA-3A and most of WCA-3B, relative to F2050. Alternative B also provides higher values in all of WCA-1, parts of WCA-2A, southern WCA-2B, and even the northern edge and center of Shark River Slough in Everglades National Park. F2050 produces moderately higher SKI values in parts of northern WCA-3A, and in central and northern WCA-2A relative to Alternative B. F2050 also produces higher SKI values in Northeast Shark Slough and significantly higher values in southern Shark River Slough.

During a high surface water year (1970, Fig. FBSK70FR.PDF), the distribution of SKI values and the differences between the scenarios is similar to the conditions described above. Under high surface water conditions, however, SKI values are higher under F2050, diminishing the magnitude of the differences between the scenarios. At even higher surface water conditions (1983, Fig. FBSK83FR.PDF), SKI values under both scenarios are lower than those predicted for 1970. Under these conditions F2050 produces higher SKI values for most of WCA-1, southern WCA-3A, Northeast Shark River Slough, Shark River Slough and East Slough, relative to Alternative B. Alternative B produces equivalent or higher SKI values, relative to F2050, in western WCA-3A, WCA-3B and the Holey Land WMA.

During extremely wet years (Fig. FBSK95FR.PDF), SKI values are high across a large proportion of the landscape under both scenarios. However, under

Alternative B, water levels are too high in parts of each of the WCA's, limiting the availability of snails to Kites. F2050, therefore, produces higher SKI values for much of the model area relative to Alternative B, although considerable spatial variations are seen, most notably in WCA-3B and south of Tamiami Trail, where Alternative B provides slightly higher SKI values.

Figures FBSKT1FR.PDF and FBSKT2FR.PDF are temporal plots of total foraging potential realized for each of the WCA's and the mean across these selected subregions. Generally, both F2050 and Alternative B show the same trajectory over time, increasing and decreasing in step with index values falling below threshold levels proposed for successful breeding in most drought years. For WCA-1 a larger proportion of potential is realized under Alternative B relative to F2050 in all but the highest water conditions (FBSKT1FR.PDF: top). There is no clear pattern in the potential realized under the two scenarios for WCA-2A and WCA-2B (FBSKT1FR.PDF: middle and bottom). For WCA-3A Alternative B equals or exceeds the realized potential produced by F2050 in all but the last four years of the simulation (FBSKT2FR.PDF: top). For WCA-3B, Alternative B realizes more potential, relative to F2050, in all years but those where the above mentioned threshold is met (FBSKT2FR.PDF: middle). Taken together, Alternative B out-performs F2050 in potential realized under conditions present early in the simulation and is roughly equivalent from 1980 onwards (FBSKT2FR.PDF: bottom).

D-C.6.6.2 Conclusion

Alternative B produces higher SKI conditions under very dry to typical hydrologic conditions, relative to F2050. This is also true in moderately high water years. However, as water levels rise, F2050 provides higher SKI values across much of the area, most notably in WCA-3A. Thus, overall Alternative B outperforms F2050 under most conditions, but in extremely wet years the opposite is true.

D-C.6.7 Alternative C vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative C versus F2050 (Revised) on Snail Kites in South Florida

D-C.6.7.1 Index Results

Figure FCSKMYFR.PDF shows the 31-year (1965-1995) average values of Snail Kite Indices (SKI) for foraging conditions across the model area. As indicated in the central panel of this set of three maps, Alternative C produces average SKI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FCSKMYFR.PDF) for nearly all of WCA-1, the southern half of WCA-2B, the northern half of WCA-3B and a large part of WCA-3A (south). F2050 results in higher SKI values for northern WCA-3A, the southern half of WCA-3B and the larger sloughs of Everglades National Park. WCA-2A shows great spatial variation in which scenario has higher SKI values, with higher values under F2050 dominating at the downstream edge of the area.

The long-term average discussed above masks divergent effects of hydrologic conditions for individual years. During a "typical" year (1977, Fig. FCSK77FR.PDF) the spatial extent of foraging conditions suitable for Kite breeding is greatly reduced under both scenarios. There is no overlap in the spatial distribution of SKI values produced by F2050 and Alternative C. Alternative C provides scattered SKI values in southern WCA-1, WCA-3B, Northeast Shark Slough and Shark River Slough. F2050 produces SKI values in southern WCA-2B, western WCA-2A, sparsely in northern WCA-3A and the Holey Land WMA.

In the dry year of 1990 (Fig. FCSK90FR.PDF), foraging conditions suitable for breeding are practically non-existent across the model area under both F2050 and Alternative C. F2050 does provide a small area of intermediate SKI values in the Holey Lands WMA, and Alternative C does so in southern WCA-1, but the overall difference between the two scenarios is negligible.

During a high rainfall year (1969, Fig. FCSK69FR.PDF, which was not an exceptionally high water year), there are spatial differences in SKI between the two scenarios, Alternative C produces equivalent or higher SKI values over all available foraging habitat in WCA-1, northern WCA-2A, southern WCA-2B, most of WCA-3A (south) and northwestern WCA-3B, relative to F2050. F2050 produces higher SKI values over southern WCA-2A and northern WCA-3A as well as part of the Holey Lands WMA. In Everglades National Park, central Shark River Slough has higher SKI values under F2050, while in the periphery of the Slough Alternative C produces higher SKI's.

During a high surface water year (1970, Fig. FCSK70FR.PDF), the distribution of SKI values and the differences between the scenarios is similar to the conditions described above. Under high surface water conditions, however, SKI values are higher under F2050, diminishing the magnitude of the differences between the scenarios. At even higher surface water conditions (1983, Fig. FCSK83FR.PDF), SKI values under both scenarios are lower than those predicted for 1970. Under these conditions F2050 produces higher SKI values for most of WCA-1, western and northern WCA-3A, southern WCA-3B, Northeast Shark River Slough, Shark River Slough and East Slough, relative to Alternative C. Alternative C produces equivalent or higher SKI values, relative to F2050, in the remaining habitat and expands into the fringes around Shark Slough and the WCA's.

During extremely wet years (Fig. FCSK95FR.PDF), SKI values are high across a large proportion of the landscape under both scenarios. However, under Alternative C, water levels are too high in parts of each of the WCA's, limiting the availability of snails to Kites. F2050, therefore, produces higher SKI values for much of the model area relative to Alternative C, although there are considerable spatial variations in this.

Figures FCSKT1FR.PDF and FCSKT2FR.PDF are temporal plots of total foraging potential realized for each of the WCA's and the mean across these selected subregions. Generally, both F2050 and Alternative C show the same trajectory over time, increasing and decreasing in step with index values falling below threshold levels proposed for successful breeding in most drought years. For WCA-1 and WCA-2A, Alternative C realizes a larger proportion of potential relative to F2050 in most years, except under very high water conditions. There is no clear pattern in the potential realized under the two scenarios for WCA-2B. For WCA-3A and B, Alternative C again realizes more potential than F2050 in most years, including most high surface water years. Taken together, Alternative C out-performs F2050 in potential realized, except in the two years of highest surface water conditions (1983 and 1995) (FCSKT2FR.PDF: bottom).

D-C.6.7.2 Conclusion

Overall, Alternative C produces higher Snail Kite SKI's under a wide range of hydrologic conditions across all regions relative to F2050, often showing a faster recovery from drought conditions. As water depth increases, however, F2050 provides higher SKI values over a large part of the landscape.

D-C.6.8 Alternative D vs. F2050 (Revised)

Assessment of the Effects of Proposed Water Regimes Alternative D versus F2050 (Revised) on Snail Kites in South Florida

D-C.6.8.1 6Index Results

Figure FDSKMYFR.PDF shows the 31-year (1965-1995) average values of Snail Kite Indices (SKI) for foraging conditions across the model area. As indicated in the central panel of this set of three maps, Alternative D produces average SKI values slightly higher than or equivalent to those of F2050 (indicated by gold and gray colors in the central panel of Fig. FDSKMYFR.PDF) for nearly all of WCA-1, the southern half of WCA-2B, the northern half of WCA-3B and a large part of WCA-3A (south). F2050 results in higher SKI values for northern WCA-3A, the southern half of WCA-3B and the larger sloughs of Everglades National Park. WCA-2A shows great spatial variation in which scenario has a higher SKI value, with higher values under F2050 dominating at the downstream edge of the area.

The long-term average discussed above masks divergent effects of hydrologic conditions for individual years. During a "typical" year (1977, Fig. FDSK77FR.PDF) the spatial extent of foraging conditions suitable for Kite breeding is greatly reduced under both scenarios. There is no overlap in the spatial distribution of SKI values produced by F2050 and Alternative D. Alternative D provides scattered SKI values in southern WCA-1, WCA-3B, Northeast Shark Slough and Shark River Slough. F2050 produces SKI values in southern WCA-2B, western WCA-2A, sparsely in northern WCA-3A and the Holey Land WMA.

In the dry year of 1990 (Fig. FDSK90FR.PDF), foraging conditions suitable for breeding are practically non-existent across the model area under both F2050 and Alternative D. F2050 does provide a small area of intermediate SKI values in the Holey Lands WMA, but the overall difference between the two scenarios is negligible.

During a high rainfall year (1969, Fig. FDSK69FR.PDF, which was not an exceptionally high water year), there are spatial differences in SKI between the two scenarios. Alternative D produces equivalent or higher SKI values over all available foraging habitat in WCA-1, northern WCA-2A, southern WCA-2B, most of WCA-3A (south) and northwestern WCA-3B, relative to F2050. F2050 produces higher SKI values over southern WCA-2A and northern WCA-3A as well as part of the Holey Lands WMA. In Everglades National Park, central Shark River Slough has higher SKI values under F2050, while in the periphery of the Slough Alternative D produces higher SKI's.

During a high surface water year (1970, Fig. FDSK70FR.PDF), the distribution of SKI values and the differences between the scenarios is similar to the conditions described above. Under high surface water conditions, however, SKI values are higher under F2050, diminishing the magnitude of the differences between the scenarios. At even higher surface water conditions (1983, Fig. FDSK83FR.PDF), SKI values under both scenarios are lower than those predicted for 1970. Under these conditions F2050 produces higher SKI values for most of WCA-1, western and northern WCA-3A, southern WCA-3B, Northeast Shark River Slough, Shark River Slough and East Slough, relative to Alternative D. Alternative D produces equivalent or higher SKI values, relative to F2050, in the remaining habitat and expands into the fringes around Shark Slough and the WCA's.

During extremely wet years (Fig. FDSK95FR.PDF), SKI values are high across a large proportion of the landscape under both scenarios. However, under Alternative D, water levels are too high in parts of each of the WCA's, limiting the availability of snails to Kites. F2050, therefore, produces higher SKI values for much of the model area relative to Alternative D, although there are considerable spatial variations.

Figures FDSKT1FR.PDF and FDSKT2FR.PDF are temporal plots of total foraging potential realized for each of the WCA's and the mean across these selected subregions. Generally, both F2050 and Alternative D show the same trajectory over time, increasing and decreasing in step with index values falling below threshold levels proposed for successful breeding in most drought years. For WCA-1 and WCA-2A, Alternative D realizes a larger proportion of potential relative to F2050 in most years, except under very high water conditions. There is no clear pattern in the potential realized under the two scenarios for WCA-2B. For WCA-3A and B, Alternative D again realizes more potential than F2050 most years. Taken together, Alternative D out-performs F2050 in potential realized, especially in the early years of the model (FDSKT2FR.PDF: bottom).

D-C.6.8.2 Conclusion

Overall, Alternative D produces higher Snail Kite SKI's under a wide range of hydrologic conditions across all regions relative to F2050, often showing a faster recovery from drought conditions. As water depth increases, however, F2050 provides higher SKI values over a large part of the landscape.

D-C.7 CAPE SABLE SEASIDE SPARROW BREEDING POTENTIAL INDEX MODEL

ATLSS
Cape Sable Seaside Sparrow
Breeding Potential Index Model
Basic Model Description

John L. Curnutt, M. Philip Nott and Jane Comiskey
The Institute for Environmental Modeling
University of Tennessee, Knoxville
Knoxville, TN 37996-1610

D-C.7.1 Introduction

As part of the Central and Southern Florida Comprehensive Study Review (Restudy) several future water management regimes have been proposed. Each of these scenarios will affect potential breeding activity of the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) disproportionately across its range.

The model considers each of three distinct drainage basin zones currently containing known sub-populations of the sparrow.

The model briefly describes these in order of importance relative to current total population level of the sparrow. The first of these areas includes the core of the sparrow's range and lies within the Long Pine Key / South Taylor Slough drainage basin (Ingraham Highway area). Effects on this sub-population will be most significant to the population as a whole. Secondly, the westernmost sub-population occupies the East Slough drainage basin adjacent to the western edge of Shark's slough below Tamiami trail. This sub-population has been most affected by changes in water delivery since 1992, which restricted breeding activity and also resulted in drastic changes in vegetation patterns (Nott et al. in press). Finally, we consider the peripheral and highly fragmented sub-population within North Taylor Slough (and the southern portion of Northeast Shark Slough), that comprises only a small percentage of the total population.

The model express the effects of proposed scenarios as changes in the spatial pattern of breeding potential with reference to these three drainage basins with separate sub-populations. For brevity's sake we refer to them as the core, western and eastern areas, respectively.

D-C.7.2 Methods

The model estimates a sparrow breeding potential index (BPI) for those landscape cells which have the appropriate habitat type (Muhlenbergia dominated prairie) or on which sparrows have been observed to nest. The sparrow BPI model is driven by input data from the South Florida Water Management Model (SFWMM). These data, which are provided as daily water depths for each 2 x 2 mile area in the region covered by the model, are processed by the ATLSS landscape model into finer resolution hydrology. Water depths at the 500-m scale of resolution for ATLSS index models are based on a pseudo-topographic map, which incorporates information from a 28.5-meter resolution vegetation map (see high resolution hydrology and pseudotopography for a more detailed description (HYDRO___.DOC)).

The sparrow BPI reflects the duration and spatial extent of the annual dry season during which the water level in any cell remains below the nesting threshold level of 16cm. Computation of the BPI is based on knowledge of how hydrologic factors affect sparrow breeding success, including critical water level thresholds for each stage of the breeding cycle. The model uses water depth estimates to make spatially explicit predictions of the number of potential breeding cycles for each landscape cell. Each cell will have 0, 1, or 2 complete (45-day) cycles per breeding season.

A sparrow breeding cycle consists of a period of exploration/mating (10 days for first cycle, 5 days for subsequent cycles), nest building, egg laying, incubation of eggs, hatching, nestling stage, walking stage, and fledgling stage. For sparrows to raise young successfully, a window of 45 successive dry days between January 1 and June 30 is required for the fledglings to reach the walking stage. If a cycle is interrupted by rising water levels before the walking stage, we assume breeding was unsuccessful and the nestlings die. A new cycle begins with the next dry day.

The model overlays the computed brood cycle grid with a habitat-type map, utilizing known habitat preferences for sparrow colonization to compute breeding potential indexes from cell by cell brood cycle counts. Sparrows nest on landscape cells of short hydroperiod marl prairie characterized by dense stands of graminoid species (typically Muhlenbergia), usually below 1-m in height, uninterrupted by higher vegetation (trees or shrubs that would give potential predators a perch from which to survey the nesting area.). The vegetation map used is the April 1996 version of The Nature Conservancy (TNC) vegetation map. When selecting Muhlenbergia-dominated cells, we exclude those 500-m resolution cells with lower than 15% overall Muhlenbergia content, as determined by the proportion of constituent 28.5-m resolution cells categorized as Muhlenbergia (type 33) in the TNC map. In addition we include only those cells which are elements of appropriately sized larger clusters of Muhlenbergia cells. Breeding potential values for each cell are weighted by the higher of two values: the proportion of Muhlenbergia in that cell or a weighting factor reflecting the number of sparrows observed nesting and how recently birds were observed there.

Using BPI estimates for cells with preferred habitat in each drainage basin, the model plots time series graphs showing the percentage of available habitat in which successful breeding occurred over the 31-year period for which SFWMM simulated hydrology is available. Three-panel maps are used to show spatial comparisons between breeding potential for two scenarios and display the differences between them. The model presents maps, which represent 31-year averages, and also construct comparisons for selected years (i.e. high, low and average rainfall years as well as other years showing significant trends).

It is important to note that the sparrow BPI reflects the effect of hydrologic conditions for individual years. Obviously, sequences of bad years will have more serious effects than bad years interspersed among a number of good years. In the latter case the population may recover during the drier years. Some compensation for effects of successive dry years is provided in the BPI by computing a multiplicative weighting factor, which represents the mean over previous simulation years of a term reflecting short and long hydroperiod effects for each cell.

Estimates of scenario effects on the temporal patterns of population size require use of the individual based demographic model currently being developed.

As the duration of wet year sequences within any scenario approaches the maximum life span of the sparrow, the probability of local extinction increases.

Output associated with the ATLSS Cape Sable Seaside Sparrow Breeding Potential Index Model.

In accordance with ATLSS file naming conventions, each file name will consist of the characters: UVXXYYZZ.EXT

"U" or "_" => the Base, typically F for the F2050 base or E for the C1995 base
"V" or "_" => the alternative scenario or base
"XX" => "BC" for the ATLSS Cape Sable Seaside Sparrow Breeding Potential Index Model
"YYZZ" => 4 character mnemonic, described below
"."
"EXT" = "PDF" or "TXT" or "DOC" => PDF, tabular text or documentation

ATLSS Cape Sable Seaside Sparrow Breeding Potential Index

1. Maps

Map outputs used to characterize results of the Cape Sable Seaside Sparrow Breeding Potential Index Model will consist of eight image files in PDF file format. Each map shows a "Set" of model results, comparing one SFWMM hydrologic scenario to another, following the conventions for ATLSS comparisons of two model runs. Each map has three panels. The left panel displays index values for either an alternative or base scenario; the right panel displays index values for a base scenario (e.g., the Future without Project Conditions Case, or F2050). The middle panel displays the cell-by-cell difference between index values for the two compared scenarios (e.g., ALT-A minus F2050).

Grid cells in the left and right panels are color-coded to represent the (positive) values of the displayed index, which range between 0 and 1. Cell colors in the center panel represent either positive (shades of gold) or negative (shades of blue) differences between index values displayed in the left panel and those in the right panel. Color keys are provided at the bottom of each map. Each map depicts the model area at either a Fine (500-meter x 500-meter) or Coarse (2-mile) scale of resolution.

For each of six selected years, images will provide a spatial display of index values for that year. In addition, an image file is provided for the mean of all simulated years. The selected years include years with high, low, and typical rainfall, and several additional years that serve to highlight differences between the compared scenarios.

The mnemonic characters are composed according to the convention:

"YY" = Last two digits of the year
"ZZ" = CR - Coarse (2 mile) resolution, FR - Fine (500 meter) resolution

Listing of ATLSS Cape Sable Seaside Sparrow map files:

File Name	Time Period
UVBC69ZZ.PDF	A High Rainfall Year (1969)
UVBC70ZZ.PDF	Highlight Scenarios (1970)
UVBC77ZZ.PDF	A Typical Rainfall Year (1977)
UVBC83ZZ.PDF	Highlight Scenarios (1983)
UVBC90ZZ.PDF	A Low Rainfall Year (1990)
UVBC95ZZ.PDF	Highlight Scenarios (1995)
UVBCMYZZ.PDF	Mean of All Years (1965->1995)

2. Time Series

Time series sets associated with the ATLSS Cape Sable Seaside Sparrow Breeding Potential Index will display breeding potential values for three applicable subregions only. These show percentage of available habitat in which successful breeding occurred for each year.

File Name	Description
UVBCTSZZ.PDF	Percentage of available habitat in which successful breeding occurred for each year in each of three subregions.

3. Histograms None.

4. Tables None.

D-C.7.3 F2050 (Revised) vs. C1995 (Revised)

Assessment of the effects of proposed water regimes C1995 (Revised) vs F2050 (Revised) upon the potential breeding success and population dynamics of the Cape Sable Seaside-Sparrow.

The interpretation of results for the C1995 vs. F2050 hydrologic scenario includes a discussion of the results of both the Breeding Potential Index (BPI) and the spatially-explicit individual-based model, SIMSPAR. The BPI model provides single year snapshots of the effects of hydrology on the availability of breeding habitat throughout the sparrow's range. SIMSPAR, while only covering the region encapsulating the western sparrow subpopulation (see SIMSPAR model description), has the advantage of showing cumulative effects of sequences of wet or dry years. In addition to these two models, we apply the results of SIMSPAR to a population viability analysis (PVA).

D-C.7.3.1 Breeding Potential Index Model

The C1995 scenario positively affects sparrow breeding potential relative to F2050 for nearly all sparrow habitat. This is true for wet years (FEBC69FR.PDF, FEBC70FR.PDF, FEBC83FR.PDF) and even for typical and dry years (FEBC77FR.PDF, FEBC90FR.PDF). For two small areas, Lower Taylor Slough and the "stairsteps" region along the border of Everglades National Park and southern Big Cypress, the F2050 produces slightly higher BPI values over most hydrologic conditions. The difference between the BPI values produced under the two scenarios is accentuated under high surface water conditions (FEBC69FR.PDF, FEBC70FR.PDF, FEBC83FR.PDF, FEBC95FR.PDF). At extremely high surface water conditions sparrow breeding is greatly diminished west of Shark River Slough under both scenarios, however, east of the slough C1995 produces very high BPI values relative to F2050 (FEBC95FR.PDF).

D-C.7.3.2 Individual-based Model - SIMSPAR

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates the population variability for the western sparrow breeding area. The results of the C1995 scenario are shown on FESPTRAJ.PDF along with those from F2050.

Both F2050 and C1995 lead to a persistent, although variable breeding population. Figure FESPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin at 308 birds (the initial population for the western area - see Model Description). After a similar increase from 1965 to 1966, the predicted breeding populations quickly diverge under the two scenarios with C1995 increasing to a mean (calculated over 20 repetitions) of 500 breeding individuals by 1969 while under F2050 the breeding population slightly declines until 1971. The predicted breeding population under C1995 remains higher than under F2050 throughout the remainder of the model run, significantly so until 1980. Since the two scenarios produce the same trajectory over the model period the higher predicted populations under C1995 may be the result of the more favorable breeding conditions in the first three years under C1995. After the initial increase in breeding populations, both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Of these extreme breeding populations only the peak of 1978/1979 shows significant differences between the two scenarios with C1995 producing a mean breeding population of about 1800 individuals and F2050 producing 1100 individuals in 1979. The predicted breeding populations decline to 650 and 480 individuals under C1995 and F2050, respectively, in 1985. The populations then climb to 1950 and 1550 individuals under C1995 and F2050, respectively, in 1991/1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching just under 500 individuals in 1995 under both scenarios.

Figure FESPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV positively correspond with mean predicted breeding population (FESPMPOP.PDF). Suggesting that the stochastic nature of the model leads to higher variability with higher initial populations. Across all years, C1995 exhibits lower CVs than does F2050, never exceeding 0.15. Under F2050, after the fourth year the CV fluctuates between 0.15 and 0.3.

The fledgling productivity maps (FESPPROD.PDF) show that, averaging over all years, C1995 was more conducive to sparrow production than F2050 (FESPPROD.PDF: bottom). As discussed above, this initial difference in productivity (FESPPROD.PDF: top) resulted in higher predicted breeding populations under C1995 relative to F2050 for the first 15 model years. In 1994 (FESPPROD.PDF: middle), more fledgling were produced under F2050 relative to C1995 across the area studied. This was also the case in 1987 (not shown). For all other model years, C1995 produced more fledglings over more of the area than F2050. However, in ten years F2050 produced more fledglings in the northern one-third of occupied sparrow habitat.

D-C.7.3.3 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the model. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-")that the population will drop below a specified number over time. Under C1995, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the model period and a probability of 1.0 that it fall below 500 after two years (_ESPPTQX.PDF). Note that on this figure all of the lines are overlaid and only the last line (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF) there is a probability of 0.2 that the population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses F2050 shows an increasing probability of the population exceeding levels of up to 500 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching levels above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching levels above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under C1995 (_ESPPTQE.PDF), after 10 years the probability of reaching levels above 250 is 1.0 and above 500 is 0.9. After 25 years the probability of reaching levels above 1000 is 1.0 and above 2000 is 0.15. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the model. Under both scenarios (FESPPIER.PDF) the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 2000 breeding individuals is 0.5 under C1995 and 0.0 under F2050.

D-C.7.3.4 Conclusion

Under C1995 the sparrow breeding population reaches higher numbers early in the model years relative to F2050. This difference carries through until the final, high water years when the difference between the predicted breeding populations are insignificant. Overall, C1995 allows for higher fledgling productivity than F2050 and, partially as a consequence of this, C1995 breeding population estimates are less variable than those produced under F2050. The fledgling productivity maps show that, under either scenario, conditions are favorable enough for breeding sparrows to colonize nearly all available breeding habitat even though the model begins with the very constricted spatial distribution of breeding that we have witnessed in the recent high water years (compare FESPPROD.PDF top and middle).

D-C.7.4 Alternative A vs. F2050 (Revised)

Assessment of the effects of proposed water regimes Alternative A versus F2050 (Revised) upon the Potential Breeding Success and Population Dynamics of the Cape Sable Seaside-Sparrow.

As with the previous hydrologic scenario, the interpretation of results for Alternative A and F2050 includes a discussion of the results of both the Breeding Potential Index (BPI) and the spatially-explicit individual-based model, SIMSPAR. The BPI model provides single year snapshots of the predicted effects of hydrology on the availability of breeding habitat throughout the sparrow's range. SIMSPAR, while only covering the region encapsulating the western sparrow subpopulation (see SIMSPAR model description), has the advantage of showing cumulative effects of sequences of wet or dry years. In addition to these two models, we apply the results of SIMSPAR to a population viability analysis (PVA).

D-C.7.4.1 Breeding Potential Index Model

The F2050 scenario positively affects sparrow breeding potential relative to Alternative A for nearly all sparrow habitat east of Shark River Slough (FABCMYFR.PDF). This is true for wet years (FABC69FR.PDF, FABC70FR.PDF, FABC83FR.PDF) and even for typical and dry years (FABC77FR.PDF, FABC90FR.PDF). Indeed, F2050 produces higher BPI values east of Shark River Slough, relative to Alternative A, for every year in the simulation except 1965 (not shown), when BPI values for the two scenarios are equivalent. Generally, the magnitude of difference between the two scenarios east of the Slough is greatest under higher water conditions (FABC69FR.PDF, FABC83FR.PDF). In extremely high water years (FABC95FR.PDF), the spatial extent of suitable breeding conditions east of the Slough is greatly reduced.

For sparrow BPI values west of Shark River Slough, F2050 provides slightly higher values at the southern end of East Slough in 23 of the simulation years. This is seen in the 31-year mean (FABCMYFR.PDF) and, to varying degrees, in dry, "typical" and slightly higher water years (FABC90FR.PDF, FABC77FR.PDF, FABC69FR.PDF) but not in moderate to high water years (FABC70FR.PDF, FABC83FR.PDF, FABC95FR.PDF). For the remainder of potential sparrow breeding sites west of Shark River Slough, Alternative A provides higher BPI values, relative to F2050 (FABCMYFR.PDF). Under dry, "typical" and high rainfall conditions (FABC90FR.PDF, FABC77FR.PDF, FABC69FR.PDF), BPI values are only slightly higher under Alternative A, relative to F2050. In high to extremely high water conditions (FABC70FR.PDF, FABC83FR.PDF, FABC95FR.PDF), the differences are accentuated and Alternative A provides significantly higher BPI values, relative to F2050, for the area as a whole. This is partially due to the greater spatial extent of suitable breeding habitat west of Shark River Slough possible under Alternative A relative to F2050.

D-C.7.4.2 7Individual-based Model - SIMSPAR

SIMSPAR, unlike the breeding potential index model, provides a method of analyzing the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative A scenario are shown in Fig. FASPTRAJ.PDF along with those from F2050.

Both F2050 and Alternative A lead to a persistent, although variable breeding population. Figure FASPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Alternative A results consistently in significantly higher mean populations. The two predicted populations diverge after the first year of the simulation, and it may be this early difference that accounts for the subsequent higher populations under Alternative A. Both scenarios produce two peaks in predicted numbers (1979/1980 and 1991/1992) and one trough (1984/1985). Alternative A produces a mean breeding population of about 1600 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 650 and 480 individuals under Alternative A and F2050, respectively, in 1985. The populations then climb to 2200 and 1550 individuals under Alternative A and F2050, respectively, in 1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 600 and 450 individuals for Alternative A and F2050, respectively, in 1995.

Figure FASPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV correlate positively with mean predicted breeding population (FASPMPOP.PDF), more so for F2050 than for Alternative A. After the first 4 years of the simulation, Alternative A exhibits lower CV's than does F2050. The lower CV's for Alternative A suggest that the ability of the population to reach higher numbers sooner, relative to F2050, allows for greater spatial distribution of breeders and, consequently, more stability in numbers between repetitions.

The fledgling productivity maps (FASPPROD.PDF) show that, averaging over all years, Alternative A is more conducive to sparrow production than F2050 (FASPPROD.PDF: bottom). In 1980 (FASPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative A across much the model area. This is the only year that F2050 produced more fledglings across the model area. In 14 other years, F2050 produced more fledglings in variously sized portions of the northern third of the model area. Even for these years, however, many more fledglings were produced under Alternative A over more of the model area than under F2050. In the extremely high water year of 1995 (FASPPROD.PDF: middle), Alternative A allows fledgling productivity over more of the study area, relative to F2050. Under both scenarios productivity is greatly reduced in 1995.

D-C.7.4.3 7Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the simulation. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative A, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the simulation period, a probability of 0.25 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after six years (_ASPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that he population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative A (_ASPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.9. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 1.0 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FASPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 1.0 under Alternative A and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 1.0 under Alternative A and 0 under F2050.

D-C.7.4.4 Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative A and F2050 are significant, but complicated by the opposite effects that the scenarios have on sparrow breeding potential on either side of Shark River Slough. Generally, F2050 is more conducive to sparrow breeding east of the Slough and Alternative A is more conducive to breeding on the west side of the Slough. Since the BPI is not a quantitative measure, we are not able to determine the exact trade-off in predicted sparrow breeding given this spatially-based dichotomy. SIMSPAR is quantitative, and we show that the better breeding conditions west of the Slough under Alternative A relative to F2050 can lead to more sparrows. In the absence of a similar model for the area east of the Slough we are unable to determine which scenario is better for the global sparrow population.

An additional concern is that long-term habitat effects of conditions that are either too wet or too dry are difficult to assess with the BPI model. Specifically, long-term effects of dryness in the eastern area, which are difficult to measure, may counter-balance short-term effects of wet conditions, which are easily measured by counting days when water depths are above a threshold value for a given year. Hence, without a long-term vegetation change model, a scenario might be judged to be superior based on length of breeding season, when long-term changes in vegetative communities due to dryness under that water regime could lead to shrub invasion or changes in fire patterns. These, in turn, could have detrimental effects on sparrow breeding habitat.

D-C.7.5 Alternative B vs. F2050 (Revised)

Assessment of the effects of proposed water regimes Alternative B versus F2050 upon the Potential Breeding Success and Population Dynamics of the Cape Sable Seaside-Sparrow.

As with previous hydrologic scenarios, the interpretation of results for Alternative B and F2050 includes a discussion of the results of both the Breeding Potential Index (BPI) and the spatially-explicit individual-based model, SIMSPAR. The BPI model provides single year snapshots of the predicted effects of hydrology on the availability of breeding habitat throughout the sparrow's range. SIMSPAR, while only covering the region encapsulating the western sparrow subpopulation (see SIMSPAR model description), has the advantage of showing cumulative effects of sequences of wet or dry years. In addition to these two models, we apply the results of SIMSPAR to a population viability analysis (PVA).

D-C.7.5.1 Breeding Potential Index Model

The F2050 scenario positively affects sparrow breeding potential relative to Alternative B for nearly all sparrow habitat east of Shark River Slough (FBBCMYFR.PDF). This is true for wet years (FBBC69FR.PDF, FBBC70FR.PDF, FBBC83FR.PDF) and even for typical and dry years (FBBC77FR.PDF, FBBC90FR.PDF). Indeed, F2050 produces higher BPI values east of Shark River Slough, relative to Alternative B, for every year in the simulation except 1965 (not shown) when the values for the two scenarios are equivalent. Generally, the magnitude of the difference between the two scenarios east of the slough is greatest under higher water conditions (FBBC69FR.PDF, FBBC83FR.PDF). In extremely high water years (FBBC95FR.PDF), the spatial extent of suitable breeding conditions east of the slough is greatly reduced.

For sparrow BPI values west of Shark River Slough, F2050 provides slightly higher values at the southern end of East Slough in 18 of the simulation years. This is evident in the 31-year mean (FBBCMYFR.PDF) and, to varying degrees, in dry, "typical" and moderately high water years (FBBC90FR.PDF, FBBC77FR.PDF, FBBC69FR.PDF, FBBC70FR.PDF) but not in very high water years (FBBC83FR.PDF, FBBC95FR.PDF). For the remainder of potential sparrow breeding sites west of Shark River Slough, Alternative B provides higher BPI values, relative to F2050 (FBBCMYFR.PDF). Under dry, "typical" and high rainfall conditions (FBBC90FR.PDF, FBBC77FR.PDF, FBBC69FR.PDF), BPI values are only slightly higher under Alternative B, relative to F2050. In high to extremely high water conditions (FBBC83FR.PDF, FBBC95FR.PDF), the differences are accentuated and Alternative B provides significantly higher BPI values, relative to F2050, for the area as a whole. This is partially due to the greater spatial extent of suitable breeding habitat west of Shark River Slough possible under Alternative B relative to F2050.

D-C.7.5.2 Individual-based Model - SIMSPAR

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking into account the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative B scenario are shown in Fig. FBSPTRAJ.PDF, along with those from F2050.

Both F2050 and Alternative B lead to a persistent, although variable, breeding population. Figure FBSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Alternative B results consistently in significantly higher mean populations. The two predicted populations diverge after the first year of the simulation and it may be this early difference that accounts for the subsequent higher populations under Alternative B. Both scenarios produce two peaks in predicted numbers (1979/1980 and 1991/1992) and one trough (1984/1985). Alternative B produces a mean breeding population of about 1550 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 700 and 480 individuals under Alternative B and F2050, respectively, in 1985. The populations then climb to 2050 and 1550 individuals under Alternative B and F2050, respectively, in 1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 600 and 450 individuals for Alternative B and F2050, respectively, in 1995.

Figure FBSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV correlate positively with mean predicted breeding population (FBSPMPOP.PDF), more so for F2050 than for Alternative B. After the first 6 years of the simulation, Alternative B exhibits lower CV's than does F2050. The lower CV's for Alternative B suggest that the ability of the population to reach higher numbers sooner, relative to F2050, allows for greater spatial distribution of breeders and, consequently, more stability in numbers between repetitions.

The fledgling productivity maps (FBSPPROD.PDF) show that, averaging over all years, Alternative B is more conducive to sparrow production than F2050 (FBSPPROD.PDF: bottom). In 1978 (FBSPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative B across much the model area. This occurred for the year 1987 and 1980 as well (not shown). In six other years, F2050 produced more fledglings in only the northern part of the model area. For all other simulation years, more fledglings were produced under Alternative B over more of the model area than under F2050. In the extremely high water year of 1995 (FBSPPROD.PDF: middle), Alternative B allows fledgling productivity over more of the study area, relative to F2050. However, under both scenarios productivity is greatly reduced in 1995.

D-C.7.5.3 7Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the simulation. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative B, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the simulation period, a probability of 0.6 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after six years (_BSPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative B (_BSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.5. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.75 that the population will reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FBSPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 1.0 under Alternative B and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.75 under Alternative B and 0 under F2050.

D-C.7.5.4 7Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative B and F2050 are significant, but complicated by the opposite effects that the scenarios have on sparrow breeding potential on either side of Shark River Slough. Generally, F2050 is more conducive to sparrow breeding east of the slough and Alternative B is more conducive to breeding on the west side of the slough. Since the BPI is not a quantitative measure we are not able to determine the exact trade-off in predicted sparrow breeding given this spatially based dichotomy. The SIMSPAR model is quantitative, and shows that the better breeding conditions west of the slough under Alternative B relative to F2050 can lead to more sparrows. In the absence of a similar model for the area east of the slough we are unable to determine which scenario is better for the global sparrow population.

An additional concern is that long-term habitat effects of conditions that are either too wet or too dry are difficult to assess with the BPI model. Specifically, long-term effects of dryness in the eastern area, which are difficult to measure, may counter-balance short-term effects of wet conditions, which are easily measured by counting days when water depths are above a threshhold value for a given year. Hence, without a long-term vegetation change model, a scenario might be judged to be superior based on length of breeding season, when long-term changes in vegetative communities due to dryness under that water regime could lead to shrub invasion or changes in fire patterns. These, in turn, could have detrimental effects on sparrow breeding habitat.

D-C.7.6 Alternative C vs. F2050 (Revised)

Assessment of the effects of proposed water regimes Alternative C versus F2050 (Revised) upon the Potential Breeding Success and Population Dynamics of the Cape Sable Seaside-Sparrow.

As with previous hydrologic scenario, the interpretation of results for Alternative C and F2050 includes a discussion of the results of both the Breeding Potential Index (BPI) and the spatially-explicit individual-based model, SIMSPAR. The BPI model provides single year snapshots of the predicted effects of hydrology on the availability of breeding habitat throughout the sparrow's range. SIMSPAR, while only covering the region encapsulating the western sparrow subpopulation (see SIMSPAR model description), has the advantage of showing cumulative effects of sequences of wet or dry years. In addition to these two models, we apply the results of SIMSPAR to a population viability analysis (PVA).

D-C.7.6.1 Breeding Potential Index Model

The F2050 scenario positively affects sparrow breeding potential relative to Alternative C for nearly all sparrow habitat east of Shark River Slough (FCBCMYFR.PDF). This is true for wet years (FCBC69FR.PDF, FCBC70FR.PDF, FCBC83FR.PDF) and even for typical and dry years (FCBC77FR.PDF, FCBC90FR.PDF). In moderately dry (1972 through 1976, not shown) and, to some extent, in typical years (FCBC77FR.PDF), Alternative C provides higher BPI values just east of Shark River Slough proper and in the southern marl prairies east of the Slough. For all but very high surface water conditions (FCBC70FR.PDF, FCBC83FR.PDF, FCBC95FR.PDF), when sparrow breeding is precluded under both scenarios, F2050 provides higher BPI values relative to Alternative C for the southern end of East Slough. For the remainder of the sparrow's potential breeding habitat west of Shark River Slough, Alternative C produces higher BPI values relative to F2050. This is true for all conditions (FCBC90FR.PDF, FCBC77FR.PDF, FCBC83FR.PDF, FCBC69FR.PDF, FCBC70FR.PDF, FCBC95FR.PDF), and is accentuated under very high surface water conditions (FCBC70FR.PDF, FCBC83FR.PDF, FCBC95FR.PDF), when breeding is more curtailed under F2050 relative to Alternative C.

D-C.7.6.2 7Individual-based Model - SIMSPAR

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative C scenario are shown in Fig. FCSPTRAJ.PDF along with those from F2050.

Both F2050 and Alternative C lead to a persistent, although variable breeding population. Figure FCSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Predicted breeding populations under the two scenarios are very similar through time. Alternative C results in significantly higher mean populations only from 1967 through 1977. Both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Alternative C produces a mean breeding population of about 1400 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 500 and 480 individuals under Alternative C and F2050, respectively, in 1985. The populations then climb to 1750 and 1550 individuals under Alternative C and F2050, respectively, in 1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 500 individuals in 1995 under both scenarios.

Figure FCSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV correlate positively with mean predicted breeding population (FCSPMPOP.PDF). Through the 1970's and through the 1990's, Alternative C exhibits lower CV's than does F2050. Although the CV's of both scenarios are similar, the lower values in the crucial wet years of 1992 - 1995 for Alternative C suggest that the breeding population has more of a chance of persisting through extreme conditions under this scenario relative to F2050.

The fledgling productivity maps (FCSPPROD.PDF) show that, averaging over all years, Alternative C is more conducive to sparrow production than F2050 (FCSPPROD.PDF: bottom). In 1980 (FCSPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative C across the area studied. This was also the case in 1978, 1980, 1987, and 1992 (not shown). For all other model years, more fledglings were produced under Alternative C over more of the model area than under F2050. However, for eight of these years (not shown) more fledglings were produced under F2050 in parts of the model area. In the extremely high water year of 1995 (FCSPPROD.PDF: middle), Alternative C allows fledgling productivity over more of the study area, relative to F2050. However, under both scenarios productivity is greatly reduced in 1995.

D-C.7.6.3 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the model. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative C, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the model period, a probability of 0.9 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after one year (_CSPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative C (_CSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.45. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.05 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FCSPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 0.95 under Alternative C and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.10 under Alternative C and 0 under F2050.

D-C.7.6.4 Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative C and F2050 are minor. Alternative C appears to be more conducive to breeding population recovery after a decline relative to F2050. This is apparent in the fledgling productivity maps and the PVA results.

D-C.7.7 Alternative D vs. F2050 (Revised)

Assessment of the effects of proposed water regimes Alternative D versus F2050 (Revised) upon the potential breeding success and population dynamics of the Cape Sable Seaside-Sparrow.

As with previous hydrologic scenario, the interpretation of results for Alternative D and F2050 includes a discussion of the results of both the Breeding Potential Index (BPI) and the spatially-explicit individual-based model, SIMSPAR. The BPI model provides single year snapshots of the predicted effects of hydrology on the availability of breeding habitat throughout the sparrow's range. SIMSPAR, while only covering the region encapsulating the western sparrow subpopulation (see SIMSPAR model description), has the advantage of showing cumulative effects of sequences of wet or dry years. In addition to these two models, we apply the results of SIMSPAR to a population viability analysis (PVA).

D-C.7.7.1 Breeding Potential Index Model

The F2050 scenario positively affects sparrow breeding potential relative to Alternative D for nearly all sparrow habitat east of Shark River Slough (FDBCMYFR.PDF). This is true for wet years (FDBC69FR.PDF, FDBC70FR.PDF, FDBC83FR.PDF) and even for typical and dry years (FDBC77FR.PDF, FDBC90FR.PDF). F2050 also provides higher BPI values relative to Alternative D for the "stairstep" region of Big Cypress and Everglades National Park and for the prairies just west of Shark River Slough. In the former area under all hydrologic conditions and in the latter area under all but extreme high water conditions. Under both scenarios, during extreme high water years (FDBC83FR.PDF, FDBC95FR.PDF) the spatial extent of sparrow breeding habitat is greatly reduced, especially west of Shark River Slough.

Alternative D produces higher BPI values relative to F2050 for the area in and around East Slough during dry, "typical", and high rainfall conditions (FDBC90FR.PDF, FDBC77FR.PDF, FDBC83FR.PDF). During extreme high water years, breeding is precluded in and around East Slough (FDBC69FR.PDF). Under these conditions Alternative D provides for some restricted breeding potential, but neither scenario provides significant amounts of breeding habitat.

D-C.7.7.2 Individual-based Model - SIMSPAR

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative D scenario are shown in Fig. FDSPTRAJ.PDF along with those from F2050.

Both F2050 and Alternative D lead to a persistent, although variable breeding population. Figure FDSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Predicted breeding populations under the two scenarios are very similar through time. Alternative D results in significantly higher mean populations only from 1973 through 1977. Both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Alternative D produces a mean breeding population of about 1400 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 600 and 480 individuals under Alternative D and F2050, respectively, in 1985. The populations then climb to 1750 and 1550 individuals under Alternative D and F2050, respectively, in 1991. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 500 individuals in 1995 under both scenarios.

Figure FDSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV positively correspond with mean predicted breeding population (FDSPMPOP.PDF). From 1975 onwards, Alternative D exhibits lower CV's than does F2050, never exceeding 0.20. Under F2050, after the fourth year the CV fluctuates between 0.15 and 0.3.

The fledgling productivity maps (FDSPPROD.PDF) show that, averaging over all years, Alternative D is more conducive to sparrow production than F2050 (FDSPPROD.PDF: bottom). In 1980 (FDSPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative D across the area studied. This was also the case in 1978 and 1987 (not shown). For all other model years, more fledglings were produced over more of the model area under Alternative D than under F2050. However, for nine of these years (not shown) more fledglings were produced in portions of the model area under F2050. In the extremely high water year of 1995, higher fledgling productivity is seen under Alternative D (FDSPPROD.PDF: middle).

D-C.7.7.3 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the model. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative D, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the model period, a probability of 0.8 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after one year (_DSPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative D (_DSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.3. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.15 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FDSPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 0.95 under Alternative D and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.10 under Alternative D and 0 under F2050.

D-C.7.7.4 Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative D and F2050 are minor. Alternative D appears to be more conducive to breeding population recovery after a decline relative to F2050. This is apparent in the fledgling productivity maps and the PVA results.

D-C.7.8 Alternative D13R vs. F2050 (Revised)

Assessment of the effects of proposed water regimes Alternative D13R versus F2050 (Revised) upon the Potential Breeding Success and Population Dynamics of the Cape Sable Seaside-Sparrow

As with previous hydrologic scenario, the interpretation of results for Alternative D13R and F2050 includes a discussion of the results of both the CSSS Breeding Potential Index (BPI) and the spatially-explicit individual-based model, SIMSPAR. The BPI model provides single year snapshots of the effects of hydrology on the availability of breeding habitat throughout the sparrow's range. SIMSPAR, while only covering the region encapsulating the western sparrow subpopulation (see SIMSPAR model description), has the advantage of showing cumulative effects of sequences of wet or dry years. In addition to these two models, we apply the results of SIMSPAR to a population viability analysis (PVA). In all figure legends Alternative D13R is referred to as Alt G - this is in keeping with our alphanumeric code for labeling figures.

D-C.7.8.1 Breeding Potential Index Model

The F2050 scenario positively affects sparrow breeding potential relative to Alternative D13R for sparrow habitats east of Shark River Slough (FGBCMYFR.PDF) under most hydrologic conditions. The magnitude of the difference in BPI values is greatest in wet years (FGBC69FR.PDF, FGBC70FR.PDF, FGBC83FR.PDF) and least for typical and dry years (FGBC77FR.PDF, FGBC90FR.PDF). F2050 also provides higher BPI values relative to Alternative D13R for the southern portion of the western sparrow breeding area under all but the wettest hydrologic conditions. Alternative D13R provides higher BPI values relative to F2050 in the northern portion of the western breeding area. Under both scenarios, during extreme high water years the spatial extent of sparrow breeding habitat is greatly reduced, especially west of Shark River Slough.

D-C.7.8.2 Individual-based Model - SIMSPAR

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates the population variability for the western sparrow breeding area. Results of the Alternative D13R scenario are shown on FGSPTRAJ.PDF, along with those from F2050.

Both F2050 and Alternative D13R lead to a persistent, although variable breeding population. Figure FGSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin at 308 birds (the initial population for the western area - see Model Description). The predicted breeding populations under the two scenarios are very similar through time. Alternative D13R results in significantly higher mean populations only from 1967 through 1970 and from 1972 through 1977. Both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Alternative D13R produces a mean breeding population of about 1400 individuals and F2050 producing 1100 individuals in 1978. The predicted breeding populations decline to 600 and 480 individuals under Alternative D13R and F2050, respectively, in 1985. The populations then climb to 1750 and 1550 individuals under Alternative D13R and F2050, respectively, in 1991. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 500 individuals in 1995 under both scenarios.

Figure FGSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV positively correspond with mean predicted breeding population (FGSPMPOP.PDF). From 1975 onwards, Alternative D13R exhibits lower CV's than does F2050, never exceeding 0.20. Under F2050, after the fourth year the CV fluctuates between 0.15 and 0.3.

The fledgling productivity maps (FGSPPROD.PDF) show that, averaging over all years, Alternative D13R was more conducive to sparrow production than F2050 (FGSPPROD.PDF: bottom). In 1980 (FGSPPROD.PDF: top), more fledgling were produced under F2050 relative to Alternative D13R across the area studied. This was also the case in 1978 and 1987 (not shown). For all other simulation years, Alternative D13R produced more fledglings over more of the area than F2050 did. However, for nine of these years (not shown) F2050 produced more fledglings in parts of the model area. In the extremely high water year of 1995, Alternative D13R allows higher fledgling productivity (FGSPPROD.PDF: middle).

D-C.7.8.3 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the simulation. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative D13R, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the simulation period, a probability of 0.9 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after one year (_GSPPTQX.PDF). Note that on this figure all of the lines are overlaid and only the last line (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF) there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that it will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses F2050 shows an increasing probability of the breeding population exceeding levels of up to 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative D13R (_GSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.2. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.2 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FGSPPIER.PDF) the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 1.0 under Alternative D13R and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.2 under Alternative D13R and 0 under F2050.

D-C.7.8.4 Conclusion

Alternative D13R produces lower BPI values relative to F2050 in the eastern sparrow breeding area and in the southern portion of the western breeding area under most hydrologic conditions. The results of SIMSPAR suggest that the sparrow population can reach higher levels more often under Alternative D13R, relative to F2050. Alternative D13R also produces a more stable sparrow population and it appears to be more conducive to breeding population recovery after a decline relative to F2050. This is apparent in the fledgling productivity maps and the PVA results.

D-C.8 INDIVIDUAL-BASED MODEL - SIMSPAR

SIMSPAR

Version 1.3

A Spatially-explicit Individual-based Object-oriented Simulation Model for the Cape Sable seaside sparrow in the Everglades and Big Cypress Landscapes

Philip Nott, Jane Comiskey, John Curnutt and Louis Gross
The Institute for Environmental Modeling
Tennessee Knoxville, TN 37996-1610

D-C.8.1 Introduction

The Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) is an ecologically isolated subspecies of the seaside sparrow (Beecher 1955). Recent surveys estimate a population size of approximately 3000 individuals (from 6000+ in 1992), and its range is restricted to the extreme southern portion of the Florida peninsula, almost entirely within the boundaries of the Everglades National Park and Big Cypress National Preserve (Werner 1975, Bass and Kushlan 1982). The sparrow currently breeds in marl prairies typified by dense stands of graminoid species usually below 1m in height and naturally inundated by freshwater during part of the year. As water levels recede during the dry season in late winter and spring, the sparrows establish territories and start nesting in dense grass tussocks. Several broods may result from a single male territory if hydrologic conditions allow (Lockwood et al. 1997). If water levels do not recede early enough in spring, nesting may be delayed, and if water levels subsequently rise during the nesting season, eggs or nestlings may be drowned. Recent declines have occurred in the sparrow population across its entire range, probably due to higher water levels in recent years (Pimm et al. 1995). Because the current range of the sparrow is limited to a few hundred square kilometers and because it is subject to flooding and fires, the population is highly vulnerable. The Everglades restoration project (Hinrichson 1995) plans to change the hydrology of the southern Everglades. Changing water levels in parts of the sparrow's range would affect the reproductive success of the sparrow. This model attempts to quantify the relative impact of alternative hydrologic regimes on the survival of sparrow populations.

D-C.8.2 SIMSPAR Version 1.3

Several important features are supported in Version 1.3. Significantly, the ATLSS habitat layer (TNC GAP analysis) is spatially integrated with the existing topology and with extensive sparrow survey data. Subsequent analysis provides a set of rules with which to define potential breeding habitat. SIMSPAR predicts population levels and spatial distributions of breeding activity that correlate well with field data.

D-C.8.3 SIMSPAR landscape

The landscape of the sparrow's range is modeled explicitly as a set of spatial cells of fine enough resolution (500m) to represent areas of similar vegetation, topography, and hydrology. The spatial extent of the model is an area west of Shark River Slough covering 18 x 28.5 km. In this implementation of SIMSPAR only the western subpopulation is included, since it is the only region for which field estimates of fine resolution topography are available. SIMSPAR is capable of being applied to other subpopulations when these topographic data become available.

1. Universal Transverse Mercator coordinates describe the spatial extent of the area modeled, which encapsulates the western sub-population (UTM Zone 17: Northing 2 851 070, Southing 2 821 570, Easting 517 665, Westing 499 665). This area is expressed as a 500m-resolution landscape (59 rows x 36 columns) and corresponds geographically to the top left-hand box shown in SPARLAND.PDF. The symbols within this box mark the historical locations of breeding sparrows determined from extensive surveys in 1981, and every year since 1992 (Curnutt et al. 1998).

2. This portion of the 1994 TNC habitat map overlays the topography previously derived from water depth measurements made during the 1995 extensive sparrow survey. Interpolating non-uniformly spaced estimates of elevation using an inverse distance method creates this topography.

3. We determined from the fine-scale 30m-resolution TNC habitat map, the percentage cover of each habitat type within each 500m resolution cell. This is represented by a false color image of the area shown in WESTTNCH.PDF, black lines delineate the boundaries of each 500m cell considered. A key to the 25 commonest (by % cover) classes depicted in this image is given in WESTTNCK.PDF.

4. We analyzed the fine scale habitat data associated with the 79 known locations of breeding sparrows observed in the 1992 extensive sparrow survey (Nott in prep.). Sonny Bass of Everglades National Park conducted this survey. The results of these analyses are summarized as a set of 41 habitat type tolerances and 2 habitat preference rules, tabulated in TNCRULES.TXT and described briefly below.

* The 41 individual habitat types do not cover more than a certain percentage of any 500m-resolution cell in which breeding sparrows were observed in 1992.

* The majority (76) of the 79 known 1992 breeding locations contain greater than 70% coverage of habitat types 30,33, and 39.

* Only 4 of the 79 known 1992 breeding locations are associated with less than 30% coverage of 'wetter' marshland habitat types (0 23 24 25 29 31 32 34 38 40 41).

* The Cape Sable Seaside-Sparrow is known to avoid trees when establishing breeding territories. Many trees exist across the western landscape that are sub-30m resolution features and therefore do not appear in the TNC habitat map. We complemented the TNC map by determining the locations of tree infested survey sites from the 1992 extensive survey data. The trees Bass observed at these sites include pine, hardwood, cypress, willow and mangrove.

5. The results of these analyses are summarized in WESTLAND.PDF. Cells which do not meet the criteria set in the first three rules are marked as non-habitat cells and are shown as diagonal crosses (x). The cells in which survey trees occurred are marked as non-habitat; with vertical crosses (+). Cells in which an asterix (*) appears are cells defined as non-habitat by both the analysis of TNC data and the known locations of trees from extensive survey data.

The resultant landscape contains fewer cells available for breeding than version 1.0 in which the available habitat was simply defined by an upper limit of elevation. We might expect results to be more variable between simulations given the patchiness of available breeding habitat in version 1.3 to those of version 1.0 due to the effects of inherent stochastic processes on isolated pockets of breeding individuals.

D-C.8.4 Individual based approach

SIMSPAR provides continuous, spatially-explicit estimates of population size and structure by following the actions, growth, reproduction and mortality of each individual sparrow in the region. It follows the state of each individual sparrow including its sex, age, reproductive status and location. The model increases the age of an individual each day and updates its status according to movement and behavior rules. The backbone of the model is a simple flow of decisions and actions that affect individuals in relation to abiotic factors and other individuals. The model is stochastic in that there are probability distributions for each state change of an individual, thus requiring a set of Monte Carlo simulations for each scenario.

1. Each individual sparrow in the population is modeled during the breeding period. This may occur sometime between mid-February and as late as early August of each year, dependent upon hydrologic conditions. In particular, the model tracks the sex, age, breeding status, of each model individual from egg to the end of its life. For mature males, the model tracks establishment of breeding territories, finding a mate, the start of nesting, and the status of eggs and nestlings on a daily basis. The life cycle parameters used in the model are taken from life history studies of the sparrow (Werner 1975, Lockwood et al. 1997).

One important such parameter is that of annual adult survival rate. Pimm (pers. comm.) reports an analysis of banding data (A. m. mirabilis) suggesting a survival rate of 0.5. Post and Greenlaw's (1982) analysis of data for resident *Ammodramus maritimus maritimus* in New York salt marshes suggests 0.57-0.6. Both Werner (1975) and Post et al. (1983) suggest a value of 0.85 for territorial males, but both these studies used low sample numbers over a single year (N=16, N=21 respectively). A review by Martin and Li gives an average value of 0.55 for both sexes. This is based on a study by Nichols et al. (1981) of 112 permanent resident seaside sparrows over a 10 year period using the Jolly-Seber technique. SIMSPAR adopts an adult survival rate of 0.6.

2. The relationship of sparrow breeding activity to water depth is modeled. Water depth in spatial cells is tracked daily through a hydrologic model. A spatial cell is not available for breeding activity (specifically mating and nest building) until the water level in that cell falls below a threshold level of 5 cm. Any rise in the water level above 14 cm in a particular spatial cell during the nesting season is assumed to cause nest abandonment for sparrows that have nests in that cell. The elevation of a cell relative to the water stage determines the length of the effective reproductive season for the pair of sparrows and the vulnerability of the nest to flooding. The sparrows are not modeled in detail during the non-breeding season. Age-specific mortality rates are assigned during that period probabilistically, currently the age dependent mortality is set at 1.0 - 0.6 = 0.4 for all age classes.

3. At the beginning of each breeding season males that previously owned territories return to those nesting territories as do the females. Females may not remain in that cell during the breeding season, as females are relatively mobile and may range up to 4 kilometers to find a mate. Recruits return to a habitable location in the vicinity of their natal site. Dispersal occurs before the beginning of the breeding season, are dispersing individuals move stepwise across the landscape searching for suitable breeding habitat.

An individual chooses a cell in its 8-cell neighborhood with equal probability. An individual cannot move to a non-habitat cell (as per WESTLAND.PDF), or a cell it has previously visited but failed to occupy. This is defined as a 'self- avoiding random flight' henceforth known as SARF. This assumes the individual has gained a 'perfect knowledge' of the location and status of cells it previously visited. At each step an individual tests the cell to determine the availability of vacant territories. If a vacant territory exists, it will end its search and is assigned to that cell. If no vacant territories exist it will attempt to move again following the rules described above.

Individuals start their search in their natal cell and with each step there is a 0.1 probability of mortality. This simulates the danger of moving during which time they risk predation and starvation. If an individual encounters a cul-de-sac in which it cannot move to a cell it has not already visited it remains there as a floater. This process results in cells being saturated with males, a roughly equal number of females, and a number of 'floaters' able to occupy territories that become available due to the death of the male 'owner' or its mate. It also results in a number of individuals dispersing to adjacent potential breeding habitat where they can attempt to breed.

These rules have the effect that after a productive year in which many individuals fledged successfully the extent of the area occupied by sparrows increases. The distribution of dispersal distances reveals that most individuals disperse locally within 0-2 km, but a few may disperse as far as 5-6 km. After wet years recruits have a higher probability of ending their search in or close to their natal site thereby saturating previously productive cells. In this case dispersal is normally restricted to 0-2km.

Applying these rules to the validation run (using real NP205 stage height data 1981-1997) results in simulations that resemble the temporal and spatial pattern seen in the results of the extensive sparrow surveys of 1981,1992, and 1993-1997.

D-C.8.5 Model population initialization

The 'seed' population used in SIMSPAR Version 1.3 is both spatially and numerically explicit. It is based on extensive helicopter survey counts of singing males at the vertices of a 1km grid. Bass and Kushlan (1983) multiply the number of singing male sparrows by a factor of 16 to estimate the total number of birds within 1km2.

The seed SIMSPAR population distribution consists of a composite distribution of 1993, 1995, 1996 and 1997 sparrow observations, not just the 1997 distribution. We assume the extensive helicopter survey misses low levels of breeding activity at these historical locations, the so-called 'veil' effect. This same effect is observed in validation runs of SIMSPAR in which randomly chosen cells are sampled for the presence of singing males. No males are detected in some cells but breeding activity occurs at some time during the breeding season.

There are several possible reasons why breeding activity may be undetectable at a site (i.e. no males were singing). Either water conditions are unsuitable, the males are not singing while caring for walking fledglings or, singing males are too distant to be heard. In summary, the initial population is distributed among 5 main patches depicted by the white circles in SPARTOPO.PDF.

Determining the initial population size and distribution requires processing of the raw data. Firstly, because several years of data are combined to produce the initial distribution more singing males are present than are present in 1997 alone. Secondly, because the locations of breeding sparrows were surveyed at a 1km-resolution, these map out into every other 500m-resolution SIMSPAR cell. To deal with this problem we extrapolate each observation to fill the remaining 3 cells of a 2 x 2 cell block equivalent to 1km2 in area. We multiply the total number of birds per cell (given by the composite distribution above) by a factor of 16/(No. of 500m cells in 1km2) = 4, in accordance with the correction factor of Bass and Kushlan (1983). Finally, we halve this number to produce an initial population size of 308 birds.

D-C.8.6 Life cycle and behavioral parameters

The life cycle and behavioral parameter values used in the model produce population-level estimates close to the field estimates when the real NP205 hydrologic dataset (for the period 1977-1996) is used to drive the model. These values are documented in table F5SPARAM.TXT. Many of these remain the same as for Version 1.0 with a few notable exceptions:

The maximum allowable density of breeding territories per cell is set to 4, equivalent to a maximum of 16 breeding pairs per 1km2. This equates to 4 singing males recorded in the extensive survey. SIMSPAR assumes a uniform spatial distribution of the maximum density of breeding territories per cell. Observed densities vary between 1 and 16 but the relationship between territory density and habitat heterogeneity is not yet fully understood.

The onset of nesting activity is crucial to the number of broods a pair of sparrows may produce. The earliest recorded nesting activity occurred mid-March in both 1996 and 1997, despite the fact conditions were dry prior to that date (Lockwood pers. comm.). Therefore, SIMSPAR assumes an environmental trigger, probably photoperiod, is responsible for the onset of breeding. Accordingly, the SIMSPAR breeding cycle begins at the end of February and continues until the beginning of August. Given initially dry conditions, the peak of the first breeding cycle predicted by SIMSPAR occurs between mid-March and mid-April, similar to the peak of first brood activity observed in the field. During the SIMSPAR breeding cycle males may mate a maximum of three times given suitable short-hydroperiod conditions, and may successfully raise three broods.

D-C.8.7 Hydrology model

The model is driven by daily water level data from a single cell close to the sub-populations under study. Specifically, we designed and tested the model using historical data from a National Park Service hydrologic monitoring station. The western area is influenced by the hydrologic patterns experienced at the station NP205 located at (Northing 2825223 Easting 515235).

In light of the sensitivity of the model to variations in water depth, we have reevaluated our choice of the particular SFWMM 2-mile x 2-mile grid cell for representing water depth at Gage NP205. This gaging station lies near the juncture of 4 SFWM grid cells. After reviewing graphs of SFWMM calibration/validation depth values for these four cells, in comparison with historical gage data, we have chosen the cell, numbering from the upper left, in the 47th row and 16th column (which would be 46,15 if numbered from 0) to use for all comparisons in the upcoming evaluations. It is our understanding that ENP hydrologists use the 46th row and 16th column, which is our row 45 column 15 or, counting from lower left, starting from 1, their row 20, column 16), or in some cases the mean of values for the four cells.

D-C.8.8 Stochasticity

The model is initialized with a population of 308 sparrows reflecting the size of the 1997 population estimate for this region (Curnutt et al. 1998). The individuals are placed in higher elevation cells but not at ones for which trees and shrubs dominate the vegetation, concordant with the findings of Nott et al. (1998). The initial locations do not vary among replicates. A number of replicate simulations (typically 20) are run for each hydrologic scenario. Each replicate employs a different random number seed which causes variability in the temporal and spatial patterns of successful breeding. The "variability" incorporated in this model affects individuals' breeding locations, mate choice, mating success, clutch size, gender, dispersal and mortality. Due to this individual-level stochasticity, population- level estimates from the model vary among replicates. This stochasticity allows for construction of a population viability analysis, in which estimates are made of the probability of population levels falling below or going above certain thresholds. These probabilities are calculated by determining what fraction of the replicate simulations cross these thresholds.

D-C.8.9 Population Viability Analysis (PVA)

All scenario comparisons are made using 3 distinct PVA techniques: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the model.

a) Time to quasi-extinction (TQX) is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time.

b) Time to quasi-explosion (TQE) is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time.

c) Interval explosion risk (IER) is the probability that the population will reach a certain number over the period of the model.

Acknowledgements

Phil Nott wishes to thank all parties who attended his presentation of this model on February 19th 1998 at the Center for Natural Resources in Everglades National Park, and at the meeting on April 24th at SFWMD headquarters in Palm Beach. Many invaluable comments and suggestions were made, some of which are included in this version.

Output associated with the ATLSS Individual-based Cape Sable Seaside Sparrow Model.

In accordance with ATLSS file naming conventions, each file name will consist of the characters:

"X" or "_" => the Base, typically F for the F2050 base or E for the C1995 base
"X" or "_" => the alternative scenario or base
"SP" => the ATLSS Individual-based Cape Sable Seaside Sparrow Model
"XXXX" => 4 character mnemonic
"."
"PDF" or "TXT" or "DOC" => PDF, tabular text or documentation

ATLSS Individual-based Cape Sable Seaside Sparrow

1. Maps

Map outputs used to characterize results of the Individual-based Cape Sable Seaside Sparrow component of ATLSS will consist of a number of image files in

PDF file format. A 30m-resolution habitat map of the western region is shown in WESTTNCH.PDF with its associated key WESTTNCK.PDF. A 500m-resolution map of the topology and associated non-habitat cells is shown in WESTLAND.PDF ,superimposed on this map are the locations of the initial population distribution.

SIMSPAR also outputs a "Set" of model results, comparing a Base case to a Scenario, following the conventions for ATLSS comparison of two model runs. The extent of the map is the western region of the Everglades as shown on the map "SPARLAND.PDF". Each map has 3 panels. The left panel is an alternative or base scenario. The right panel is the base scenario, typically the Future without Project Conditions Case. The middle panel is the difference between the two scenarios.

Each map depicts the model area at a fine (500-meter x 500-meter) scale of resolution, with each cell color coded to represent the annual productivity value or the difference between the annual productivity value in the alternative scenario and the base scenario. For more information on the productivity values, see the section on Visualization above.

For each of a list of years, the images will provide a spatial display of productivity values during that year. In addition, there is an image file for the mean of all simulated years. The list of years are those that serve to highlight the differences between the scenarios.

The mnemonic characters are composed according to the convention:

"XX" = Last two digits of the year
"XX" = PM - Productivity Map

An example of an ATLSS Individual-based Cape Sable Seaside Sparrow map file name. FASPMYPM.PDF - Comparison map displaying all years mean productivity of F2050 Base and the Alternative A scenario.

2. Time Series

Time series sets associated with the ATLSS Individual-based Cape Sable Seaside Sparrow will display replicate population trends, the variability of populations and population viability analyses. For information on population trends and variability, see the section on Visualization above. For information on population viability see the sections on Stochasticity and Visualization above.

File Name	Description
XXSPTRAJ.PDF	Shows a single line representing population trajectories for each replicate simulation and both a base and a scenario run.
XXSPCVAR.PDF	Summarizes the coefficient of variation in predicted population levels for both a base and a scenario run.
XXSPPTQX.PDF	Presents probabilities of time to quasi-extinction based upon replicates for either a base or scenario run.
XXSPPTQE.PDF	Presents probabilities of time to quasi-explosion based upon replicates for either a base or scenario run.
XXSPPIER.PDF	Presents interval explosion risk based upon replicates for both a base and a scenrio run.
XXSPMPOP.PDF	Presents the mean and standard deviation of the predicted breeding population size for both a base and a scenario run.

3. Histograms None.

4. Tables None

D-C.8.10 F2050 (Revised) vs. C1995 (Revised)

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates the population variability for the western sparrow breeding area. The results of the C1995 scenario are shown on FESPTRAJ.PDF along with those from F2050.

Both F2050 and C1995 lead to a persistent, although variable breeding population. Figure FESPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin at 308 birds (the initial population for the western area - see Model Description). After a similar increase from 1965 to 1966, the predicted breeding populations quickly diverge under the two scenarios with C1995 increasing to a mean (calculated over 20 repetitions) of 500 breeding individuals by 1969 while under F2050 the breeding population slightly declines until 1971. The predicted breeding population under C1995 remains higher than under F2050 throughout the remainder of the model run, significantly so until 1980. Since the two scenarios produce the same trajectory over the model period the higher predicted populations under C1995 may be the result of the more favorable breeding conditions in the first three years under C1995. After the initial increase in breeding populations, both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Of these extreme breeding populations only the peak of 1978/1979 shows significant differences between the two scenarios with C1995 producing a mean breeding population of about 1800 individuals and F2050 producing 1100 individuals in 1979. The predicted breeding populations decline to 650 and 480 individuals under C1995 and F2050, respectively, in 1985. The populations then climb to 1950 and 1550 individuals under C1995 and F2050, respectively, in 1991/1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching just under 500 individuals in 1995 under both scenarios.

Figure FESPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV positively correspond with mean predicted breeding population (FESPMPOP.PDF). Suggesting that the stochastic nature of the model leads to higher variability with higher initial populations. Across all years, C1995 exhibits lower CVs than does F2050, never exceeding 0.15. Under F2050, after the fourth year the CV fluctuates between 0.15 and 0.3.

The fledgling productivity maps (FESPPROD.PDF) show that, averaging over all years, C1995 was more conducive to sparrow production than F2050 (FESPPROD.PDF: bottom). As discussed above, this initial difference in productivity (FESPPROD.PDF: top) resulted in higher predicted breeding populations under C1995 relative to F2050 for the first 15 model years. In 1994 (FESPPROD.PDF: middle), more fledgling were produced under F2050 relative to C1995 across the area studied. This was also the case in 1987 (not shown). For all other model years, C1995 produced more fledglings over more of the area than F2050. However, in ten years F2050 produced more fledglings in the northern one-third of occupied sparrow habitat.

D-C.8.10.1 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the model. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-")that the population will drop below a specified number over time. Under C1995, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the model period and a probability of 1.0 that it fall below 500 after two years (_ESPPTQX.PDF). Note that on this figure all of the lines are overlaid and only the last line (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050

(F_SPPTQX.PDF) there is a probability of 0.2 that the population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses F2050 shows an increasing probability of the population exceeding levels of up to 500 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching levels above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching levels above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under C1995 (_ESPPTQE.PDF), after 10 years the probability of reaching levels above 250 is 1.0 and above 500 is 0.9. After 25 years the probability of reaching levels above 1000 is 1.0 and above 2000 is 0.15. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the model. Under both scenarios (FESPPIER.PDF) the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 2000 breeding individuals is 0.5 under C1995 and 0.0 under F2050.

D-C.8.10.2 Conclusion

Under C1995 the sparrow breeding population reaches higher numbers early in the model years relative to F2050. This difference carries through until the final, high water years when the difference between the predicted breeding populations are insignificant. Overall, C1995 allows for higher fledgling productivity than F2050 and, partially as a consequence of this, C1995 breeding population estimates are less variable than those produced under F2050. The fledgling productivity maps show that, under either scenario, conditions are favorable enough for breeding sparrows to colonize nearly all available breeding habitat even though the model begins with the very constricted spatial distribution of breeding that we have witnessed in the recent high water years (compare FESPPROD.PDF top and middle).

D-C.8.11 Alternative A vs. F2050 (Revised)

SIMSPAR, unlike the breeding potential index model, provides a method of analyzing the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative A scenario are shown in Fig. FASPTRAJ.PDF along with those from F2050.

Both F2050 and Alternative A lead to a persistent, although variable breeding population. Figure FASPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Alternative A results consistently in significantly higher mean populations. The two predicted populations diverge after the first year of the simulation, and it may be this early difference that accounts for the subsequent higher populations under Alternative A. Both scenarios produce two peaks in predicted numbers (1979/1980 and 1991/1992) and one trough (1984/1985). Alternative A produces a mean breeding population of about 1600 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 650 and 480 individuals under Alternative A and F2050, respectively, in 1985. The populations then climb to 2200 and 1550 individuals under Alternative A and F2050, respectively, in 1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 600 and 450 individuals for Alternative A and F2050, respectively, in 1995.

Figure FASPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV correlate positively with mean predicted breeding population (FASPMPOP.PDF), more so for F2050 than for Alternative A. After the first 4 years of the simulation, Alternative A exhibits lower CV's than does F2050. The lower CV's for Alternative A suggest that the ability of the population to reach higher numbers sooner, relative to F2050, allows for greater spatial distribution of breeders and, consequently, more stability in numbers between repetitions.

The fledgling productivity maps (FASPPROD.PDF) show that, averaging over all years, Alternative A is more conducive to sparrow production than F2050 (FASPPROD.PDF: bottom). In 1980 (FASPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative A across much the model area. This is the only year that F2050 produced more fledglings across the model area. In 14 other years, F2050 produced more fledglings in variously sized portions of the northern third of the model area. Even for these years, however, many more fledglings were produced under Alternative A over more of the model area than under F2050. In the extremely high water year of 1995 (FASPPROD.PDF: middle), Alternative A allows fledgling productivity over more of the study area, relative to F2050. Under both scenarios productivity is greatly reduced in 1995.

D-C.8.11.1 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the simulation. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative A, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the simulation period, a probability of 0.25 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after six years (_ASPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that he population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative A (_ASPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.9. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 1.0 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FASPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 1.0 under Alternative A and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 1.0 under Alternative A and 0 under F2050.

D-C.8.11.2 Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative A and F2050 are significant, but complicated by the opposite effects that the scenarios have on sparrow breeding potential on either side of Shark River Slough. Generally, F2050 is more conducive to sparrow breeding east of the Slough and Alternative A is more conducive to breeding on the west side of the Slough. Since the BPI is not a quantitative measure, we are not able to determine the exact trade-off in predicted sparrow breeding given this spatially-based dichotomy. SIMSPAR is quantitative, and we show that the better breeding conditions west of the Slough under Alternative A relative to F2050 can lead to more sparrows. In the absence of a similar model for the area east of the Slough we are unable to determine which scenario is better for the global sparrow population.

An additional concern is that long-term habitat effects of conditions that are either too wet or too dry are difficult to assess with the BPI model. Specifically, long-term effects of dryness in the eastern area, which are difficult to measure, may counter-balance short-term effects of wet conditions, which are easily measured by counting days when water depths are above a threshold value for a given year. Hence, without a long-term vegetation change model, a scenario might be judged to be superior based on length of breeding season, when long-term changes in vegetative communities due to dryness under that water regime could lead to shrub invasion or changes in fire patterns. These, in turn, could have detrimental effects on sparrow breeding habitat.

D-C.8.12 Alternative B vs. F2050 (Revised)

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking into account the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative B scenario are shown in Fig. FBSPTRAJ.PDF, along with those from F2050.

Both F2050 and Alternative B lead to a persistent, although variable, breeding population. Figure FBSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Alternative B results consistently in significantly higher mean populations. The two predicted populations diverge after the first year of the simulation and it may be this early difference that accounts for the subsequent higher populations under Alternative B. Both scenarios produce two peaks in predicted numbers (1979/1980 and 1991/1992) and one trough (1984/1985). Alternative B produces a mean breeding population of about 1550 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 700 and 480 individuals under Alternative B and F2050, respectively, in 1985. The populations then climb to 2050 and 1550 individuals under Alternative B and F2050, respectively, in 1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 600 and 450 individuals for Alternative B and F2050, respectively, in 1995.

Figure FBSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV correlate positively with mean predicted breeding population (FBSPMPOP.PDF), more so for F2050 than for Alternative B. After the first 6 years of the simulation, Alternative B exhibits lower CV's than does

F2050. The lower CV's for Alternative B suggest that the ability of the population to reach higher numbers sooner, relative to F2050, allows for greater spatial distribution of breeders and, consequently, more stability in numbers between repetitions.

The fledgling productivity maps (FBSPPROD.PDF) show that, averaging over all years, Alternative B is more conducive to sparrow production than F2050 (FBSPPROD.PDF: bottom). In 1978 (FBSPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative B across much the model area. This occurred for the year 1987 and 1980 as well (not shown). In six other years, F2050 produced more fledglings in only the northern part of the model area. For all other simulation years, more fledglings were produced under Alternative B over more of the model area than under F2050. In the extremely high water year of 1995 (FBSPPROD.PDF: middle), Alternative B allows fledgling productivity over more of the study area, relative to F2050. However, under both scenarios productivity is greatly reduced in 1995.

D-C.8.12.1 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the simulation. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative B, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the simulation period, a probability of 0.6 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after six years (_BSPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative B (_BSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.5. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.75 that the population will reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FBSPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 1.0 under Alternative B and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.75 under Alternative B and 0 under F2050.

D-C.8.12.2 Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative B and F2050 are significant, but complicated by the opposite effects that the scenarios have on sparrow breeding potential on either side of Shark River Slough. Generally, F2050 is more conducive to sparrow breeding east of the slough and Alternative B is more conducive to breeding on the west side of the slough. Since the BPI is not a quantitative measure we are not able to determine the exact trade-off in predicted sparrow breeding given this spatially based dichotomy. The SIMSPAR model is quantitative, and shows that the better breeding conditions west of the slough under Alternative B relative to F2050 can lead to more sparrows. In the absence of a similar model for the area east of the slough we are unable to determine which scenario is better for the global sparrow population.

An additional concern is that long-term habitat effects of conditions that are either too wet or too dry are difficult to assess with the BPI model. Specifically, long-term effects of dryness in the eastern area, which are difficult to measure, may counter-balance short-term effects of wet conditions, which are easily measured by counting days when water depths are above a threshhold value for a given year. Hence, without a long-term vegetation change model, a scenario might be judged to be superior based on length of breeding season, when long-term changes in vegetative communities due to dryness under that water regime could lead to shrub invasion or changes in fire patterns. These, in turn, could have detrimental effects on sparrow breeding habitat.

D-C.8.13 Alternative C vs. F2050 (Revised)

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative C scenario are shown in Fig. FCSPTRAJ.PDF along with those from F2050.

Both F2050 and Alternative C lead to a persistent, although variable breeding population. Figure FCSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Predicted breeding populations under the two scenarios are very similar through time. Alternative C results in significantly higher mean populations only from 1967 through 1977. Both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Alternative C produces a mean breeding population of about 1400 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 500 and 480 individuals under Alternative C and F2050, respectively, in 1985. The populations then climb to 1750 and 1550 individuals under Alternative C and F2050, respectively, in 1992. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 500 individuals in 1995 under both scenarios.

Figure FCSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV correlate positively with mean predicted breeding population (FCSPMPOP.PDF). Through the 1970's and through the 1990's, Alternative C exhibits lower CV's than does F2050. Although the CV's of both scenarios are similar, the lower values in the crucial wet years of 1992 - 1995 for Alternative C suggest that the breeding population has more of a chance of persisting through extreme conditions under this scenario relative to F2050.

The fledgling productivity maps (FCSPPROD.PDF) show that, averaging over all years, Alternative C is more conducive to sparrow production than F2050 (FCSPPROD.PDF: bottom). In 1980 (FCSPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative C across the area studied. This was also the case in 1978, 1980, 1987, and 1992 (not shown). For all other model years, more fledglings were produced under Alternative C over more of the model area than under F2050. However, for eight of these years (not shown) more fledglings were produced under F2050 in parts of the model area. In the extremely high water year of 1995 (FCSPPROD.PDF: middle), Alternative C allows fledgling productivity over more of the study area, relative to F2050. However, under both scenarios productivity is greatly reduced in 1995.

D-C.8.13.1 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the model. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative C, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the model period, a probability of 0.9 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after one year (_CSPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative C (_CSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.45. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.05 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FCSPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 0.95 under Alternative C and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.10 under Alternative C and 0 under F2050.

D-C.8.13.2 Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative C and F2050 are minor. Alternative C appears to be more conducive to breeding population recovery after a decline relative to F2050. This is apparent in the fledgling productivity maps and the PVA results.

D-C.8.14 Alternative D vs. F2050 (Revised)

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates population variability for the western sparrow breeding area. Results of the Alternative D scenario are shown in Fig. FDSPTRAJ.PDF along with those from F2050.

Both F2050 and Alternative D lead to a persistent, although variable breeding population. Figure FDSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin with 308 birds (the initial population for the western area - see Model Description). Predicted breeding populations under the two scenarios are very similar through time. Alternative D results in significantly higher mean populations only from 1973 through 1977. Both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Alternative D produces a mean breeding population of about 1400 individuals and F2050 produces 1100 individuals in 1978. Predicted breeding populations decline to 600 and 480 individuals under Alternative D and F2050, respectively, in 1985. The populations then climb to 1750 and 1550 individuals under Alternative D and F2050, respectively, in 1991. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 500 individuals in 1995 under both scenarios.

Figure FDSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV positively correspond with mean predicted breeding population (FDSPMPOP.PDF). From 1975 onwards, Alternative D exhibits lower CV's than does F2050, never exceeding 0.20. Under F2050, after the fourth year the CV fluctuates between 0.15 and 0.3.

The fledgling productivity maps (FDSPPROD.PDF) show that, averaging over all years, Alternative D is more conducive to sparrow production than F2050 (FDSPPROD.PDF: bottom). In 1980 (FDSPPROD.PDF: top), more fledglings were produced under F2050 relative to Alternative D across the area studied. This was also the case in 1978 and 1987 (not shown). For all other model years, more fledglings were produced over more of the model area under Alternative D than under F2050. However, for nine of these years (not shown) more fledglings were produced in portions of the model area under F2050. In the extremely high water year of 1995, higher fledgling productivity is seen under Alternative D (FDSPPROD.PDF: middle).

D-C.8.14.1 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the model. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative D, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the model period, a probability of 0.8 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after one year (_DSPPTQX.PDF). Note on this figure that all lines are overlaid and only the last line plotted (e.g., 500) is visible, this implies that all values above 500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF), there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that the population will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses, F2050 shows an increasing probability of the breeding population exceeding levels of 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative D (_DSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.3. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.15 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FDSPPIER.PDF), the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 0.95 under Alternative D and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.10 under Alternative D and 0 under F2050.

D-C.8.14.2 8.14.2 Conclusion

Relative differences between sparrow breeding population dynamics in the study area predicted under water regimes Alternative D and F2050 are minor. Alternative D appears to be more conducive to breeding population recovery after a decline relative to F2050. This is apparent in the fledgling productivity maps and the PVA results.

D-C.8.15 Alternative D13 vs. F2050 (Revised)

SIMSPAR, unlike the breeding potential index model, provides a method to analyze the complete history of population trends, taking account of the detailed effects of localized water dynamics on individual bird growth, survival, and reproduction. SIMSPAR produces population trajectories and calculates the population variability for the western sparrow breeding area. Results of the Alternative D13R scenario are shown on FGSPTRAJ.PDF, along with those from F2050.

Both F2050 and Alternative D13R lead to a persistent, although variable breeding population. Figure FGSPMPOP.PDF shows the mean predicted number of breeding individuals under each scenario. Both scenarios begin at 308 birds (the initial population for the western area - see Model Description). The predicted breeding populations under the two scenarios are very similar through time. Alternative D13R results in significantly higher mean populations only from 1967 through 1970 and from 1972 through 1977. Both scenarios produce two peaks in predicted numbers (1978/1979 and 1991/1992) and one trough (1984/1985). Alternative D13R produces a mean breeding population of about 1400 individuals and F2050 producing 1100 individuals in 1978. The predicted breeding populations decline to 600 and 480 individuals under Alternative D13R and F2050, respectively, in 1985. The populations then climb to 1750 and 1550 individuals under Alternative D13R and F2050, respectively, in 1991. Finally, with the onset of a series of high water years, both predicted breeding populations begin to decline, reaching about 500 individuals in 1995 under both scenarios.

Figure FGSPCVAR.PDF shows the coefficient of variation (CV) for each year calculated over replicates. Values of CV positively correspond with mean predicted breeding population (FGSPMPOP.PDF). From 1975 onwards, Alternative D13R exhibits lower CV's than does F2050, never exceeding 0.20. Under F2050, after the fourth year the CV fluctuates between 0.15 and 0.3.

The fledgling productivity maps (FGSPPROD.PDF) show that, averaging over all years, Alternative D13R was more conducive to sparrow production than F2050 (FGSPPROD.PDF: bottom). In 1980 (FGSPPROD.PDF: top), more fledgling were produced under F2050 relative to Alternative D13R across the area studied. This was also the case in 1978 and 1987 (not shown). For all other simulation years, Alternative D13R produced more fledglings over more of the area than F2050 did. However, for nine of these years (not shown) F2050 produced more fledglings in parts of the model area. In the extremely high water year of 1995, Alternative D13R allows higher fledgling productivity (FGSPPROD.PDF: middle).

D-C.8.15.1 Population Viability Analysis

The Population Viability Analysis (PVA) consists of 3 parts: time to quasi-extinction; time to quasi- explosion; and interval explosion risk. For each of these analyses we started calculations at 5 years after the start time for the simulation. Time to quasi-extinction is the cumulative probability (based on replicates, thus the term "quasi-") that the population will drop below a specified number over time. Under Alternative D13R, there is a probability of 0 that the sparrow breeding population will drop below 100 individuals over the simulation period, a probability of 0.9 that it will fall below 250, and a probability of 1.0 that it will fall below 500 after one year (_GSPPTQX.PDF). Note that on this figure all of the lines are overlaid and only the last line (e.g., 500) is visible, this implies that all values above

500 in the figure legend have the same probability. For F2050 (F_SPPTQX.PDF) there is a probability of 0.2 that the breeding population will ever fall below 100 and a probability of 1.0 that it will drop below 250.

Time to quasi-explosion is the converse of time to quasi-extinction. It estimates the probability that the population will exceed a specified number over time. As time progresses F2050 shows an increasing probability of the breeding population exceeding levels of up to 1000 individuals (F_SPPTQE.PDF). After 10 years the probability of reaching a level above 100 is 1.0 and above 250 is 0.4. After 25 years the probability of reaching a level above 500 is 1.0 and above 1000 is 0.7. There is a zero probability that the population will ever exceed 2000 individuals. Under Alternative D13R (_GSPPTQE.PDF), after 10 years the probability of reaching a level above 250 breeding birds is 1.0 and above 500 is 0.2. After 25 years the probability of reaching a level above 1000 is 1.0 and over 30 years there is a probability of 0.2 that the population would reach 2000. There is a zero probability that the population will ever exceed 3000 individuals.

Interval explosion risk is the probability that the population will reach a certain number over the period of the simulation. Under both scenarios (FGSPPIER.PDF) the probability that the breeding population would grow to more than 1000 individuals over a 31-year period is 1.0. The probability of reaching 1500 breeding individuals is 1.0 under Alternative D13R and 0.65 under F2050. The probability of reaching 2000 breeding individuals is 0.2 under Alternative D13R and 0 under F2050.

D-C.8.15.2 Conclusion

Alternative D13R produces lower BPI values relative to F2050 in the eastern sparrow breeding area and in the southern portion of the western breeding area under most hydrologic conditions. The results of SIMSPAR suggest that the sparrow population can reach higher levels more often under Alternative D13R, relative to F2050. Alternative D13R also produces a more stable sparrow population and it appears to be more conducive to breeding population recovery after a decline relative to F2050. This is apparent in the fledgling productivity maps and the PVA results.

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ATTACHMENT D

WATER QUALITY ANALYSIS

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WATER QUALITY ANALYSIS

D-D.1 BACKGROUND

The effect of Restudy alternatives on water quality conditions in the study area was one of the evaluations conducted for the Alternative Evaluation Team (AET). To perform these evaluations, an ad hoc Water Quality Team (WQT) was created to evaluate the base conditions and the alternative plans. The WQT was co-chaired by USEPA and FDEP, and consisted of staff from several Federal, state, tribal, regional, and local agencies. The WQT consisted of staff from the following agencies: USEPA, FDEP, SFWMD, USACE, FDACS, ENP, LNWR, USFWS, BCNP, NOAA/NMFS, Seminole Tribe, Palm Beach County, Broward County, Miami-Dade County.

The WQT evaluated each of the alternative plans created by the Alternative Development Team (ADT), and provided comments and recommendations for optimizing the overall performance of the alternative plans from a water quality perspective and to achieve water quality objectives.

The WQT utilized output from two water quality models to evaluate the relative performance of the alternative plans compared to current (1995) and future (2050) base conditions: the Lake Okeechobee Water Quality Model (LOWQM), which simulates conditions for certain water quality parameters within Lake Okeechobee; and, the Everglades Water Quality Model (EWQM), which simulates water column phosphorus concentrations and loads within the Everglades Protection Area. Both of the models use hydrologic output from the SFWMM to simulate water quality conditions resulting from the implementation of a Restudy alternative plan.

A third evaluation was conducted by William W. Walker, Jr. examining the effect of Restudy alternatives on the performance of the Everglades Construction Project (ECP). Walker's evaluation specifically examined the function of Component G5 (EAA Reservoir) and the projected performance of each STAs of the ECP compared to several performance targets for the ECP.

The WQT also utilized SFWMM hydrologic output for individual components in each alternative to assess potential pollution load reduction performance of the reservoirs/water storage areas and to identify potential water quality "hot spots" indicated by significant changes in water quantity (31-year average annual volumes) and discharge locations. The WQT further considered the components in the context of current regulatory programs (particularly the Everglades Program authorized under the EFA), designated use classifications pursuant to the State of

Florida's water quality standards contained in FAC Rule 62-302, and other special classifications (OFW, etc).

D-D.2 EVALUATION METHODOLOGY

For purposes of evaluating the overall performance of the base conditions and the alternative plans, the WQT divided the study area into logical sub-regions, based on the modeling and evaluation tools available and geographical distinctions. Due to model boundaries and performance measures/indicators, the WQT's sub-regions differed somewhat from the geographical scope and boundaries of the "study regions" created by the Restudy Team. For example, Florida Bay is within the ENP study region, but was not included within the ENP sub-region as part of the WQT's evaluation (no model or other evaluation output available with which to measure water quality performance). The following sub-regions were developed by the WQT for purposes of evaluating water quality for the base conditions and the alternative plans:

Lake Okeechobee;
Everglades Agricultural Area/ECP;
WCAs 2 and 3;
St. Lucie River watershed
Caloosahatchee River watershed
Loxahatchee National Wildlife Refuge
Everglades National Park
Lower East Coast

Because there are, at present, no water quality models or other quantitative evaluation tools which can be linked to hydrologic changes in the study area resulting from implementation of Restudy alternative plans, the WQT did not quantitatively evaluate water quality performance in the Kissimmee River region, Holeyland and Rotenberger WMAs, Big Cypress National Preserve, Florida Bay, and the Florida Keys. It is expected that future versions of the Everglades Landscape Model (ELM) and other water quality models will be developed which will have the capability of simulating water quality conditions in some or all of the geographic regions of the Restudy area.

Upon completion of each of the SFWMM alternative runs and subsequent posting of the hydrologic performance measures, the WQT evaluated the Starting Point, Alternatives 1-5, Alternatives A-D, and Alternative D13R. Using SFWMM output, the two water quality models (LOWQM, EWQM) were run. Concurrently, Walker's evaluation was completed for each of the alternatives as SFWMM output pertinent to the EAA/ECP became available.

The WQT met collectively to review and interpret results and prepare recommendations to the AET. In addition to evaluating the overall performance of the alternative plans, the WQT assessed the potential impact and/or benefits of individual plan components. The Team met approximately 12 times during the plan formulation and evaluation phase of the Restudy between August, 1997 and July, 1998. This iterative approach enabled the WQT to develop and improve water quality performance measures and indicators, gauge improvements in the overall performance of the alternatives from a water quality perspective, discuss water quality issues inherent in hydrologic changes from alternative run to alternative run, and to come to consensus on recommendations to be forwarded to the AET.

At the conclusion of the modeling of the alternatives, the Team ranked the alternatives based on cumulative performance within the sub-regions using selected key performance measures/indicators. Matrices for each of the sub-regions were created comparing the alternatives and base conditions (see Tables D-D-2 to D-D-7). A combined ranking matrix was prepared from which to assess the overall performance of the alternatives and conclusions and recommendations were reported to the AET. Subsequent to the creation of Alternative D13R, the Team met again to evaluate that alternative from a water quality perspective. A second ranking matrix was prepared which combined water quality performance for the two base conditions and Alternatives A through D13R (see D-D-1). The Team's consensus conclusions and recommendations were then forwarded to the Restudy Team.

D-D.3 PERFORMANCE MEASURES AND INDICATORS

The WQT evaluated the performance of the base conditions and alternative plans in the context of performance measures (which are water quality targets; e.g., 10 ppb water column phosphorus concentration) and performance indicators (which lack specific targets, but indicate relative performance; e.g., percentage of time stage maintained).

The following LOWQM performance measures/indicators were evaluated:

Average lake volume;
Average in-lake phosphorus concentration;
Average in-lake chlorophyll a concentration;
Average blue-green algae concentration;
Box-plot comparisons of phosphorus, chlorophyll a, and blue-green algae;
Differences from future (2050) base concentrations for phosphorus, chlorophyll a, and blue-green algae;
Phosphorus inflow (into lake) loads;
Phosphorus outflow (out of lake) loads;

Wet year (1995) phosphorus inflow and outflow loads;
Dry year (1984) phosphorus inflow and outflow loads; and
Cumulative phosphorus fluxes to lake sediments.

The following EWQM performance measures/indicators were evaluated:

Mean grid cell water column phosphorus concentrations within the Everglades Protection Area (EPA) by basin;
14-station (per Settlement Agreement) geometric mean phosphorus concentration within LNWR;
14-station geometric mean phosphorus concentration, LWNR (wet year and dry year);
Mean annual structural phosphorus loads into the EPA by basin;
Mean annual basin phosphorus concentration;
Mean annual combined structural phosphorus load from S-12s/S-333; and
Mean annual combined phosphorus concentration at S-12s/S-333 (per Settlement Agreement).

The following SFWMM performance measures/indicators were evaluated:
Stage Duration Curves and Stage Hydrographs for all of the reservoirs included in the alternative plans (North Reservoir, Taylor Creek/Nubbins Slough Reservoir, St. Lucie Reservoir, Caloosahatchee Reservoir, EAA Reservoir, Site 1 Reservoir, C-11 Reservoir, C-9 Reservoir, Central Lake Belt Reservoir, North Lake Belt Reservoir, Bird Drive Reservoir); Report, Lake Okeechobee Water Budget; Water budget data from FTP site.

In addition to the above-listed performance measures/indicators, William W. Walker created 24 key performance indicators illustrating the effect of the future base condition and Restudy alternative plans on the performance of the ECP (see Tables 7a – 7f).

D-D.4 RESULTS

A summary of the Water Quality Team’s conclusions and recommendations is included below in ***Table D-D-1***.

TABLE 1
Restudy Water Quality Team's
Combined *Ranking* Matrix

The Base Conditions and alternative plans were ranked on a scale of 1-7, with higher scores indicating a more preferred condition from a water quality perspective.

Subregion	**95B**	**50B**	**A**	**B**	**C**	**D**	**D13R**
1. Lake Okeechobee (see footnote 1)	2.5	2.5	2.5	6.5	4.5	6.5	4.5
2. EAA/ECP	1	3.5	7	6	3.5	2	5
3. WCAs 2 & 3 (see footnote 2)	1	6	7	2	3	4.5	4.5
4. St. Lucie Watershed	1	2	3.5	3.5	5	6	7
5. Caloosahatchee Watershed	1.5	1.5	3	4	5	6.5	6.5
6. LNWR	1	2	5	5	5	5	5
7. ENP	1.5	5	3.5	6.5	1.5	3.5	6.5
8. LEC (see footnote 3)	4.5	4.5	1	2	3	6.5	6.5
Cumulative Score	***14***	***27***	***32.5***	***35.5***	***30.5***	***40.5***	***45.5***

Footnotes

1. Ranking of alternatives for Lake Okeechobee is based on evaluation of selected performance indicators. Comparing alternatives, differences greater than one percent in relative performance calculated by the model were assigned different ranks. Although the differences between simulated conditions for the alternatives are within the uncertainty of the model, the Water Quality Team felt it was important to rank the plans for Lake Okeechobee from a water quality perspective.

2. Water Conservation Areas 2 & 3 rankings were weighted to account for relative size (acreage).

3. Ranking of the alternatives based on an evaluation of potential water quality impacts/benefits in the LEC is primarily based upon salinity targets in Lake Worth and Biscayne Bay. The presumed water quality benefits resulting from an evaluation of the hydraulic performance of selected reservoirs were also evaluated. For those performance indicators, a score of zero was

assigned to alternatives for which no hydraulic performance for the reservoirs was observed.

Recommendations to Restudy Team

1. From a water quality perspective, Alternative D13R is preferred over Alternatives B, A, & C. The 95 Base and the 50 Base were not acceptable.

2. The Water Quality Team determined that the Base Conditions and alternative plans should not be ranked based upon the U. S. Environmental Protection Agency's preliminary mercury model results (model needs further development). Atmospheric deposition is the dominant contributor of mercury in the Everglades Protection Area. Restudy alternative plans are not expected to significantly affect mercury in the Everglades Protection Area.

3. Due to a lack of model results (particularly Everglades Landscape Model results), Restudy alternative plans could not be ranked based upon an empirical evaluation of water quality impacts or benefits in Big Cypress National Preserve and the Holeyland and Rotenberger Wildlife Management Areas.

D-D.5 ISSUES OF CONCERN

Restudy components must meet State and Tribal water quality standards, as appropriate. In particular, increased flows to the Everglades Protection Area EPA (over that which is in the Future Base condition, i.e. Everglades Forever Act fully implemented) must meet the yet-to-be-established numeric phosphorus criteria for the EPA (default concentration = 10 parts per billion). The technology (and hydrologic demands, if any) required to achieve this standard has not yet been determined. Furthermore, it can be reasonably assumed that the technology (and concurrent land and hydrologic demands) will vary for Restudy components, depending upon location (e.g., runoff originating from agricultural lands with peat soils, compared to runoff originating from rock-plowed agricultural lands or lands with marl soils or urban runoff). Component design should continue to take into account current and future land uses in the vicinity of the components and the estimated land acquisition, construction, and operations costs to assure that water quality treatment facilities necessary to meet water quality standards are included in the final design.

Additionally, treatment costs may not be limited to just those necessary to achieve surface water standards. Restudy components capable of polluting groundwater (ASR, discharges in the vicinity of underground drinking water sources) must include treatment necessary to achieve groundwater quality standards prior to introduction of discharges into the groundwater.

The Team does not expect to observe a significant recovery of Lake Okeechobee during the simulation period for the models (23 years for the LOWQM). Therefore, the long-term benefits of treatment facilities and wetlands restoration in the Lake Okeechobee watershed are not readily observable in the water quality performance indicators which are available to evaluate the affect of the Restudy on the lake. Although modeling results may lead one to empirically conclude that there are no observable water quality benefits to Lake Okeechobee achieved by including water quality treatment features in the Initial Draft Plan (IDP) components when compared to Future Base Conditions, the WQT intuitively concludes that such projects and facilities will create long-term water quality benefits in Lake Okeechobee beyond the planning horizon for the Restudy.

Although the Team concurs with the method for determining mean phosphorus concentration values in the Taylor Creek/Nubbins Slough basin (528 ppb), additional information is needed about the design and operation of the STA (Component W2) proposed for that basin. While it is understood that more detailed information about the design and operation of this component would occur in future detailed design work if this component is included in the final comprehensive plan, it is noted that the STA is assumed to achieve an 80% reduction in basin loads and concentrations prior to discharge to Lake Okeechobee (this efficiency is at the upper end of the range of phosphorus reduction efficiency for STAs).

Furthermore, the WQT has not determined that 107 ppb is the correct target concentration for discharges to Lake Okeechobee (this concentration will not necessarily contribute to a reduction of ambient lake water column phosphorus concentrations below the current mean concentration of approximately 100 ppb; the Lake Okeechobee SWIM Plan update indicates that 40 ppb is the target in-lake concentration). Additional treatment works may be necessary to achieve target concentrations.

Alternative D13R increases the volume of water delivered from the ECP to the downstream WCAs by 19 percent compared to that delivered by the conceptual design utilizing the same baseline period (1979-1988). Increasing the volume of water delivered to the WCAs to achieve environmental and water supply objectives of the Restudy contributes towards achieving the 28 percent increase to the WCAs requirement contained in the EFA (F.S. 373.4592(4)(b)2). The 19 percent increase is to be achieved concurrent with other components designed to achieve optimal hydrological conditions in the Everglades. No alternative plan delivered more than 23 percent (Alternative B) greater flows via the ECP to the WCAs (see Table D-D-7b).

Components K6, X6, and Y6 involve increasing the amount of water contained within the West Palm Beach Water Catchment Area. This involves collecting runoff from the L-8, C-51, and C-17 watersheds (Class III waters), and directing it via the M-Canal and C-18 Canal to the Water Catchment Area. The C-18 Canal, M-Canal, the Water Catchment Area and Lake Mangonia are all Class I waters (Potable Water Supply). To receive water quality certification under the Clean Water Act, Restudy components which create new surface waters discharges into Class I waters would have to discharge water of sufficient quality to assure that the Class I use classification is maintained. While it is understood that the design of the components include STAs to address water quality treatment requirements, additional treatment works (over and above vegetated STAs) may be necessary to assure compliance with Class I water quality standards. To further evaluate future treatment requirements, if any, ambient pollutant loads and concentrations within the watersheds would have to be quantified and compared against minimum, general, and Class I surface waters criteria contained within Florida Administrative Code Rule 62-302.

Components D5 and GG4 involve storing Lake Okeechobee and Caloosahatchee River watershed runoff in 22 10 MGD and 200 5 MGD aquifer storage and recovery (ASR) wells, creating a total of 1,220 MGD of surface water to be injected and stored in the Floridan aquifer. These components create significant hydrologic benefits, especially in the lake. However, there are some assumptions about Lake Okeechobee and Caloosahatchee ASR as presently modeled. The technical feasibility of injecting and a 70% recovery of 1,220 MGD has not yet been proven, nor has ASR on this scale been implemented anywhere that the WQT is aware of. Second, the water quality and ecological impacts of recovering water stored in the aquifer and discharging it directly to Lake Okeechobee (Class I waters) and Caloosahatchee basin waters (Class III waters) have not been reasonably evaluated. The WQT has been made aware that the potential impacts include possible increased production of methylmercury, changes in pH and temperature, and the introduction of water containing low-to-no dissolved oxygen. Water which is recovered from ASR wells may require additional treatment (e.g., wetlands) prior to discharging to Class I (Lake Okeechobee) and Class III (Caloosahatchee basin) surface waters to maintain the use classifications and ecological integrity of those waters and downstream receiving waters. Further detailed evaluation of ASR water quality and its impact on surface waters is necessary. An ad hoc ASR Team is being created for such a purpose. However, since it may not be possible to complete such an evaluation given the schedule for drafting a feasibility report and a PEIS for the Restudy, the Restudy Team should consider including additional treatment facilities and costs in the comprehensive plan to achieve and maintain water quality and ecological targets in Lake Okeechobee and Caloosahatchee basin waters potentially affected by ASR water.

Component DDD5 involves discharging Caloosahatchee basin runoff through an STA into Lake Okeechobee. New discharges to Lake Okeechobee must meet Class I drinking water standards.

D-D.6 ADDITIONAL RECOMMENDATIONS

The surface water storage reservoirs (approximately 184,000 acres in the IDP) should be operated to optimally capture phosphorus contained in inflows and remove phosphorus from outflows. To the extent that phosphorus is a surrogate for other pollutants, optimal operation of these facilities for phosphorus removal will contribute to additional significant pollution load reductions. The Team's present recommendation for optimal operation is to maintain at least 2.5-ft. water depth in the reservoirs, with a minimum hydraulic retention (residence) time of 21 days prior to discharge. When the surface water reservoirs dry down (when depths fall below 2.5 ft.), upon re-wetting, the same optimal hydrologic operational scenario should be achieved prior to discharge.

The implications of the increased volume delivered to the ECP via the IDP on the "Phase 2" treatment requirement should be further evaluated. The STA Design Group, Everglades Technical Advisory Committee, or technical staff in support of the Technical Oversight Committee established by the Settlement Agreement could facilitate such an evaluation. Walker's evaluation indicates that future "without project" and IDP hydraulic flows and phosphorus loads could create potential performance problems in the STAs absent Phase 2 treatment facilities. Supplemental treatment technologies presently being investigated by SFWMD to achieve low phosphorus concentrations in anticipation of the yet-to-be-established numeric phosphorus criterion for the EPA utilize hydrologic records from 1979-1988 baseline period used in the Conceptual Design for the ECP (Burns & McDonnell, 1994). The WQT recommends that the 31-year 1965-1995 hydrologic period of record be used for such investigations.

The IDP creates an increase over the 2050 Base Condition in the volume of Lake Okeechobee water delivered to LEC Service Area 2 to meet water supply demands. A preliminary analysis of the partitioning of water deliveries to and through the Water Conservation Areas indicates that under certain conditions, water delivered from Lake Okeechobee to the Lower East Coast has the potential to increase phosphorus loads in the Water Conservation Areas. Given the potential for increased phosphorus loads associated with water supply deliveries from Lake Okeechobee to the LEC to create ecological impacts in the Everglades marsh, the WQT recommends that alternative sources of water to meet LEC SA2 demands be investigated (e.g. wastewater reuse in Broward County).

Given that water depths in southern LNWR exceed that predicted by the NSM, the WQT recommends that the hydrologic effect of re-directing Acme Basins discharges be further evaluated by the Restudy Team (e.g. re-directed to the LEC, or re-directed to WCA 2 after treatment). Water budget data indicate that approximately 39 k ac. ft. (average annual volume) is delivered to LNWR from the

Acme Basins (Wellington area). Acme Basins water consists of agricultural and urban runoff, which is presently untreated. The Non-ECP requirements of the EFA, when fully implemented, require that water quality strategies (e.g. BMPs, treatment facilities, land acquisition) be implemented to assure that all water quality standards are met by 12/31/06, including the yet-to-be-established numeric criterion for phosphorus. However, if excess Acme Basins water could be re-directed for other uses (water supply, wellfield enhancement, etc), hydrologic and water quality benefits could be realized in LNWR, along with a concomitant reduction in future expenditures necessary to meet the requirements of the EFA.

Water budget data for Lake Okeechobee show that approximately 79 k ac. ft. of water from the Northern L-8 Basin is discharged to Lake Okeechobee. This is the same condition as the 2050 Base (discharges without treatment). Water quality data for the structures through which these flows pass indicate that Northern L-8 water contains relatively high concentrations of total phosphorus (over 200 ppb). Lake Okeechobee water discharges to the Everglades to meet hydrologic targets and to the LEC through the Everglades create performance problems for ECP (in the case of increasing lake flows to the ECP over the design flows) and increase phosphorus loading in the Everglades. The WQT has identified several options for treating or re-directing Northern L-8 Basin water: 1) treatment of water (STAs, etc.) prior to backpumping to Lake Okeechobee to reduce in-lake phosphorus loads and subsequent downstream loads to the ECP and the EPA; 2) creation of additional storage; and 3) routing a portion of Northern L-8 Basin flows south to LNWR via a flow-way or through STA 1E to meet hydrologic targets in northern LNWR.

Table D-D-2
Lake Okeechobee Water Quality Model Results of Alternative Simulations from the Central and Southern Florida Restudy

Averaged Values From Model Simulations

TEST	CURRENT	FUTURE	ALT A	ALT B	ALT C	ALT D13R
P INLOAD kg/day	1055	1056	1053	1038	1047	1050
P OUTLOAD kg/day	381	372	374	375	374	376
MEDIAN TP mg/L	.084	.082	.082	.082	.082	.086
MEDIAN CHL mg/cubic meter	29.5	29.4	29.4	29.1	29	29.2
MAXIMUM CHLA m g/cubic meter	67.1	74.4	78.5	86.3	93.9	71.2

Rankings (higher is better)

TEST	CURRENT	FUTURE	ALT A	ALT B	ALT C	ALT D13	WEIGHT
P INLOAD	2.50	2.50	2.50	5.50	5.50	2.50	1.00
P OUTLOAD	1.00	4.00	4.00	4.00	4.00	4.00	1.00
MEDIAN TP	2.00	4.50	4.50	4.50	4.50	1.00	1.00
MEDIAN CHL	2.00	2.00	2.00	5.00	5.00	5.00	1.00
MAXIMUM TP	4.00	1.50	1.50	4.00	4.00	6.00	1.00
MAXIMUM CHLA	6.00	4.00	3.00	2.00	1.00	5.00	1.00
(AVG)	2.9	3.1	2.9	4.2	4.0	3.9	

Table D-D-3a
Water Quality Evaluation Matrix WCA-1

	95 Base	50 Base	Alt A	Alt B	Alt C	Alt D	AltD13	Weight factor
WCA-1 14 station Geo mean (entire period, ppb)	10.38	6.29	6.14	6.46	6.03	6.11	6.07	1.00
Rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Weighted rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
WCA-1 14 station Geo mean (wet year, ppb)	9.69	7.17	7.05	6.99	6.85	6.81	6.88	1.00
Rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Weighted rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
WCA-1 14 station Geo mean dry year (ppb)	10.27	4.64	4.43	4.84	4.82	4.85	4.85	1.00
Rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Weighted rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Structural TP load (MT/yr)	93.61	6.94	4.63	4.36	4.31	4.54	4.54	1.00
Rank	1.00	2.00	5.00	5.00	5.00	5.00	5.00	
Weighted rank	1.00	2.00	5.00	5.00	5.00	5.00	5.00	
Overall Score	1.43	5.54	6.61	6.61	6.61	6.61	6.61	

Table D-D-3b
Water Quality Evaluation Matrix WCA-2A

	95 Base	50 Base	Alt A	Alt B	Alt C	Alt D	Alt D13	Weight factor
Mean TP Conc (ppb)	8.94	4.67	4.80	4.93	4.89	4.89	4.71	1.00
Rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Weighted rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Structural TP load (MT/yr)	28.91	6.96	6.94	9.35	9.49	9.52	9.52	1.00
Rank	1.00	6.50	6.50	3.50	3.50	3.50	3.50	
Weighted rank	1.00	6.50	6.50	3.50	3.50	3.50	3.50	
Overall Score	1.43	7.86	7.86	5.71	5.71	5.71	5.71	

Table D-D-3c
Water Quality Model Evaluation Matrix WCA-3A

	95 Base	50 Base	Alt A	Alt B	Alt C	Alt D	Alt D13	Weight factor
Mean TP Conc (ppb)	7.55	5.35	5.45	5.42	5.76	5.77	5.65	1.00
Rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Weighted rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Structural TP load (MT/yr)	93.99	21.21	20.06	20.09	17.67	15.43	15.43	1.00
Rank	1.00	2.00	3.50	3.50	5.00	6.50	6.50	
Weighted rank	1.00	2.00	3.50	3.50	5.00	6.50	6.50	
Overall Score	1.43	4.64	5.71	5.71	6.79	7.86	7.86	

Table D-D-3d
Water Quality Model Evaluation Matrix WCA 2B

	95 Base	50 Base	Alt A	Alt B	Alt C	Alt D	Alt D13	Weight factor
Mean TP Conc (ppb)	4.77	3.75	4.09	3.80	3.85	3.87	3.75	1.00
Rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Weighted rank	1.00	4.50	4.50	4.50	4.50	4.50	4.50	
Structural TP load (MT/yr)	0.02	0.01	0.00	0.00	0.00	0.00	0.00	1.00
Rank	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Weighted rank	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Overall Score	3.57	6.07	6.07	6.07	6.07	6.07	6.07	

Table D-D-3e
Water Quality Model Evaluation Matrix WCA-3B

	95 Base	50 Base	Alt A	Alt B	Alt C	Alt D	Alt D13	Weight factor
Mean TP Conc (ppb)	4.71	4.46	4.71	5.53	5.39	5.47	5.23	1.00
Rank	6.00	6.00	6.00	2.50	2.50	2.50	2.50	
Weighted rank	6.00	6.00	6.00	2.50	2.50	2.50	2.50	
Structural TP load (MT/yr)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	1.00
Rank	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Weighted rank	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Overall Score	7.14	7.14	7.14	4.64	4.64	4.64	4.64	

Table D-D-3f
Water Quality Model Evaluation Matrix Everglades National Park

	95 Base	50 Base	Alt A	Alt B	Alt C	Alt D	Alt D13	Weight factor
Mean TP Conc (ppb)	4.26	4.50	4.76	4.73	4.73	4.77	4.78	1.00
Rank	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Weighted rank	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Structural TP load (MT/yr)	1.68	2.84	4.01	7.55	7.42	7.69	7.69	1.00
Rank	7.00	6.00	5.00	2.50	2.50	2.50	2.50	
Weighted rank	7.00	6.00	5.00	2.50	2.50	2.50	2.50	
TP load from S-12 and S-333 (MT/yr)	9.74	6.12	6.87	0.00	3.83	3.14	0.00	1.00
Rank	1.00	3.00	2.00	6.50	4.00	5.00	6.50	
Weighted rank	1.00	3.00	2.00	6.50	4.00	5.00	6.50	
S-12 and S-333 TP conc.(ppb)	10.14	5.30	5.70	0.00	8.00	7.40	0	1.00
Rank	1.00	5.00	4.00	6.50	2.00	3.00	6.50	
Weighted rank	1.00	5.00	4.00	6.50	2.00	3.00	6.50	
Overall Score	4.64	6.43	5.36	6.96	4.46	5.18	6.96	

Table D-D-4
EVALUATION MATRIX
CALOOSAHATCHEE ESTUARY/WATERSHED

Performance Indicator	**95B**	**50B**	**A**	**B**	**C**	**D**	**D13R**
1. Number of high flow events > 4500 cfs (fewer is better)	29	26	4	2	3	3	3
Rank (1-7) (higher is better)	1	2	3	7	5	5	5
2. Number of low flow events (fewer is better)	107	111	36	36	36	36	36
Rank (1-7)	2	1	5	5	5	5	5
3. % Stage Duration Curve > 2.0 ft. (higher is better)	0	0	51	51	52	53	53
Rank (1-7)	1.5	1.5	3.5	3.5	5	6.5	6.5
4. Number of times reservoir > 2.0 ft > 21 days	0	0	22	22	23	24	24
Rank (1-6)	1.5	1.5	3.5	3.5	5	6.5	6.5
Sum of Ranks	**6.0**	**6.0**	**15**	**19**	**20**	**23**	**23**
Normalized Score 1-10; (higher is better)	***2.2***	***2.3***	***5.4***	***6.8***	***7.1***	***8.2***	***8.2***

Table D-D-5
LEC Water Quality Evaluation Matrix

Performance Indicator	95B	50B	A	B	C	D	D13R
1. Lake Worth Low Flow (# mos. flow = 0; fewer is better)	30	42	45	49	42	24	24
Rank (1-7) (higher is better)	5	3.5	2	1	3.5	6.5	6.5
2. Lake Worth High Flow (# times flow avg. > 500 cfs; fewer is better)	299	216	157	124	121	96	96
Rank (1-7)	1	2	3	4	5	6.5	6.5
3. Snake Creek Dry Season Flow (T = 93)	51	43	14	29	31	28	26
Rank (1-7)	7	6	1	4	5	3	2
4. North Bay Dry Season Flow (no target; higher is better)	41	37	21	38	38	38	38
Rank (1-7)	7	2	1	4.5	4.5	4.5	4.5
5. Central Bay Dry Season Flow (T= 83)	64	73	24	41	49	63	61
Rank (1-7)	6	7	1	2	3	5	4
6. South Bay Dry Season Flow (T = 68)	52	52	39	41	89	92	92
Rank (1-7)	6.5	6.5	4	5	3	1.5	1.5
7. Snake Creek Wet Season Flow (T = 67)	121	114	57	83	87	83	79
Rank (1-7)	1	2	7	4.5	3	4.5	6
8. North Bay Wet Season Flow (no target; more is better)	99	95	51	96	97	97	97
Rank (1-7)	6	2	1	3	5	5	5
9. Central Bay Wet Season Flow (T = 161)	161	152	86	105	120	140	139
Rank (1-7)	7	6	1	2	3	5	4

Table D-D-5 (Continued)
LEC Water Quality Evaluation Matrix

10. South Bay Wet Season Flow (T = 158)	158	152	122	125	175	181	181
Rank (1-7)	7	6	1	2	5	3.5	3.5
11. % Bird Drive Res. > 1.0 ft.	0	0	0	0	0	20	20
Rank (1-7)	0	0	0	0	0	6.5	6.5
12. % C-11 Res. > 1.5 ft.	0	5	40	26	30	24	19
Rank (1-7)	0	2	7	5	6	4	3
13. % C-9 Res. > 2.0 ft.	0	0	35	0	0	0	0
Rank (1-7)	0	0	7	0	0	0	0
Sum of Ranks	**54.5**	**55**	**36**	**35**	**46**	**65.5**	**63**
Normalized Score (higher is better)	**4.5**	**4.5**	**1.0**	**2.0**	**3.0**	**6.5**	**6.5**

Table D-D-6
WATER QUALITY EVALUATION MATRIX
St. Lucie River Estuary

Performance Measure #	Descriptive Name of Performance Measure	Relative Weight	1995 Baseline	2050 Baseline	Alternative A	Alternative B	Alternative C	Alternative D
1	# Monthly flows > 1600 cfs	1	1	2	4	6	4	4
2	# Monthly flows > 2500 cfs	1	1	2	5	6	3.5	3.5
3	# Months average flow < 350 cfs	1	2	1	4	3	5.5	5.5
4	Frequency 14 day avg. flow > 1600	1	1	2	4	6	4	4
5	4 % Stage duration curve > 2.0 feet	1	1.5	1.5	4.5	3	4.5	6
6	Frequency reservoir > 2.0' >21day	1	1.5	1.5	4	3	5	6
7	Retention time 500 cfs outflow rate		1.5	1.5	4	3	5	6
		TOTALS	**9.5**	**11.5**	**29.5**	**30**	**31.5**	**35**
			SCORE 95B	**SCORE 50B**	**SCORE A**	**SCORE B**	**SCORE C**	**SCORE D**
			2.64	**3.19**	**8.19**	**8.33**	**8.75**	**9.72**

Table 7a

STA & Reservoir Performance Measures for the Everglades Restudy
Workbook for Ranking Alternatives

prepared for

U.S. Army Corps of Engineers & U.S. Department of the Interior

by

William W. Walker, Jr., Ph.D, Environmental Engineer

16-July-98

Methodology: Weighted ranking scheme described in Eric Bush e-mail to Restudy water quality group, May 13, 1998.

Preliminary Scores (Scale 1-10, higher score means better performance):

	50Base	ALT-A	ALT-B	ALT-C	ALT-D	A-D13R
BMP Performance = 25% (ECP Design)						
Concentration Criteria	5.8	8.3	7.1	4.8	3.3	5.6
Load Criteria	5.0	8.6	5.6	5.3	5.0	7.2
Hydrologic Criteria	3.8	5.0	6.7	6.7	7.1	6.3
SA/EFA Criteria	4.7	7.7	8.0	4.7	4.3	5.7
Combined	5.0	7.7	6.8	5.2	4.6	6.2
BMP Performance = 51% (1995-1997)						
Concentration Criteria	6.5	8.1	6.3	4.4	3.5	6.0
Load Criteria	7.2	8.1	5.3	5.0	4.4	5.3
Hydrologic Criteria	3.8	5.0	6.7	6.7	7.1	6.3
SA/EFA Criteria	5.0	7.7	7.7	4.7	4.3	5.7
Combined	5.9	7.5	6.4	5.0	4.6	5.8

Sheet	Description	BMP Performance
Values1	Performance Indicator Values for Each Alternative	25% (ECP Design)
Rankings1	PI Rankings & Scores	25% (ECP Design)
Values2	Performance Indicator Values for Each Alternative	51% (1995-1997)
Rankings2	PI Rankings & Scores	51% (1995-1997)
Definitions	PM Descriptions & Weights	

Note: Results shown are for illustrative purposes only.
Weighting factors to be selected by consensus & entered in 'Definitions' sheet

Input Values;

Tolerance	1%	PI values within X% of best value are equivalent & all ranked highest
Highest Score	10	Used to rescale weighted mean ranks

Workbook: RANKS.XLS 7/16/98

Table 7b

STA & Reservoir Performance Measures   Numerical Values   BMP Performance: 25% (ECP Design)

No	Performance Indicator	Units	Pd	95Base	50Base	ALT-A	ALT-B	ALT-C	ALT-D	A-D13R	Target
Concentration Criteria											
1	WCA Inflow Concentration	ppb	65-95	156	62	56	57	57	58	57	<50
2	WCA Inflow Conc., Excl. STA-5	ppb	65-95	142	60	52	54	54	54	54	<50
3	Refuge Inflow Concentration	ppb	65-95	154	50	52	52	52	55	54	<50
4	STA-1E Ouflow Conc	ppb	65-95		43	46	46	46	45	45	<50
5	STA-1W Outflow Conc	ppb	65-95		55	57	57	57	62	62	<50
6	STA-2 Outflow Conc	ppb	65-95		76	63	65	66	67	63	<50
7	STA-34 Outflow Conc	ppb	65-95		55	45	48	48	48	48	<50
8	STA-5 Outflow Conc	ppb	65-95		98	99	99	99	99	99	<50
9	STA-6 Outflow Conc	ppb	65-95		61	61	61	61	60	60	<50
Load Criteria											
10	WCA Total Load	mt/yr	65-95	253.0	104.5	98.3	104.7	102.4	104.7	102.2	Min
11	Refuge Total Load	mt/yr	65-95	106.5	19.8	21.6	21.6	21.7	23.4	23.3	Min
12	Total Load Reduction	mt/yr	65-95	0.0	164.3	168.9	169.1	166.5	168.1	168.7	Max
13	Total Load with C > 50 ppb	mt/yr	65-95	251.0	95.7	53.6	56.5	57.4	59.8	56.4	Min
14	STA ByPass Load	mt/yr	65-95	249.2	4.3	4.9	7.1	7.1	7.1	7.1	Min
15	LEC P Load	mt/yr	65-95	3.5	11.3	7.5	8.6	8.2	6.2	7.0	Min
Hydrologic Criteria											
16	Freq. Depth < 6 inches	%	65-95		2.6%	1.2%	1.1%	1.0%	1.1%	1.1%	Min
17	Freq. Depth > 4 ft	%	65-95		0.4%	0.4%	0.6%	0.8%	0.8%	0.7%	Min
18	WCA Inflow Volume	kac-ft/yr	65-95	1314	1373	1434	1493	1443	1460	1441	Max
19	Refuge Inflow Volume	kac-ft/yr	65-95	559	324	338	337	338	347	347	Max
Everglades Forever Act & Settlement Agreement Criteria											
20	WCA Inflow Concentration	ppb	79-88	151	55	48	50	51	51	50	<50 (EFA)
21	WCA Inflow Conc., Excl. STA-5	ppb	79-88		56	46	49	49	49	48	<50 (SA)
22	Refuge Inflow Concentration	ppb	79-88	154	47	49	49	49	51	51	<50 (SA, EFA)
23	STA ByPass Load	mt/yr	79-88	217.4	4.7	4.1	6.3	6.4	6.4	6.4	= 0 (SA, EFA)
24	WCA Inflow Vol Increase	%	79-88	7%	12%	14%	23%	19%	20%	19%	>=28% (EFA)

Table 7c

STA & Reservoir Performance Measures   Ranks: 5=High, 1=Low   BMP Performance: 25% (ECP Design)

No	Performance Indicator	Weight*	Pd	50Base	ALT-A	ALT-B	ALT-C	ALT-D	A-D13R	Range %
Concentration Criteria										
1	WCA Inflow Concentration	1	65-95	1	6	5	3	2	4	11%
2	WCA Inflow Conc., Excl. STA-5	1	65-95	1	6	5	3	2	4	14%
3	Refuge Inflow Concentration	1	65-95	6	4	5	3	1	2	9%
4	STA-1E Ouflow Conc	1	65-95	6	3	1	1	4	5	9%
5	STA-1W Outflow Conc	1	65-95	6	4	5	3	1	2	13%
6	STA-2 Outflow Conc	1	65-95	1	6	4	3	2	6	19%
7	STA-34 Outflow Conc	1	65-95	1	6	5	4	3	2	20%
8	STA-5 Outflow Conc	1	65-95	6	5	4	3	1	2	1%
9	STA-6 Outflow Conc	0	65-95	6	3	2	1	6	6	2%
	Weighted Mean Score (1-10)			5.8	8.3	7.1	4.8	3.3	5.6	
Load Criteria										
10	WCA Total Load	1	65-95	3	6	1	4	2	5	6%
11	Refuge Total Load	1	65-95	6	4	5	3	1	2	16%
12	Total Load Reduction	1	65-95	1	6	6	2	6	6	3%
13	Total Load with C > 50 ppb	1	65-95	1	6	4	3	2	5	67%
14	STA ByPass Load	1	65-95	6	5	2	4	1	3	45%
15	LEC P Load	1	65-95	1	4	2	3	6	5	63%
	Weighted Mean Score (1-10)			5.0	8.6	5.6	5.3	5.0	7.2	
Hydrologic Criteria										
16	Freq. Depth < 6 inches	1	65-95	1	2	4	6	5	3	120%
17	Freq. Depth > 4 ft	1	65-95	6	5	4	2	1	3	77%
18	WCA Inflow Volume	1	65-95	1	2	6	4	5	3	8%
19	Refuge Inflow Volume	1	65-95	1	3	2	4	6	6	7%
	Weighted Mean Score (1-10)			3.8	5.0	6.7	6.7	7.1	6.3	
Everglades Forever Act & Settlement Agreement Criteria										
20	WCA Inflow Concentration	1	79-88	1	6	5	3	2	4	14%
21	WCA Inflow Conc., Excl. STA-5	1	79-88	1	6	4	2	3	5	19%
22	Refuge Inflow Concentration	1	79-88	6	3	5	4	2	1	7%
23	STA ByPass Load	1	79-88	5	6	4	2	1	3	40%
24	WCA Inflow Vol Increase	1	79-88	1	2	6	3	5	4	62%
	Weighted Mean Score (1-10)			4.7	7.7	8.0	4.7	4.3	5.7	
	Combined Weighted Mean Score (1-10)			5.0	7.7	6.8	5.2	4.6	6.2	

Range % = (Max - Min) / Average; low values indicate small differences among alternatives   7/16/98
* Assigned Weights are for demonstration purposes only; these need to be determined by group consensus.
Enter alternative weights in column C of 'Definitions' table. Weight can be any value >=0.

Table 7d

STA & Reservoir Performance Measures Numerical Values BMP Performance: 51% (1995-1997)

No	Performance Indicator	Units	Pd	95Base	50Base	ALT-A	ALT-B	ALT-C	ALT-D	A-D13R	Target
Concentration Criteria											
1	WCA Inflow Concentration	ppb	65-95	114	46	45	46	46	47	46	<50
2	WCA Inflow Conc., Excl. STA-5	ppb	65-95	99	45	42	43	43	43	43	<50
3	Refuge Inflow Concentration	ppb	65-95	115	44	46	46	46	48	48	<50
4	STA-1E Ouflow Conc	ppb	65-95		42	46	46	46	45	45	<50
5	STA-1W Outflow Conc	ppb	65-95		43	45	45	45	49	49	<50
6	STA-2 Outflow Conc	ppb	65-95		49	42	44	45	45	41	<50
7	STA-34 Outflow Conc	ppb	65-95		39	36	38	38	38	38	<50
8	STA-5 Outflow Conc	ppb	65-95		89	90	90	90	90	90	<50
9	STA-6 Outflow Conc	ppb	65-95		33	34	34	34	33	33	<50
Load Criteria											
10	WCA Total Load	mt/yr	65-95	184.9	78.7	79.7	85.0	82.8	84.5	82.7	Min
11	Refuge Total Load	mt/yr	65-95	79.1	17.5	19.1	19.1	19.2	20.4	20.4	Min
12	Total Load Reduction	mt/yr	65-95	0.0	125.1	131.6	132.4	129.4	130.6	130.5	Max
13	Total Load with C > 50 ppb	mt/yr	65-95	183.0	16.7	20.2	21.5	21.5	21.6	21.5	Min
14	STA ByPass Load	mt/yr	65-95	181.1	2.7	2.9	4.2	4.2	4.2	4.2	Min
15	LEC P Load	mt/yr	65-95	3.5	11.2	7.3	8.5	8.1	6.1	6.8	Min
Hydrologic Criteria											
16	Freq. Depth < 6 inches	%	65-95		2.6%	1.2%	1.1%	1.0%	1.1%	1.1%	Min
17	Freq. Depth > 4 ft	%	65-95		0.4%	0.4%	0.6%	0.8%	0.8%	0.7%	Min
18	WCA Inflow Volume	kac-ft/yr	65-95	1314	1373	1434	1493	1443	1460	1441	Max
19	Refuge Inflow Volume	kac-ft/yr	65-95	559	324	338	337	338	347	347	Max
Everglades Forever Act & Settlement Agreement Criteria											
20	WCA Inflow Concentration	ppb	79-88	112	42	40	41	42	42	42	<50 (EFA)
21	WCA Inflow Conc., Excl. STA-5	ppb	79-88	99	42	38	40	41	40	40	<50 (SA)
22	Refuge Inflow Concentration	ppb	79-88	115	42	44	44	44	45	45	<50 (SA, EFA)
23	STA ByPass Load	mt/yr	79-88	159.5	2.8	2.4	3.7	3.7	3.8	3.7	= 0 (SA, EFA)
24	WCA Inflow Vol Increase	%	79-88	7%	12%	14%	23%	19%	20%	19%	>=28% (EFA)

Table 7e

STA & Reservoir Performance Measures   Ranks: 5=High, 1=Low   BMP Performance: 51% (1995-1997)

No	Performance Indicator	Weight*	Pd	50Base	ALT-A	ALT-B	ALT-C	ALT-D	A-D13R	Range %
Concentration Criteria										
1	WCA Inflow Concentration	1	65-95	4	6	5	2	1	3	4%
6-July-9	WCA Inflow Conc., Excl. STA-5	1	65-95	1	6	4	2	3	5	8%
3	Refuge Inflow Concentration	1	65-95	6	4	5	3	1	2	8%
4	STA-1E Ouflow Conc	1	65-95	6	3	1	1	4	5	9%
5	STA-1W Outflow Conc	1	65-95	6	4	5	3	1	2	12%
6	STA-2 Outflow Conc	1	65-95	1	5	4	3	2	6	17%
7	STA-34 Outflow Conc	1	65-95	1	6	2	5	4	3	8%
8	STA-5 Outflow Conc	1	65-95	6	5	4	2	1	3	2%
9	STA-6 Outflow Conc	0	65-95	6	2	3	1	6	6	2%
	Weighted Mean Score (1-10)			6.5	8.1	6.3	4.4	3.5	6.0	
Load Criteria										
10	WCA Total Load	1	65-95	6	5	1	3	2	4	8%
11	Refuge Total Load	1	65-95	6	4	5	3	1	2	15%
12	Total Load Reduction	1	65-95	1	6	6	2	4	3	6%
13	Total Load with C > 50 ppb	1	65-95	6	5	4	3	1	2	24%
14	STA ByPass Load	1	65-95	6	5	1	4	2	3	41%
15	LEC P Load	1	65-95	1	4	2	3	6	5	64%
	Weighted Mean Score (1-10)			7.2	8.1	5.3	5.0	4.4	5.3	
Hydrologic Criteria										
16	Freq. Depth < 6 inches	1	65-95	1	2	4	6	5	3	120%
17	Freq. Depth > 4 ft	1	65-95	6	5	4	2	1	3	77%
18	WCA Inflow Volume	1	65-95	1	2	6	4	5	3	8%
19	Refuge Inflow Volume	1	65-95	1	3	2	4	6	6	7%
	Weighted Mean Score (1-10)			3.8	5.0	6.7	6.7	7.1	6.3	
Everglades Forever Act & Settlement Agreement Criteria										
20	WCA Inflow Concentration	1	79-88	2	6	5	3	1	4	5%
21	WCA Inflow Conc., Excl. STA-5	1	79-88	1	6	3	2	4	5	11%
22	Refuge Inflow Concentration	1	79-88	6	3	5	4	2	1	5%
23	STA ByPass Load	1	79-88	5	6	4	2	1	3	40%
24	WCA Inflow Vol Increase	1	79-88	1	2	6	3	5	4	62%
	Weighted Mean Score (1-10)			5.0	7.7	7.7	4.7	4.3	5.7	
	Combined Weighted Mean Score (1-10)			5.9	7.5	6.4	5.0	4.6	5.8	

Range % = (Max - Min) / Average; low values indicate small differences among alternatives   7/16/98

* Assigned Weights are for demonstration purposes only; these need to be determined by group consensus.
Enter alternative weights in column C of 'Definitions' table. Weight can be any value >=0.

Table 7f

STA & Reservoir Performance Measures - Definitions

No	Performance Indicator	Sign	Weight	Description
Concentration Criteria				
1	WCA Inflow Concentration	-1	1	average inflow concentration to WCA's*
2	WCA Inflow Conc., Excl. STA-5	-1	1	same as 1, excluding STA-5; basins considered in Settlement Agreement*
3	Refuge Inflow Concentration	-1	1	average inflow concentration to Refuge *
4	STA-1E Ouflow Conc	-1	1	average outflow concentration from STA-1E, including bypasses
5	STA-1W Outflow Conc	-1	1	average outflow concentration from STA-1W, including bypasses
6	STA-2 Outflow Conc	-1	1	average outflow concentration from STA-2, including bypasses
7	STA-34 Outflow Conc	-1	1	average outflow concentration from STA-34, including bypasses
8	STA-5 Outflow Conc	-1	1	average outflow concentration from STA-5, including bypasses
9	STA-6 Outflow Conc	-1	0	average outflow concentration from STA-6, including bypasses
Load Criteria				
10	WCA Total Load	-1	1	total load to WCA's *
11	Refuge Total Load	-1	1	total load to Loxahatchee National Wildlife Refuge *
12	Total Load Reduction	1	1	total load reduction (outflow - inflow) accomplished by STA's & Reservoirs
13	Total Load with C > 50 ppb	-1	1	total load with concentration > 50 ppb *
14	STA ByPass Load	-1	1	total bypass load for all STA's *
15	LEC P Load	-1	1	load in urban-water supply deliveries through WCA's, bypassing treatment
Hydrologic Criteria				
16	Freq. Depth < 6 inches	-1	1	frequency of depths < 6 inches, area-weighted mean across all STA's
17	Freq. Depth > 4 ft	-1	1	frequency of depths > 4 feet, area-weighted mean across all STA's
18	WCA Inflow Volume	1	1	total inflow volume to WCA's *
19	Refuge Inflow Volume	1	1	total inflow volume to Refuge *
Everglades Forever Act & Settlement Agreement Criteria				
20	WCA Inflow Concentration	-1	1	average inflow conc. To WCA's, 1979-1988 base period*
21	WCA Inflow Conc., Excl. STA-5	-1	1	average inflow conc. To WCA's, excluding STA-5, 1979-1988 base period*
22	Refuge Inflow Concentration	-1	1	average inflow conc to Refuge, 1979-1988 base period *
23	STA ByPass Load	-1	1	total bypass load for all STA's, 1979-1988 base period*
24	WCA Inflow Vol Increase	1	1	percent increase in total WCA inflow volume, relative to 1979-1988 base pd*

* excluding urban water-supply deliveries
Signs: +1 higher values are preferred, -1 lower values are preferred
Weights are used to calculate weighted-mean rankings within each category; enter values >=0

ATTACHMENT E

FINAL AET REPORT ON THE D13R4 SCENARIO

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Attachment E
Final AET Report on the D13R4 Scenario

D-E.1 OVERVIEW

The Alternative Evaluation Team for the C&SF Restudy conducted a preliminary evaluation of the D13R4 scenario during a meeting of the full AET on 20 January 1999. The objective of this modeling exercise was to determine the feasibility of improving D13R, by capturing additional surplus water from the amount discharged to tide each year, and of conveying that "new" water (plus redistributing excessive water in the Water Conservation Areas) to better meet performance targets in the natural system. Scenarios designed to convey urban runoff water into the natural system have not previously been considered during the lengthy AET/ADT plan formulation process. The D13R4 scenario reported on here was clearly the most successful of four scenarios (R1–R4) that were developed during an intensive, multi-agency planning and modeling process, which began in November 1998.

The AET found that the overall performance of Scenario D13R4, as modeled on 13-14 January, included both gains and losses when measured against the 1995 base, 2050 base, and D13R conditions. D13R4 captured an average of 253,000 acre feet/year of new water for the natural system from Palm Beach and Broward counties. This new water, combined with excessive water from the WCAs, provided an average of 271,000 acre feet of new water each year to Everglades National Park and an average of 77,000 acre feet of new water to Biscayne Bay each year. The increased annual mean flows to the park and Biscayne Bay are expected to produce substantial improvements towards meeting the hydrological performance targets for these two areas. Although D13R4 also provided modest improvements in northeast WCA 3A and northeast 2B, by reducing the number of undesirable high water events in these two subregions, this scenario increased the number of undesirable high water events in WCAs 2A and 3B to a level greater than that predicted for the two base conditions. D13R4 also created undesirable increases in the depth and duration of flooding in the Pennsuco wetlands. By delivering urban water to the natural system, this scenario raises a number of new water quality questions.

The AET recognizes that much new information regarding the potential performance of D13R was gained during the modeling of the four scenarios R1-R4 of D13R. The hydrological responses during the modeling of these four scenarios convincingly demonstrated the operational flexibility of D13R, and offers encouraging documentation that additional improvements can be achieved during the detailed planning phases of the restoration program.

Table 1
Details of Flows to Tide
Thousand Acre Feet/year
(+ indicates water captured)

Canal/Structure	95BS	D13R	D13R4	D13R-D13R4
C-51 @ S-155	**375**	**173**	**74**	**+99**
C-16 @ S-41	**90**	**31**	**13**	**+18**
C-15 @ S-40	**94**	**33**	**13**	**+20**
Hillsboro @ G-56	**125**	**28**	**29**	**-1**
PBC subtotal	684	265	129	+136
C-14 @ S-37A	**106**	**97**	**49**	**+48**
C-13 @ S-36	**53**	**25**	**15**	**+10**
NNR @ G-54	**69**	**99**	**40**	**+59**
Broward subtotal	228	221	104	+117

The AET recommended that the specific features of D13R4 that allowed for the capture and conveyance of substantial amounts of new water for the natural system be incorporated into the Recommended Plan, D13R, contingent upon:

- Finding ways to reduce the number of damaging high water events in WCA 2A and 3B to a level at or below the level predicted for D13R.
- Adequately treating the stormwater runoff from the C-51 east/C-13/14 basins directed into the Everglades Protection Area to meet all state and federal water quality standards to enable ecological restoration to be achieved.
- Moderating excessive high water events in the Pennsuco wetlands.

It was agreed that these concerns can best be resolved during the finer scale modeling and planning which will occur as a part of detail design work. The addition of these features should allow greater operational flexibility during future efforts to improve the overall performance of D13R. An issue paper may be required from the Restudy's water quality team, to more fully explore the questions being raised by the use of urban water to meet natural system targets in Everglades National Park.

D-E.2 "BULLET" SUMMARY EVALUATIONS OF D13R4

D-E.2.1 Water Quality

For the first time, 253,000 acre feet/year of urban runoff was captured, treated, and sent into the natural system to augment flows to Everglades National Park and Biscayne Bay, raising the following questions:

- D13R4 assumes that the technology exists for treating urban stormwater for a whole suite of water quality parameters beyond nutrients.
- There may not be sufficient land available to adequately treat the volume of wet season runoff this scenario requires.
- Due to complex pollutant loads associated with urban runoff, future permitting of new discharges of treated urban runoff to Outstanding Florida Waters (ENP & Biscayne Bay) is expected to be difficult for the responsible regulatory agencies.
- The additional treatment and routing facilities add a new layer of complexity to the sequencing of the implementation plan
- Benefits of the new water will not be seen until all necessary water treatment components are up and running.

D-E.2.2 Total System

- Connectivity was similar to D13R except for an increase in extreme depth differences between WCA-2 and WCA-3.
- Sheetflow in WCA-2B showed an NSM-like pattern for the first time. Flows also improved across Tamiami Trail east of L-67 and the eastern part of Everglades National Park.
- Fragmentation was the same as D13R. No additional canals and levees were removed within the natural system.

D-E.2.3 Northern Estuaries

- Caloosahatchee: No change.
- St Lucie Estuary: One additional discharge event over the 31-year period of record.
- Lake Worth: Far fewer adverse discharges of fresh water.

D-E.2.4 Lake Okeechobee

- No change.

D-E.2.5 Lower East Coast

- Water supply performance is the same as D13R except there are two additional months in Broward County of low water conditions along the coast in the 31-year period of record.

D-E.2.6 Northern and Central Everglades

- Eastern and northeastern WCA-3A and WCA-2B are better, but still far from the NSM envelope. New problems arose in WCA-2A and WCA-3B. The modest benefits were seen in some of the more degraded areas but serious problems developed in more pristine parts of the system.

- Southern WCA-2A: Much worse than all plans and base conditions in extreme high water and extreme low water conditions. Increasing the flows through WCA-2A during the wet season only raised depths without helping increase hydroperiods into the dry season.

- WCA-2B: Extreme lows improved in the northern part, extreme highs increased slightly in some areas and there were substantial improvements in hydroperiod. Part of WCA-2B is approaching NSM-like conditions; the rest is still outside the NSM envelope.

- Eastern WCA-3A: General improvement in extreme high water conditions, particularly the area east of the Miami Canal. South of Alligator Alley, high water conditions are still poor. Extreme low water conditions did not change. The area is still outside the NSM envelope for both high and low water extremes.

- WCA-3B: High water conditions worsened. In the west, they are worse than the 1995 base, in the east they are worse than both bases. Both the frequency and depths of high events are far outside the NSM envelope for any NSM landscape. This problem must be resolved.

D-E.2.7 Pennsuco

- Both water levels and hydroperiods worsened relative to D13R. Water levels in the Pennsuco increased sufficiently higher to present a threat to tree islands.

D-E.2.8 Biscayne Bay

- An additional 77,000 acre feet/year of water was sent to Biscayne Bay, greatly improving conditions. Flows could be balanced better between parts of the bay but there is obviously the flexibility within the plan to do so.

- With some minor redirection of wet season flows between Central and South Biscayne Bay, D13R4 could meet targets in Central and South Biscayne Bay without reuse water from the proposed South Miami-Dade coastal reuse facility.

D-E.2.9 Model Lands

- D13R4 slightly increases water levels in coastal wetlands, particularly east of U.S. 1 during the dry season.

D-E.2.10 Big Cypress

- No change from D13R. Some water that used to flow west toward Roberts Lake Strand under NSM conditions still tends to move east as it did in D13R, apparently because of topography differences between NSM and SFWMM in the jetport vicinity. This is not good, but not a major problem.

D-E.2.11 Southern Everglades

- D13R4 delivered 271,000 acre feet/year of "new" water to Everglades National Park and performance measures closely approached targets for Shark River Slough and the Florida Bay coastal basins and exceeded targets in Rockland Marl Marsh. More detailed AET analyses of D13R4 for the southern Everglades will be available the week ending January 29, 1999.

- Endorsement of D13R4 by the AET regarding benefits to the southern Everglades should be strongly conditional on reversing potentially damaging effects to WCA-2A and WCA-3B and on providing adequate water quality treatment during detailed design and modeling.

D-E.2.12 Endangered Species

- Preliminary analysis shows no change to Cape Sable Seaside Sparrow, maybe a slight improvement for eastern populations.

- Improved conditions for wood storks, crocodiles, and manatees.

- ATLSS modeling results may show some snail kite concerns.

D-E.2.13 Uncertainties

- The NSM topography in NE Shark River Slough is assumed to be the same as current topography, although recent data collected by EPA scientists indicate that substantial soil subsidence has occurred since the 1940's. This discrepancy in the topographic model very likely affects the depth targets for NESS. If the NSM topography were altered to have comparable soil subsidence assumptions for WCA-3B north of Tamiami Trail and NESS south of Tamiami Trail, then target depths in NESS would probably be shallower, less water will be needed to meet those targets, and excess depths in WCA-3B would be reduced.

D-E.3 FULL AET REPORT ON D13R4

D-E.3.1 Water Quality

D-E.3.1.1 Introduction

The Water Quality Sub-team of the Restudy AET met by teleconference on Wednesday, January 27, 1999 to review Scenario D13R4 and to discuss comments and recommendations on the new scenario to the AET and the Restudy Team. The following persons participated in the teleconference: Eric Hughes and Dan Scheidt (USEPA); Bill Walker (consultant, DOI); Ken Tarboton, Tom Fontaine, Max Day, Jeff Needle, Siaka Kone, Zhenquan Chen, and Maxine Cheeseman (SFWMD); Betty Grizzle (USFWS); Nancy Gassman (Broward Co. DNRP); Mike Zimmerman and Sarah Bellmund (ENP); Herb Zebuth and Eric Bush (FDEP); and, Jim Riley (USACE).

Scenario D13R4 captures additional stormwater runoff in developed areas of Palm Beach and Broward County canals currently discharging to tide in Alternative D13R (the alternative plan selected by the Restudy Team), diverting it to the Water Conservation Areas. The purpose of the scenario was to increase overland flows into Everglades National Park and surface water flows discharged to Biscayne Bay. To accomplish this, C-51 Canal, C-15, C-16, Hillsboro Canal, C-13 Canal, C-14 Canal, and North New River basin runoff is routed (via pumps and other structural modifications) to storage components created by Alternative D13R and discharged to WCA-2A, Biscayne Bay, and Everglades National Park. A more detailed description of Scenario D13R4 is accessible via the Restudy web site, www.restudy.org.

D-E.3.1.2 Performance Based Comments

The effects of Scenario D13R4 on phosphorus loads and concentrations in the Everglades Protection Area can be modeled with SFWMD's Everglades Water Quality (phosphorus) Model (EWQM); however, the model had not yet been run for the scenario at the time of this writing. It should be noted that one of the Water Quality Team's previously agreed upon performance indicators for the EWQM was structural phosphorus loads discharged into the Everglades Protection Area. To meet the water quality requirements of the Everglades Forever Act, structural discharges to the Everglades Protection Area for Restudy alternatives/scenarios are assumed to be at the default phosphorus concentration criterion in the EFA (10 ppb). Using the structural phosphorus load performance indicator, and considering that Scenario D13R creates a new discharge into WCA-2A (173,000 acre feet/year, 31-year average), Scenario D13R4 would rank lower (not as preferred) from a water quality perspective in terms of relative performance in WCA 2A compared to Alternative D13R. It should be further noted that the EWQM cannot simulate potential water quality impacts in urban areas east of the WCAs.

The Everglades Landscape Model (ELM) would also be useful for modeling water quality and ecological responses in WCA-2A.

An initial evaluation of Scenario D13R4 was conducted using water budget data from the SFWMM. 31-year average flow volumes at selected structures for the 2050 Base, Alternative D13R, and Scenario D13R4 are compared below:

Table 2
31-year Average Flow Volumes at Selected Structures

Structure(s)	50B	D13R	D13R4
Site 1 Res to WCA 2A	0	0	173
S144-145-146s		158	501
S140A	175	460	468
NLB to B Bay (comb.)	0	88	138
NLB to ENP	0	0	88
CLB to B Bay (comb.)	0	0	71
CLB to ENP	0	95	80

Legend/Notes:
1) All flow volumes indicated are 31-year averages, in k ac. ft.
2) S144-145-146s are existing structures discharging from WCA-2A into WCA-2B
3) S140A discharges into NW WCA-3A; wq treatment via ECP/Non-ECP facilities
4) NLB = North Lake Belt Storage Area
5) B Bay = Biscayne Bay
6) CLB = Central Lake Belt Storage Area
7) ENP = Everglades National Park

Using water quality data from the SFWMD and Palm Beach and Broward County monitoring programs, mean phosphorus concentrations were determined by Dr. William Walker using an urban land use model for the basins contributing runoff captured in Scenario D13R4. Mean phosphorus concentrations are summarized below:

Table 3.
Mean phosphorus concentrations

C-51 Basin	122 ppb
C-15 Basin	366 ppb
C-16 Basin	214 ppb
Hills. Basin	154 ppb
C-14 Basin	123 ppb
C-13 Basin	138 ppb
C-12 Basin	199 ppb
NNR Basin	43 ppb

The C-51, C-15, C-16, and Hillsboro basins contribute runoff to be stored in the Palm Beach Agricultural Reserve and Site 1 water storage areas/STAs. The combined flow-weighted mean concentration of phosphorus was calculated to be 166 ppb.

The C-14, C-13, C-12, and North New River basins contribute runoff to be stored in the North and Central Lake Belt water storage areas/STAs. The combined flow-weighted mean phosphorus concentration was calculated to be 80 ppb.

STA sizes necessary to treat runoff to an interim target phosphorus concentration of 50 ppb were calculated for the Site 1/WCA-2A and Lake Belt discharges using the above combined flow-weighted mean phosphorus concentrations. Calculations were performed by Siaka Kone, SFWMD. Using the settling rate constant of 10.2 m/yr from the conceptual design for the Everglades Construction Project, the following STA sizes were calculated:

Table 4
Calculation of STA sizes

Site 1/Hillsboro STA	6,303 ac.
Lake Belt to ENP STA	1,238 ac.
Lake Belt to Biscayne Bay	1,083 ac

The sensitivity of STA size to enhanced STA performance (increased phosphorus settling rate constant) was also checked. Increasing the settling rate reduces the calculated area requirements for STAs.

Water quality data for contaminants other than phosphorus in Broward County surface waters (Hillsboro, C-14, C-13, C-11 basins) were also reviewed. Data summaries were provided by Dr. Nancy Gassman, Broward County DNRP. Mean dissolved oxygen levels were occasionally recorded below the State of Florida criterion (5.0 mg/l) and the Broward County criterion (4.0 mg/l). In addition to elevated concentrations of phosphorus, mean total nitrogen values occasionally exceeded the Broward County standard of 1.5 mg/l (there is no numeric criterion for total nitrogen in state water quality standards). Fecal coliform bacteria concentrations were also found to be occasionally elevated above the Florida and Broward County maximum concentration criterion (800-colonies/100 ml). Specific conductance at freshwater sites was also found to occasionally exceed the State of Florida Class III criterion (1275 u mhos/cm). Several trace metals have also been detected, including: arsenic, cadmium, chromium, copper, iron, lead, selenium, and zinc.

In sampling work conducted in 1997 and 1998, the following pesticides were also detected in Broward County surface waters: atrazine, diazanon, simazine, malathion, and ethion (BCDNRP 1999, draft).

D-E.3.1.3 Performance-Based Recommendations

None at this time; Scenario D13R4 was created to test the flexibility of the preferred alternative (Alternative D13R) to deliver increase flow volumes to Everglades National Park and Biscayne Bay. The Water Quality Subteam has identified a number of issues of concern (see Section IV below) which should be further addressed if the Restudy recommended plan was modified to perform as modeled in Scenario D13R4.

D-E.3.1.4 Water Quality Subteam Issues

1. Restudy components must meet state and tribal water quality standards, as appropriate. In particular, increased flows to the Everglades Protection Area must meet the yet-to-be-established Phase 2 numeric phosphorus criterion (default concentration = 10 ppb). The technology best suited to achieve the Phase 2 phosphorus criterion has not yet been determined. Calculations performed to evaluate Scenario D13R4 indicate that the proposed treatment area size for the Site 1 STA (2,160 ac.) is not sufficient to meet interim phosphorus treatment requirements (to achieve 50 ppb, 6,303 ac. is required) for discharges to WCA-2A, let alone Phase 2 treatment requirements.

2. In addition to phosphorus, several other pollutants have been identified in the urban runoff to be captured, stored, treated, and discharged to WCA-2A, ENP, and Biscayne Bay. In some of the developed basins/sub-basins to be backpumped, there is minimal potential to retrofit those areas with standard stormwater BMPs (e.g., detention/retention, vegetative filters, etc.). Reduction of pollutant loads via stormwater BMPs may be problematic.

3. The treatment efficacy of STAs for some of the constituents of urban runoff are unknown, and surface water quality criteria have not been developed for some of the pollutants identified. The long-term cumulative effects and ecological risk of discharging treating urban runoff containing small concentrations of pollutants to natural systems must be evaluated fully as part of future planning and design efforts associated with Scenario D13R4 and subsequent alternatives that may involve the use of urban stormwater runoff as a source of water to the natural system.

4. Diverting urban runoff for storage and backpumping to the Everglades or redirecting runoff for discharge to Biscayne Bay may have a deleterious effect on existing downstream water bodies in Palm Beach and Broward Counties by reducing dilution effects. According to FDEP's 1998 Section 303(d) list of water bodies not meeting water quality standards, there are several water bodies in Palm Beach and Broward Counties not supporting designated uses (Class III waters). Diversion of runoff, especially relatively clean runoff, may result in degradation of water quality in downstream areas. Furthermore, backpumping of the C-13 and C-14 Canals may degrade water quality in western portions of the canals by bringing in water of lower water quality from the east. It should also be noted that the Broward County data reviewed are from quarterly sampling activities; stormwater

runoff captured during and subsequent to storm events is likely to be of poorer quality containing first flush contaminants.

5. Scenario D13R4 creates a new point source discharge into the WCA-2A. This is not a desirable condition from a water quality perspective, as pollutants (and ecological responses) are concentrated within the zone of influence of the point source discharge. If pursued, a spreader swale or other mechanism should be designed to create overland flow conditions.

6. Scenario D13R4 increases the volume of water discharged to WCA-3A via the modified S140 pump station (Component RR4; see Table 1). Although it is understood that the upstream sources of the S-140 flows involve ECP/Non-ECP facilities, if subsequent planning and design work indicates that the proposed scenario creates performance deficiencies in those facilities, modifications of those treatment facilities would be necessary to accommodate increased flows while meeting water quality standards for discharges to the Everglades Protection Area.

7. The operations description for Scenario D13R4 indicates that urban runoff stored in the deep impoundment area at Site 1 will be injected via ASR facilities proposed for that component (Component M). Water quality data reviewed to date show multiple violations of surface water quality criteria, including the presence of pesticides. Underground injection control (UIC) regulations require that drinking water standards must be met prior to injection into underground sources of drinking water. Considering the unknown efficacy of conventional STAs to treat all contaminants that may be present in urban runoff to drinking water standards, regulatory approval of ASR as proposed would be difficult under current UIC regulations.

8. Everglades National Park and Biscayne Bay are Outstanding Florida Waters (OFWs) pursuant to Florida Administrative Code rule 62-302. OFWs are subject to an anti-degradation requirement based on conditions at the time of OFW designation. Discharges of treated urban runoff containing minute concentrations of pollutants may conflict with OFW discharge regulatory criteria.

9. The settlement agreement to the federal Everglades lawsuit sets phosphorus concentration limits for Everglades National Park at Shark River Slough and Taylor Slough/Coastal Basins and defines a compliance determination methodology. Operations as proposed for Scenario D13R4 may necessitate modifications to the compliance determination methodology.

10. Scenario D13R4 creates a 343.0 k ac. ft./yr. (31-year average; see Table 1 in Section II, above) flow volume increase through the S-144-145-146 structures complex, which discharge flows from WCA-2A to 2B. The long-term cumulative effects and ecological response of a flow increase of this magnitude must be evaluated fully as part of future planning and design efforts associated with Scenario D13R4. Also, it should be noted that the S-144-145-146 structures are

governed by the Non-ECP discharge structures requirements of the EFA; schedules and strategies developed under the EFA to assure that water quality standards in the EPA are met may have to be modified to account for increased flows in this location.

D-E.3.1.5 General Recommendations

1. If Scenario D13R4 or other alternatives that involve the use of urban stormwater runoff as a source of water for the natural system are to be pursued further, conceptual treatment area sizes should be increased to provide adequate treatment capacity per standard design practices. Additional contingencies (land area requirements, construction and operation costs) should be included in future planning and design actions to assure that EFA Phase 2 treatment requirements will be met for discharges to WCA-2A and Everglades National Park.

2. Alternative routing and treatment facilities to deliver increased overland flows to Everglades National Park and surface water flows to Biscayne Bay should be considered.

3. The Everglades Water Quality and Everglades Landscape Models should be run to compare water quality and ecological responses of Scenario D13R4 to Future Base and Alternative D13R simulated conditions (and other alternatives which involve the use of urban stormwater runoff as a source of water for the natural system) to Future Base and Alternative D13R simulated conditions. A subsequent evaluation should then be conducted by the Water Quality Team.

4. Local monitoring programs should be utilized to provide additional information for refining treatment technologies and the sizes of treatment areas necessary to reduce concentrations of pollutants in future detailed planning and design work.

5. Water and habitat quality impacts to natural areas east of the WCAs should also be investigated for those basins acting as sources of runoff.

D-E.3.2 Total System

D-E.3.2.1 Fragmentation Performance Measure

In D13R4, the number of miles of canals and levees stayed the same as in D13R. This performance measure is based on the artificial structures within the Everglades Protection Area, Rotenberger and Holey Land Wildlife Management Areas, Big Cypress National Preserve because these structures affect natural resources more so than those found within the urban or agricultural area. Any additional structures constructed as part of D13R4 would be located outside the natural system so they were not included in this measure.

Table 5
Miles of Canals and Levees Affecting Natural Areas

	1995 Base	2050 Base	D13R	D13R4	1995 Base – D13R4
Miles of Canals	330	311	184	184	-146
Miles of Levees	400	400	318	318	-82

D-E.3.2.2 Continuity Performance Measure

Hydropattern Comparison Across Barriers: The overall score for Alternative D13R for the differences in water levels across barriers or transects was 0.6 for all eight transects including Loxahatchee NWR (WCA-1) and the remaining barrier between WCA-2 and WCA-3. Alternative D13R4's score was also 0.6. The score remains relatively low because the system is not completely decompartmentalized.

Table 6
Continuity: Water level differences across barriers compared to NSM

	1995 Base	2050 Base	D13R	D13R4
LNWR/WCA2	0.0	0.0	0.0	0.0
WCA2-3	0.0	0.0	0.0	0.0
Miami Canal North	0.1	0.4	0.5	0.5
Miami Canal South	1.0	1.0	1.0	1.0
L-67	0.0	0.1	0.2	0.2
Tamiami Trail West	0.0	0.4	1.0	1.0
Tamiami Trail East	0.5	0.7	1.0	1.0
L-28	0.6	0.9	1.0	1.0
Average 3-9	0.4	0.6	0.8	0.8
Average 1-8	0.3	0.4	0.6	0.6

D-E.3.2.3 Sheetflow Performance Measure

Average annual overland flow volumes across a variety of transects showed both improvements and reductions in flow between D13R and D13R4 but the final overall score improved from 0.7 to 0.8, if L-67 was included; both scores were 0.9 if L-67 was excluded. Improvements were seen in dry season flows across T-8, the transect across eastern Alligator Alley, and both wet and dry season flows westward across T-21 Shark River Slough and T-18, eastern Tamiami Trail. Dry season flows were reduced across T-25 in the eastern Big Cypress and T-7 in Alligator Alley west. The biggest differences were seen across two transects not used in earlier analyses because no changes had been seen before. Flows across T-19, the north-south transect just west of L-31N and T-20, the L-67 extension, reversed direction to their normal westward flow and volumes increased greatly. Between D13R and D13R4, scores for T-19, west of L-31N improved from (dry season) 0.6 to 0.9 and (wet season) 0.5 to 1.0. T-20 (L-67 extension) scores rose from (dry season) 0.7 to 0.8 and (wet season) 0.7 to 0.9.

Table 7
Flow volumes across transects

	1995 Base	2050 Base	D13R	D13R4
Big Cypress Group	0.8	0.3	0.9	0.9
Central Everglades	0.8	0.3	0.8	0.8
Southern Everglades	0.8	0.3	0.9	1.0
Tamiami Trail Group	0.6	0.2	0.9	0.9
L-67	0.1	0.0	0.1	0.1
Score (avg. of all)	0.6	0.2	0.7	0.8
Score (w/o L-67)	0.6	0.3	0.9	0.9
East ENP (new)			0.6	0.9

D-E.3.3 Lake Okeechobee

D-E.3.3.1 1995 Base

Under the revised 1995 Base, hydrologic conditions are not optimal for the lake ecosystem, in terms of the frequency of extreme high and low lake stage events.

The lake experiences 3 events per decade (on average) in which stages fall below 11 ft, a low water depth at which nearly all of the littoral zone is dry and unsuitable as habitat for fish and other aquatic biota. This equates to a score of 0.4, reflecting poor conditions from the standpoint of protecting ecosystem health. Prolonged moderate low lake stages (<12 ft for > 1 year) occur at a frequency of 1 in 10 years, giving a score of 0.9, indicating good conditions for ecosystem health. Extreme high lake stages (>17 ft), which can cause wind and wave damage to near-shore plant communities and transport nutrients into the pristine littoral zone, occur at a frequency of 2 in 10 years, giving a score of 0.7, indicating moderate conditions. Prolonged moderate high lake stages (>15 ft for > 1 year), which harm the ecosystem through a variety of mechanisms (reduced light penetration, loss of benthic plants, increased circulation of nutrient rich water to near-littoral regions) occur at a frequency of 2 in 10 years. This gives a score of 0.7, again indicating moderate conditions. Spring (January – May) lake level recessions (from 15 to 12 ft), considered beneficial to various ecosystem components, occur only twice per decade (on average). This is considered to be too infrequent to support a healthy littoral zone. The performance measure receives a score of 0.

Overall, the 1995 base condition receives a score of 0.6, indicating conditions that are not suitable for long-term support of a healthy lake ecosystem.

D-E.3.3.2 2050 Base

Conditions worsen for Lake Okeechobee under the 2050 Base, in regard to an increased frequency of harmful low water events caused by greater regional demands on the lake. However, there are fewer harmful high water events under this base condition than under the 1995 Base.

The lake experiences 4 events per decade (on average) in which stages fall below 11 ft. This equates to a score of 0, reflecting a high likelihood of severe harm to the ecosystem and its values. Prolonged moderate low lake stages (<12 ft for > 1 year) occur at a 2 in 10 year frequency, giving a score of 0.7, reflecting moderate conditions. Extreme high lake stages (>17 ft) and prolonged moderate high lake stages (>15 ft for >1 year) occur at frequencies of 1 in 10 and 2 in 10 years, respectively, giving scores of 0.9 (good) and 0.7 (moderate). As in the 1995 base, spring lake level recessions occur only once every five years, and the associated performance measure receives a score of 0, reflecting harmful conditions for the littoral zone.

Overall, the 2050 base condition receives a score of 0.5, indicating conditions that are detrimental to the long-term health of the lake ecosystem.

D-E.3.3.3 Alternatives D13R, D13R2 and D13R4

The hydrologic conditions experienced by Lake Okeechobee are nearly identical (from the standpoint of ecological effects) for planning alternatives D13R, D13R2 and D13R4. All three represent substantial improvements in comparison with the 1995 and 2050 base conditions. Over 70% of the stage duration curve falls within the restoration goal of a 12 to 15 ft depth range under these alternative plans, as compared with only 50% under the 1995 Base and 45% under the 2050 Base.

Under alternatives D13R, D13R2 and D13R4, extreme low lake stage events (<11 ft) occur at a frequency of 1 in 10 years (on average), giving a score of 0.9 (good). Prolonged moderate low lake stages (<12 ft for >1 year) occur less often than 1 in 10 years, giving a score of 1.0 (excellent). Prolonged moderate high lake stages (>15 ft for >1 year) and extreme high lake stages (>17 ft) occur at frequencies of 1 in 10 years. This gives scores of 0.9 (good) for these performance measures. There are, on average, 3 spring recession events per decade under these alternatives, and this equates to a score of 0.

The overall score for alternatives D13R, D13R2 and D13R4 are 0.8, indicating moderate to good conditions.

D-E.3.3.4 Conclusions

The 2050 Base, with increased regional demands on the lake, and without features of the Restudy, has two effects on Lake Okeechobee: (1) it worsens conditions in regard to more frequent low stage events; and (2) it improves conditions in terms of fewer extreme high stage events. This does not represent a balanced improvement for the ecosystem, which is what the Restudy is striving to achieve.

Alternatives D13R, D13R2 and D13R4, which are nearly identical in performance, represent marked improvements in hydrologic conditions for the lake. Hydrologic conditions in the lake not only are improved over the 2050 Base, but also are improved relative to the 1995 Base; this means that alternatives D13R, D13R2 and D13R4 may be viewed as progress towards restoration.

At this point, it should be reiterated that the improved scores under the D13R alternatives are clearly a function of extensive use of ASR to move water out of and into the lake during periods of high and low lake stages, respectively.. If this technology proves to be infeasible, hydrologic benefits to the lake observed in the alternatives may be substantially reduced. A previous scenario involving removal of Lake Okeechobee ASR resulted in substantially inferior performance, both in terms of extreme high and low lake stage events.

Table 8
Scores for the priority
hydrologic performance measures
for Lake Okeechobee

Performance Measure	**1995 Base**		**2050 Base**		**Alt D13R**		**Alt D13R2**		**Alt D13R4**	
	#	score	#	score	#	score	#	score	#	score
<11 ft	3	0.4	4	0.0	1	0.9	1	0.9	1	0.9
<12 ft / >1 yr	1	0.9	2	0.7	0	1.0	0	1.0	0	1.0
>15 ft / >1 yr	2	0.7	1	0.9	1	0.9	1	0.9	1	0.9
>17 ft	2	0.7	2	0.7	1	0.9	1	0.9	1	0.9
Sp. Recession	2	0.0	2	0.0	3	0.0	3	0.0	3	0.0
Weighted CSI	0.6		0.5		0.8		0.8		0.8	

values indicate the number of events per decade (average for 30-yr period of record); scores are calculated as described in the document entitled "Priority Hydrologic Performance Measures for Lake Okeechobee," and the weighted CSI value is calculated using the Lake Okeechobee ROGEM equation.

D-E.3.4 Lake Okeechobee Service Area

This section presents the Lake Okeechobee Service Area (LOSA) sub-team evaluation and scoring results for Restudy Alternative D13R4.

First, results of earlier evaluations are summarized to set a context for the evaluation of D13R4. The LOSA sub-team in its previous reports indicated that Alternatives A, C and D come close to meeting the water supply level of service goal and are judged to have good performance, with Alternative D being clearly the best performer. When the LOSA sub-team evaluated Alternative D13R, it found that the modifications to Alternative D13 that resulted in Alternative D13R had no significant effect on the good performance of Alternative D with respect to Lake Okeechobee Service Area water supply.

The principal goal utilized by the LOSA sub-team was that the alternatives should be able to meet all demands in a 1 in 10-year drought. It was also agreed that the best available indicator that this was being done would be if the number of years with water shortage restrictions were not more than 3 in the simulation period. In developing the count of years with water restrictions, certain events with very minor restrictions were not counted. None of the alternatives reach this goal (3 or less events) but with 5 events Alternatives D, D13R and D13R4 all come close.

The strong performance of Alternatives A, C and D is further evidenced when the duration (total months of supply side management with restrictions greater than 18,000 acre feet/year) of the water restriction periods is considered. For Alternative D, LOSA is under restrictions only 9 months in the simulation period, while for Alternatives D13R and D13R4 there are only 8 months of restrictions.

The same scoring analysis, which was completed for earlier alternatives, was also completed for Alternative D13R4. The reader is referred to the previous evaluations for explanations of the rationale and procedure for the scoring analysis. The scoring results for Alternatives D, D13R and D13R4 are provided in Table 9 below. Attachments A and B detail the calculations presented in Table 9. The data in the table indicate that all three alternatives score essentially the same. Alternatives D13R and D13R4 show a slightly better score because they each have one less month of water shortage than does Alternative D.

Table 9
LOSA Water Supply Scoring Results for Alternatives D, D13R and D13R4

Alternative	Frequency Score	Duration/ Severity Score	Combined Score
Alternative D	0.926	0.853	0.890
Alternative D13R	0.926	0.862	0.894
Alternative D13R4	0.926	0.862	0.894

D-E.3.4.1 Attachment A

Calculation of Frequency Scores

Alternative	Number of Water Years with Restrictions	Frequency Score = (30 – Years with Restrictions)/27
Alternative D	5	0.926
Alternative D13R	5	0.926
Alternative D13R4	5	0.926

D-E.3.4.2 Attachment B

Calculation of Duration/Severity Scores

Note that the scaled duration/severity score is calculated using the following formula:

Scaled duration/severity score = 1 – (Combined Duration Severity Score for the Alternative÷Combined Duration Severity Score for the Worst Alternative)= 1 – (Combined Duration Severity Score for the Alternative÷109).

Alternative D

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1981	168,350	4	4	8
1982	95,040	2	3	5
1990	39,820	1	2	3
Total Combined Duration/Severity Score				16
Scaled Duration/Severity Score				.853

Alternative D13R

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1981	167,720	4	4	8
1982	95,140	2	3	5
1990	39,680	1	1	2
Total Combined Duration/Severity Score				15
Scaled Duration/Severity Score				.862

Alternative D13R4

Water Years With SSM Cutbacks	Highest Monthly Cutback	Severity Score	Duration Score	Combined Duration/ Severity Score = Severity Score + Duration Score
1981	166,570	4	4	8
1982	98,050	2	3	5
1990	36,350	1	1	2
Total Combined Duration/Severity Score				15
Scaled Duration/Severity Score				.862

D-E.3.5 Caloosahatchee Estuary

Performance Measure: The number of times salinity envelope criteria were not met for the Caloosahatchee Estuary.
Goal: A base flow of 300 cfs is needed to maintain appropriate salinities.
Performance: The number of minimum flow violations is well below the target value and the same as D13R.

Performance Measure: The number of times high discharge criteria (mean monthly flow > 2,800 and 4,500 cfs) were exceeded for the Caloosahatchee Estuary.
Performance: The number of high flow violations is well below the target value and the same as D13R.

Performance Measure: Regulatory releases from Lake Okeechobee.
Goal: None are desired.
Note: D13R4 had one regulatory release.

D-E.3.5.1 Recommendations

Overall, D13R4 is the same as D13R in the Caloosahatchee basin.

D-E.3.6 St. Lucie Estuary

Performance Measure: Number of times salinity envelope criteria were not met for the St. Lucie Estuary.
Goal: A base flow of 350 cfs is needed to maintain appropriate salinities.
Performance: D13R4 is the same as D13R and the base flow target has been met.

Performance Measure: Number of times high discharge criteria (mean monthly flow > 1,600 & 2,500 cfs) were exceeded for the St. Lucie Estuary.
Goal: No regulatory releases, and reduction in high discharges for > 14 days.

D13R4 is the same as D13R, except that D13R4 has one more >1600 cfs violation. In both D13R and D13R4, the targets are almost met for that estuary (See the St. Lucie issue paper for the AET).

D-E.3.6.1 Recommendations

Detailed planning in the Indian River Lagoon Feasibility Study should be able to help make any additional improvements.

D-E.3.7 Lake Worth Lagoon

Performance Measure: Wet/Dry Season Average Flows Discharged to Lake Worth through S-40, S-41 & S-155 for the 31-year simulation.
Goal: To meet target flows to the Lake Worth Lagoon (0 - 500 cfs).

Performance: D13R4 is greatly improved over D13R and is the best plan so far. Much of the flow to the Lake Worth Lagoon was captured and sent south. The number of times the flow is >500 cfs decreased from 96 to 22 events in D13R4.

D-E.3.8 Northern and Central Everglades

D-E.3.8.1 Loxahatchee NWR (Indicator Regions 26 and 27)

Average annual hydroperiods in both indicator regions 26 and 27 are within 1% of target values defined by the 1995 Base and closely match Alternative D13R results. Compared to Alternative D13R, the mean inundation duration in Alternative D13R4 decreases slightly in north LNWR according to the performance of Indicator Region 27 (96 weeks in Alternative D13R compared to 85 weeks in Alternative D13R4) but the number of events increases (16 events in D13R, 18 events in D13R4). Inundation duration and number of events in indicator region 26 (south LNWR) exactly match Alternative D13R results.

Average annual duration of extreme low water events remains at 0% for both indicator regions meeting 1995 Base target values.

Extreme high water performance in Alternative D13R4 closely matches Alternative D13R. As stated in previous alternative evaluation summaries for this region, there remains uncertainty about the effect of high water on tree islands in southern LNWR. However, alternative D13R4 conforms overall to current hydrologic management objectives for the refuge.

D-E.3.8.2 Holey Land and Rotenberger WMAs

This region performs identically to Alternative D13R.

D-E.3.8.3 WCA-2A

Southern WCA-2A developed a problem with extreme high water under the D13R4 scenario. In Indicator Region 24 there are 52 weeks of depths greater than

2.5 ft over the 31 year period of record, compared with 18 weeks under D13R, 9 under the 2050 Base, 3 under the 1995 Base, and zero under NSM.

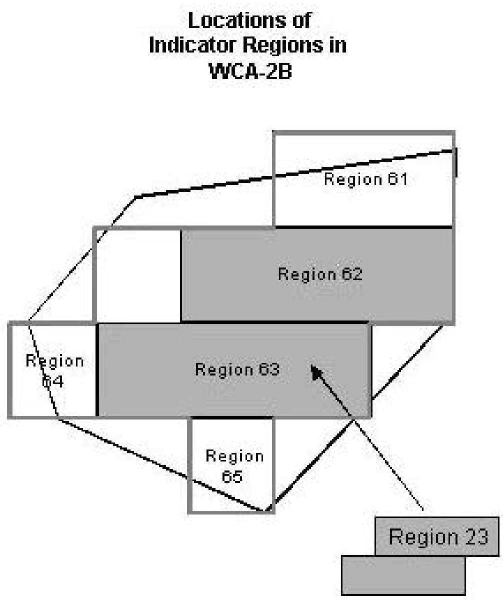
Southern WCA-2A had an excess of dry-downs to more than 1.0 ft below ground in D13R (12 events occupying 5% of time). It was hoped that discharges into WCA-2A from the Site 1 facility would alleviate this problem in D13R4. Unfortunately, flows from Site 1 are largely during the wet season and lead to increased high water, without alleviating the low water problem.

D-E.3.8.4 WCA-2B

The frequencies of extreme high and low water in Indicator Region 23 are very similar in D13R4 and D13R. However, when Indicator Region 23 is split into two separate indicator regions, improvements are seen by way of a lower frequency of extreme low water in the northern portions of the WCA. "New" Indicator Region 62 (Fig 1), which consists of the northern three cells of Indicator Region 23, shows a reduction in the frequency of depths more than 1.0 ft below ground, from 13% in D13R to 9% of time in D13R4. Although there is a slight increase in the frequency of extreme high water compared to D13 (5% vs. 3%), this is accompanied by a substantial improvement in hydroperiod, from 59% in D13R to 79% in D13R4. Overall, Indicator Region 62 has reduced low water compared to the 1995 Base and reduced high water compared to the 2050 Base. This area may be approaching conditions that are "NSM-like" for a sawgrass plains type of landscape, but the frequency of extreme low water is still of concern.

"New" Indicator Region 63, which occupies the southern and less-elevated part of Indicator Region 23 (Fig 1), exhibits a lower frequency of depths greater than 2.5 ft compared to D13R (27% vs. 33% of time). Both D13R and D13R4 are substantial improvements over the 1995 and 2050 Bases for extreme high water but they remain outside the range of NSM values for high water frequencies in the remnant peat landscape.

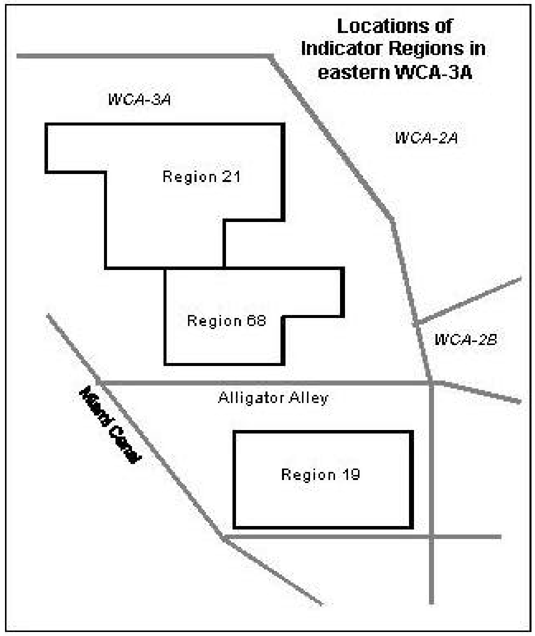
Figure 1



D-E.3.8.5 Eastern and Northeastern WCA-3A

The overall frequency of extreme high water in eastern and northeastern WCA-3A is reduced relative to D13R. In NE WCA-3A (Indicator Region 21), extreme high water is one-third as frequent in D13R4 as in D13R (2 vs. 6 events, occupying 1% rather than 3% of time); D13R4 is about the same as the 1995 and 2050 Bases (marginally better), whereas D13R had more frequent extreme high water than either Base. In Eastern WCA-3A (Indicator Region19), the frequency of depths greater than 2.5 ft is reduced from 19% of time in D13R to 15% of time in D13R4; both models had less extreme high water than the 1995 Base but more than the 2050 Base. In between these two indicator regions, in "new" Indicator Region 68 (Fig 2), trends are similar to those seen in Indicator Region19 although there is a much lower absolute frequency of extreme high water. When compared with NSM, Indicator Region 21 is similar to target values, but Indicator Regions 19 and 68 are not.

Figure 2



Extreme low water in northeastern WCA-3A (Indicator Region 21) is not improved in D13R4 compared to D13R, but is still slightly worse than the 2050 Base conditions.

Overall, performance is improved within WCA-3A east of the Miami Canal, but the area south of Alligator Alley still remains far from NSM target values for extreme high water.

D-E.3.8.6 WCA-3B

The frequency of extreme high water in WCA-3B increased in D13R4 compared to D13R, for all four indicator regions evaluated. Indicator Region 15 in western WCA-3B increased from five high water events under D13R (3% of time) to 10 high water events under D13R4 (5% of time); this is more extreme than the 1995 Base (1% high water) and similar to the 2050 Base (5% high water). Indicator Region 16 in eastern WCA-3B has an increase from 13 high water events in D13R (5% of time) to 19 high water events in D13R4 (11% of time). This is more extreme than either the 1995 or 2050 bases (3% and 8% high water, respectively). It is also a high frequency of extreme depths than that seen under NSM for any indicator regions within the remnant peat landscape. Two “new” indicator regions that were delineated in northern WCA-3B (Indicator Regions 22 and 27) also show increases in the frequency of extreme high water in D13R4 compared with D13R.

D-E.3.8.7 Pennsuco Wetlands

Both water levels and hydroperiods worsened relative to D13R. D13R4 resulted in a substantial increase in the number of high water events over those reported for both bases and D13R. In addition, the average duration of flooding in Pennsuco North has more than doubled relative to NSM projections and is more than 4 times longer than either base condition. Water levels in the Pennsuco increased relative to D13R and were sufficiently higher in D13R4 to present a threat to tree island resources in the basin.

*Pennsuco North Stage Duration Curve: The D13R4 curve is higher than the 1995 and 2050 Bases and higher than D13R. The D13R4 curve shows slightly higher water levels than D13R during most of the period of record, but water levels are reduced relative to D13R2. The high water level exceedance count shows a strong increase in the number of weeks where the high water target is exceeded for D13R2 (147 weeks) and D13R4 (196 weeks) relative to D13R (23 weeks). The stage hydrographs show that several of these high water events are of sufficient duration to cause possible flooding impacts to existing tree islands. Inundation pattern shows that there would be no drydown for most years in this basin if D13R4 were implemented as described. D13R hydroperiod and hydropattern would be preferred for this region.

*Pennsuco South Stage Duration Curve: Same comments as Pennsuco North, but the number of weeks that the high water target is exceeded is 118 weeks for D13R2, 161 weeks for D13R4, and 18 weeks for D13R.

D-E.3.8.8 Overall Northern and Central Everglades

There is some improvement in two areas – eastern/northeastern WCA-3A and WCA-2B – that were deficient under D13R; however, these areas still deviate from target conditions. Other areas, notably southern WCA-2A and WCA-3B, deviate further from targets than under D13R. Overall, substantial regions of the WCA system fall outside the range of performance seen in NSM for indicator regions in the peat landscape. D13R4 performance in southern and south central WCA-3A was relatively similar to D13R.

D-E.3.9 Southern Everglades

Alternative D13R provides substantial improvement toward the attainment of restoration targets for the southern Everglades in comparison to base conditions and Alternative D. However, questions remain about D13R regarding its adequacy in achieving restoration in three areas of the southern Everglades. Those areas are annual flow volumes down Shark River Slough, related salinity regimes in the coastal basins of Florida Bay, and duration of uninterrupted flooding in the rockland marl marsh. The additional hydrologic modeling that led to D13R4 determines how much performance in the three areas can be improved by capturing runoff that is presently lost to tide along the lower east coast. The modeling exercise captures runoff that does not appear necessary to prevent saltwater intrusion or to sustain the water demands of the lower east coast service areas. It routes that water either through the water conservation areas or through the eastern flow corridor for delivery either to northeast Shark River Slough or to Biscayne Bay.

Two major concerns that surface during the D13R4 modeling exercise are water quality and water conservation area hydrologic parameters. For the first time in alternative plan analyses for the Restudy, urban runoff water is delivered to the natural system. While provisions are made in the modeling to treat the questionable water quality of that urban runoff, uncertainty is acknowledged regarding both the adequacy of that treatment and the level of treatment that will be necessary before the delivery of such water to the natural system. The other concern is that efforts to correct the problems in the southern Everglades exacerbate ecologically damaging high water conditions in portions of the water conservation areas. Both of these problems must be addressed in detailed design before the features modeled in D13R4 can be implemented.

The following analysis focuses on the benefits of D13R4 regarding the three problem areas in the southern Everglades. The many other performance measures that have been analyzed in previous model runs are more cursorily examined to insure that D13R4 has not decreased performance in those areas.

D-E.3.9.1 Shark River Slough

D13R4 provides a mean annual flow volume of 1,258 acre feet down mid Shark River Slough, which represents a 166,000 acre foot annual average increase compared to D13R. The performance of D13R4 translates to 81% achievement of the NSN45F target of 1,561,100-acre feet/year, compared to 70% under D13R, 52% under 2050BSR, and 44% under 1995BSR.

The increased flow volume down Shark River Slough has no net effect on the number of dry events during the period of record in the slough indicator regions, compared to D13R, because most of the increased flow volume occurs during the wet season. Likewise, there is only slight improvement in the seasonal distribution of flows in an increase from 92% concordance with NSM45F in D13R to 94% in D13R4. Mean depth during periods of flooding shows a modest increase from a 77% match in D13R to an 83% match in D13R4.

D-E.3.9.2 Florida Bay Coastal Basins

The gains in Shark River Slough flow volume and water depth are reflected in water stages at the P-33 gage in the central slough. The stage at P-33 is correlated to salinity in the coastal basins of Florida Bay, in that P33 stage is indicative of freshwater heads throughout much of Everglades National Park that drive flow to the coastal basins. Stages equaling or exceeding 6.3 feet msl at P-33 indicate the avoidance of undesirable high-salinity events in the coastal basins. Stages of 6.3+ increase in frequency from 220 months in D13R to 235 months in D13R4 during the 31-year period of record. This represents a 91% achievement of the NSM45F target of 258 months, compared to 85% in D13R, 69% in 50BSR, and 48% in 95BSR. Stages equaling or exceeding 7.3 feet msl, indicate the attainment of desirable low-salinity events in the coastal basins. Stages of 7.3+ increase in frequency from 16 months in D13R to 23 months in D13R4 during the 31-year period of record. This represents a 77% achievement of the NSM45F target of 30 months compared to 53% in D13R, 7% in 2050BSR, and 23% in 1995BSR.

D-E.3.9.3 Rockland Marl Marsh

The gains in Shark River Slough flow volume also extend to the higher-elevation wetlands of the Rockland Marl Marsh to the east of the slough. The mean duration of uninterrupted flooding in the Rockland Marl Marsh increases from 30 weeks in D13R to 37 weeks in D13R4. The performance of D13R4 represents an84% achievement of the 44-week NSM45F target, compared to 68% in D13R, 52% in 2050BSR, and 27% in 1995BSR. Accompanying the increase in mean duration of flooding is a decrease in the mean duration of dry events from 21 weeks in D13R to 18 weeks in D13R4.

D-E.3.9.4 Conclusions for Southern Everglades

The hydrologic benefits to the southern Everglades of Alternative D13R can be increased if the features of model run D13R4 can be incorporated during the detailed modeling and design phases of the Restudy. Performance increased to greater than 80% of the NSM45F target in each of the three problem areas that were identified for the southern Everglades – Shark River Slough flow volume, Florida Bay coastal basin salinity regime, and Rockland Marl Marsh duration of uninterrupted flooding. The endorsement of the benefits of D13R4 in the southern Everglades is strongly conditional on addressing the water quality concerns and correcting the high-water conditions in the Water Conservation Areas during detailed modeling and design.

D-E.3.10 Lower East Coast Service Area

The Lower East Coast Service Area (LECSA) is divided into four service areas: North Palm Beach, and Service Areas 1, 2, and 3. The North Palm Beach Service Area extends from northern to central Palm Beach County, encompassing approximately one-third of the county and includes one primary canal, the C-17. Service Area 1 covers the remainder of Palm Beach County and a small portion of Broward County to just below the Hillsboro Canal. There are four primary canals that traverse the service area: C-51, C-16, C-12, and the Hillsboro Canal. Service Area 2 includes most of Broward County and a portion of Miami-Dade County. It extends south from the Hillsboro Basin to just south of the C-9, which lies in

Miami-Dade County. Four primary coastal canals extend through Service Area 2: C-14, C-13, North New River, and C-9. Service Area 3 includes the remainder of Miami-Dade County from the C-9 Basin south to near the tip of the peninsula. There are three primary coastal canals in Service Area 3: C-4, C-6 and C-2. Although the county boundaries extend west to the center of the state, the service areas only include those portions of the counties east of the protective levees.

D-E.3.10.1 Background: Water Supply

The performance measures used for the Lower East Coast to evaluate Restudy alternatives for water supply relate to the frequency and duration of water supply cutback events and the ability to maintain primary coastal canals. Water supply cutbacks are mandatory reductions imposed by the District on the LECSA utilities and general population to conserve existing water supplies when a shortage is imminent. Water supply cutback events usually occur during the dry season, when replenishment of stored water is limited.

During the dry season structural releases are periodically made from the Water Conservation Areas (WCAs) and Lake Okeechobee to maintain ground water levels and to minimize the possibility of saltwater intrusion along the coast. The Lower East Coast uses this water from the regional system to recharge secondary canal networks, wellfields and other recharge areas, and lakes. These ancillary systems are maintained by the local utilities to continue meeting public water supply demands. During the wet season and under normal conditions, rainfall and seepage account for the vast majority of recharge to the LECSA surface and ground water system that supplies this area.

During extended dry periods, Lake Okeechobee and the WCAs are important sources of surface water supply for large regions of South Florida. WCAs 1, 2A and 3A are the primary sources of supplemental surface water supply for the Lower East Coast Service Areas 1, 2, and 3, respectively. When water stored in the WCAs and Lake Okeechobee is scarce, for instance during a drought, the urban water supply demands are restricted (cut back) in order to conserve the remaining supplies in the regional system. Although the service areas are able to continue to meet some demands through local sources, all service areas are dependent on the WCAs and Lake Okeechobee to supplement surface water supply and support urban public water supply demands. This is true for all of the service areas except Northern Palm Beach Service Area, which relies on local supplies.

The availability of recharge water to the LECSA via surface or ground water through either seepage or structural flows from the regional system can be evaluated based on the surface water storage in Lake Okeechobee. The storage volume within the lake gives a more quantitative indicator that a water shortage condition may be approaching. The water supply cutbacks in the LECSA are based partly on the available surface water storage in Lake Okeechobee. However, the primary triggering mechanism for implementing the LECSA cutbacks is related to ground water levels within the LECSA.

Low ground water levels near the coast increase the vulnerability of the Biscayne aquifer to saltwater intrusion. Continuing to meet urban water demands may exacerbate ground water levels and therefore cutbacks are necessary when there is a threat to the resource. Low storage levels in the Lake Okeechobee at the beginning of the dry season are indicative of a prolonged storage problem that dictates when the cutbacks can be removed while low ground water levels indicate immediate problems within the LECSA. Either of these triggers, Lake Okeechobee or local ground water levels, can initiate a water supply cutback and are reflected in the ability to meet the 1-in-10 level of service water supply goal. Although regional water supplies or local ground water levels may rebound during the dry season, cutbacks are continued through the end of the dry season, May, to ensure protection of the Biscayne aquifer.

The availability of water from the regional system to recharge the LECSA via structural discharges can be evaluated based on the ability to maintain the primary coastal canals above their saltwater intrusion criteria. This third performance measure, maintaining the surface water levels and continuing their recharge functions, is critical to protecting the Biscayne aquifer from saltwater intrusion. However, it should be noted that saltwater intrusion could still occur even if the primary canals are maintained. Some areas along the salt front cannot be adequately recharged from the regional system to offset local demands on ground and surface waters or to abate saltwater intrusion. Local conditions and demands can contribute to the movement of the salt front as well by lowering ground water levels.

The primary coastal canal performance measure is indicative of the ability to meet the proposed criteria for minimum flows and levels for the Biscayne aquifer. Chapter 373, F.S. directs all of the water management districts to establish minimum flows and levels for surface waters and aquifers within their jurisdiction. The District will be proceeding with rule development for the minimum level criteria for the Biscayne aquifer in the near future. The minimum level criteria for the Biscayne aquifer was utilized in the SFWMM model to reflect future demands from the regional system.

The performance measures described herein rely upon a linear relationship between performance and the scores developed for comparative purposes. Only the 1-in-10 level of service performance measure was normalized. No weighting was applied to the performance measures since all were considered equally important to continue the functions of the Biscayne aquifer and other resources in the Lower East Coast.

D-E.3.10.2 Performance Measures and Indicators

Two performance measures and one performance indicator are analyzed for each service area. In Service Area 3, an additional performance indicator, Ability to maintain South Miami-Dade Canals, was analyzed. These performance measures were selected due to their ability to measure how the alternative performs in protecting the Biscayne aquifer and providing recharge to the aquifer for public water supply. These measures are indicative of how well the conceptual designs may perform together on a regional scale. Additional feasibility studies and detailed designs will need to be pursued prior to implementation of any of the components included in the Comprehensive Plan.

1) Ability to meet the 1-in-10 water supply planning goal: The frequency of water supply cutbacks is indicative of the reliability of regional and local water supplies through various weather and resource conditions. Water supplies in Lake Okeechobee supplement deliveries to the LECSA to maintain ground water levels to prevent saltwater intrusion near the coast. Public water supplies are reduced or cutback at the well field in response to low surface water levels in Lake Okeechobee or ground water levels near the coast. The planning goal is to find a balance between ability of the regional system to supplement recharge of the aquifer and meet the public water supply planning goal of a 1-in-10 year level of service in the lower east coast of Florida. The planning goal is in terms of the frequency of cutback events and is defined as no more than three cutback events, no more than seven months in duration over the period of record. A cutback event can begin in the fall and continue through the spring, therefore the maximum number of cutback events in the period of record is thirty. The score represents the number of cutback events during the period of record minus the three allowed events compared to the maximum number of years the 1-in-10 year level of service planning goal can be met. Alternatives that equaled or exceeded the goal, i.e. had three or less cutback events, scored 100% (no extra credit was given for exceeding the planning goal).

Score =[1 · ((# of cutback events · 3 years)/27 years)]100 = % of years goal met

2) Percentage of months not in a water supply cutback: The duration of water supply cutbacks is another characteristic of a drought event and is used as an indicator of the reliability of water supplies. The number of months of water supply cutbacks incurred in a service area capture the lengths of time urban demands are not met. The increased or decreased length of the cutback events is captured by counting the total number of months when the service area is in a water supply cutback, regardless of the severity of the cutback, as a percentage of the total number of months in the period of record. This percentage of time would be subtracted from one to reflect the improvement, increasing amount of time not in a water supply cutback, attributable to the alternative.

Score =[1 · ((# of months service area in cutback)/372 months)]100 = % of time in a cutback

3) Ability to maintain saltwater intrusion criteria: Maintaining the primary coastal canals above the saltwater intrusion criteria is critical to protecting the Biscayne aquifer from saltwater intrusion and is part of the proposed criteria for minimum flows and levels. Each Service Area includes several primary coastal canals that have saltwater intrusion criteria developed for them. In the SFWMM, the stage of the coastal canal is compared to the criteria on a daily basis. If the canal is unable to be maintained for a week, the event is counted towards the time the saltwater intrusion criteria was not met. All canals were weighted equally except in Service Area 3, where the C-6 and C-2 were weighted more than the C-4 due to their ability to provide wellfield recharge. The performance measure is reported as the percentage of time the canal stage is below the saltwater intrusion criterion, which is subtracted from one to report the percentage of time the canal is above the saltwater intrusion criterion.

Score = [1- % of time not able to maintain canals]100 = % of time able to maintain canals

4) Maintaining water levels in south Miami-Dade canals: At this time, saltwater intrusion criteria do not exist for the major canals in southern Miami-Dade County. However, it is important to evaluate water levels in these canals because encroachment of the salt front into the Biscayne aquifer has occurred previously in this area. Plus, major public water supply wellfields are located in southern Miami-Dade County. This area was evaluated by using the stage duration curves for the following structures: C-100A @ S-123, C-1 @ S-21, C-102 @ S-21A, and C-103 @ S-20F. The stage duration curves were used to evaluate the alternatives in two ways: 1) the distance by which an alternative's water level fails to reach two feet NGVD at the 90th percentile of the stage duration curve; and 2) the percentile at which an alternative's stage duration curve meets the 50th percentile of the 1995 Base stage duration curve.

In the first scenario, two feet NGVD was used for comparison in keeping with the Ghyben-Herzberg relationship which estimates that one foot of fresh water head is required to protect 40 feet of aquifer. The aquifer along the coast in southern Miami-Dade is approximately 80 feet that would require two feet of fresh water head. The 90th percentile of the stage duration curve was used since that percentile reflects lower stages of the dry season when the risk of saltwater intrusion is increased. The score is calculated from the distance of the base conditions and alternatives to the two feet NGVD on the stage duration curve. Alternatives that equaled or exceeded the target scored 100% (no extra credit was given for exceeding the target).

Score = [(2 - Distance/2)] x 100 = % of meeting 2 foot target

The second scenario used the 50th percentile of the 1995 Base to evaluate performance since it represents approximately the midpoint between the wet and dry seasons and can be viewed as "average conditions" for the 1995 Base. The score reflects the percentile at which a base condition or alternative meets or exceeds the water level at the 50th percentile of the 1995 Base. Saltwater encroachment has occurred in the period of record and, therefore, exceeding the 50th percentile is considered an improvement but may not prevent further encroachment.

The base conditions and alternative scores were determined by averaging the scores for the two scenarios.

D-E.3.10.3 Flood Protection

Flood protection is one of the authorized purposes of the Restudy and will be evaluated and addressed during the detailed design phase of the study. Due to the grid size and type of model used during the Restudy alternative evaluation process, the performance measures available for the Lower East Coast Service Area are of limited value for direct evaluation of an alternative's affect upon flood protection. However, one performance indicator is applicable for the southern Miami-Dade County agricultural areas in Service Area 3, stage duration curves, and is used in this evaluation.

D-E.3.10.4 Urban Areas East of the Protective Levee in the Lower East Coast

Flood protection should be improved or at least not degraded by the selected plan. In many instances, the alternatives have reduced or eliminated adverse impacts to flood control associated with the components selected in the urban areas of the Lower East Coast. The alternatives provide additional water storage capacity through water preserve areas, reservoirs and aquifer storage and recovery, reducing the maximum stages in the canals during large rainfall events.

The risk of flooding may be decreased with the additional storage components; however, it is difficult to discern the improvements at this point in the alternative evaluation. The model used to evaluate the effects of the components on regional hydrology is not conducive for evaluating storm and flood events. The model uses a daily time step; storm and flood events occur within hours. One-performance indicator gauges the change in peak stages compared to the 1995 Base on a regional basis. The primary drawback of this performance indicator is that it does not distinguish between ground and surface water levels.

After the final plan is selected, this performance indicator will be used to identify areas of potential decreased flood protection coupled with site specific information regarding flood prone areas. Information regarding existing flood prone areas will be gathered from District and USACE staff familiar with the Lower East Coast supplemented with interviews with local government officials and other who have technical input. These areas will be mapped using the SFWMM grid cell boundaries and will be identified by the appropriate basin. These identified areas will undergo further evaluation in subsequent feasibility reports to determine what actions are necessary. In addition, portions of the study area outside of the boundaries of the SFWMM grid will need to be evaluated for flooding impacts through a separate process as well.

D-E.3.10.5 Agricultural Area along the L-31N

One performance measure graphic was developed for use in six cells in the western areas of southern Miami-Dade County (Lower East Coast Service Area 3) to compare the relative performances of the different alternatives. It is labeled "end of the month stage duration curve 1983-1993", and compares an 11-year target stage duration curve to the 31-year stage duration curves representing the performances of the bases and alternatives. The relative comparison of an 11-year curve to a 31-year curve appeared to be appropriate for use at the higher stages, but did not compare as well at the mid to lower stages.

D-E.3.10.6 Scoring Procedures

Because the comparisons between the curves are most appropriate at the higher stages, it was decided to use the point where the stage duration curves intersect with the "10 % time equaled or exceeded" line on the graphs. For each of the six indicator cells, the difference between where an alternative or base curve intersects the 10 % line and where the target curve intersects the 10 % line is measured (in tenths of a foot).

Only the increases in stages relative to the target are included in the matrix. The actual differences are shown in the first half of the matrix, and are used in the alternative scoring methodology described below. If an alternative performance falls below the target (performance is better than the target), a score of 0 is given. This is shown in the second half of the matrix. The values for all the cells are summed and normalized so the final scores range between 0 and 1.

A second scoring methodology that gives credit for flood protection above the target was used for comparison. In order to normalize the alternatives' scores, five (5) was added to each sum so the final numbers were all positive. The resulting values are shown as an "alternative score".

D-E.3.10.7 Interpretation of Results

Using the first scoring methodology, alternatives D13R and D13R4. performed equally. There is no measurable difference between the stage duration curves at the 10% line. The operational changes that were implemented in the C-111 basin in all alternatives are thought to be the reason for this result.

In looking at the second scoring methodology where credit is given for an increase in flood protection in some of the northern cells, alternatives D13R and D13R4 perform equally well. Since exceeding the target line is a "bonus" and it only occurred in some of the cells, it's not recommended to base selection of a preferred alternative on these results. They are presented only for informational purposes.

Alternative D13R4 performed equally to Alternative D13R. There were no changes in operations in this area, so the performance did not change.

Table 10

	R10 C25	R13 C25	R15 C26	R17 C27	R19 C27	R20 C27	
Difference in stage in tenths of a foot							**Totals**
95Base	1	1	2	-1	0	0	3
50Base	5	7	6	1	1	-2	18
Alt D13R	0	3	4	-3	-2	-3	-1
Alt D13R4	0	3	4	-3	-2	-3	-1
Increases in stage relative to the Target (tenths)							
95Base	1	1	2	0	0	0	4
50Base	5	7	6	1	1	0	20
Alt D13R	0	3	4	0	0	0	7
Alt D13R4	0	3	4	0	0	0	7
		SCORE			**Alternative Score**		
95Base		0.9				0.73	
50Base		0.3				0.23	
Alt D13R		0.8				0.87	
Alt D13R4		0.8				0.87	

D-E.3.10.8 Other Issues

Reductions in discharges to tidal waters proposed in D13R4: Reductions in discharges to tidal waters may cause both water quality and natural area impacts in response to the lowering of the flushing rates. With reduced fresh water discharges to tide, groundwater (typically low in dissolved oxygen) will contribute a larger portion of the base flow of these tidal bodies of water. Also, with reduced flushing rates the headwaters may be more inclined to be biologically conditioned with a potentially high incidence of undesirable algal blooms. Within Broward County the contrast between the tidal portion of the Middle River (C-13), which has good water quality, with the North Fork of New River (C-12), which has continuing unsolved water quality problems, may be a good example of the result of reduced fresh water flow. In addition, with a decrease in fresh water discharges the salinity regimes of the downstream tidal water will increase. Examples are the C-10 canal and Intracoastal Waterway between Port Everglades and Haulover Inlet. Both are prone to hypersaline conditions because of little or no fresh water discharges. Chloride levels as high as 22,000 mg/l have been recorded from dry season samples from the C-10 canal. Increased salinity regimes may have a profound change on the ecology of these waters and on the surrounding natural areas, such as cypress remnant stands on the New River, Cypress Creek and Middle River. In further evaluation of alternative D13R4, the operational schedule should consider minimizing these potential impacts.

Design of West Miami-Dade Reuse Facility in D13R4: The reconfiguration of discharge from the West Dade Reuse facility is of concern. Under D13R, discharge from the facility was proposed to either to the Bird Drive Recharge Area or the South Dade Conveyance System (SDCS). Pumping to the Bird Drive Recharge Area could provide an additional margin of water quality polishing prior to recharging the Biscayne aquifer and subsequently the West Wellfield (located just south of the Bird Drive Recharge Area) or to meeting demands elsewhere. Alternative D13R4 propose to move this water directly to the SDCS without temporary storage in a marsh system.

D-E.3.10.9 Interpretation of Scores for LECSAs

Summary: Based on the above interpretation of the performance measures, Alternatives D13R and D13R4 perform equally well and substantially improve water supplies compared to the 2050 Base for the Lower East Coast Service Area. The component changes between Alternative D13R and D13R4 do not negatively effect the LECSAs as modeled with the SFWMM. The one exception is a slight increase in water supply cutbacks in Service Area 2. The additional two months of cutbacks is not significant in itself, but do cause concern and warrants further investigation during the next phase of study.

North Palm Beach Service Area: The North Palm Beach Service Area scores very well, almost reaching the established goals in all alternatives. The scores for alternatives D13R and D13R4 reach 99%. The performance of the primary canals reaches their goals in all of the alternatives. The 1-in-10 level of service planning goal scores are met. The duration of cutbacks scores are very high as well and are just shy of reaching their goal. Compared to the 2050 Base, either of the proposed alternatives relying on alternative sources would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in the North Palm Beach Service Area.

Service Area 1: Service Area 1 performs very well almost reaching the established goals in alternatives D13R and D13R4. The Scores for Alternative D13R and D13R4 reach 99%. The performance of the primary canals reaches their goals in both of the alternatives despite keeping more water west of the control structures to meet other demands further south in the system. The 1-in-10 level of service planning goal scores very high in all alternatives, above 95%. The duration of cutbacks scores are very high as well and are just shy of reaching their goal. Compared to the 2050 Base, either of the proposed alternatives relying on alternative sources would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in Service Area 1.

Service Area 2: Service Area 2 performs well in alternatives D13R and D13R4. The average scores for these two alternatives are 93% for D13R4 and 96% for D13R. This compares very favorably to the 2050 Base, which scores only 54% for Service Area 2. The ability to maintain primary coastal canals performed well in both of the alternatives. It is just shy of reaching its goal despite keeping more water west of the control structures to meet other demands further south in the system. The 1-in-10 level of service planning goal score for all of the alternatives is significantly higher than the 2050 Base, which has cutbacks almost every year, scoring a dismal 4%. Although Alternative D13R4 scores slightly lower than D13R, the actual difference is two more months of cutbacks over the period of record in Alternative D13R4. This is reflected in the duration performance measure. The duration of cutbacks scores improve significantly when compared to the 2050 Base. Compared to the 2050 Base, either of the proposed alternatives would provide additional water supplies to meet projected water demands, reduce the frequency and duration of water supply cutbacks and help abate saltwater intrusion in Service Area 2.

Service Area 3: In Service Area 3, the overall performance improves in alternatives D13R and D13R4 compared to the 2050 Base. The score for these two alternatives is 92%. This compares favorably to the 2050 Base, which scores only 70% for Service Area 3. Both of the alternatives performed well in maintaining the primary coastal canals. The other canals in southern Miami-Dade County score well, but fail to perform well enough to reach their targets. Both of the alternatives' perform equally well to improve meeting the 1-in-10 level of service planning goal when compared to the 2050 Base. The duration of cutbacks scores very high for both alternatives, with Alternatives D13R and D13R4 performing equally well. Except for maintaining water levels in southern Miami-Dade canals, the performance of both of the alternatives as evaluated in the matrix exceeds the performance of the 2050 Base.

Table 11
Subregion: Lower East Service Area*

Performance Measure	1995 Base	2050 Base	Alt D13R	Alt D13R
Ability to Meet 1-10 water supply planning goal for NPB SA	70%	56%	100%	100%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in NPB SA	100%	100%	100%	100%
% of Months Not in Water Supply Cutbacks in NPB SA	87%	81%	96%	96%
North Palm Beach Service Area Average Score	86%	79%	99%	99%
Ability to Meet 1-10 water supply planning goal for SA 1	63%	40%	100%	100%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 1	100%	100%	100%	100%
% of Months Not in Water Supply Cutbacks in SA 1	87%	76%	96%	96%
Service Area 1 Average Score	83%	72%	99%	99%
Ability to Meet 1-10 water supply planning goal for SA 2	26%	4%	93%	85%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 2	94%	95%	100%	100%
% of Months Not in Water Supply Cutbacks in SA 2	75%	62%	95%	94%
Service Area 2 Average Score	65%	54%	96%	93%
Ability to Meet 1-10 water supply planning goal for SA 3	78%	56%	95%	95%
Ability to Maintain Primary Coastal Canals at or above Salt-water Intrusion Criteria in SA 3	77%	89%	100%	99%
Ability Maintain Water Levels in South Dade Canals**	58%	56%	77%	77%
% of Months Not in Water Supply Cutbacks in SA 3	89%	79%	95%	95%
Service Area 3 Average Score	76%	70%	92%	92%
Average Weighted Score	77%	69%	96%	96%

* Flood protection not evaluated in this matrix

D-E.3.11 Biscayne Bay

D-E.3.11.1 Biscayne Bay Flows

Flows to South and Central Biscayne Bay increased and exceeded targets, but dry season flows to Snake Creek were less than D13R and less than target, and dry season flows to the Miami River decreased relative to D13R.

****Snake Creek***: D13R4 flows are very slightly reduced relative to D13R in the wet season, but are reduced by 23% relative to D13R in the dry season. Flows under D13R4 exceed the target in the wet season but are only 22% of target for the dry season (28% of target for D13R).

North Bay: D13R4 flows are approximately equal to 2050 Base and D13R flows in both wet and dry seasons, and are slightly smaller than 1995 Base flows.

****Miami River***: D13R4 flows are 14% higher in the wet season but 1% lower in the dry season than D13R. Since no targets were specifically set for the Miami River, flow volumes to this region should be considered interim until such time as a thorough evaluation is conducted of hydrodynamic and water quality issues in this portion of Biscayne Bay.

Central Bay: D13R4 flows are higher than the target, D13R, 1995 Base and 2050 Base. Both wet season and dry season targets would be met without any input of South Miami Dade coastal reuse water.

South Bay: D13R4 flows are higher than the target, D13R, 1995 Base and 2050 Base. The dry season target would be met without any input of South Miami Dade coastal reuse water.

Card and Barnes Sounds and Manatee Bay: While no specific performance measures were prepared concerning flows to southernmost Biscayne Bay, this area is expected to be seriously deficient in freshwater inflow relative to needs, once current C111 plans are implemented, and the objective is to replace canal discharge with overland flow through adjacent coastal wetlands. Expected improvements in overland flow can be estimated based on water levels in the wetlands (i.e., the Model Lands). While D13R4 provides slightly higher water levels in the coastal wetlands, compared to D13R, this is not likely to be enough to overcome the serious deficiency in consistent freshwater flow to that part of the bay.

Target and Model-Estimated Mean Annual Surface Flows to Biscayne Bay (in thousands of acre feet/year) under the 1995 base condition and Alternatives D13R and D13R4 (values for Central Bay and South Bay are calculated without coastal reuse water inputs).

Table 12. Surface Water Flows to Biscayne Bay

	Wet season	Dry season

Region	Target	95Base	D13R	D13R4	Target	95Base	D13R	D13R4
Snake Creek	67	121	79	78	93	51	26	20
North Bay		99	97	97		41	38	37
Miami River		132	43	49		60	18	17
Central Bay	161	161	142	170	83	64	78	104
South Bay	158	158	136	149	68	52	56	69

D-E.3.11.2 Biscayne Bay Ground Water

North Biscayne Bay Ground Water 1 Stage Duration Curve: There is minimal difference between D13R4 and D13R.

North Biscayne Bay Ground Water 2 Stage Duration Curve: There is minimal difference between D13R4 and D13R.

Central Biscayne Bay Ground Water Stage Duration Curve: There is minimal difference between D13R4 and D13R.

South Biscayne Bay Ground Water Stage Duration Curve: There is minimal difference between D13R4 and D13R.

D-E.3.12 C-111/Model Lands Basin

Model Lands South (IR 5) Weekly Stage Duration Curve: D13R4 levels are approximately equal to D13R except at the driest 20% of the record, where D13R4 shows an improvement over D13R.

C-111 Perrine Marl Marsh (IR 4) Stage Duration Curve, Model Lands North Weekly (IR 6) Stage Duration Curve, North C-111 (IR 47) Stage Duration Curve: D13R4 water levels show a minor improvement over those in D13R.

Table 13
C-111/Model Lands Performance

Indicator Region Average Score	95Base	2050Base	D13R	D13R4
Indicator Region 4 (C-111 Perrine Marl Marsh)	0.640	0.555	0.795	0.827
Indicator Region 5 (Model Lands South)	0.448	0.484	0.864	0.877
Indicator Region 6 (Model Lands North)	0.534	0.546	0.636	0.642
Indicator Region 47 (North C-111)	0.564	0.653	0.800	0.826
Total Regional Average Score	0.547	0.559	0.774	0.793

D-E.3.13 Big Cypress

D-E.3.13.1 AREA/SUBREGION/INDICATOR REGIONS

Different portions of the Big Cypress subregion are used in the different matrix equations.

D-E.3.13.2 PERFORMANCE MEASURES

1. Mean NSM Hydroperiod Matches for North Big Cypress National Preserve for the 31 year simulation

2. Mean NSM Hydroperiod Matches for South Big Cypress National Preserve for the 31 year simulation

3. Normalized Weekly Stage Duration Curves for Indicator Regions 13, 31, 36-40, 45, and 42-43

4. Average Annual Overland Flows toward Gulf of Mexico from Big Cypress National Preserve for the 31 year simulation

5. Inundation Duration Summary for Indicator Regions: Average Flood Duration

D-E.3.13.3 Scoring Explanation

All of the scores are relative to NSM conditions in the Big Cypress.

A = percent of North Big Cypress National Preserve that matches NSM (PM #1). This provides a spatial measure of one of the more impacted portions of the Big Cypress that lies along its northern border. Impacts are due primarily to agricultural development and its associated canals upstream (north) of this area. In addition, there may be some model boundary problems in this area, possibly related to the fact that the area to the north is included in the Natural System Model, but not the South Florida Water Management Model.

B = percent of South Big Cypress National Preserve that matches NSM (PM #2). This provides a spatial measure of the relatively unimpacted portion of the Big Cypress. This area is dominated by rainfall inputs, and as a result, exhibits few effects of hydrologic alterations beyond its boundaries. Hydrologic effects of the Restudy alternatives occur primarily along the Big Cypress boundary with the Everglades.

C (for individual Indicator Regions) = 1 - {absolute number [(percent of time flooded for NSM) - (percent of time flooded for Base or Alternative)] /100} (PM #3). This provides a measure of deviation from NSM hydroperiod for an

Indicator Region. This deviation is almost always a reduction in hydroperiod. The selected Indicator Regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the Alternatives on the western portion of the Big Cypress. Initially all of the Indicator Regions were evaluated separately (Table 14).

Equations were developed to combine some Indicator Regions in a simple additive form because of different influences in different areas. Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

D_n(for individual Indicator Regions) = 1 – absolute number [(maximum deviation from NSM hydrograph) / (maximum range of NSM water level fluctuation)] (PM #3). This provides a measure how much water levels have been altered from NSM conditions as a function of the NSM range of fluctuation for an Indicator Region. A certain degree of deviation in an area with a large natural fluctuation would be less significant than in an area with a small natural fluctuation. Typically, the greatest deviation occurs when the water table is declining through the first foot or two below the ground surface, it is smallest at its lowest point on the hydrograph, and it is relatively small when the water table is above ground. The selected Indicator Regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the Alternatives on the western portion of the Big Cypress. Initially all of the Indicator Regions were evaluated separately (Table 14).

Equations were developed to combine some Indicator Regions in a simple additive form because of different influences in different areas (Table 14). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

G = 1 – absolute number [(deviation of average flood duration from NSM average flood duration) / (NSM average flood duration)] (PM #5). This provides a measure of deviation from NSM for average duration of individual flooding events for an Indicator Region. This deviation is usually a reduction in the duration of inundation. The selected Indicator Regions are all in the eastern portion of the Big Cypress near its border with the Everglades, since there is little effect of any of the Alternatives on the western portion of the Big Cypress. Initially all of the Indicator Regions were evaluated separately (Table 14).

Equations were developed to combine some Indicator Regions in a simple additive form because of different influences in different areas (Table 14). Indicator Regions 31, 36-40, and 45 were combined since they are all probably influenced by flows in the vicinity of South L-28 (South Big Cypress). Indicator Regions 42 and 43 were combined since they are both in the area affected by the L-28 Interceptor and the Western Feeder Canal (North Big Cypress). Indicator Region 13 was not combined with any other Indicator Regions (Southeast Big Cypress).

E_w = 1 – absolute number [(deviation of wet season flows from NSM flows) / (NSM wet season flows)] (PM #4)

E_d = 1 – absolute number [(deviation of dry season flows from NSM flows) / (NSM dry season flows)] (PM #4)

Total flows during the wet and dry season provide another way of expressing hydrologic conditions and how they change in response to proposed Alternatives in particular portions of the Big Cypress. The flow cross-sections evaluated included the Eastern Big Cypress and Lostman's. Initially the flow cross-sections were evaluated separately by wet and dry season (Table 14).

I have developed simple additive equations for each flow cross-section to combine the wet and dry season information (Table 14).

D-E.3.13.4 Summary Equations

I subsequently developed summary equations for major geographic regions of the Big Cypress that were distinct in terms of their response to the various Restudy alternatives (Table 14). These major areas were: North Big Cypress, which was only affected by Alternatives C and D where the L-28 Interceptor canal and levee system were modified; South Big Cypress, which was affected primarily by alterations to the south end of the L-28 canal and levee and in the adjacent Water Conservation Area 3A; and Southeast Big Cypress, which being on the border between the Everglades and southeast portion of the Big Cypress Swamp, is affected by the numerous alterations to the Everglades.

For each of these geographic areas, a simple additive equation was developed to combine variables C_n, D_n and G_n for the same Indicator Region(s) to summarize information on deviations in hydroperiod, water depth, and average flood event duration in these areas. In North Big Cypress, I included variable A in this simple additive equation. In South Big Cypress, I included variable B and variable E for flows across the Eastern Big Cypress along Tamiami Trail. In Southeast Big Cypress, I included variable E for flows across the Lostman's cross-section south of Tamiami Trail.

I also developed a single equation that combined the three Big Cypress regions.

D-E.3.13.5 Discussion

Scores were developed separately for each variable in each Indicator Region and for each cross-section or boundary (Table 14). I then combined them in a stepwise fashion, as described above, so that the AET would be able to comment on what is gained and lost as each Performance Measure was combined with others. Originally I developed two sets (with or without flows) of the three summarizing equations, with the goal of reducing all of the variables to three scores, one for the North Big Cypress, one for the South Big Cypress, and one for the southeastern Big Cypress. I ultimately produced two whole Big Cypress equations, again depending on whether flow parameters are used or not in the equations.

As a result of discussions at the late May AET meetings, I decided to focus on using the information contained in the three geographically separate equations that included the flow cross-section information (Table 14). Each of these three summary rows of the matrix provided distinctive information relevant to understanding influences that each of the Alternatives had on the Big Cypress.

All of the effects on the North Big Cypress occurred in Alternatives C and D, and were retained in D13, D13R, and D13R4. The effects resulted from filling the L-28 Interceptor Canal and removing its western levee, creating openings for water to move south along the Western Feeder Canal, and replacing S-190 with a pump station to maintain upstream drainage. This scenario also required some sort of water treatment capability to assure that all water moving south and southwest from the upstream canal system would provide only clean water. These components converted an area about two cells wide for most of the length of the L-28 Interceptor along its western side to approximately NSM conditions. Because the locations of the restored cells and the Indicator Regions available in the vicinity were not the same, the low matrix scores did not adequately reflect the high degree of restoration that actually occurred in portions of this area from the implementation of these components.

In the South Big Cypress, the most significant changes occurred in Alternative D, with the removal of the L-28 Tieback Levee. With this structure removed, hydrologic conditions showed almost complete restoration to NSM conditions, including restored hydroperiods and increased flows across the eastern portion of the Big Cypress. The model results for D13, D13R, and D13R4 were almost identical to one another, and (delete "both") showed generally small but distinct increased deviations from NSM (drier than NSM) as compared to Alternative D. The matrix values for D13 were almost identical to the 95 Base conditions in this area, but were higher (wetter) than for the 2050 Base. When looking at the hydrologic responses to these alternatives for individual Performance Measures and Indicator Regions, the geographic area where the deviations were greatest was in the vicinity and downstream of the jetport. We determined that the jetport was not modeled in the SFWMM, so it is not the cause of the problem. The somewhat poorer conditions in South Big Cypress relative to NSM in the D13 scenarios seemed to be associated with the movement of water to the east rather the west as occurred under NSM conditions in the vicinity of the Jetport. This change in flow direction appeared to result from a slightly lower-than-NSM topography that currently exists in this area in the SFWMM. It did not occur prior to Alternative D13 because of the presence of L-28.

In the southeastern Big Cypress along its border with the Everglades and below Tamiami Trail, the most significant changes occurred in Alternative B, when the L-28 and L-29 levees and canals were removed. According to the model, there were larger areas showing reduced hydroperiods and the reductions in hydroperiods and flows were greater than in Alternatives A, C, or D, all of which were close to NSM condition. In Alternative C, the L-28 and only the western portion of L-29 were restored, which was sufficient to return conditions in this area close to NSM. The removal of the L-28 Tieback in Alternative D did not seem to affect this portion of the Big Cypress. Alternatives D13, D13R, and D13R4 produced generally small and variable responses among the various Performance Measures, resulting in an overall minor difference in the summary matrix value for this portion of the Big Cypress.

D-E.3.13.6 Summary

The combination of components in Alternative D produced the greatest benefits in terms of restoring the largest amount of area in the Big Cypress to approximately NSM conditions. It also seems that several of the most beneficial components could be implemented in any of the Alternatives, since they operate pretty much independently from the rest of the Everglades ecosystem. This would be the situation for the L-28 Interceptor and L-28 Tieback components. Changes to the L-28 South and L-29 have more extensive and complex interactions with other parts of the Everglades.

In using the colors and grades to differentiate restoration success as indicated by the various Performance Measures for each the Bases and Alternatives (A-D, D13, D13R, D13R4), I used matrix value ranges of 86-100 (green, grade A), 71-85 (yellow, grade B), and <71 (red, grade C). These ranges generally seemed to do a reasonably good job of sorting restoration gains and losses for the Big Cypress region that were associated with each of the Alternatives. The only portion of the region where these results could be misinterpreted is the North Big Cypress. The portion of this area influenced by the L-28 Interceptor system should be included in the green grade A category in Alternatives C, D, D13, D13R, and D13R4. The portion further west still shows severe hydrologic impacts, even in these latter Alternatives. However, based on a helicopter overflight of the area to assess its condition and our understanding of how the models are operating in this area, it is very likely that these impacts are merely the result of modeling problems, and in reality are much less severe than suggested by the SFWMM.

There were no significant changes in the Big Cypress performance measures from alternative D13R. North Big Cypress has not changed since Alternative C when the L-28 Interceptor canal and its west levee were removed and water from the upstream North and West Feeder canals was distributed as sheet flow across the northeastern Big Cypress. Southeast Big Cypress has maintained fairly constant conditions since Alternative A, with the exception of Alternative B, which produced the most adverse effects of Alternatives A-D and the D13s. Hydrologic conditions in the South Big Cypress were closest to NSM under Alternative D and were close to 1995 Base conditions and slightly better than the 2050 Base in the D13R scenarios. The somewhat poorer conditions in South Big Cypress relative to NSM in the D13 scenarios seemed to be associated with the movement of water to the east rather than the west as occurred under NSM conditions in the vicinity of the Jetport. This change in flow direction appeared to result from a slightly lower-than-NSM topography that currently exists in this area in the SFWMM. It did not occur prior to Alternative D13 because of the presence of L-28.

Table 14
Big Cypress Basin

VARIABLE	NSM	1995	2050	ALT A	ALT B	ALT C	ALT D	D13R	D13R4
Percent of North Big Cypress that Matches NSM / 100									
A	1.00	0.47	0.46	0.46	0.49	0.64	0.64	0.64	0.64
Percent of South Big Cypress that Matches NSM / 100									
B	1.00	0.99	0.97	0.97	0.92	0.99	1.00	0.99	0.97
Reduction in Percent of Time Inundated from NSM Condition									
C-13	1.00	0.99	0.93	0.99	0.95	0.99	0.99	1.00	1.00
C-31	1.00	0.90	0.90	0.90	0.91	0.94	0.94	0.94	0.94
C-36	1.00	0.94	0.92	0.92	0.91	0.95	1.00	0.94	0.94
C-37	1.00	0.93	0.91	0.91	0.91	0.94	0.99	0.95	0.95
C-38	1.00	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98
C-40	1.00	0.97	0.97	0.96	0.96	0.97	1.00	0.98	0.98
C-45	1.00	0.99	0.97	0.97	0.98	0.99	0.99	0.99	0.99
C-42	1.00	0.81	0.81	0.81	0.81	0.92	0.92	0.92	0.92
C-43	1.00	0.35	0.34	0.34	0.34	0.63	0.63	0.63	0.63
Maximum Deviation from NSM Stage Duration Curve									
D-13	1.00	0.95	0.92	0.98	0.95	0.96	0.97	0.99	0.99
D-31	1.00	0.94	0.94	0.94	0.95	0.96	0.96	0.96	0.96
D-36	1.00	0.97	0.95	0.95	0.95	0.96	0.98	0.96	0.96
D-37	1.00	0.95	0.95	0.95	0.95	0.96	0.99	0.96	0.96
D-38	1.00	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
D-39	1.00	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98
D-40	1.00	0.98	0.98	0.98	0.96	0.98	0.99	0.98	0.98
D-45	1.00	0.98	0.98	0.97	0.98	0.98	0.99	0.98	0.98
D-42	1.00	0.89	0.89	0.89	0.89	0.94	0.94	0.94	0.94
D-43	1.00	0.51	0.50	0.50	0.51	0.57	0.57	0.57	0.57
Percent Change in Flow from NSM Condition / 100									
Ew-east BC	1.00	0.76	0.72	0.72	0.73	0.80	0.99	0.84	0.83
Ed-east BC	1.00	0.65	0.55	0.45	0.50	0.53	0.78	0.65	0.60
Ew-Lostman's	1.00	0.60	0.68	0.93	0.79	0.98	0.96	0.97	0.95
Ed-Lostman's	1.00	0.63	0.42	0.91	0.63	0.91	0.88	0.98	0.93
Average Flood Duration									
G-13	1.00	0.93	0.89	0.96	0.86	1.00	1.00	0.86	0.93
G-31	1.00	0.93	0.93	0.93	0.93	0.93	1.00	1.00	1.00
G-36	1.00	0.89	0.78	0.72	0.78	0.83	0.94	0.83	0.83
G-37	1.00	0.82	0.71	0.71	0.71	0.76	0.94	0.82	0.82
G-38	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
G-39	1.00	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
G-40	1.00	0.91	0.87	0.83	0.87	0.91	1.00	0.96	0.96
G-45	1.00	0.91	0.91	0.91	0.91	0.91	1.00	0.91	0.91
G-42	1.00	0.55	0.55	0.55	0.55	0.73	0.73	0.73	0.73
G-43	1.00	0.13	0.13	0.13	0.13	0.45	0.45	0.45	0.45
NORTH BIG CYPRESS									
A	1.00	0.47	0.46	0.46	0.49	0.64	0.64	0.64	0.64
Reduction in Percent of Time Inundated from NSM Condition									
C42-C43	1.00	0.58	0.58	0.58	0.58	0.78	0.78	0.78	0.78

VARIABLE	NSM	1995	2050	ALT A	ALT B	ALT C	ALT D	D13R	D13R4
Maximum Deviation from NSM Stage Duration Curve									
D42-D43	1.00	0.70	0.70	0.70	0.70	0.76	0.76	0.76	0.76
Average Flood Duration									
G42-G43	1.00	0.34	0.34	0.34	0.34	0.59	0.59	0.59	0.59
Summary - North Big Cypress									
	1.00	0.52	0.52	0.52	0.53	0.69	0.69	0.69	0.69
SOUTH BIG CYPRESS									
Percent of South Big Cypress that Matches NSM / 100									
B	1.00	0.99	0.97	0.97	0.92	0.99	1.00	0.99	0.97
Reduction in Percent of Time Inundated from NSM Condition									
C31,C36-C40	1.00	0.95	0.94	0.94	0.94	0.96	0.98	0.96	0.96
Maximum Deviation from NSM Stage Duration Curve									
D31, D36-D40	1.00	0.97	0.96	0.96	0.96	0.97	0.98	0.97	0.97
Average Flood Duration									
G31, G36-G40	1.00	0.89	0.85	0.84	0.85	0.87	0.95	0.90	0.90
Percent Change in Flow from NSM Condition / 100									
(Ew+Ed)/2 East BC	1.00	0.70	0.63	0.58	0.62	0.66	0.88	0.75	0.72
Summary - South Big Cypress									
	1.00	0.90	0.87	0.86	0.86	0.89	0.96	0.91	0.90
SOUTHEAST BIG CYPRESS									
Reduction in Percent of Time Inundated from NSM Condition									
C-13	1.00	0.99	0.93	0.99	0.95	0.99	0.99	1.00	1.00
Maximum Deviation from NSM Stage Duration Curve									
D-13	1.00	0.95	0.92	0.98	0.95	0.96	0.97	0.99	0.99
Average Flood Duration									
G-13	1.00	0.93	0.89	0.96	0.86	1.00	1.00	0.86	0.93
Percent Change in Flow from NSM Condition / 100									
(Ew+Ed)/2 Lostman's	1.00	0.61	0.55	0.92	0.71	0.94	0.92	0.98	0.94
Summary - Southeast Big Cypress									
	1.00	0.87	0.82	0.96	0.87	0.97	0.97	0.96	0.97

D-E.3.14 ATLSS / Threatened and Endangered / Keystone Species

D-E.3.14.1 Cape Sable seaside sparrow

For the western subpopulation, inspection of performance measure graphics for indicator region 46 might suggest a negligible difference in effects to sparrows for the D13R4 and D13R alternatives. However, ATLSS individual-based modeling for this subpopulation is relatively sensitive to what appear to be minor shifts in the stage duration curves. A small change in the timing and duration of flooding can have a pronounced effect on population projections in the ATLSS model. ATLSS modeling results for D13R4 are similar to D13R, but show a greater tendency for subpopulation numbers to drop below 500 individuals. In addition, D13R4 results are only a slight improvement over 2050 Base conditions according to the ATLSS results. The Service believes that these results indicate that there is potential for significant adverse effects to the western subpopulation of the Cape Sable seaside sparrow within the range of flexibility demonstrated for alternative D13R. As a result, any Restudy implementation effort that proceeds toward the "wetter" range of possible D13R scenarios must exercise extreme caution with regards to possible effects on the sparrow's western subpopulation. ATLSS individual modeling for these subpopulations provides a far more detailed and sophisticated analysis of expected effects on sparrow demographics than do the indicator region graphics. Therefore, the U.S. Fish and Wildlife Service believes that the ATLSS modeling provides the best currently available scientific information for assessing effects to the endangered Cape Sable seaside sparrow.

For the eastern subpopulations C, E and F, D13R4 hydroperiods are significantly increased as compared to D13R and are slightly longer than NSM. While it is difficult to predict what effects these longer-than-NSM hydroperiods might have on the eastern marl prairie habitats, adverse effects to sparrow habitat have been documented as a result of increased hydroperiods resulting from S332 pumping in subpopulation C. Careful monitoring will be necessary if/when such a scenario is implemented. Overall, D13R4 should provide improved habitat conditions for the sparrow as compared to 2050 Base.

D-E.3.14.2 Wood stork

Based on John Ogden's revised stork performance measure (Table 15), alternative D13R4 provides significantly improved conditions for nesting in the historically important Shark Slough and Taylor Slough mangrove fringe as compared to D13R and both base cases.

D-E.3.14.3 Crocodile and Manatee

Based on the Shark and Taylor Slough flow lines, and P-33 salinity predictions for Florida Bay, D13R4 should provide increased habitat suitability for crocodiles and manatees as compared to D13R and both base cases.

D-E.3.14.4 Snail kite

ATLSS snail kite foraging index results show that foraging condition values for both D13R4 and 2050 Base are high across large parts of the remaining Everglades under very wet conditions. However, under D13R4, water levels are too high in parts of each of the WCAs to provide effective snail kite foraging. In addition, losses of snail kite nesting substrate in these areas, particularly in WCA-3B, would be expected during high water conditions produced by D13R4. Under very dry conditions, D13R4 provides slightly higher foraging condition values than 2050 Base in WCA-1, WCA-3B and the periphery of Shark Slough. Overall, D13R4 results are similar to those for D13R, except for reduced foraging and nesting habitat under very wet D13R4 conditions.

Table 15
Summary of wood stork performance measure elements

Performance Element	NSM	95 Base	2050 Base	D13R	D13R4
IR 9 innundation duration	176	75	98	156	174
IR 10 innundation duration	321	93	108	398	265
IR 9 ratio to NSM	1.0	0.43	0.56	0.89	0.99
IR 10 ratio to NSM	1.0	0.29	0.34	1.24 (0.76)*	0.83
IR average	1.0	0.36	0.45	1.07	0.91
Taylor Slough flow volume	83	102	69	74	82
Shark Slough flow volume	1519	702	826	1097	1255
TS ratio to NSM	1.0	1.23	0.83	0.89	0.99
SS ratio to NSM	1.0	0.46	0.54	0.72	0.83
Flow average	1.0	0.85	0.69	0.81	0.91
Weighted score		0.51	0.53	0.79	0.89

* reflects correction for % less than NSM, allowing correct calculation of weighted score.

APPENDIX E

SOCIO-ECONOMICS

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APPENDIX E
SOCIO – ECONOMICS

E.1 INTRODUCTION

E.1.1 BACKGROUND

The Central and Southern Florida (C&SF) Project, authorized in 1948, is a regional system of levees, canals, water control structures, and management operations that were designed to provide flood control, water supply, and other services to southern Florida. Although the project has performed its intended purposes well, it has also contributed to the decline of the south Florida ecosystem, including the Everglades. In response to this decline, Congress authorized the U.S. Army Corps of Engineers (Corps) to conduct the C&SF Project Comprehensive Review Study (Restudy) to develop a comprehensive plan for the purpose of restoring, preserving, and protecting the south Florida ecosystem. The Restudy is being conducted in cooperation with the South Florida Water Management District (SFWMD), the non-Federal sponsor.

The Congressional authorization for the Restudy (Water Resources Development Act of 1996) specifies that the comprehensive plan include features necessary to provide: (1) for the protection of water quality in, and the reduction of the loss of fresh water from, the Everglades and (2) for the water-related needs of the region, including flood control, water supply, and other objectives of the C&SF project. The C&SF Restudy reconnaissance report was completed in November 1994. The feasibility phase of the Restudy was initiated in August 1995. In the authorizing legislation, Congress directed that the feasibility study – and the Environmental Impact Statement – be completed by 1 July 1999.

E.1.2 PURPOSE OF THIS INVESTIGATION

This investigation assesses the economic effects of the five alternative ecosystem restoration plans formulated in the feasibility phase of the Restudy. The economic evaluation of the alternative restoration plans includes five principal elements:

1. <u>Socio-economic Profile of the Study Area</u>: This profile includes population and economic forecasts for the region, as well as projections of future water demand.

2. <u>Anticipated Effects of Alternative Plans on the National Economic Development (NED) Account</u>: Alternative plans could result in positive or negative effects on net national economic efficiency due to project-induced impacts on the following economic activities in south Florida:

- Agricultural water supply,
- Municipal and industrial (M&I) water supply,
- Flooding potential,
- Commercial navigation,
- Recreation (Everglades-related), and
- Commercial and recreational fishing.

3. Evaluation of Project Costs: Project costs include all expenditures required to implement the alternative plans. These costs will be shared by the Federal government and the State of Florida. Project costs include those for initial construction; lands; relocations; rights of way; rehabilitation, replacement, and repair; and operations and maintenance (O&M) (including the costs of post-construction monitoring and adaptive management).

4. Regional Economic Development (RED) Effects: The potential RED effects of the alternative plans include changes in income, employment, or economic output of the region.

5. Other Social Effects (OSE): The potential social effects of the alternative restoration plans include effects on minority, elderly, and disadvantaged groups, population displacement, and effects on community cohesion.

The economic analysis for the C&SF Restudy was conducted consistent with Federal statutes and Corps policy. Procedures for estimating NED and RED effects are specified in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 10 May 1983), Engineering Regulation (ER) 1105-2-100, and other Corps guidance.

E.1.3 STUDY AREA

The Restudy study area encompasses the 16-county jurisdictional area of the SFWMD. At the heart of the study area – and the C&SF Project – is Lake Okeechobee. This shallow lake encompasses approximately 730 square miles, making it the second largest freshwater lake within the contiguous United States. Lake Okeechobee is primarily fed by the Kissimmee River basin to the north. Water leaves the lake through three principal avenues. First, as a result of the warm south Florida climate, the lake loses tremendous amounts of water to evaporation. Second, when lake stages are excessively high, water is released eastward to the Atlantic Ocean via the St. Lucie canal, and also westward to the Gulf of Mexico via the Caloosahatchee River. Finally, lake water is released southward via a system of water supply structures and canals. Major water supply conduits include: the Miami, North New River, Hillsboro, and West Palm Beach canals. These canals convey water for: (1) agricultural uses in the Everglades Agricultural Area (EAA), (2) agricultural and M&I uses in the eastern portions of Palm Beach, Miami-Dade, and Broward counties (and by extension, Monroe County, whose water supply comes from Dade County wells), and (3) maintenance of water levels and flows in the Water Conservation Areas (located southeast of Lake Okeechobee) and the Everglades National Park (via the Water Conservation Areas).

The SFWMD has divided south Florida into a set of water supply planning areas. These planning areas are referenced frequently in this document. They include the Lake Okeechobee Service Area (LOSA) and the Lower East Coast (LEC) of south Florida. These areas include the five sub-areas of the LOSA and the three urbanized service areas of the LEC. The five LOSA sub-areas consist of: (1) northern Palm Beach County, (2) the Everglades Agricultural Area which primarily lies within western Palm Beach County but also eastern Hendry County, (3) the northern lake district, (4) the Caloosahatchee basin, and (5) the St. Lucie basin. LOSA also includes two Seminole Indian reservations, Brighton and Big Cypress. The three service areas (SA1-SA3) within the LEC primarily lie within Palm Beach, Broward, and Miami-Dade counties, respectively.

E.1.4 ALTERNATIVE RESTORATION PLANS

The five alternative restoration plans (A, B, C, D, and D13R) have been formulated in the feasibility phase of the Restudy. Each alternative consists of a suite of structural and operational changes to the C&SF Project. These modifications to the regional water management system are designed to change the hydrology of south Florida to achieve the Restudy objectives, primarily restoration of the structures and functions of the Everglades ecosystems.

E.1.5 METHODOLOGY

A number of factors were considered prior to developing the methodologies used to evaluate the economic effects of the alternative restoration plans. These factors include: available analytical tools, economic theory, Federal policy, obtainable data, and time and budgetary constraints. These factors are discussed below.

E.1.5.1 South Florida Water Management Model

The SFWMD's South Florida Water Management Model (SFWMM) is the primary analytical tool being used in the C&SF Restudy to evaluate and compare the hydrologic effects of the alternative plans. The SFWMM is a regional-scale, continuous simulation, hydrologic model that was developed by the SFWMD. The SFWMM simulates the hydrology and water management of southern Florida from Lake Okeechobee to Florida Bay. The SFWMM spans a region that includes most of Florida south of Lake Okeechobee. Of this region, 7,600 square miles are divided into a 2-mile by 2-mile model grid. The SFWMM simulates system-wide hydrologic responses to daily climatic parameters (rainfall and evapotranspiration) in each of these 4-square mile cells.

The entire LEC, as well as two LOSA sub-areas (the EAA and Northern Palm Beach County) are included in the model grid. While flows to and from some tributaries to Lake Okeechobee, such as the Kissimmee River, are included in the model, they are not contained within the 4 square-mile grid cells. Similarly, the Caloosahatchee and the St. Lucie basins – both part of the LOSA – are not included in the grid.

The SFWMM simulates infiltration, percolation, evapotranspiration, surface and groundwater flows, levee underseepage, canal-aquifer interaction, current or proposed water management structures, and current or proposed operation rules for those structures. The model does not allow for dynamic changes in south Florida's land use/land cover or for changes in the C&SF infrastructure during the simulation period. As a result, the simulations associated with existing and future with and without plan conditions represent water management in the C&SF system given static structural and operational parameters under 31 years of historic climatic conditions (1965-1995). The current version of the model generates over 11,000 sequential daily simulations to cover the 31-year simulation period.

E.1.5.2 Limitations of the SFWMM Model for Use in Economic Analyses

The SFWMM is an operational model whose primary purpose is to assist the SFWMD in optimizing water management and allocation decisions. The model was not designed to conduct economic analysis, but does include many indicators of hydrologic change which can have economic consequences. To assist in estimating the economic effects of water management decisions, the SFWMD developed the Economic Post-Processor (EPP) to estimate the economic effects of cutbacks in agricultural and urban water supply during drought periods. The EPP was used in the Restudy economic analysis to estimate the impacts of alternative restoration plans on the frequency and duration of drought-induced changes in agricultural and urban water supply. Other categories of economic effects were estimated by conducting "outside-the-model" analyses of various SFWMM-generated hydrologic performance indicators.

E.1.5.3 Without-Plan and With-Plan Conditions

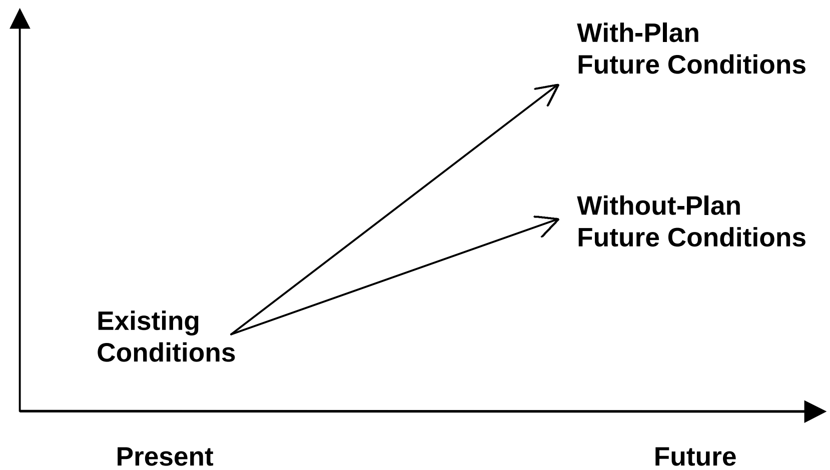
Using the SFWMM as the principal tool for evaluating the economic effects of alternative restoration plans requires some practical modifications to the traditional with and without-plan analysis procedures typically used in Corps of Engineers water resource planning studies. In a traditional feasibility investigation, a probabilistic analysis is conducted to project conditions expected to occur throughout the planning period (typically 50 years), both with and without implementation of a plan. "Average annual" economic impacts are estimated by evaluating a range of possible future conditions, weighting the likelihood (i.e., probability) of these conditions by their economic effects, and then statistically combining them. The difference between "average annual" with and without-plan conditions constitutes the net annual economic impacts (positive or negative) of the alternative plans.

This type of with and without-plan analysis had to be modified during the C&SF Restudy to account for the limitations imposed by SFWMM. As stated previously, the SFWMM is a simulation model which equally weighs each of the days in the 31-year simulation period. As a result, it is not possible to use SFWMM to determine the likelihood of occurrence of any given hydrologic event. While the 31 years of past climate data are considered representative of future climatic conditions, they are of insufficient duration to assign frequencies of occurrence to specific simulated hydrologic events (e.g., 25-, 50-, or 100-year return period events).

Therefore, the economic effects of the alternative restoration plans were estimated by comparing two "snapshots" of study area conditions that are expected to exist in the future, those with and those without restoration. As illustrated in ***Figure 1.5.3-1***, an alternative restoration plan (i.e., with-plan future conditions) will likely generate different economic effects – higher or lower – than those expected in the absence of restoration (i.e., without-plan future conditions). [This hypothetical figure is conceptual, and the with- and without-plan future conditions could be reversed, depending on the plan and the specific impact category.] For the Restudy, the SFWMM was used to generate two sets of simulations, 1995 and 2050, which were used as proxies for existing and future study area conditions Historical land use (1990) and historical water consumption data (1995) were used to estimate existing (1995) without-plan conditions. In the same way, projected future (2010) land use and projected (2050) water consumption were used to estimate the 2050 without-plan conditions. The model also simulates the changes in hydrologic conditions that are expected to occur with implementation of the alternative restoration plans (with-plan conditions) for 2050. Future without-plan and with-plan conditions were then compared to estimate the impacts of alternative restoration plans.

Depending on the alternative and the type of economic impact, changes resulting from implementation of a restoration plan may be desirable or undesirable when compared to the future without-plan condition. For example, alternatives which include modifications to the C&SF system to provide additional water storage areas may result in fewer economic losses associated with agricultural (irrigation) water shortages. This would be a desirable ancillary benefit of restoration.

FIGURE 1.5.3-1
COMPARISON OF WITH- AND WITHOUT-PLAN CONDITIONS



No attempt was made to project impacts for interim time periods or to discount effects back to present worth, because the rates of hydrologic change and habitat recovery in response to restoration efforts could not be determined. Only existing conditions and desired "end state" conditions could be accurately predicted by the SFWMM analysis. Since these are the causal factors which yield economic effects, it was also not possible to estimate economic consequences for interim years.

Two types of comparisons can be made to assist in the decision making process based on this type of with and without-plan analysis. First, existing (1995) conditions and future (2050) without-plan conditions can be compared to indicate how economic conditions might change over time in the absence of any restoration action. For example, future population growth in south Florida could be expected to place additional strains on the regional water supply system. Consequently, more frequent and more severe urban water shortages (relative to existing conditions) could be expected in the coming decades, in the absence of any Everglades restoration effort.

Second, without-plan future (2050) conditions and with-plan future (2050) conditions can be compared to determine what impact Everglades restoration activities are expected to have following implementation of a project. This is the typical comparison used to estimate the beneficial and negative effects of project implementation.

One type of comparison is not appropriate, however. Direct comparison of existing (1995) and future with-plan (2050) conditions is inappropriate, because it confuses the effects of plan induced changes with the longitudinal effects of future land use and demographic changes which will occur irrespective of a restoration project. Such a comparison would not allow decision makers to isolate the economic changes occurring in the study area regardless of whether restoration action is taken, or to determine the actual impacts of restoration actions.

E.1.5.4 Sources and Causes of Economic Effects

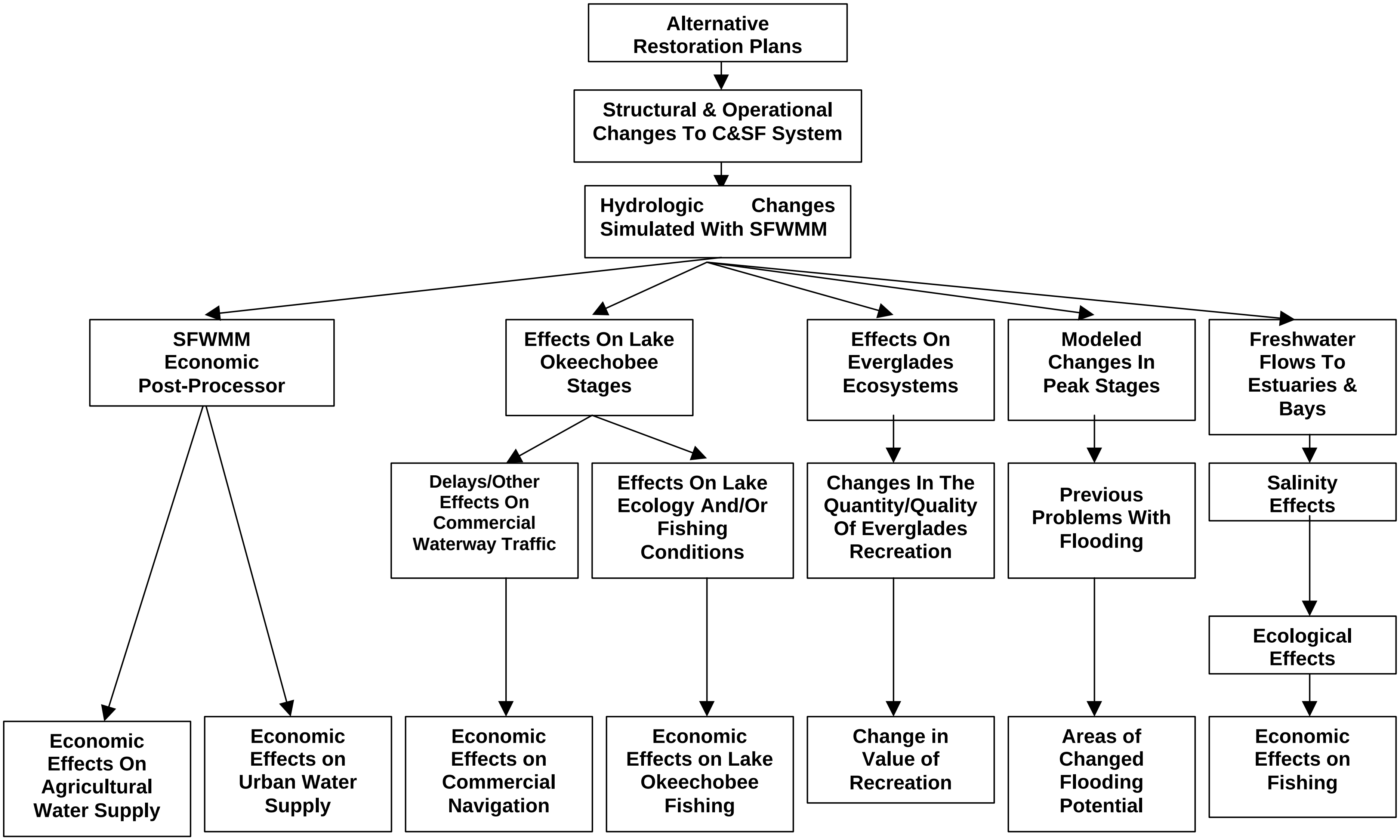
The potential economic impacts of the alternative restoration plans are a secondary consequence of the hydrologic changes which are expected to result from the proposed structural and operational modifications to the C&SF system. Figure 1.5.4-1 traces the causal linkages between the structural and operational modifications to the C&SF system and the different categories of economic effects.

Some categories of economic impact, such as urban and agricultural water supply effects, can be estimated directly from SFWMM-simulated hydrologic changes associated with each alternative restoration plan. Other economic effects, such as commercial and recreational fishing impacts in the St. Lucie and Caloosahatchee estuaries and in Biscayne and Florida bays, are less directly linked to the hydrologic changes resulting from the alternative restoration plans. In this latter case, the chain of cause and effect includes: the impacts of project-induced changes in water release rates, the impacts of changes in release rates on the productivity of the fisheries, and the impacts of changes in the fisheries on the net income of commercial fishing operations and the quality of recreational fishing experiences. As will become evident throughout this analysis, the difficulties in estimating these chains of cause and effect have important consequences for our ability to quantify the economic effects of the alternative plans. Economic analyses cannot be applied to estimate the value of physical or ecological impacts of the alternative plans if those impacts cannot first be defined and quantified.

E.1.5.5 Methodology for Conducting Economic Analysis

Since a traditional cost-benefit analysis was not conducted for the Restudy, the alternative restoration plans were compared using information in monetary and non-monetary units (***Figure 1.5.5-1***). The economic analysis of the Restudy's alternative restoration plans include: (1) the NED costs (in monetary terms), (2) the anticipated environmental benefits resulting from restoration measures (in non-monetary terms), (3) the positive and adverse NED effects expected to occur in the following economic impact categories: agricultural water supply, municipal and industrial water supply, commercial navigation, recreation, and commercial fishing (in monetary and non-monetary terms) and (4) the positive and adverse regional economic effects (RED) resulting from project implementation. This section of the report addresses items (1), (3) and (4) above.

FIGURE 1.5.4-1
SOURCES OF ECONOMIC EFFECTS



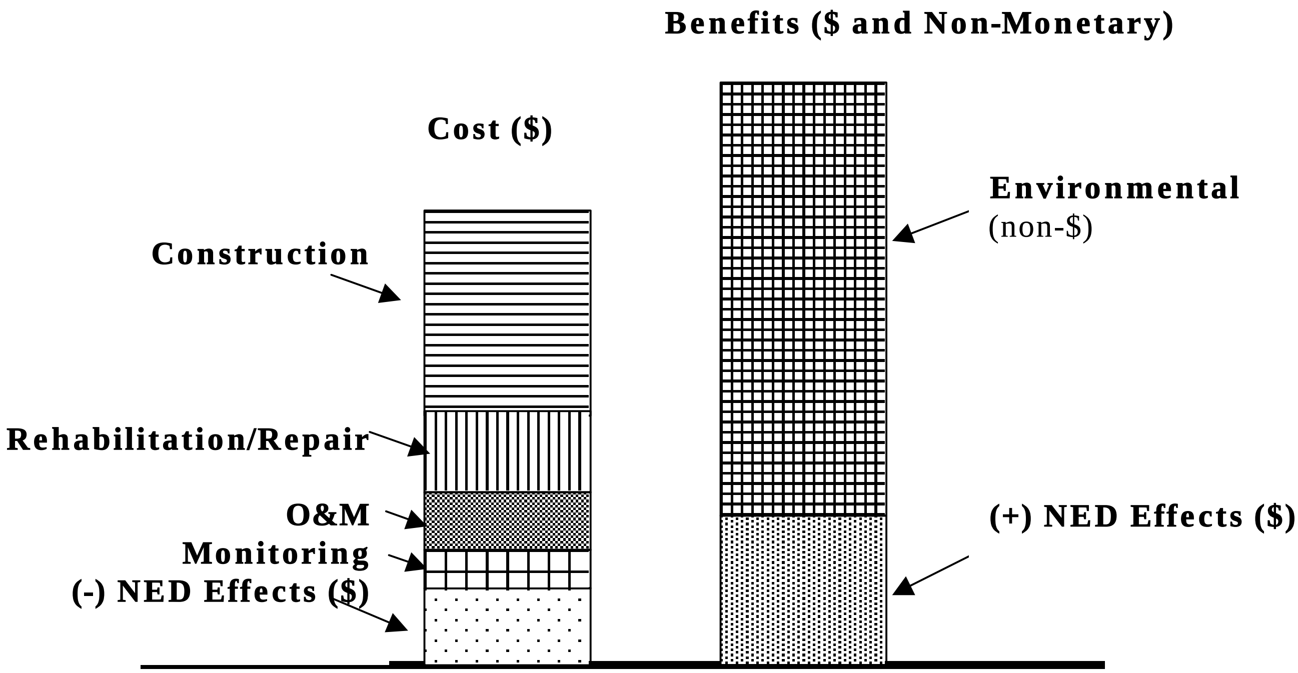


FIGURE 1.5.5-1
CONCEPTUAL COMPARISON OF RESTORATION COSTS AND BENEFITS

The methodologies used to conduct economic analysis studies for the C&SF Restudy were determined based on a combination of factors, including: economic theory, Corps of Engineers' ecosystem restoration and economic evaluation policies, and the characteristics of methodologies used by economists to value ecosystem benefits. The most important consequence of this determination is that traditional cost-benefit analysis procedures were not used to evaluate the primary output of the alternative restoration plans, i.e., improvements in environmental quality. Instead, cost effectiveness evaluation procedures were used to compare the costs and non-monetary ecosystem benefits of the proposed restoration efforts. The reasons for this decision are summarized below.

Theoretically, the economic basis for making policy decisions about whether to invest public funds in ecosystem restoration in South Florida is the same as for any other government spending program. The monetary and non-monetary costs and benefits of any proposed government project should be compared in order to determine whether the expenditure is justified and to select the plan which maximizes the net benefits to society for the investment of public funds. A conceptual comparison of costs and benefits of ecosystem restoration is illustrated in Figure 1.5.5-1. [In order to simplify the illustration, the full range of potential costs and benefits are not included in this figure; and, relative sizes of costs and benefits are conceptual.]

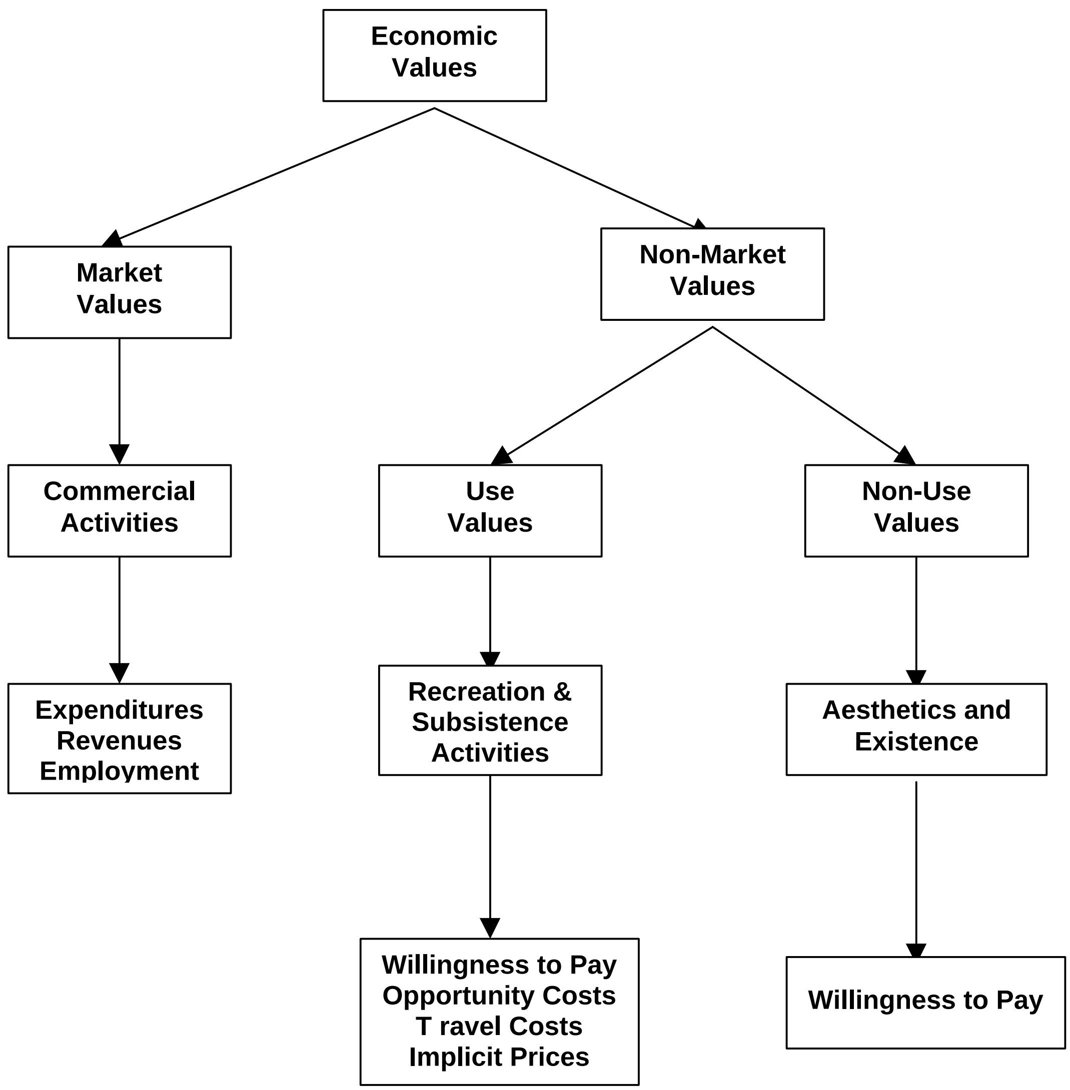
The costs of ecosystem restoration projects include: initial construction costs; major rehabilitation and repair costs; operations and maintenance (O&M) costs; post-construction monitoring costs; and adverse NED effects. Typically, these costs can be expressed in monetary (i.e., dollar) terms.

The principal challenge of ecosystem restoration economics is estimating the value of restoration benefits. As illustrated in Figure 1.5.5-1, the primary purpose (and therefore the primary benefits) of each alternative plan is ecosystem restoration. The benefits of ecosystem restoration are usually expressed by ecologists in non-monetary units, such as acres of specific habitat created or enhanced, indices of biological productivity associated with habitat improvement, or increased abundance and/or diversity of particular species of plants or animals. For decision making purposes, it would be desirable to express ecosystem restoration benefits in monetary terms, in order to compare them with project costs. Expressing the costs and benefits of alternatives in a common, monetary metric would facilitate selection of the best restoration plan for a given site. However, calculating the monetary value of environmental amenities is both difficult and controversial. Environmental amenities are public goods that are generally not exchanged in the marketplace. For marketable commodities (i.e., items that people buy and sell), the demand, and prices paid, for these goods can be used as “proxies” for determining their value to consumers. In the absence of data on consumers’ expenditures for environmental amenities, resource economists have attempted to develop techniques that can be used to estimate their value using indirect indicators of consumers’ “willingness to pay” for ecosystem restoration.

Figure 1.5.5-2 portrays a schematic of the different approaches used by economists to measure the economic value of both market and non-market goods. Market goods are produced by commercial activities. The value of these goods can be estimated based on the expenditures made to produce them, the prices paid by the purchaser, the income they generate for the producer, and the employment generated by producing them.

Ecosystems provide a myriad of goods and services to society. As explored by Costanza et al. (1997), these goods and services include climate regulation, water regulation, soil formation, waste treatment, food production, genetic resources, and recreation. Costanza et al. (1997) estimated that on a global scale the average annual value of ecosystem goods and services is in the range of $33 trillion. Many of the goods and services provided by ecosystems at the global scale are also provided by the Everglades ecosystems to south Florida and the nation.

FIGURE 1.5.5-2
DIFFERENT APPROACHES USED TO EVALUATE THE ECONOMIC VALUE OF BOTH MARKET AND NON-MARKET GOODS



For goods and services that are not purchased in the marketplace, non-market valuation approaches must be used to infer their value to the public. There are direct and indirect use values for these goods and services. Use values refer to the value consumers obtain from using a good that is related to an environmental amenity. For example, recreational fishermen in Florida Bay obtain direct use value from the Florida Bay fishery. The fishermen also obtain indirect use values from the Everglades ecosystem, since it provides ecological functions which contribute to the productivity of the Florida Bay fishery. Use values can be either consumptive or non-consumptive. Consumptive use values refers to the cases for which the good is consumed by the user and is no longer available to others, such as waterfowl hunting. Non-consumptive use values refer to the value obtained by a user in cases for which the good remains to be used by others in the future, such as catch-and-release fishing or bird-watching.

It is reasonable to expect that the alternative restoration plans will generate additional use values to the public. Non-market activities which would benefit from restoration plans include: recreational fishing, subsistence activities, and a whole variety of ecotourism related activities (e.g., bird-watching, hiking, canoeing, etc.).

Non-use values include the values the public obtains from simply knowing that the good or resource is available, even if they have not used it previously. Individuals may value a good simply from knowing it exists (existence value) or because the may want to have the opportunity to use it at some future time (option value).

Again, it is reasonable to expect that the alternative restoration plans will generate additional non-use values to the public. The tremendous interest in and support for Everglades restoration, not just in south Florida but throughout the country (and the world), is an indication that a broad segment of society values the Everglades ecosystem, even though most have never experienced the area first hand.

Theoretically, it should be possible to determine the value of restoring the Everglades ecosystem by asking people what they would be willing to pay for different levels and types of restoration projects, or by observing what they spend on ancillary costs (e.g., travel, subsistence, equipment, etc.) when they engage in these non-market experiences. Economists have developed a variety of techniques to estimate society's willingness to pay for these types of non-marketable environmental amenities. These economic valuation techniques include market-based, surrogate market, and non-market methodologies (see Freeman, 1993).

Market-based approaches estimate the value of environmental resources using information generated in the marketplace. These approaches include: changes in factors of production, valuation of complimentary goods and services, defensive expenditures, and market valuation of the next best alternative. Surrogate-market techniques estimate value on the basis of preferences revealed in surrogate markets. These techniques include: the travel cost method and hedonic valuation. The contingent valuation method (CVM) is the most widely accepted non-market valuation methodology. CVM is perceived as the most effective technique to determine society's willingness to pay for environmental protection and/or restoration and is the only technique able to estimate non-use (i.e., option and existence) values. This method is based on carefully designed surveys which solicit respondent's willingness to pay for a specific environmental resource in a given condition. The survey is intended to reveal both users' and non-users' willingness to pay for the resource.

Unfortunately, these surrogate-market techniques, including CVM, have significant shortcomings which lead to concerns about their reliability and validity. They are especially problematic in cases for which respondents are unfamiliar with the environmental amenity, when the issue is controversial, or where it generates strong reactions, based on ethical, rather than economic motivations. Most importantly for the Restudy effort, the reliability and validity of these techniques are especially questionable in situations in which the actual changes that would result from the restoration efforts are difficult to precisely describe or visualize. Finally, stated preference methods, such as CVM, can be expensive to implement, especially when multiple alternatives are being evaluated.

Therefore, Corps of Engineers ecosystem restoration policy has been formulated in recognition of the practical limits of available economic tools to value environmental resources. As specified in Corps of Engineers ecosystem restoration policy (EC 1105-2-210: Ecosystem Restoration in the Civil Works Program), ecosystem restoration projects are not subject to traditional benefit-cost analyses. Economic justification of ecosystem restoration is not required in the traditional sense of ensuring that the monetary benefits of the alternative plans exceed their monetary costs. An ecosystem restoration proposal must still be justified by comparing the monetary and non-monetary costs and benefits of restoring degraded ecosystems. However, Corps ecosystem restoration evaluation procedures focus on the non-monetary benefits of restoration, comparing these benefits to monetary costs through the use of cost effectiveness and incremental cost analysis procedures.

Costanza et al. (1997) argue that despite the uncertainties surrounding ecosystem valuation, the decisions that society makes about ecosystems imply valuations. One clear expression of the value of the Everglades ecosystem was made by the U.S. Congress in the authorization for the reconnaissance and feasibility studies of the Restudy and by the Administration in its strong support for the restoration effort. The explicit authorizing language and funding appropriations are tangible expressions of the value of the Everglades ecosystem to our society, as expressed through public policy decisions.

E.1.6 PRIOR STUDIES

The regional scale of this investigation, the diversity of potential economic effects of the alternative restoration plans, and the Restudy's accelerated schedule dictated the use of prior studies – and other secondary information – to the extent possible. These studies are contained in the reference list presented at the end of thisAppendix. However, the prior studies of two institutions deserve particular recognition. First, the Natural Resources Conservation Service (NRCS) was previously engaged in an interagency agreement with the Corps to perform agricultural water supply impact analyses. NRCS personnel were instrumental in developing a baseline of information regarding the relationships between crop yields and water stress. Personnel involved in the interagency cooperation were consulted as part of this study, and they provided valuable information and insight. Second, the SFWMD has previously conducted a wide variety of studies that directly or indirectly support this investigation. Interviews with SFWMD staff and review of SFWMD reports have contributed greatly to this investigation.

E.1.7 ORGANIZATION OF REPORT

The chapters which follow evaluate the economics of the five alternative restoration plans. Chapter 2 develops a socio-economic profile for the region, and Chapter 3 contains the water demand forecasts for the region. These chapters develop the basis for critical physical and economic effects of the with and without-plan future conditions. These effects were incorporated into the SFWMM runs and were instrumental in the assessment of potential NED effects of the alternative restoration plans in subsequent chapters, including agricultural water supply (Chapter 4), M&I water supply (Chapter 5), flooding (Chapter 6), commercial navigation (Chapter 7), recreation (Chapter 8), and commercial and recreational fishing (Chapter 9). The costs of the alternative plans are presented in Chapter 10. The regional economic effects and other social effects of the alternative plans are explored in Chapters 11 and 12, respectively. Finally, Chapter 13 presents a summary of the economic effects of the alternative plans and conclusions.

E.2 POPULATION AND ECONOMY

E.2.1 OVERVIEW

This section of the appendix includes a description of the economic and demographic aspects of the study area. This descriptive information provides insight into the study area's socio-economic characteristics, and provides part of the basis for different facets of the economic impact evaluation work in the rest of this appendix.

Population and employment projections are key input data for future M&I (municipal and industrial) estimated water use. Estimated future M&I water use is required input for using the SFWMM, the main analytical tool being used in this study. The socio-economic data are also important in the assessment of the "other social effects," discussed in Section 12 of this Appendix.

The people who live in the study area, and the economic activity in which they are engaged, comprise important components of the area's total environment. In addition to the direct use of this data for the water use projections and other social effects mentioned above, they represent the socio-economic environment for the other impact topics of flooding, water use shortages, fishing, recreation, and navigation.

Any course of action forthcoming from this study will have effects throughout an economic system as well as the natural ecosystem(s) whose health and sustenance is the impetus for, and a major focus of, this investigation. The economic system is connected with the natural ecosystem and in general is ultimately dependent upon it for survival. Changes in the economic system can cause change in the natural ecosystem and vice versa. It is significant, therefore, to describe and understand the general economic and social environment within which such changes could take place. The main focus of economic impact evaluation efforts has been to describe the impacts of alternatives being considered for implementation. Nevertheless, this broader description is also necessary and important.

E.2.2 STUDY AREA

The study area includes all of the area of the Central and Southern Florida (C&SF) Project with the exception of the Upper St. Johns River Basin. The study area stretches from Orlando to the southern tip of Florida and encompasses all or parts of 16 counties, an area of approximately 18,000 square miles.

The descriptive data for the study area is reported and described at the county level of aggregation. It has been grouped into multi-county sub-regions that roughly coincide with the physiographic regions that have been identified for purposes of the Programmatic Environmental Impact Statement (PEIS) evaluation work. Some of the counties could be considered to be in more than one of the physiographic regions. For purposes of this grouping of data, each county is assigned to only one of the regions. As a result, some regions, for purposes of this presentation of descriptive information, have no counties assigned to them. The multi-county subregional areas are outlined in the following table.

TABLE 2.2-1
LOCATION OF STUDY AREA COUNTIES
BY PHYSIOGRAPHIC SUBREGION

Physiographic Subregion	Study Area Counties
Lower East Coast	Palm Beach Broward Miami-Dade
Florida Keys	Monroe
Big Cypress	Collier Hendry
Caloosahatchee	Lee Glades Charlotte
Everglades Agricultural Area[1/]	[1/]
Upper East Coast	Martin St. Lucie
Lake Okeechobee[2/]	[2/]
Kissimmee	Highlands Okeechobee Osceola Polk Orange

[1/] The EAA is essentially comprised of western Palm Beach County and a small part of eastern Hendry County, but these counties are already being accounted for in other subregions.
[2/] The Lake Okeechobee subregion would likely be comprised of parts of the counties bordering the lake (Hendry, Glades, Okeechobee, St. Lucie, and Palm Beach), but these counties are already being accounted for in other subregions.

Although the study area does not include 100% of each of the 16 counties, the data presented in this section of the appendix cover the full county areas. As described in the discussions about regional economic impacts later in this appendix, a 12 county subset of the study area has been chosen to more realistically represent the economic area of influence for evaluating these regional impacts (it excludes Charlotte, Highlands, Orange and Polk Counties).

E.2.3 POPULATION AND ECONOMY

E.2.3.1 General

Economic and demographic data for the study area, comprised of 16 south Florida counties, can be viewed in a variety of ways. No matter how viewed, the picture which emerges is that of generally higher average incomes than for the rest of the State and Nation, and greater economic and population growth than for the rest of the Nation. This is particularly true of southeast Florida, and while true in terms of the overall study area, some localities do not share in this overall trend. Other key important features of the economic landscape are agricultural activity, fishing, tourism, and recreation. As discussed elsewhere in this appendix, implementation of any of the Comprehensive Plan alternatives being considered in this study will likely have impact implications for all of these areas of economic activity.

The south Florida study area is home to just over 6 million people, about half of Florida's population. This relationship between the study area's population and that of the State has been so for some time and is likely to continue. Population growth tends to exceed the national rate of growth, a trend which continues, although at a declining rate.

Florida's economy is characterized by strong wholesale and retail trade, government and service sectors. Florida's warm weather and extensive coastline attract vacationers and other visitors and helps to make the State a significant retirement destination for people from all over the country. Agricultural production and fisheries are also important sectors of the State's economy, and are especially significant to portions of the study area. While compared to the national economy, the manufacturing sector has played less of a role in Florida, but high technology manufacturing has begun to emerge as a significant sector in the State over the last decade.

Most of the population and economic activity in the study area is concentrated along the Lower East Coast (LEC – Miami-Dade, Broward, and Palm Beach Counties). Per capita income (PCI) for the study area as a whole is above that for the State. The LEC three-county area's PCI is even higher.

Much of the study area's economic profile is similar to that for the State. The profile of the Lower East Coast (LEC) area is likewise similar to that of the overall study area. There are, however, obvious and important differences between individual counties within the study area. Since the majority of the population and economic activity reflected in available statistics is located in the LEC area, the remaining area is by comparison sparsely populated and is the location of important natural environment and agricultural areas, as well as Seminole and Miccosukee Indian Tribal lands.

For a description of the economy to be relevant, it needs to show how the study area relates to the State of Florida and the U.S., as well its distribution within the study area itself. The economy, like the natural ecosystem, is also dynamic and evolves and changes through time. Besides spatial and sector or category-of-activity distribution, change through time is important. The amount of available descriptive data is vast and incomprehensible in raw form. This discussion attempts to reasonably reduce this voluminous body of background information to a meaningful description

E.2.3.2 Population

The 16 south Florida counties which combine to make up the study area had a 1990 population of 6.3 million, accounting for about half of Florida's total. This share has changed very little over the past 20 years, and projections show this proportion to remain somewhat stable over the next 50 years. Over 60 percent of this south Florida population is in the three southeast coast counties of Palm Beach, Broward, and Dade. As with all projections, less certainty can be attached to projections the farther they are into the future. The same is true for estimates for smaller areas as compared with estimates for larger areas. This study's focus is on conditions with vs. without a plan in the year 2050. It is important to realize that there is uncertainty about these projections because they are for a relatively small area, and for a relatively distant future point in time.

Table 2.3.2-1 summarizes the existing and projected population in the study area. The 1990 figures are from the U.S. Census. The future estimates are based on “medium” (there are also “high” and “low” estimates) projections of the Bureau of Economic and Business Research, University of Florida, State of Florida (BEBR) through 2020 (as far into the future as they go), extrapolated to 2050 based on rates of growth exhibited by projections available from the Bureau of Economic Analysis (BEA), U.S. Department of Commerce. The BEA projections used extend to 2040. The 2040-2050 rate of growth is based on an extension of the BEA rate from 2020 to 2040, the last two projection years for the BEA county level projections.

Table 2.3.2-1
STUDY AREA POPULATION ESTIMATES, 1990-2050

Population (1,000's)					
	Year				
Subregion/County	1990	2010	2015	2020	2050
Lower East Coast					
Palm Beach	864	1,271	1,374	1,477	1,661
Broward	1,256	1,660	1,758	1,855	2,043
Miami-Dade	1,937	2,778	3,024	3,095	3,286
Subtotal	4,057	5,709	6,156	6,427	6,990
Share of Study Area	64%	62%	62%	61%	61%
Florida Keys					
Monroe	78	100	105	110	126
Share of Study Area	1%	1%	1%	1%	1%
Big Cypress					
Collier	152	284	316	349	402
Hendry	26	39	42	44	49
Subtotal	178	323	358	393	451
Share of Study Area	3%	4%	4%	4%	4%
Caloosahatchee					
Lee	335	511	556	602	681
Glades	8	12	12	13	14
Charlotte	111	186	206	226	255
Subtotal	454	709	774	841	950
Share of Study Area	7%	8%	8%	8%	8%
Upper East Coast					
Martin	101	150	162	175	201
St. Lucie	150	241	265	289	328
Subtotal	251	391	427	464	529
Share of Study Area	4%	4%	4%	4%	5%
Kissimmee					
Highlands	68	103	111	120	134
Okeechobee	29	44	48	51	57
Osceola	108	218	246	274	308
Polk	405	544	578	611	669
Orange	678	1,021	1,110	1,200	1,336
Subtotal	1,288	1,930	2,093	2,256	2,504
Share of Study Area	20%	21%	21%	22%	22%
Grand Total	6,306	9,162	9,913	10,491	11,550
Share of Florida Total	49%	50%	51%	50%	50%
Florida Total	12,938	18,252	19,599	20,778	22,889
Share of U.S.	5%	6%	7%	7%	8%

Table 2.3.2-2
STUDY AREA POPULATION RATES OF GROWTH
1990-2050

	Average (% Per Year) Population Growth			
Subregion/County	1990-2010	2010-2015	2015-2020	2020-2050
Lower East Coast				
Palm Beach	1.95%	1.57%	1.46%	0.39%
Broward	1.40%	1.15%	1.08%	0.32%
Miami-Dade	1.82%	1.71%	0.47%	0.20%
Subtotal	1.72%	1.52%	0.87%	0.28%
Florida Keys				
Monroe	1.25%	0.98%	0.93%	0.45%
Big Cypress				
Collier	3.17%	2.16%	2.01%	0.47%
Hendry	2.05%	1.49%	0.93%	0.36%
Subtotal	3.02%	2.08%	1.88%	0.46%
Caloosahatchee				
Lee	2.13%	1.70%	1.60%	0.41%
Glades	2.05%	0.00%	1.61%	0.25%
Charlotte	2.61%	2.06%	1.87%	0.40%
Subtotal	2.25%	1.77%	1.67%	0.41%
Upper East Coast				
Martin	2.00%	1.55%	1.56%	0.46%
St. Lucie	2.40%	1.92%	1.75%	0.42%
Subtotal	2.24%	1.78%	1.68%	0.44%
Kissimmee				
Highlands	2.10%	1.51%	1.57%	0.37%
Okeechobee	2.11%	1.76%	1.22%	0.37%
Osceola	3.57%	2.45%	2.18%	0.39%
Polk	1.49%	1.22%	1.12%	0.30%
Orange	2.07%	1.69%	1.57%	0.36%
Subtotal	2.04%	1.63%	1.51%	0.35%
Study Area Total	1.89%	1.59%	1.14%	0.32%
Florida Total	1.74%	1.43%	1.18%	0.32%

Table 2.3.2-3
STUDY AREA POPULATION GROWTH, 1990-2050
RANKED BY COUNTY

County/Area	% Change 1990-2050
Osceola	185.19%
Collier	164.47%
Charlotte	129.73%
St. Lucie	118.67%
Lee	103.28%
Martin	99.01%
Highlands	97.06%
Orange	97.05%
Okeechobee	96.55%
Palm Beach	92.25%
Hendry	88.46%
Study Area Total	83.16%
Florida Total	76.91%
Glades	75.00%
Dade	69.64%
Polk	65.19%
Broward	62.66%
Monroe	61.54%
U.S. Total	21.37%

The BEA and BEBR projections, which both contribute to the above projection estimates, are based on different methodologies and assumptions, and as a result, differ in projected growth. In general, the BEBR projections tend to reflect slightly higher growth than the BEA projections for South Florida. In the past, BEBR projections have been closer to actual growth in Florida, and consequently have been used for planning purposes in Corps of Engineers water resource planning studies in Florida. This represents a slight departure from the agency practice of using BEA projections for most feasibility studies and investigations. This practice insures that to the extent projections affect study conclusions, all such studies will have been done using a set of nationally consistent projections.

The small area projections made available by BEA are governed by national and state control totals. The use of BEBR projections instead of BEA projections only marginally affects study outcomes, at the same time making projections used in planning studies closer to the mark. The BEBR county level projections follow the same control total principle at the state level, as that which is used in the county level BEA projections, relative to national and state totals. The BEA county level projections used in this analysis are from "County Projections to 2040" (U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, Regional Economic Analysis Division, 1992).

The BEBR population projections used in this analysis, from the Florida Populations Studies, Projections of Florida Population by County, 1995-2020 (University of Florida, 1995), represent BEBR's medium range projections (low and high estimates are also developed in BEBR's population studies). In the case of Miami-Dade County, additional adjustments have been made reflecting growth closer to, but slightly below, the BEBR high range estimate. These higher growth trends reflect the anticipated impact of a 1994 United States agreement with Cuba permitting increased immigration from the island. These growth estimates have been made by the Miami-Dade County Planning Division, which has been carefully tracking ongoing growth and immigration trends for the county. It is possible that other counties' future growth will deviate from the set of population projections used in the Restudy. This can be especially so in the case of counties with relatively small populations, such as Hendry, Glades, Okeechobee, and Highlands, for example. Relevant adjustments to the recommended plan can be made as necessary in the future to the extent that underestimation or overestimation of population growth proves to have been the case.

Florida is the fourth most populated state in the nation, with a 1990 estimated 12.9 million total residents. Its past is marked by rapid post World War II growth, which accelerated Florida's share of the U.S. population from just under 2% in 1950 to just over 5% in 1990. This trend is expected to continue, although at a more modest rate, so that about 8% of the U.S. population will be in Florida by 2050. The resulting state population is expected to grow another 75% by 2050, reaching nearly 23 million by then. Growth rates for both the state and the C&SF counties have averaged close to three times the average annual percent growth rates for the U.S. as a whole during recent decades. Future growth rate differences are expected to diminish.

The LEC three-county area comprises about 9.5% of the state's land area but is home to 31% of Florida's population. Population growth is fueled by in-migration, as it continues to be both a leading location for retirement as well as a haven for refugees from such places as Cuba, Haiti, Nicaragua, and Guatemala. By contrast, the group of primarily agrarian counties bordering the shores of Lake Okeechobee (Glades, Highlands, Martin, Okeechobee, St. Lucie, and Hendry Counties, but excluding Palm Beach County), while similar in size to the LEC counties, comprise only about 6% of the study area's population. There is a similar comparison between the LEC subregion and all of the other subregions with the exception of the Kissimmee subregion, comprising just over 20% of Florida's population during the 1990-2050 time period. The Kissimmee subregion's relatively large share of the study area's population, though, is skewed by the inclusion of large urban areas that are actually outside of the study area and outside of the economic area of influence for this investigation, although their counties have been included as discussed earlier. Excluding these areas, the LEC accounts for about 80% of the study area population.

The population growth rate for the south Florida study area is expected to continue to exceed the national rate, but this trend is expected to lessen. By the year 2050, the population of the study area is estimated to still be about half of the State's population of 23 million people. Over 60% of this population is expected to inhabit the three southeast coast counties of Palm Beach, Broward, and Dade. To accommodate this growth, urban development likely will continue. Population growth over the 1990-2050 period is projected to exceed that for the State of Florida as a whole in all but four of the 16 study area counties, two of which (Broward and Dade) are in the LEC.

The following two tables outline the ethnic/racial distribution of the study area population, and the percentage of population over age 65 (1990 Census).

TABLE 2.3.2-4
RACIAL/ETHNIC POPULATION DISTRIBUTION

Area	Total	White	Black	American Indian Eskimo or Aleut	Asian or Pacific Islander	Other	Hispanic
U.S.	100%	84%	12%	0.8%	2.8%	0.2%	9.1%
Florida	100%	83%	14%	0.3%	1.2%	1.8%	12.2%
Study Area	100%	81%	15%	0.2%	1.2%	2.8%	20.5%
Subregion/County							
Lower East Coast							
Palm Beach	100%	85%	12%	0.1%	1.0%	1.5%	7.7%
Broward	100%	82%	15%	0.2%	1.4%	1.3%	8.6%
Dade	100%	73%	21%	0.2%	1.4%	5.0%	49.2%
Subregion	100%	78%	17%	0.2%	1.3%	3.1%	27.8%
Florida Keys							
Monroe	100%	92%	5%	0.3%	0.8%	1.4%	12.3%
Big Cypress							
Collier	100%	91%	5%	0.3%	0.4%	3.3%	13.6%
Hendry	100%	72%	27%	2.1%	0.4%	8.6%	22.3%
Subregion	100%	89%	8%	0.5%	0.4%	4.1%	14.9%
Caloosahatchee							
Lee	100%	91%	7%	0.2%	0.6%	1.2%	4.5%
Glades	100%	79%	12%	5.7%	0.2%	3.1%	8.0%
Charlotte	100%	95%	4%	0.1%	0.7%	0.3%	2.5%
Subregion	100%	92%	6%	0.3%	0.6%	1.1%	4.1%
Upper East Coast							
Martin	100%	92%	6%	0.2%	0.5%	2.0%	4.7%
St. Lucie	100%	81%	16%	0.2%	0.7%	1.3%	4.0%
Subregion	100%	86%	12%	0.2%	0.6%	1.6%	4.3%
Kissimmee							
Highlands	100%	87%	10%	0.3%	0.6%	1.8%	5.1%
Okeechobee	100%	84%	6%	0.5%	0.5%	8.3%	11.8%
Osceola	100%	89%	5%	0.3%	1.5%	3.3%	11.9%
Polk	100%	84%	13%	0.3%	0.6%	1.3%	4.1%
Orange	100%	80%	15%	0.3%	2.1%	2.8%	9.6%
Subregion	100%	82%	13%	0.3%	1.4%	2.5%	7.9%

Note: Hispanic = any race

Source: 1995 Florida Statistical Abstract , 1992 Statistical Abstract of The United States (1989 Data)

TABLE 2.3.2-5
STUDY AREA POPULATION OVER AGE 65

Area	Population Over 65
U.S.	12.7%
Florida	18.4%
Lower East Coast	
Palm Beach	24.0%
Broward	20.0%
Dade	14.0%
Florida Keys	
Monroe	17.8%
Big Cypress	
Collier	23.9%
Hendry	11.3%
Caloosahatchee	
Lee	25.1%
Glades	21.9%
Charlotte	36.1%
Upper East Coast	
Martin	28.3%
St. Lucie	22.1%
Kissimmee	
Highlands	34.5%
Okeechobee	17.2%
Osceola	14.4%
Polk	20.0%
Orange	10.8%

Source: 1995 Florida Statistical Abstract , 1992 Statistical Abstract of The United States (1989 Data)

The overall study area racial/ethnic population distribution is similar to that of the State as a whole except that the Hispanic population is significantly higher for the study area than for Florida (20% vs. 12%). Besides being more Hispanic than the State and Nation, the study area population's Hispanic proportion varies greatly by county and subregion (over 49% in Miami-Dade County, and over 27% for the LEC, and less than half the State percent share in most of the Caloosahatchee and Upper East Coast subregion counties, plus Polk County in the Kissimmee subregion). While the white-black distribution is similar for the study area and the State (15% and 14%, respectively), there exists striking variability in this distribution from county to county, and subregion to subregion (92% white in the Florida Keys and Caloosahatchee subregions, to 78% white in the LEC subregion; 95% white in Charlotte County to 72% white in Hendry County). The study area's Native American population as a percent of the total is similar to that for the State (.2% vs. .3%, respectively), both of which are below the percent share for the Nation

(.8%), although there are relatively very high concentrations of this group in the Hendry and Glades County populations (2.1% and 5.7%, respectively). Asian and Pacific Islander population tends to be below the share of the total for the State and Nation in the study area, with the exception of the LEC, where the distribution is similar to the State (1.3% vs. 1.2%, respectively), but below the national average of 3.0%.

There are significantly more people in the over 65 age category in Florida than in the rest of the country (18.4% vs. 12.7%). This trend is exemplified in most counties and subregions of the study area. Most counties and subregions are near, or way above even the Florida average percentage. Only two counties (Dade and Orange), have populations with less than the national average percentage over 65.

E.2.3.3 Economy

The 16-county study area had a 1990 per capita personal income about 8% above that for the State as a whole, while the LEC area (Palm Beach, Broward, and Dade Counties) is about 15% higher than the State's. Florida's per capital personal income is a little higher (less than 1% higher) than for the Nation. About half of the study area's counties have per capita incomes greater than either the State or the Nation. Slightly over half of Florida's employment and earnings takes place in the study area. Nearly two thirds of this is concentrated in the populous LEC three county area. Excluding the northernmost counties of Polk, Orange, and Osceola, which are technically part of the study area, but which realistically fall outside of the main focus of this study, the three-county LEC area accounts for about 80% of most of the statistics of aggregate socio-economic activity for the study area.

Employment and income in the south Florida study area have continued to grow in recent decades at rates about the same as for the State, and about half again faster than the national average. Growth has been significantly greater in the southwest counties and the Florida Keys (taken as a group--Monroe, Collier, Hendry, Lee, and Charlotte), and in the counties around Lake Okeechobee (Glades, Highlands, Martin, Okeechobee, and St. Lucie) than elsewhere in the study area.

As with many of the other socio-economic statistics, the percent of households by county below the poverty threshold varies considerably throughout the study area. Only the Upper East Coast subregion ranks better than both the State and the Nation in this category. All other subregions have some counties above, and some below, this measure of economic well-being, for the State and/or Nation. A majority of the counties in the study area fare better than this percentage for the State and Nation. Four of the 16 study area counties have a higher percentage of households below the poverty threshold than the Nation.

TABLE 2.3.3-1
PERCENT OF HOUSEHOLDS BELOW
POVERTY THRESHOLD

Area	Percent
United States	10.3%
Florida	9.0%
Lower East Coast	
Palm Beach	6.2%
Broward	7.1%
Dade	14.2%
Florida Keys	
Monroe	7.0%
Big Cypress	
Collier	6.4%
Hendry	15.3%
Caloosahatchee	
Lee	6.1%
Glades	9.7%
Charlotte	5.2%
Upper East Coast	
Martin	5.0%
St. Lucie	8.5%
Kissimmee	
Highlands	11.3%
Okeechobee	14.8%
Osceola	6.9%
Polk	9.4%
Orange	7.8%

Source: 1995 Florida Statistical Abstract , 1992 Statistical Abstract of The United States (1989 Data)

TABLE 2.3.3-2
PERCENT OF HOUSEHOLDS BELOW POVERTY THRESHOLD RANKED BY COUNTY

Area	Percent
Hendry	15.3%
Okeechobee	14.8%
Dade	14.2%
Highlands	11.3%
United States	10.3%
Glades	9.7%
Polk	9.4%
Florida	9.0%
St. Lucie	8.5%
Orange	7.8%
Broward	7.1%
Monroe	7.0%
Osceola	6.9%
Collier	6.4%
Palm Beach	6.2%
Lee	6.1%
Charlotte	5.2%
Martin	5.0%

Source: 1995 Florida Statistical Abstract, 1992 Statistical Abstract Of The United States (1989 Data)

The economy of south Florida is based on services, agriculture, and tourism. While manufacturing has not played a traditionally major role in the economy, this sector has experienced significant growth in recent years. The service industry is associated with the over 65 population which constitutes nearly one-fourth of the residents of Broward and Palm Beach Counties and fourteen percent of Dade's population. These individuals tend to have incomes independent of employment and require additional medical, financial, and household services. This relatively strong services part of the South Florida economy is reflected in percent of total employment and income in the services industry, which is consistently higher than for the State as a whole, which is in turn higher than for the Nation. The exception to this tendency is for those counties whose economic profiles reflect their heavy agricultural orientation, relative to other sectors. For example, in Hendry, Glades, Highlands, and Okeechobee counties, the relative share of farm earnings and employment is roughly 20 to 30 times what it is for the other counties, while the relative share of the services industry tends to be smaller for these counties.

Agricultural production in the region, excluding the Everglades Agricultural Area (EAA), is virtually all in winter vegetables, tropical fruits and vegetables, citrus and nursery crops. Florida is the national leader in citrus fruit production and the manufacture of processed citrus products, accounting for over 80% of the nation's citrus production. Florida is the world leader in the production of grapefruit, accounting for nearly a third of the world's annual supply, and ranks second to Brazil in the world production of oranges, accounting for almost one fifth of the world's supply. Florida produces 100% of the Nation's tangelos and over 95% of its limes. Florida also is the second ranking state in the production of fresh vegetables. South Florida shares significantly in this agricultural productivity. All but three of top thirteen Florida agricultural production counties, as measured by total cash receipts in 1991, are within the study area. And all but two of the study area's 16 counties are in the top half of Florida's counties, as ranked this way.

The EAA economy is based largely on agriculture, the primary focus for the economies of the area's towns of Clewiston, South Bay, Belle Glade, and Pahokee. Besides being the home towns of most of the permanent labor force, they support much of the agriculturally related supply and processing activities and are the headquarters of many of the agricultural enterprises. They also support the industry oriented to serving recreational use in the southern part of Lake Okeechobee. A seasonal influx of agricultural workers increases the population of towns in this area during the vegetable growing and harvesting seasons. This trend used to be more significant when sugar cane harvesting was largely a labor intensive activity. This activity is now mechanized.

Agriculture in the EAA relies on over 500,000 acres of rich muck soils irrigated, drained and under cultivation. On these acres are produced sugarcane, vegetables, sod and rice. Farm employment in the EAA is very seasonal because of the seasonal nature of crop production and harvest activity, although somewhat less so now that sugar cane is mechanically harvested. Year round farm employment is about 4,000 full time employees.

While the vegetables are packed and shipped fresh and are not subject to extensive processing, sugar cane is locally processed which adds considerably to its value and the local output of the industry. Six sugar mills in the EAA process all the cane produced in south Florida, both inside and outside the EAA. All sugar cane is grown under contract for processing at these mills. The mills produce raw sugar, molasses and other by-products. A portion of the raw sugar receives further processing at the sugar refineries located in the EAA. A large portion of the raw sugar is processed outside of Florida.

One of the areas of direct economic impact of the implementation of alternative plans covered in this report is the EAA, where thousands of acres of water storage areas requiring land acquisition would be located, as a part of Comprehensive Plan alternatives. Economic statistics dramatically reveal the especially strong agricultural orientation of the economies of the rural counties bordering Lake Okeechobee. While the majority of the EAA is in western Palm Beach County, it is part of this larger agricultural region. Farm earnings as a percent of total earnings for these counties ranges from 3.3% to 47.2% (3.3% for Palm Beach, 35.2% for Hendry, 47.2% for Glades, 17.9% for Highlands, 16.6% for Okeechobee, 7.6% for St. Lucie, and 8.3% for Martin). By comparison, farm earnings for the United States is only 1.5% of total earnings, and for the State of Florida this figure is 2%. The story is similar for farm employment for these counties. In stark contrast, the economic profiles of Broward and Dade Counties include farm earnings and employment percent shares of totals for these counties far below the State and national averages (less than 1%).

There are also strong per capita income differences between the urbanized LEC and the agricultural areas. Compared to the state and the nation, the LEC counties have larger per capita incomes, while the agricultural counties bordering Lake Okeechobee (with the exceptions of Martin and Palm Beach) have lower per capita incomes.

In the Everglades National Park (ENP) area, small scale agricultural activities existed historically. Much of the marginal land was abandoned from the 1940s to the 1960s, and all agriculture had ceased by 1975. Prior to the official creation of the park in 1947, there existed some small scale lumbering and logging, hunting and fishing. The park's land use activities have been directed at preservation of the natural environment. Some low impact human activities are allowed, involving education, research, and recreation. These activities are the basis for ENP's contribution to the Florida economy.

The economic activity of the Florida Keys/Florida Bay area is somewhat indicated by its land use patterns, which illustrate a predominance of residential activities oriented toward the water and commercial activities along the main (and only) highway. Primary activities in the Monroe County-Florida Keys area are tourism and fishing. Both are related to some extent to conditions in Florida Bay. There has been growing concern that conditions in Florida Bay are worsening. Many observers feel that these changes have been related to decreases in freshwater inflow from the Florida mainland (the Everglades), due at least in part to C&SF Project drainage and flood control features constructed in recent decades.

The relationship between tourism and fishing and the environmental health and vitality of Florida Bay is fairly obvious. These are mainstays of the Monroe County/Florida Keys economy, as reflected by the relative domination of economic activity there in the following sectors: services; retail trade; and fisheries ("agricultural services, forestries, fisheries & other"). Monroe County plays a strong role in Florida's well-developed commercial fishing industry, accounting for about 20% of the State's total in recent years. Shrimp has historically been the most valuable species caught, accounting for over 40% of total sales in the state. There is concern that recent precipitous declines in commercial fish landings in conjunction with degrading conditions in Florida Bay are causally related to these changes, and that continuation of these trends will result in even more fishery declines. Earnings in the economic sector which includes commercial fishing account for nearly 4% of Monroe County earnings, a dramatically higher share than for the U.S., and also significantly higher relatively than for the state overall. Employment in this sector accounts for over 8% of total employment in the county, with similar relative comparisons to the state and nation.

Since 1986, commercial fishing employment has declined by about 10%, with larger declines (50%) in real personal income (i.e., after adjusting to remove the effects of inflation). Much of this drop in fishing activity is in the harvesting of pink shrimp. Some of the decline is likely related to recession, international competition in the shrimp business, and perhaps other causes besides degrading environmental conditions in the bay. But during this period, there have been observations of significant environmental degradation. Estimated total losses in the Monroe County economy over the eight year period from 1986 to 1994 have amounted to about 1% of employment and 2% of personal income.

TABLE 2.3.3-3
STUDY AREA EMPLOYMENT
1990, 2010

Area	Civilian Nonagricultural Employment		Total Employed Persons		Civilian Unemployment Rate (%)	
	1990	2010	1990	2010	1990	2010
Florida	5,387.4	8,355.5	6,068.3	8,630.9	5.9%	5.9%
Lower East Coast						
Palm Beach	359.8	577.0	399.8	595.5	6.6%	7.8%
Broward	514.3	796.2	625.6	860.7	5.5%	6.0%
Dade	880.5	1,146.2	942.6	1,164.6	7.0%	8.5%
Subregion	1,754.6	2,519.4	1,968.0	2,620.8		
Subregion % of FL	32.6%	30.2%	32.4%	30.4%		
Florida Keys						
Monroe	31.0	46.3	39.7	51.4	3.3%	3.1%
Subregion % of FL	0.6%	0.6%	0.7%	0.6%		
Big Cypress						
Collier	63.1	123.9	69.0	127.3	5.6%	6.8%
Hendry	6.1	10.3	11.2	17.4	11.2%	14.7%
Subregion	69.2	134.2	80.2	144.7		
Subregion % of FL	1.3%	1.6%	1.3%	1.7%		
Caloosahatchee						
Lee	126.7	148.2	222.1	240.6	4.3%	4.4%
Glades	0.7	1.4	2.9	4.2	8.8%	10.9%
Charlotte	27.9	53.5	39.5	66.3	5.0%	4.9%
Subregion	155.3	203.1	264.5	311.1		
Subregion % of FL	2.9%	2.4%	4.4%	3.6%		
Upper East Coast						
Martin	38.2	61.5	41.9	59.5	6.6%	8.3%
St. Lucie	41.4	66.9	62.6	94.1	11.5%	14.2%
Subregion	79.6	128.4	104.5	153.6		
Subregion % of FL	1.5%	1.5%	1.7%	1.8%		
Kissimmee						
Highlands	17.9	28.0	23.4	32.9	8.1%	10.2%
Okeechobee	6.3	10.7	12.5	17.9	8.1%	11.1%
Osceola	37.0	79.5	55.8	109.3	4.9%	4.5%
Polk	154.5	209.3	180.2	240.2	8.9%	7.7%
Orange	438.8	774.3	369.2	577.2	5.5%	4.4%
Subregion	654.5	1,101.8	641.1	977.5		
Subregion % of FL	12.1%	13.2%	10.6%	11.3%		
Study Area	2,744.2	4,133.2	3,098.0	4,259.1		
Study Area % of FL	50.9%	49.5%	51.1%	49.3%		

Source: The Florida Long-Term Economic Forecast 1977, Volume 2 – State & Counties, University of Florida, Bureau of Economic and Business Research.

TABLE 2.3.3-4
STUDY AREA REAL PER CAPITA INCOME
1990, 2010

Area	Real Per Capita Income		Relative to State of Florida	
	1990	2010	1990	2010
Florida	$20,236	$25,909	100%	100%
Lower East Coast				
Palm Beach	$31,354	$42,408	155%	164%
Broward	$23,987	$28,846	119%	111%
Dade	$18,977	$23,610	94%	91%
Florida Keys				
Monroe	$22,979	$32,218	114%	124%
Big Cypress				
Collier	$29,313	$36,358	145%	140%
Hendry	$16,217	$20,153	80%	78%
Caloosahatchee				
Lee	$20,920	$26,035	103%	100%
Glades	$13,160	$17,259	65%	67%
Charlotte	$18,647	$23,441	92%	90%
Upper East Coast				
Martin	$30,695	$39,803	152%	154%
St. Lucie	$16,179	$19,680	80%	76%
Kissimmee				
Highlands	$16,628	$19,349	82%	75%
Okeechobee	$13,847	$16,873	68%	65%
Osceola	$15,565	$17,905	77%	69%
Polk	$16,443	$20,520	81%	79%
Orange	$19,096	$23,757	94%	92%

Source: The Florida Long-Term Economic Forecast 1977, Volume 2 – State & Counties, University of Florida, Bureau of Economic and Business Research.

TABLE 2.3.3-5
AVERAGE ANNUAL PERCENT CHANGE
1990-2010

Area	Civilian Nonagricultural Employment	Total Employed Persons	Real Per Capita Income
Florida	2.22%	1.78%	1.24%
Lower East Coast			
Palm Beach	2.39%	2.01%	1.52%
Broward	2.21%	1.61%	0.93%
Dade	1.33%	1.06%	1.10%
Subregion	1.83%	1.44%	
Florida Keys			
Monroe	2.03%	1.30%	1.70%
Big Cypress			
Collier	3.43%	3.11%	1.08%
Hendry	2.65%	2.23%	1.09%
Subregion	3.37%	2.99%	
Caloosahatchee			
Lee	0.79%	0.40%	1.10%
Glades	3.53%	1.87%	1.36%
Charlotte	3.31%	2.62%	1.15%
Subregion	1.35%	0.81%	
Upper East Coast			
Martin	2.41%	1.77%	1.31%
St. Lucie	2.43%	2.06%	0.98%
Subregion	2.42%	1.94%	
Kissimmee			
Highlands	2.26%	1.72%	0.76%
Okeechobee	2.68%	1.81%	0.99%
Osceola	3.90%	3.42%	0.70%
Polk	1.53%	1.45%	1.11%
Orange	2.88%	2.26%	1.10%
Subregion	2.64%	2.13%	
Study Area	2.07%	1.60%	

Source: The Florida Long-Term Economic Forecast 1997, Volume 2 – State & Counties, University of Florida, Bureau of Economic and Business Research.

E.3 MUNICIPAL & INDUSTRIAL WATER DEMAND

E.3.1 OVERVIEW

Two projections of future water consumption for the year 2050 have been made for the Lower East Coast study area. The two scenarios differ in terms of the assumed level of water use conservation. The higher estimate, Projection A, is based on the same percentage distribution and usage of conservation flow devices and irrigation restrictions in effect in 2050 as in 1990. The lower estimate, Projection B, is based on the full implementation of existing federal, state, and South Florida Water Management District mandatory regulations and programs. This lower bound projection scenario represents 100% use and effectiveness of ultra-flow devices by the year 2050.

The higher Projection A estimate for the year 2050 is about 1450 MGD. The lower Projection B estimate is about 1200 MGD, approximately 18% less than Projection A. In this study, the 2050 base condition (the “without-plan” condition) assumes a more moderate application of conservation practices and effectiveness, representing a level of consumption about 12% below the 2050 Projection A estimate.

The principal analytical tool being used to evaluate the alternative plans being considered in this study is the South Florida Water Management Model (SFWMM). This model simulates changes in South Florida hydrology which would result from these alternatives, represented by structural and operational modifications to the Central & Southern Florida Project (C&SF) Project. It simulates a 31 year period of hydrometeorological conditions, using historical data for the 1965-1995 period, to represent a broad range of potential conditions which could be expected to take place over the long run. The outputs of these simulations are used to measure the effects of alternatives being considered in this study.

A major part of the evaluation of alternatives consists of comparing SFWMM output associated *with* a particular alternative in place, with SFWMM output representing conditions *without* the alternative. This comparison of “with-plan” vs. “without-plan” conditions is made for projected conditions for the year 2050. These conditions include an assumed level of water use that is representative of population and economic conditions estimated to exist in 2050.

A key input to this analysis is the estimated water use requirement of the population and economy, in the area covered by the SFWMM, in the year 2050. The SFWMM simulation process estimates as output the demands of this area for agricultural irrigation and for the water management requirements of the C&SF project (salinity control, flood control, etc.). But the municipal and industrial (M&I) demand is required input for running the SFWMM. The 2050 projected M&I water use demands by the residential, commercial, industrial, and public administration sectors of the water using population and economy have been estimated using the IWR-MAIN Water Use Forecasting System.

The basis for the M&I projections used in this study is a water use demand forecast which was prepared under contract for the Jacksonville District, Corps of Engineers, by Gulf Engineers & Consultants, Inc., Baton Rouge, Louisiana (GEC), for specific sub-areas of the SFWMM coverage area. The sub-areas for which these projections are being used in the C&SF evaluations, referred to as Service Areas 1, 2, and 3 (SA1, SA2, and SA3), and the northern Palm Beach County service area, comprise what is widely referred to as the Lower East Coast (LEC), which consists of the populated developed portions of Palm Beach, Broward, and Dade Counties along Florida's southeast Atlantic coast. The 2050 IWR-MAIN demand forecast for these large areas was then converted into specific well withdrawal volumes, conforming to input data format required by the SFWMM.

The northern Palm Beach County service area and SA1 coincide roughly with the eastern developed portion of Palm Beach County, but includes a small portion of northern Broward County. SA2 consists of the rest of Broward County, plus a small portion of northern Miami-Dade County. The demands for SA3, consisting of the remainder of Miami-Dade County, include water demands of the Florida Keys (Monroe County), since water for this area is supplied from SA3 well fields.

E.3.2 SUMMARY OF 2050 M&I DEMANDS BY SERVICE AREA

The Projection A average daily M&I demand for water use in the year 2050 is summarized in ***Table 3.2-1***. The table shows that water use is fairly evenly distributed among the LEC Counties. The Service Areas which coincide mainly with the developed portion of Palm Beach County account for 31 percent of total forecast M&I use, with about 29 percent in Service Area 2, which roughly coincides with Broward County. Service Area 3 use, representing demand in most of Miami-Dade County and the Florida Keys (Monroe County), is somewhat higher in terms of its share of the total.

These 2050 Projection A estimates reflect a level of conservation practices that is the same as estimated to be in place in 1990. That is, the same percentage distribution of the use of restrictive flow devices among all uses in place in 1990 is assumed to be in place for the 2050 usage, and therefore probably can be viewed safely as an upper bound forecast estimate.

TABLE 3.2-1
SUMMARY OF 2050 M&I DEMANDS BY SERVICE AREA – PROJECTION A

Service Area	M&I Demands (MGD)	Percent of Total
Northern Palm Beach County	101.25	7
SA1	349.20	24
SA2	422.24	29
SA3	577.00	40
Total	**1449.69**	**100**

Another set of forecast use estimates, representing 100% use of ultra-flow restrictive devices in place for all consumers by 2050, was also made. The 2050 summary results of this conservation Projection B scenario, which can be viewed as a lower bound forecast estimate, are shown in ***Table 3.2-1***. These conservation projections represent continued implementation of the mandatory federal, state, and SFWMD requirements and programs.

TABLE 3.2-2
SUMMARY OF 2050 M&I DEMANDS BY SERVICE AREA
CONSERVATION PROJECTION B

Area	M&I Demands (MGD)	Percent Reduction *
Northern Palm Beach County	83.66	17.37
SA1	294.18	15.76
SA2	345.72	18.12
SA3	474.80	17.71
Total	**1198.36**	**17.34**

*-From Projection A

The IWR-MAIN forecasts have been categorized by residential, commercial, industrial, public administration, and unaccounted for uses. The percentage breakdown in ***Table 3.2-3*** provides a profile of these uses in the study area for 2050 for Projection A. As the tabulation shows, this profile is generally similar throughout the study area, although residential use is more heavily weighted in southern areas.

TABLE 3.2-3
DISTRIBUTION OF 2050 DEMAND
BY END USE AND BY SERVICE AREA, PROJECTION A

End Use	Northern P. B. County	SA1	SA2	SA3	Total
Residential	47%	49%	56%	58%	54%
Commercial & Industrial	36%	37%	28%	22%	29%
Public & Other	17%	14%	16%	20%	17%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

The demand projections made using IWR-MAIN are made by large areas because the projections are driven by economic and demographic projections, which have been made at the county-wide level. But the SFWMM input requires that the demand input be in the form of well withdrawals, by month, in MGD, spatially identified by grid-cell location, using the SFWMM matrix of 4 square mile (2 mi. x 2 mi.) cells. This information has been developed for existing well pumpages. The conversion of the above projected service area water use into grid-cell based well withdrawal data has been developed using known existing well field locations, and the likelihood of future locations and operations.

The SFWMM runs that are being used for the C&SF Comprehensive Review Study include scenarios for the years 1995 and 2050, and represent both public and private wells. The well withdrawals being used for the 1995 scenario are based on existing known withdrawals, amounting to a total of 803.6 MGD, and represent part (but not all) of the total demand/use in 1995 for the projection area. Excluded are golf course and commercial landscape irrigation (estimated by the SFWMM simulation as a part of the evapotranspiration simulation calculations), deep well withdrawals from the brackish Floridan aquifer, and some other uses which are not consumptive. For example, water is used in rock mining operations, but it is returned immediately after use (consisting mainly of washing rock cuttings), and therefore such use is not really a consumptive use. Instead, it is more representative of moving water from one place to another in the system. Floridan aquifer withdrawals do not represent a withdrawal from the water system modeled by the SFWMM and are outside of the Everglades system.

E.3.3 DEMAND FORECAST METHODOLOGY & PROCEDURES

E.3.3.1 About IWR-MAIN

E.3.3.1.1 Theoretical Basis

Perhaps the simplest approach for predicting future water use is the use of projected gross per capita water use rates and projected population. Gross per capita use can be observed from known water consumption and known population. Projections can be made for different population growth scenarios combined with varying assumptions about future changes in the capita use. such a simplified approach has been found to be inadequate for Corps planning studies and was not used in this study.

IWR-MAIN (Version 6.1), a PC-based software tool used to make projections for water use in this study, is based on observed relationships between water use and causal factors, or determinants, of urban demand for water. Causal relationships have been developed separately for residential and non-residential use. Forecasting relationships used in IWR-MAIN for the residential sector are based on the integration of approximately 60 studies of residential water demand, which contained about 200 empirically estimated water use equations.

For the residential sector, the generalized form of the equation for projected average use is (IWR-MAIN User's Manual and System Description, April 1995, p. D-2):

$$Q = a \; I^{d1} \; MP^{d2} \; e^{(FC)(d3)} \; H^{d4} \; HD^{d5} \; T^{d6} \; R^{d7}$$

where

Q	=	predicted water use in gallons per day
I	=	median household income ($1,000's)
MP	=	effective marginal price ($/1,000 gal)
e	=	base of the natural logarithm
FC	=	fixed charge ($)
H	=	mean household size (persons/household)
HD	=	housing density
T	=	maximum-day temperature (degrees F)
R	=	total seasonal rainfall (inches)
a	=	intercept in gallons/day
d1...d7	=	elasticity values for each independent or explanatory variable

The above relationship can be approximated for any residential subsector, season, purpose (e.g., indoor, outdoor), depending on data availability.

Elasticity is a measure of the relationship between water use and a given explanatory or independent variable. For example, an income elasticity of +0.5 would indicate that a one percent increase in income would result in a .5 percent increase in water use. Some representative sample default elasticities contained in IWR-MAIN are outlined in the ***Table 3.3.1.1-1***.

Table 3.3.1.1-1
Representative Default Elasticities for Residential Water Use Contained in IWR-MAIN

Explanatory Variable	Single Family Summer	Multi-Family Summer
Income	+0.4000	+0.4000
Persons per Household	+0.4000	+0.4000
Housing Density	-0.6500	-0.3000
Marginal Price	-0.2500	-0.1500
Fixed Charge	-0.0015	-0.0010
Maximum-Daily Temperature	+1.5000	+1.2000
Total Rainfall	-0.2500	-0.1000

Forecasting relationships used in IWR-MAIN for the nonresidential sector are based on over 10 years of research on the relationship between employment and water use in over 7,000 establishments representing the eight major industry groups throughout the United States. For the non-residential sector, the generalized form of the equation for projecting water use is:

$$Q = a \; PR^{d1} \; MP^{d2} \; CDD^{d3} \; OTH^{d4}$$

where

Q = water use in gallons/employee/day
PR = labor productivity
MP = marginal price ($/1,000 gal)
CDD = cooling degree days (number of days)
OTH = other (user added)
a = model intercept (gallons/employee/day)
d1...d4 = elasticities for independent/explanatory variables

The above relationship is designed to be approximated by Standard Industrial Classification (SIC) group. While this model is operational within the IWR-MAIN model, the elasticities for all of the explanatory and independent variables are currently set to zero, since there are currently no available elasticities for them. As a result, this version of IWR-MAIN uses a single coefficient equation to calculate water use by industry group for nonresidential use:

$$Q = GED * E$$

where

Q	=	water use in gallons per day
GED	=	gallons per employee per day
E	=	number of employees

E.3.3.1.2 History

The IWR-MAIN system has its origins in work during the 1960's by researchers conducting investigations with the Residential and Commercial Water Use Research Projects at Johns Hopkins University, and for the U.S. Office of Water Resources Research. The original system was called MAIN, which was followed by improvements in MAIN II. These early analytical tools were based on research by Howe and Linaweaver (1967); Wolff, et. al.; and other researchers. The initial system was developed by Hittman Associates, Inc., in the late 1960's.

The U.S. Army Corps of Engineers Institute for Water Resources improved upon the MAIN system, renaming it the IWR-MAIN Water Use Forecasting System, and modifying the model during the 1980's. Ultimately a PC version was created, and new use coefficients and computation techniques were incorporated into the new model based on newly available data and research literature. Improvements continue to be made and are the basis for new updated versions when they are documented and become available for distribution and use.

Current IWR-MAIN development is being accomplished by Planning and Management Consultants, Ltd. (PMCL), of Carbondale, Illinois, under the sponsorship of the Institute for Water Resources, U.S. Army Corps of Engineers; Metropolitan Water District of Southern California; Phoenix Water Services Department; and Illinois Department of Transportation.

IWR-MAIN has been used for forecast studies for a number of major water utilities in the U.S.. Some of these are: Indianapolis Water Company; Phoenix Water and Wastewater Department; Metropolitan Water District of Southern California; El Paso Water Utility; Binghamton, New York; Springfield City Water, Light, and Power; Southwest Florida Water Management District; Las Vegas Valley Water District; and the City of San Diego Water Utilities Department.

E.3.3.2 Data Collection and Model Calibration

Before the water demand forecasting projections can be made, the important steps of utility data collection, and calibration and verification of the IWR-MAIN model must be made.

E.3.3.2.1 Utility Data Collection

Data were collected for 1990 and 1994 from utilities in Palm Beach County (representing approximately 53% of total water use in the county), Broward County (54% of total county water use), and Miami-Dade County (91% of total county water use). Data collection was accomplished with a field survey to obtain the following water data requirements of IWR-MAIN:

- Number of accounts billed monthly by user category
- Quantity of water sold monthly by user category
- Water production by month
- Water and wastewater prices in effect
- Monthly water use for the largest customers
- Water conservation measures in effect

The utility companies in the data collection sample provided detailed data for a large portion of the water usage within the study area, covering a wide area, and including different types of development. For example, data coverage includes areas with high seasonal variations, such as resort areas along the Atlantic coast, highly developed urban and suburban areas, and rural communities. There was a high degree of cooperation on the part of the utility companies in this data collection effort.

E.3.3.2.2 Calibration and Verification of IWR-MAIN Model

E.3.3.2.2.1. Summary

The final result of the calibration and adjustment procedures resulted in a model-produced 1990 estimate for this water demand forecast study area, 913.05 MGD, that is within 2.4 percent of the actual use for that year, 935.52 MGD (U.S. Geological Survey).

IWR-MAIN estimates *demand* (not supply source), and therefore, as shown in ***Table 3.3.2.2.1-1***, the sector breakdown for the IWR-MAIN estimates is categorized by use. The USGS estimates given in ***Table 3.3.2.2.1-2*** are in terms of slightly different use categories, and partly also by supply (i.e., self-supplied vs. utility-supplied). Although the individual breakdown categories may not be completely comparable, the overall totals are. The USGS and IWR-MAIN totals are comparable because *they both represent estimates of total use*, even though the category breakdown formats are different.

Table 3.3.2.2.1-1
Summary of IWR-MAIN Estimated 1990 Water Use For Service Areas Comprising Palm Beach, Broward, and Dade Counties (MGD)**

	Service Area					
Sector	**Northern P. B. County**	**Western P. B. County*** **	**SA1**	**SA2**	**SA3**	**Total***
Residential	23.86	3.20	87.66	150.20	187.79	452.71
Commercial & Industrial	23.64	4.41	86.60	92.45	105.04	312.14
Public & Other	8.43	1.76	30.95	32.82	74.23	148.19
Total	**55.93**	**9.37**	**205.21**	**275.47**	**367.07**	**913.05**

* Totals may not add due to rounding.
** Miami-Dade County demand includes Florida Keys (Monroe County); the Keys are supplied from Miami-Dade County well fields.
*** Western Palm Beach County M&I demand, representing 1% of the total, is not included in the SFWMM calculations.

A good choice for a base year for use in creating an IWR-MAIN forecast is a census year because of abundant socio-economic data availability for model calibration. Hence, 1990, a census year, was chosen to be the base year. The fact that 1990 was a dry year with some mandated water use cutbacks, and the fact that the verification backcast year, 1994, was a wet year without such cutbacks (but with lower irrigation demands), combined to test the predictive capability of the model. As discussed below, the 1990-calibrated model turned out to be a relatively good predictor of 1994 demand. This was due in part to the fact that 1990 and 1994 weather variables, which would be expected to account for some of the variation between the two dissimilar years' consumption patterns, were used to estimate use in 1990 and 1994 in the calibration and verification procedures, respectively. Long term projections through to the 2050 planning horizon used long term average weather variables.

Table 3.3.2.2.1-2
USGS 1990 COUNTY Water Use Estimates*
(MGD)

Use Category	Palm Beach	Broward	Dade**	Total
Public Supply Domestic	112.80	132.25	212.36	457.41
Public Supply Commercial	22.52	28.14	44.33	94.99
Public Supply Industrial	9.59	15.45	30.00	55.04
Public Other	3.24	2.25	6.51	12.00
Public Use	16.47	14.44	32.42	63.33
Public Subtotal	164.62	192.53	325.62	682.77
Self Supply Domestic	21.34	9.60	10.75	41.69
Self Supply Comm/Indust.	32.17	1.63	40.34	74.14
Self Supply Subtotal	53.51	11.23	51.09	115.83
Golf Courses	44.39	21.31	10.39	76.09
Thermoelectric	0.00	0.05	2.26	2.31
Other Irrigation (Comm)	15.61	25.49	17.39	58.49
Total	**278.16**	**250.61**	**406.75**	**935.52**

* Data are from Water Withdrawals, Use, Consumption, and Trends in Florida, 1990, USGS Water Resources Investigations Report 92-4140, and unpublished USGS data.
** Miami-Dade County demand includes Florida Keys (Monroe County); the Keys are supplied from Miami-Dade County well fields.

E.3.3.2.2.2. Residential

Data collected from the utilities surveyed were entered into the IWR-MAIN system, and 1990 use quantities were estimated by the system for the sampled utility service areas. Initial test runs proved that the model estimates are closer to the utility service area estimates when summer elasticity values are used year round. The elasticity values were adjusted appropriately. The calibration procedure involves adjusting the coefficient (intercept) so that the model will estimate the actual water use for 1990.

The next step was to use this calibrated model to estimate 1994 use for the same utility service areas, as a test of model effectiveness. For the sampled utilities for which this initial model was constructed, the overall average residential MGD use predicted by the model was six percent below actual use for the 1994 verification. This differential varied by residential subsector and by season. For such small areas, it is highly unlikely that the IWR-MAIN equations will predict values that are identical to actual values in a verification procedure such as this one for 1994 with a model reflecting 1990 conditions. As a rule of thumb, according to IWR-MAIN procedural guidance, differences in the three to five percent range indicate good performance; differences exceeding 10 percent usually mean further calibration is needed. The 6 percent difference in the verification procedure was deemed to be reasonable, and certainly well below the 10% difference threshold suggesting further calibration.

Additional calibrations were made to reflect residential water use patterns in areas within the SFWMM study area, but outside of the utility service areas whose sampled data was used in the initial calibration. Such calibrations were intended to reflect differences in unaccounted for losses, pumpage vs. treatment quantity differences, and per housing unit water consumption patterns. County-wide 1990 USGS data were used for these additional calibration adjustments. These adjustments helped to make the overall calibration much closer, and enabled extrapolation of water use estimates to the rest of the county areas.

E.3.3.2.2.3. Nonresidential

The nonresidential sector includes commercial, industrial, and public administration use. Model estimation is simply a matter of employment combined with per employee average water use coefficients. These use coefficients exist in the model for the eight major industry groups, and by further more detailed breakdown into employment industry subgroups at the 2- and 3-digit SIC code level. There are 432 such categories of nonresidential water use per employee coefficients available within the version of IWR-MAIN used in this analysis (the most recent available at the time).

A test using Miami-Dade County employment data and nonresidential water use for 1990 was conducted to determine the best SIC level for predicting nonresidential water use. The 3-digit SIC code employment and water use coefficients came closest. While there are no reliable employment projections at the 3-digit SIC code level, the 3-digit water use coefficients were calibrated to reflect the 3-digit code employment mix within each major group in each county, using 1990 data. This calibration produced adequate estimates for 1990 except for Palm Beach County, which required additional adjustments to account for high water use for golf courses, parks, and sports facilities.

E.3.3.2.2.4. Adjusting County Estimates to SFWMM Service Area Boundaries

The economic demand models within IWR-MAIN are driven by independent demographic and economic variables that must be specified for the base year of the forecast (1990) to reflect conditions within the study area. Criteria for selection of a base year are that data must be available for both actual water use, and for the economic and demographic independent variables to be used in the forecast. Most of the required demographic and economic input variables are available from the census, making the latest census year a good choice for a base year. Census employment data is by residence and IWR-MAIN requires employment data by place of work; consequently, other data sources were used for employment.

The SFWMM service area boundaries do not coincide with county boundaries, which required manipulation of the data. This was accomplished by overlaying SFWMM service area maps onto census maps to determine which census block groups and which portions of census block groups fall into each service area. To estimate the portion of each census area included within each service area, census TIGER (Topologically Integrated Geographic Encoding and Referencing system and database developed at the Census Bureau) files were used to develop maps, broken down by block group boundaries, of the counties within the study area. The SFWMM service area boundaries were overlaid onto these maps, allowing land area portions within each block group located within each service area to be identified. For the urbanized developed areas, population and housing data for block groups that straddle service area boundaries were estimated to be in proportion to the area breakdown between different service areas. For the less populated areas, data for block groups bisected by service area boundaries were apportioned in accordance with locations of communities known to be population centers. This was necessary because in such areas it is significantly unlikely that population would be proportional to area. For example, 10 percent of the area of a rural census block group could contain nearly 100% of the population.

For employment, 1990 county estimates were taken from The Florida Long-Term Economic Forecast, Volume 2, State and Local Counties (University of Florida, Bureau of Economic and Business Research, 1995). It should be recognized that this represents a departure from the data presented in the previous section of this appendix. This is due to the fact that at the time the water projections were prepared, the more recent data shown in the previous section were not yet available. The county level data were adjusted to represent SFWMM service area boundaries using the percent of population estimated for each service area at the block group level as a proxy for the employment percentage distribution. Housing types for population in each area were estimated based on known categories from water use data collected from utilities. Household income and persons per household data were based on census county-level data.

E.3.3.3 Projection of Use Estimates to the Year 2050

E.3.3.3.1 Background

The next step was to use the model to estimate water use to the year 2050, using economic and demographic projections. The 2050 use estimate is necessary input for the planning evaluations being used to compare alternatives, which are based to a great extent on SFWMM simulation calculations representing estimated conditions, including M&I water use, in 2050. M&I water use affects plan formulation and recommendations, because of the relationship between M&I water use and the other water needs of South Florida. These effects are incorporated into the SFWMM simulation procedures and calculations, and are reflected in SFWMM output.

As explained previously, the 2050 use estimate is the only *forecast* estimate actually used as input in the SFWMM simulation runs. The simulations which use 1995 M&I demand as input are based on USGS estimates of *actual* use. The 2050 forecast estimate is part of an IWR-MAIN set of projections that include use estimates from the present through 2050. Two sets of projections were made: a high projection (Projection A) based on levels of conservation in 2050 that are the same as now (i.e., no change in intensity of conservation); and a conservation projection scenario (Projection B) based on full implementation of existing federal, state, and SFWMD programs and requirements..

E.3.3.3.2 Projection A

The Projection A demands for selected years are outlined in ***Table 3.3.3.2-1***.

Table 3.3.3.2-1
Projection A – Average Forecast Estimated Total Use
For Indicated Year (MGD)

Service Area	1995	2000	2010	2030	2050
Northern P. B. County	62.02	72.44	88.56	96.39	101.25
SA1	216.02	251.66	306.45	332.82	349.20
SA2	294.99	328.86	380.19	407.13	422.24
SA3	367.36	424.28	511.43	562.82	577.00
Total	**940.49**	**1077.24**	**1286.63**	**1399.16**	**1449.69**

As discussed previously, the IWR-MAIN model verification procedure revealed that for the sampled utilities, the 1994 average residential use as predicted by the model was about 6% below actual use, considered to be reasonable. USGS estimates available for 1995 total actual use, when compared with 1995 model projections for the entire area, differ similarly. The model estimated projection for the 4 service areas, 940.49 MGD, is about 6% below USGS actual use data for 1995, just over 1,002 MGD, for the three county area. Considering that about 1% of the three county area (Western Palm Beach County) use is not included within the projection area boundaries, the model estimate is closer to 5% below actual use.

USGS 1995 actual use estimate data for the three county area is shown in ***Table 3.3.3.2-2***.

In the Projection A estimates, the only increases in use efficiency are due to the effect of the increasing block rate structure used by most utilities (higher price per additional units of water used). Projected future water consumption patterns also change because of changes in the socio-economic profile (employment mix, housing, income, etc.).

Table 3.3.3.2-2
USGS 1995 county Water Use Estimates* (MGD)

Use Category	Palm Beach	Broward	Dade **	Total
Public Supply Domestic	124.85	144.57	245.76	515.18
Public Supply Commercial	28.88	38.56	60.68	128.12
Public Supply Industrial	5.12	6.54	11.93	23.59
Public Other	2.99	2.84	4.24	10.07
Public Use	25.04	29.79	49.92	104.75
Public Subtotal	186.88	222.30	372.53	781.71
Self Supply Domestic	17.19	2.16	12.71	32.06
Self Supply Comm/Indust.	22.95	0.34	43.38	66.67
Self-Supply Subtotal	40.14	2.50	56.09	98.73
Golf Courses	43.10	23.44	13.75	80.29
Thermoelectric	0.00	0.49	1.35	1.84
Other Irrigation (Comm)	8.28	28.64	3.04	39.96
Total	**278.40**	**277.37**	**446.76**	**1,002.53**

* Data are from Water Withdrawals, Use, Consumption, and Trends in Florida, 1995, USGS Water Resources Investigations Report 98-4140, and unpublished USGS data.
** Miami-Dade County demand includes Florida Keys (Monroe County); the Keys are supplied from Miami-Dade County well fields.

E.3.3.3.3 Projection B

The conservation Projection B estimates reflect the additional reduction of water consumption by end use water fixtures. IWR-MAIN estimates of water demand per employee and per housing unit include the identification of twenty end uses, such as toilets, showerheads, bathroom faucets, dishwashers, and lawn irrigation. Three categories of use are defined and used in IWR-MAIN: nonconserving, conserving, and ultra conserving. Default values within the model for these three categories of use for toilets, for example, are: 5.5 gallons per flush for *nonconserving* toilets, 3.5 gallons per flush for *conserving* toilets, and 1.6 gallons per flush for *ultraconserving* toilets.

The Projection B conservation scenario use estimates are based on all new construction and remodeling using ultra-low flow water fixtures. Those fixtures included in this conservation scenario are toilets, sink faucets, and showerheads. These projections also assume the gradual changing over to ultra-low flow devices throughout the period of analysis so that by 2050, all fixtures in all units will be ultra-low flow devices. In addition, Projection B includes conservation practices for lawn irrigation designed to achieve a 10% savings between conserving and ultraconserving housing units. These practices are comprised of lawn irrigation allowed only during the period from 5 p.m. to 9 a.m., and the requirement that automatic sprinkler systems be equipped with rain sensors.

Area-specific usage rates for nonconserving, conserving, and ultraconserving fixtures, available from the larger utilities, were used in the projections for the 1990 base year. Otherwise, the IWR-MAIN default values were used. For the four service areas, the assumed levels of end use conservation measures in place in 1990 are outlined in ***Table 3.3.3.3-1***.

Table 3.3.3.3-1
Assumed Distribution of Conservation in 1990
by Housing Type

Service Area	Single Family		Multi-Family		Mobile Home	
	Conserving	Non-Conserving	Conserving	Non-Conserving	Conserving	Non-Conserving
Northern P. B. County	36%	64%	40%	60%	NA	NA
SA1	36%	64%	40%	60%	NA	NA
SA2	19%	81%	25%	75%	36%	64%
SA3	16%	84%	8%	92%	NA	NA

The ultraconserving end use rates assumed for each service area are outlined in ***Table 3.3.3.3-2***.

Table 3.3.3.3-2
Ultraconserving End Use Rates By Service Area

Service Area	Toilets (gal. Per flush)	Faucets (gal. per min.)	Showerheads (gal. per minute)
Northern P. B. County	1.6	1.6	2.5
SA1	1.6	1.6	2.5
SA2	1.6	2.0	2.5
SA3	1.6	2.0	2.5

The Projection B conservation demands for selected years are outlined in ***Table 3.3.3.3-3***.

Table 3.3.3.3-3
Projection B - Average Forecast Estimated Total Use
For Indicated Year (MGD)

Service Area	1995	2000	2010	2030	2050
Northern P. B. County	61.17	68.85	80.09	82.59	83.66
SA1	213.24	240.26	279.90	289.57	294.18
SA2	284.98	308.54	341.71	346.39	345.72
SA3	359.55	403.00	464.06	482.49	474.80
Total	**918.94**	**1020.65**	**1165.76**	**1201.04**	**1198.36**

The percentage reductions in total average use within each service area resulting from the Projection B conservation scenario estimates, compared with the Projection A estimates, are shown in ***Table 3.3.3.3-4***.

Table 3.3.3.3-4
Reduction in Total Average Use Resulting from Projection B Conservation Scenario*

Service Area	1995	2000	2010	2030	2050
Northern P. B. County	1.37%	4.96%	9.56%	14.32%	17.37%
SA1	1.33%	4.53%	8.66%	13.00%	15.76%
SA2	3.39%	6.18%	10.12%	14.92%	18.12%
SA3	2.13%	5.01%	9.26%	14.27%	17.71%
Total	**2.29%**	**5.25%**	**9.39%**	**14.16%**	**17.34%**

* Extent to which conservation Projection B is lower than Projection A.

E.3.3.3.4 Population and Employment Projections

Water demand forecasts using IWR-MAIN require, as input, projections of housing, employment, and income. Housing projections have been derived from population projections. Population, employment, and income projections are available from the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, and from the Bureau of Economic and Business Research (BEBR), University of Florida, State of Florida. The BEA and BEBR projections are based on different methodologies and assumptions, and as a result, differ in projected growth. In general, the BEBR projections tend to reflect slightly higher growth than the BEA projections for South Florida. The BEBR estimates tend to be closer to actual growth in Florida, and consequently have been used for planning purposes in Corps of Engineers water resource planning studies in Florida. This represents a slight departure from the agency practice of using BEA projections for most feasibility studies and investigations. Consistent use of BEA projections insures that to the extent projections affect study conclusions, all such studies will have been done using a set of nationally consistent projections.

The small area projections made available by BEA are governed by national and state control totals. The use of BEBR projections instead of BEA projections only marginally affects study outcomes, at the same time making projections used in planning studies closer to the mark. The BEBR county level projections follow the same control total principle at the state level, as that which is used in the county level BEA projections, relative to national and state totals.

At the time these water use forecasts were prepared, BEA projections were available at the county level to the year 2040. Available BEBR projections extended to 2005. The BEBR employment and population projections were extended to 2050 using BEA growth rates for these “out” years. This resulted in a BEBR projection higher, but somewhat “parallel” to the BEA projected growth track in the later years of the planning period. The 2040-2050 rate of growth was based on an extension of the BEA rate from 2020 to 2040, the last two projection years for the BEA county level projections. As mentioned previously, it should be recognized that the projections used at the time these water use forecasts were prepared predate the data discussed and referred to in the previous section.

The BEBR population projections used in this analysis, from The Florida Long Term Economic Forecast, Volume 2, State and Counties (University of Florida, 1995), represent BEBR’s medium range projections (low and high estimates are also developed in BEBR’s population studies). In the case of Miami-Dade County, additional adjustments have been made reflecting growth closer to, but slightly below, the BEBR high range estimate. These higher growth trends reflect the anticipated impact of the 1994 United States agreement with Cuba permitting increased immigration from the island. These growth estimates have been made by the Miami-Dade County Planning Division, which has been monitoring ongoing growth and immigration trends for the county.

Estimated population and employment projections for the four service areas used to forecast water M&I demands for the year 2050 are summarized ***Table 3.3.3.4-1***. The basis for the estimates is as described above.

Table 3.3.3.4-1
Projected Population and Employment in 2050,
Florida Lower East Coast Service Areas*

	LEC Service Area				
Category	**N. P.B.**	**SA1**	**SA2**	**SA3**	**Total**
Population	342,758	1,245,829	2,203,306	2,952,565	6,744,458
Total Employment	131,147	481,845	947,333	1,141,435	2,701,760
Construction	6,655	24,169	40,840	42,012	113,677
Manufacturing	6,473	23,709	46,239	65,993	142,414
Transportation	4,205	15,702	40,386	85,717	146,009
Wholesale	5,783	21,913	60,133	100,112	187,941
Retail	27,348	99,456	172,438	191,864	491,106
Finance	7,503	27,505	54,029	76,041	165,078
Services	56,754	205,010	330,396	400,327	992,547
Government	13,516	49,886	106,453	160,023	329,878
Other	2,910	14,495	96,418	19,286	133,110

* Some totals may not add due to rounding.

Summary population and total employment projections for the service areas for selected years from 1990 through 2050 are shown in ***Tables 3.3.3.4-2*** and ***3.3.3.4-3***.

Table 3.3.3.4-2
Estimated Population by Service Area for Selected Years 1990-2050

Service Area	1990	2000	2010	2030	2050
Northern P. B. County	187,642	234,737	280,183	317,881	342,758
SA1	691,746	860,090	1,021,462	1,156,557	1,245,829
SA2	1,406,411	1,643,637	1,866,904	2,074,926	2,203,306
SA3	1,719,946	2,037,509	2,466,588	2,814,351	2,952,565
Total Population	**4,005,745**	**4,775,974**	**5,635,137**	**6,363,715**	**6,744,458**

Table 3.3.3.4-3
Estimated Employment by Service Area for Selected Years 1990-2050

Service Area	1990	2000	2010	2030	2050
Northern P. B. County	86,877	110,845	128,931	130,975	131,147
SA1	322,456	409,742	475,138	481,719	481,845
SA2	698,318	847,559	961,531	960,137	947,333
SA3	836,935	972,367	1,150,017	1,174,510	1,141,435
Total Employment	**1,944,586**	**2,340,513**	**2,715,617**	**2,747,341**	**2,701,760**

The above projection estimates, along with associated companion income and housing projections, were used as input in the IWR-MAIN model, which resulted in the projected water demands by service area.

The county projections, which are the basis for the service area projections, are outlined in the ***Tables 3.3.3.4-4*** and ***3.3.3.4-5***.

Table 3.3.3.4-4
Estimated Population by County for Selected Years
2000-2050

County	2000	2010	2030	2050
Palm Beach	1,080,244	1,289,384	1,462,868	1,577,347
Broward	1,463,687	1,642,700	1,816,256	1,933,303
Dade	2,294,751	2,778,002	3,169,671	3,325,335
Total	**4,838,682**	**5,710,086**	**6,448,795**	**6,835,985**

Table 3.3.3.4-5
Estimated Employment by County for Selected Years
2000-2050

County	2000	2010	2030	2050
Palm Beach	510,049	593,166	602,503	603,295
Broward	764,949	861,713	857,062	847,897
Dade	1,095,131	1,295,210	1,322,795	1,285,545
Total	**2,370,130**	**2,750,090**	**2,782,360**	**2,736,737**

As mentioned earlier, Monroe County water use is supplied by Miami-Dade County wellfields. Monroe County population is currently just over 80,000, and is projected to reach 125,000 by 2050.

E.3.3.3.5 Average Per Capita Consumption

Per capita rates of use were not used as an input variable in this study, as explained earlier. But the estimated future water use totals can be divided by the population projections for the respective service areas, revealing the resulting average per capita use. ***Table 3.3.3.5-1*** shows the average gallons per capita daily consumption for total average use resulting from the two projection scenarios. There is variation among the different using sectors, and from area to area, but these overall averages provide an indication of the underlying trends resulting from the forecast procedures.

Table 3.3.3.5-1
Average Per Capita Water Use Resulting
From Projections A and B
(gallons per capita per day)

Year	Projection A	Projection B
2000	226	214
2010	228	207
2030	220	189
2050	215	178

E.3.3.3.6 Projections Used in SFWMM Simulations

As discussed previously, the higher Projection A estimates include nominal use efficiencies in the future that represent only the effects of higher prices for incrementally higher levels of water use, and the level of conservation practices already in effect (i.e., with no changes in this pattern/profile of use).

A more realistic future water use scenario would likely include the effects of federal, state, and SFWMD water conservation regulations and policies. The conservation projections (Projection B) discussed above reflect 100% participation in this program by 2050, including full use and effectiveness of ultra-flow devices, and result in forecast water use estimates that are about 18% below the Projection A estimate for 2050. A more moderate application and effectiveness of the practices and techniques that make up the Projection B conservation scenario, would result in about two-thirds of this conservation, or estimated water use about 12% less than the 2050 estimate for Projection A. This level of conservation in use was determined by relaxing some of the assumptions within the IWR-MAIN model, so that less than 100% of fixtures are operating with fully effective ultra-low flow criteria.

In the initial formulation procedure, the Projection A figures were used as SFWMM input. The 12% reduction discussed above, a more credible and more reasonable scenario, was used in the final formulation to represent the 2050 without-plan condition. This level of water consumption and conservation represents the most likely future scenario without implementation of a comprehensive plan resulting from the C&SF Comprehensive Review Study.

E.3.4 COMMENT

These projections are based on fairly reliable relationships between water use and its known causative factors. The confidence of long term projections of such key determinants of water demand as population and employment is diminished the farther into the future the projections are extended , and the smaller the area for which the projections are being estimated. These projections have been made for both a relatively small area, and for a fairly distant future. Although they are best estimates, it is important to recognize their limitations, in view of these observations .

The higher Projection A scenario presumes a continuation of existing use patterns. If conservation practices were to be assumed in the projection scenario, consisting of ultra-low flow devices being in use in 100% of the area by the year 2050, this could result in 2050 forecast demand ranging from 15% to 18% less than Projection A. Both projection scenarios reflect a degree of use efficiency, as discussed above, and as demonstrated by the decline in per capita use during projection period. Such figures and comparisons, while helpful in gaining an understanding of trends, should be viewed with caution since they include water use throughout the economy, and are broad average relationships whose true meaning is limited and perhaps impossible to really fully understand. As mentioned earlier, such simplistic relationships as per capita average use rates are not used in the projection methodology of IWR-MAIN.

Finally, the projection scenario is only one of many possible outcomes for the population and economy of South Florida 50 years from now. The scenario being used is believed to be a reasonable mid-range best estimate of the set of conditions expected to influence water use in the year 2050. Consequently, the resulting estimated future municipal and industrial water use requirements is a reasonable projection to use in this study.

E.4 AGRICULTURAL WATER SUPPLY

E.4.1 OVERVIEW

Agriculture in south Florida generates approximately $3.8 billion in annual economic activity. Agricultural activity in south Florida is concentrated in the Everglades Agricultural Area (EAA), to the south and east of Lake Okeechobee; in basins adjacent to Lake Okeechobee (particularly the Caloosahatchee and St. Lucie Basins); and in rural areas within the coastal basins of Miami-Dade, Broward, and Palm Beach counties. Principal crops include sugarcane, vegetables, tropical fruit, citrus, sod, ornamental plants, and nursery production. Agriculture in south Florida is supported by the region's abundant rainfall – approximately 59 inches along the Lower East Coast and approximately 49 inches in the middle of the peninsula. Unfortunately, this rainfall is not distributed uniformly throughout the year, since the region has distinct wet (May through September) and dry (October through April) seasons. Especially during the dry season, and when precipitation is below normal (i.e., droughts), supplemental irrigation is required for much of the region's agriculture.

During droughts, agricultural water users have higher irrigation water demands, since evapotranspiration is high and soil moisture is not recharged by rainfall. However, during these periods of high water demand, water supplies usually are at their lowest levels. Consequently, water shortage management policies are implemented which restrict use of water so that agricultural water users do not always receive as much water as they would like. Irrigation water shortages can have negative economic consequences for farmers, since water stress can reduce crop yields and can induce crop mortality. Residential water users in urban areas of the LEC can also be subject to water management policies which can limit the use of irrigation water, which is needed for urban and suburban landscaping. These shortages can also have negative economic consequences for landscaping and can result in diminished aesthetics (i.e., brown lawns) and renovation or replacement costs for expired turf or ornamental landscaping.

The Lake Okeechobee Service Area (LOSA), which includes the EAA, is more dependent on agricultural water supplies from Lake Okeechobee than the LEC. During periods of normal rainfall, agricultural – and urban – water users in the LEC have not in the past required significant supplemental water from the lake. In addition to rainfall, the LEC receives significant groundwater recharge via easterly seepage from the Water Conservation Areas under the north-south levee system which serves as a boundary between the LEC and the Everglades. However, during prolonged drought events, significant volumes of water from Lake Okeechobee can be required by the LEC to supplement local water supplies and to prevent saltwater intrusion into wellfields.

The potential effects of five alternative restoration plans (Alternatives A, B, C, D, and the Recommended Plan) on agriculture in south Florida are based on the magnitude and frequency of irrigation water shortages. The net economic effects of the alternative restoration plans are the differences between the expected crop losses resulting from agricultural water shortages under with- and without-project conditions.

The SFWMD has developed an economic post-processor (EPP) to assess the monetary effects of agricultural and urban water supply shortages. The EPP, which is embedded in the South Florida Water Management Model (SFWMM), was designed to estimate the economic losses due to agricultural and urban water supply demands not being met.. The EPP was the principal analytical tool used to evaluate agricultural water supply effects of the alternative restoration plans. The analysis of the alternatives is based upon the profile of south Florida agriculture presented below. The profile includes a description of agriculture in the LOSA and the LEC.

E.4.2 AGRICULTURE IN THE LAKE OKEECHOBEE SERVICE AREA

Table 4.2-1 presents the acreage of irrigated agriculture in the sub-areas of the LOSA, which include the EAA, the Caloosahatchee and St. Lucie basins, and the north shore of Lake Okeechobee. As indicated in this table, there are 742,668 acres of irrigated agricultural land in the LOSA. Agricultural activities in the LOSA sub-areas are described below.

TABLE 4.2-1
IRRIGATED ACREAGE IN THE LOSA

LOSA Sub-Area	Irrigated Acreage
EAA	521,920[1]
North Shore	13,380[2]
Caloosahatchee Basin	138,337[3]
St. Lucie Basin	49,073[4]
Total LOSA	742,668

Sources:
[1] SFWMD. 1995.
[2] Hall, C.A. Lake Okeechobee Supply-Side Management Plan. SFWMD. 1991.
[3] SFWMD. Long-Range Demands for the Caloosahatchee Basin. 1997.
[4] SFWMD. Long-Range Demands for the St. Lucie Basin. 1997.

E.4.2.1 Everglades Agricultural Area (EAA)

The EAA encompasses an area of approximately 593,000 acres. As indicated in ***Table 4.2.1-1***, the EAA contains approximately 542,000 acres under cultivation. Sugarcane is the dominant crop type, accounting for over 90% of the land under cultivation. The remaining land under cultivation (less than 10%) is occupied by rice, row crops, and sod. Row crops include corn, celery, radishes, and lettuce.

The total EAA acreage in Table 4.2.1-1 does not equal the EAA acreage in Table 4.2-1 for two reasons. First, the two figures represent land use in different years (1995 and 1997). Second, as described below, rice cultivation in the EAA typically serves as a supplemental crop between harvest and replanting of sugarcane. Consequently, the sugarcane and rice acreage significantly overlap.

TABLE 4.2.1-1
AGRICULTURAL LAND USES IN THE EAA

Crop	Acreage	Percent of Total
Sugarcane	485,881	90%
Rice[1]	25,000	5%
Row Crops	16,689	3%
Sod	13,258	2%
Total EAA	541,878	100%

Sources: Hendry and Palm Beach County Tax Appraisers, 1997
[1] IFAS Extension Agent, Palm Beach County.

E.4.2.1.1 Sugarcane

The EAA is very well suited to sugar production. This area provides approximately 22% of total sugar produced in the United States (Lord & Suarez, 1997). In 1989, sugarcane production in the EAA accounted for more than $750 million in agricultural production and 20,000 full-time jobs (Snyder and Davidson, 1994). The EAA has thick organic muck soils and adequate water supplies from precipitation and from Lake Okeechobee via a network of water supply canals. Planting typically occurs in the autumn and winter months. Fertilizer and cane stalks are placed in the furrows, and the cane is sub-irrigated by maintaining a water table depth of approximately 20 inches below the ground surface. While some growth occurs during the winter months, most of the cane growth takes place from May through September. The cane plant will be ready for harvest after approximately 16 months. The harvest season is from October to March. During harvest, the cane is burned to facilitate harvesting. In the last four years, the harvesting of sugarcane in the EAA has become entirely mechanized. The cane is transported by truck or train to one of the seven mills located in the EAA.

Multiple crops can be harvested from a single planting of sugarcane. The root stock is left in place after the first harvest and new growth will arise from the cane stubble. The first regrowth (i.e., ratoon) can be harvested again in another 11 months. Again, the root stock is left in place, and a second ratoon will be ready in another 11 months. Some farms will harvest up to four ratoons, but yields decline with each successive ratoon. After 2-4 ratoons, the stubble is disked out. After harvesting the last ratoon, farmers must decide whether to replant immediately or leave the field fallow until the following autumn. Sugarcane farmers in the EAA typically leave their fields fallow following the mid-winter harvest of the final ratoon until the following fall. Fallow fields are routinely flooded to kill pests and limit soil subsidence. If there is a successive planting, more cane can be harvested the following year. However, if the field is left fallow, yields would be higher once the field is replanted. Many farmers will balance these competing incentives by replanting half of the field and leaving the other half fallow. For this reason, Alvarez (1997) estimates that the following crop distribution would be typical of EAA sugarcane farms at any given point in time: plant cane (25%), first ratoon (25%), second ratoon (25%), fallow (12.5%), and roads, canal, ditches (12.5%).

Sugarcane grown in the EAA is converted into raw sugar and blackstrap molasses at the seven sugar mills found in the area. Sugarcane must be milled rapidly after it has been harvested to avoid degradation of its sugar content. The raw sugar is then shipped to sugar refineries located throughout the United States where it undergoes additional processing. There are two refineries located in south Florida which serve the Florida markets for refined sugar.

E.4.2.1.2 Non-Sugar Crops

As indicated in Table 4.2.1-1, the EAA also supports a variety of non-sugar crops. Most of the non-sugar crops are also grown by sugarcane farmers, who grow rice, vegetables, or sod as supplemental crops. Among the non-sugar crops, rice occupies the most acreage in the EAA. Rice cultivation is small, but it could grow in importance for five reasons. First, rice cultivation is being encouraged by the University of Florida's Institute for Food and Agricultural Science (IFAS) to retard soil subsidence in the EAA. Second, rice production is also recommended by the SFWMD as a way to reduce phosphorus loading into the Everglades, since rice requires less fertilizer than sugarcane. Third, there is already a rice mill in the EAA which has sufficient capacity for increased rice cultivation. Fourth, rice is a good companion crop for sugarcane, since it allows sugar farmers to plant and to harvest a crop of rice during the period in which they would otherwise leave their fields fallow following the final ratoon. Finally, although rice cultivation in the EAA has historically had low profitability relative to sugarcane, world rice prices have been rising in recent years.

Vegetable row crops in EAA are almost entirely winter crops. These crops are primarily leaf crops, such as lettuce, cabbage, parsley, and celery. Many farmers rotate their vegetable cultivation between celery and sweet corn; others rotate lettuce or radishes and sweet corn. In the EAA, vegetables are primarily winter crops, for two principal reasons. First, prices are much higher during the winter months. Second, farmers are able to control soil moisture during the winter months (i.e., dry season) with irrigation. Despite the fact that there are three vegetable packing houses in the EAA, vegetable production in the EAA is limited and will likely remain small. Three primary factors limit vegetable production in the EAA. First, vegetable production has greater risk and uncertainty than sugarcane cultivation. Second, the experience of EAA farmers is with sugarcane cultivation, not with vegetable production. Third, and most importantly, the EAA sugar mills need large inputs of sugarcane to remain profitable. Therefore, the lands owned by the sugar companies will likely remain in sugarcane production as their primary crop. In addition, there are multiple incentives for EAA farmers to grow sugarcane as their principal crops, rather than vegetables. As a condition for membership in the farmers co-operatives, farmers must often provide certain minimum amounts of sugar to the mills, and land leases in the EAA often place limits on non-sugar cultivation.

Sod is grown primarily in the southern portion of the EAA, which is an area of declining suitability for sugarcane due to soil subsidence. Sod production can be economically attractive, since turfgrass sod prices are currently in the range of $0.12 per square foot. Once turfgrass has been planted, it is typically harvested without replanting for the next three to five years. Some farmers harvest more than one crop per year during this period. The sod is harvested in ribbons using oscillating knives which slice off approximately one inch of crown, root, and soil. Approximately 25% of the turfgrass is left behind as seed material (Haydu et al, 1992). The remnant strips are tilled for even distribution in the field. A portion of each field is replanted every five years to rejuvenate the field.

E.4.2.1.3 Soil Subsidence

Soil subsidence (i.e., the reduction of land surface elevation) is an important factor in EAA agriculture. The organic muck soils of the Everglades were formed under anaerobic conditions, and as a result, they are only partially decomposed. The organic matter has formed thick peat soils that overlie the limestone bedrock of south Florida. When organic soils are drained, they subside toward the bedrock as aerobic conditions allow further decomposition (i.e., oxidation) of the organic material. In addition to oxidation, subsidence following drainage is increased by loss of buoyancy, peat shrinkage, fires, and erosion.

In general, the muck soils of the EAA are deeper to the north, near Lake Okeechobee. Consequently, soil subsidence is not as much of a problem near the lake as it is in the southern EAA, where soils are relatively shallow. This advantage for the northern areas within the EAA is reinforced by the climatic influences of the lake, which can help protect crops from south Florida’s occasional frosts. In some southern zones of the EAA, subsidence has reduced the soil layer to less than six inches (the point at which farming is often considered no longer profitable). Another negative aspect of subsidence is that as the soil layer thins, the soil chemistry changes, and the application of additional nutrients (i.e., fertilizer) is required, increasing production costs and decreasing profits from farming.

Historically, the rate of subsidence in the EAA has been approximately one inch per year. Rapid subsidence combined with limited soil depth (to bedrock) has raised concerns about the sustainability of agriculture in the EAA . However, the current rate of subsidence has fallen to approximately 0.56 inches per year (Shih et al., 1997). There are several explanations for the subsidence rate reduction. These include:

- The EAA land-forming program allows higher water tables without crop damage.
- Current varieties of sugarcane, vegetables, and pasture are more tolerant of higher water tables, which limits soil oxidation.
- Farmers are holding more water on their farms as part of phosphorus Best Management Practices (BMPs).
- As land subsides, the same amount of water results in a higher water table relative to land surface elevations.
- Sugarcane has become the dominant crop in the EAA. Cane experiences 70-75% less subsidence than other EAA crops. Sugarcane cover results in lower soil temperatures, which slows oxidation.
- Remaining organic material does not oxidize as quickly as material which has already oxidized.

It appears that reduction in subsidence rates and control of phosphorus releases from the EAA to the Everglades using BMPs are complementary objectives. When subsidence was occurring at the rate of one inch per year, Morris (1975) estimated that oxidation caused the release of 78 pounds of phosphorus per acre per year. This is equivalent to 400% of the average rate of fertilizer phosphorus applied in the EAA (Sanchez, 1990).

E.4.2.1.4 Irrigation Practices in the EAA

The organic (muck) soils of the EAA require careful water management to maximize yields of sugarcane and other crops and to limit soil oxidation and subsidence. Irrigation in the EAA is subsurface, and the soil moisture available to crops depends on the elevation of the water table relative to the land surface. Consequently, EAA farmers carefully manage their water resources to control the water tables on their farms. When water levels are excessively low (for example, during the dry season or droughts) farmers withdraw water from the EAA canal network typically by gravity flow. When water levels are excessively high during the wet season, they pump water from the fields to the canals for drainage.

Farmers in the EAA must consider multiple factors in controlling the water table. Farmers have incentives to maintain high water levels (relative to the surface elevation) in order to: (1) ensure that plants receive sufficient moisture, (2) limit soil oxidation and subsidence, (3) control pests, (4) avert muck fires (which can occur when organic soils become excessively dry), and (5) store water on their farms if shortages of irrigation supplies or downturns in precipitation are expected. Unfortunately, there is an overriding reason for keeping water tables relatively low. Most crops cannot tolerate long periods in flooded soils. If water tables are either too high or too low, the crops become stressed. Crop yields decline, and mortality will be experienced if adverse conditions persist. For sugarcane, farmers balance these considerations and generally attempt to maintain water tables at 20 inches below the surface. If water tables fall, the plant roots will follow the water table downward. If the water levels rebound, crop yields can be reduced, as the plants experience stress from excessive water.

E.4.2.1.5 Land Use in the EAA

EAA land use estimates are incorporated into the SFWMM for 1995 and 2050 and are used in this investigation as the basis for analyzing existing and future with- and without-project conditions. Land use estimates affect most aspects of water management in south Florida, and are critical determinants of the potential economic effects of the Restudy alternatives. The SFWMM applies broad land use categories for agricultural and other land uses in south Florida for two reasons. First, agricultural land uses can be extremely difficult to forecast, since crop types in any given area can change from year to year, and larger scale land use changes – such as the conversion of agricultural land to urban and suburban uses – can occur rapidly as well. As a result, it is more realistic to forecast future land uses with broad land use categories. Second, the 4 square-mile resolution of the model's grid cells is relatively coarse for purposes of assessing the economic value of agricultural water supply impacts of the alternative restoration plans in a localized region.

The SFWMM was designed to simulate the hydrology of south Florida. The SFWMM does not project future land uses, but includes land use projections derived outside the model as input parameters. The model's design considers land use patterns only to the extent that they influence water management decisions. Assumptions about the type of irrigation technology applied to each particular crop (and associated water losses via evapotranspiration) are included in the model for each agricultural land use category.

Agriculture land use designations in SFWMM assign each 4-square mile grid cell to a single crop type, based on the predominant crop located in the cell. Since non-sugar crops in the EAA are spatially diffuse and do not dominate a single cell, only sugarcane is registered under the model's 4 square-mile grid cell resolution. Therefore, the 1995 and 2050 base conditions evaluated in the SFWMM classify all of the agricultural land in the EAA as devoted to sugarcane production. As will be evident later in this report, the model's homogenization of agriculture in the EAA has implications for calculating the economic impacts of the alternative restoration plans.

The acreage devoted to sugarcane cultivation (and agriculture in general) in the EAA under present and future without-plan conditions is expected to decrease from 529,920 acres (1995 condition) to 491,520 acres (2050 condition). The projected decrease is primarily due to the purchase of agricultural land for new Stormwater Treatment Areas. The four alternative restoration plans (A-D) and the Recommended Plan would convert an additional 60,000 acres of EAA sugarcane land to reservoirs to provide additional storage for the C&SF system.

E.4.2.2 Caloosahatchee and St. Lucie Basins

Agriculture in the Caloosahatchee and St. Lucie basins differs significantly from agriculture in the EAA. Soils in these basins are generally sandy, rather than organic (muck). Consequently, irrigation is applied from the surface, and subsidence is not a significant problem.

The sandy soils of the Caloosahatchee and St. Lucie basins also support a different mix of crops than the organic soils of the EAA. Agricultural land uses in the Caloosahatchee and St. Lucie basins are presented in ***Tables 4.2.2-1*** and ***4.2.2-2***. Citrus is the dominant crop type in both basins. The agricultural water needs in these basins that are not met with local sources are met with water released from Lake Okeechobee into these two outlet waterways. The Caloosahatchee basin is an area of expanding agricultural activity with increasing agricultural water demands.

TABLE 4.2.2-1
AGRICULTURAL LAND USES IN THE CALOOSAHATCHEE BASIN IN 1994

Crop	Acreage	Percent of Total
Citrus	78,113 acres	56 %
Sugarcane	50,359 acres	36 %
Vegetables	8,091 acres	6 %
Sod	1,296 acres	1 %
Ornamentals	478 acres	<1 %
Total	138,517 acres	100 %

Source: SFWMD. Draft Long-Range Demands for the Caloosahatchee Basin. 1997.

TABLE 4.2.2-2
AGRICULTURAL LAND USES IN THE ST. LUCIE BASIN IN 1996

Crop	Acreage	Percent of Total
Citrus	43,071 acres	88 %
Vegetables	5,538 acres	11 %
Sugarcane	449 acres	1 %
Nursery	15 acres	<0.1 %
Total	49,073 acres	100 %

Source: SFWMD. Draft Long-Range Demands for the St. Lucie Basin. 1997.

E.4.3 AGRICULTURE IN THE LOWER EAST COAST

The three service areas of the LEC also contain large areas of agricultural land use. Soil types in the LEC are generally sandy, rather than the organic (muck) soils found in the EAA. Consequently, irrigation is usually applied from the surface, and subsidence is not a significant problem.

The sandy soils of the LEC also support a different crop mix than the organic soils of the EAA. Table 4.3-1 presents the 1995 and 2050 agricultural land use patterns contained in the SFWMM for the LEC service areas, including northern Palm Beach County.

These values were extracted from the SFWMM by the EPP. The EPP considers only those SFWMM land use categories for which economic effects of water shortages can be generated. The EPP uses six broad categories of land use: urban, nursery, golf courses, low-volume (LV) irrigated agriculture (such as citrus and avocados), overhead (OV) irrigated agriculture (such as tomatoes), and other agriculture (including sod, sugarcane, and rice). As suggested in this table, tomatoes are intended to represent truck vegetables grown with overhead irrigation system.

There are significant differences in crop mixes in the three service areas. However, the differences found in this table are understated, since the SFWMM's land use categories are based on irrigation technology and crop water consumption, not crop type. As an illustration of the complexity of LEC agriculture, Miami-Dade County, located in Service Area 3, currently has thousands of acres under cultivation with specialty Cuban vegetables. In addition, Miami-Dade County supports cultivation of over 35 varieties of tropical fruits, with 20 different varieties grown on a commercial scale (Degner et al., 1997).

The categories of urban landscaping and golf courses – which are primarily suburban land uses – are included in the SFWMM as agriculture, since they are maintained with irrigation water that is supplemented directly or indirectly with water from the regional water supply system. While these two land uses are not strictly agricultural, they will be included in the discussions of agricultural water supply throughout this report. As indicated in the National Golf Foundation's National Golf Course Directory, there are 239 golf courses in the LEC distributed as follows, by county: Palm Beach (149), Broward (51), and Dade (39).

Figures 4.3-1 and ***4.3-2*** illustrate the percent changes in agricultural land uses from 1995 to 2050 for each of the three service areas of the LEC, northern Palm Beach County, and the entire LEC. As indicated in Figures 4.3-1 and 4.3-2 (and Table 4.3-1), the three LEC service areas and northern Palm Beach County are anticipated to have large increases in urban land uses between 1995 and 2050. The increases suggest conversion of agricultural land to urban land uses. However, agricultural land use represents less than one-quarter of the land use in the service areas. The land use profile presented in this table is therefore not comprehensive, since the economic post-processor only includes those land use categories for which economic impacts are estimated. This is the reason for the apparent inconsistency in the 1995 and 2050 land use sub-totals shown in ***Table 4.3-1***.

E.4.4 AGRICULTURAL WATER MANAGEMENT DURING SHORTAGES

To estimate the potential damages associated with shortages in agricultural water supply it is necessary to understand (1) how irrigation water supplies are managed during drought periods and (2) how the SFWMM simulates water management during agricultural water shortages. Agricultural water use during droughts is the result of regional decisions made by water management institutions, such as the SFWMD; and local decisions made by water users, including individual farmers. These two levels of water management decision making during droughts are discussed below for the LEC and LOSA.

E.4.4.1 Water Management in the LEC

As described in the preceding chapter, when current or future water supplies are not expected to meet water demands, the SFWMD may institute a series of progressively more severe management measures to conserve water supplies. The SFWMD's Water Shortage Plan provides specific guidelines for water restrictions which are based on the type of use and the severity of the drought. As outlined in the shortage plan, voluntary reductions are initially requested during moderate shortages, but mandatory cutbacks in water use may be required if shortages become more severe.

TABLE 4.3-1
IRRIGATED AGRICULTURAL LAND USE DISTRIBUTION IN THE LEC: 1995, 2050 (in acres)

Land Use	SA1		SA2		SA3		North Palm Beach County		Total	
	1995	2050	1995	2050	1995	2050	1995	2050	1995	2050
Urban Landscape	34,381	58,824	49,866	74,121	61,911	90,015	8,343	15,614	154,501	238,574
Nursery	4,140	6,474	608	2,478	2,622	10,133	143	541	7,513	19,626
Golf	10,644	13,588	7,891	8,982	3,232	4,165	2,993	6,573	24,760	33,308
Agricultural – Low Volume	11,238	3,141	2,880	7	16,883	8,646	4,950	1,018	35,951	12,812
a. Citrus	11,207	3,141	2,880	7	6,190	0	4,949	1,018	25,226	4,166
b. Avocado & Other Fruits	31	0	0	0	10,693	8,645	0	0	10,724	8,645
Agricultural – Overhead (tomatoes)	26,610	8,595	755	18	46,165	28,515	2,390	615	75,920	37,743
Agricultural - Other	7,026	1,806	2,744	2,756	1,097	3,198	49	0	10,916	7,760
a. Sod	2,434	748	1,469	2,723	347	3,198	49	0	4,299	6,669
b. Sugar	4,592	1,057	1,274	32	749	0	0	0	6,615	1,089
c. Rice	0	0	0	0	0	0	0	0	0	0
Total Agriculture	94,039	92,428	64,744	88,362	131,910	144,672	18,868	24,361	309,561	349,823
Total Service Area	430,808	430,808	401,920	401,920	744,960	744,960	227,840	227,840	1,804,800	1,804,800
% Represented	22%	21%	16%	22%	18%	19%	8%	11%	17%	19%

Source: SFWMD. 1998.

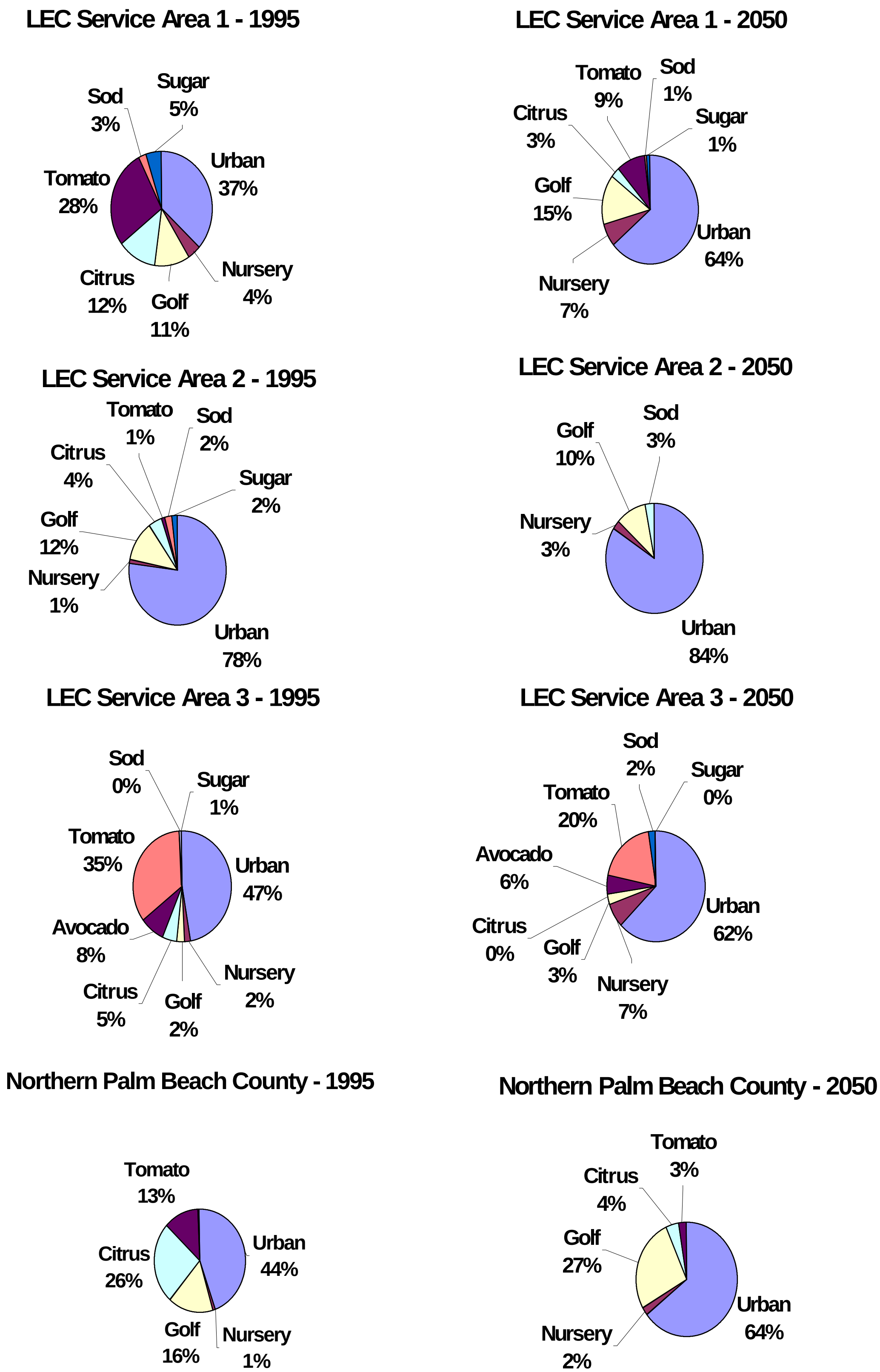
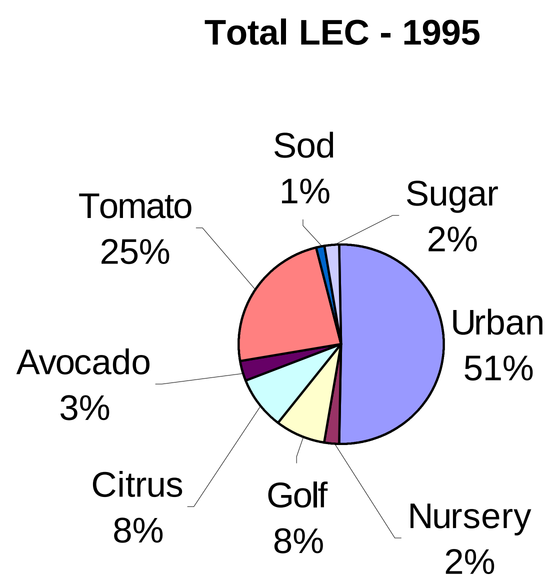


FIGURE 4.3-1
IRRIGATED LAND USE: LEC SERVICE AREAS, 1995, 2050



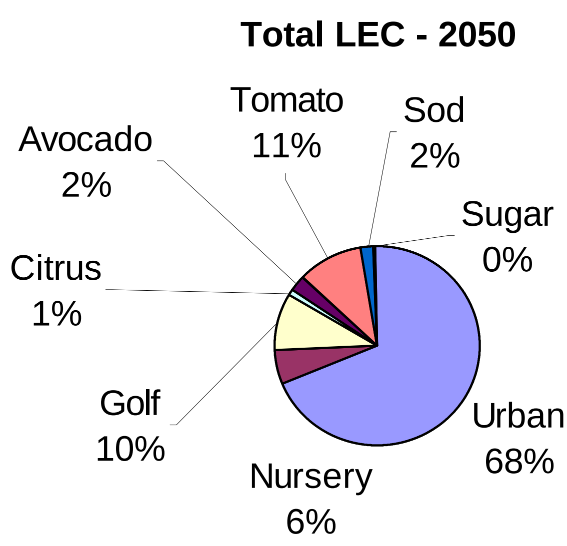


FIGURE 4.3-2
LEC IRRIGATED LAND USE
1995, 2050

The four phases of water supply shortages in the Water Shortage Plan stipulate cutbacks by water users in the LEC, including agricultural and urban water usage. For each phase, the plan stipulates the time of day, time duration, and/or quantity of water usage by irrigation uses, including:

Agriculture	Freeze protection
Crop irrigation	Nurseries
Livestock	Urban irrigation
Aquaculture	Recreation areas
Soil flooding	Golf courses

Agricultural water use is specified by the Water Shortage Plan for each crop type and irrigation method in the LEC. In general, the plan attempts to provide for agricultural water supply needs while progressively reducing water use through the four shortage phases. The water use cutbacks imposed on agricultural water use in phases 1 and 2 are relatively modest compared to those experienced by other water use sectors, such as urban landscaping, golf courses, and recreational areas.

The SFWMM does not model water quality, and groundwater levels are used as surrogate measures of salinity intrusion. In the model, hydraulic head (i.e., water level) is monitored at key trigger wells and canals. When simulated water levels fall below specific thresholds, water shortages are simulated with cutbacks in agricultural water use consistent with ***Table 4.4.1-1***. These are estimates of the water use limitations which may be imposed in each of the phases.

TABLE 4.4.1-1
CUTBACKS FOR SIMULATING AGRICULTURAL WATER USE RESTRICTIONS IN THE LEC

Water Usage or Class	Phase I	Phase II	Phase III	Phase IV
Urban Landscape*	20.0	13.3	6.7	3.3
Nursery	14.5	7.3	4.2	3.0
Agriculture – Overhead	6.1	6.1	3.6	3.6
Agriculture – Low Volume	20.0	20.0	20.0	20.0
Agriculture – Other	20.0	20.0	4.5	3.6
Golf Course	4.8	3.2	1.4	0.6

* For irrigation use, cutbacks represent maximum irrigation application rates in inches/month.
Source: SFWMD. Draft Documentation for the South Florida Water Management Model. 1997.

E.4.4.2 Water Management in the LOSA

The phased restrictions in the Water Shortage Plan are not applied to agriculture in the LOSA. Instead, agricultural water users in the LOSA are subject to supply-side management (SSM) for Lake Okeechobee. The required agricultural water use restrictions of the Water Shortage Plan are assumed to have been met when LOSA water users comply with the lake's SSM plan.

During severe droughts, water levels in Lake Okeechobee drop as inflows are exceeded by water losses from releases and evaporation. If water levels fall sufficiently, SSM is instituted for the lake. The amount of water available for use is a function of anticipated rainfall, evaporation, and water needs (for the balance of the dry season) in relation to the amount of water currently in storage. The SSM schedule for the lake is illustrated in ***Figure 4.4.2-1***. SSM begins when lake levels fall below the watch and warning levels and enter Zone A. The upper limit of Zone A represents a storage amount sufficient to meet all demands through the end of the dry season (June 1) provided that all basins receive at least 100% of normal rainfall during that period. Each of the zones represents storage levels with assigned probabilities of shortage. For example, if the stage in the wet season is in Zone A or lower, the area has a 50% or greater probability of exceeding the target allowable lake level established for Lake Okeechobee for June 1 (11 feet).

During periods of SSM, the SFWMD calculates weekly water allocations for each agricultural water user in the LOSA. Available water supplies are estimated based on lake levels, evaporation and rainfall estimates. Allocations are made by comparing normal water requirements with available water supplies.

The SFWMD has allowed EAA farmers substantial flexibility in choosing when to receive their expected allocation during shortages because of the importance of controlling water tables for crop production. Under SSM, water allocations to agricultural users in the LOSA are progressively cutback as shortages become more severe (Zones A to D). However, the SFWMD governing board may allow agricultural users to borrow against their seasonal allocation in the first four months of the dry season. A major reason for borrowing is to maintain yields in sugarcane which will be harvested during that dry season. The behavior of LOSA farmers in the face of water supply shortages is based on the vulnerability of their particular crops to water stress and the value of those crops.

Some crops are more vulnerable to water stress than others. For example, sugarcane is more tolerant to water stress than most vegetables. If sugarcane experiences stress from too much or too little water early in its growing season, the growth of the cane is stunted, and harvest biomass is diminished. However, while crop yields are diminished by water stress, crop mortality of sugarcane only occurs under extremely dry conditions.

Many sugarcane farmers prefer that their crops experience some water stress prior to harvest. If water stress occurs within two months prior to harvest, the biomass will be reduced, but there will also be a desirable increase in sugar content.

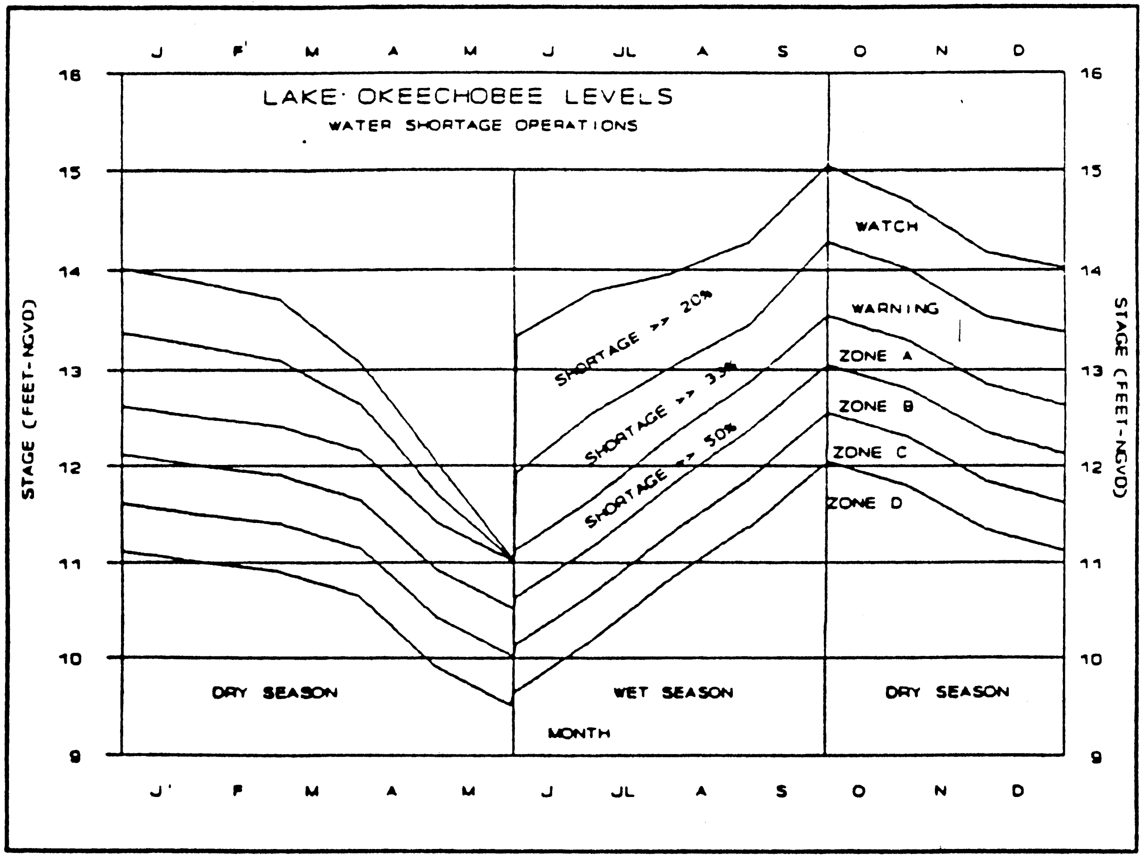


FIGURE 4.4.2-1
SUPPLY-SIDE MANAGEMENT SCHEDULE

Source: Hall, C.A. Lake Okeechobee Supply-Side Management. SFWMD. 1991.

Sugar content can be enhanced by as much as 10% by water stress if it is accompanied by desirable growing conditions (e.g., sunny and cool weather). Some sugarcane farmers prefer to raise or lower the water table to control the amount and timing of water stress prior to harvest. Other farmers prefer to stress the sugarcane chemically. However, this stress must be carefully controlled and timed. If sugarcane is stressed too severely, the reduction in biomass will also be accompanied by a reduction in sugar content, since wilted leaves and dried stalks contain little sugar.

Changes in crop yield are a critical determinant of farm income and can induce changes in crop mix or farming practices. For farmers in the EAA who grow sugarcane and vegetables, decisions during water shortages are based on expected crop-specific responses to water stress and the relative value of each crop. Farmers will allocate water on their lands based upon the greatest marginal value of the scarce irrigation water. Vegetables and sod can quickly suffer large yield effects and crop mortality in response to stress from water shortages. Consequently, when water allocations from the regional water system are reduced, farmers will typically give vegetables, sod, and rice priority over sugarcane (Schueneman, 1997). As a result, vegetables and other non-sugar crops in the EAA are not expected to experience significant irrigation cutbacks during shortages, since sugarcane will be the primary recipient of irrigation cutbacks.

Farmers weigh their present needs against their future needs with careful consideration. The type of crop, timing during the growing season, and anticipated cutbacks are included in their decision making process. Interviews conducted with a variety of experts on EAA agriculture indicate that farmers will generally borrow as much water as they can against their future allocation in order to fully satisfy the water needs of their crops for as long as possible (Alvarez, 1997; Schueneman, 1997). In general, farmers in the EAA will accept the risk of extreme cutbacks later in the season in order to meet their full irrigation needs earlier in the season. Their behavior is supported by experience. During the 1981-1982 drought, widespread borrowing against seasonal water allocations by farmers in the EAA was reinforced by above-normal rainfalls later in the growing season, mitigating the deferred impacts of the drought (Hall, 1991). The SFWMD policy of always meeting at least one-third of the supplemental irrigation requirements of farmers in the EAA may give additional impetus for farmers to borrow against their seasonal water allocations.

Reductions in agricultural water deliveries from Lake Okeechobee to south Florida may or may not actually result in economic losses to farmers. The 1981-1982 experience cited above is testament to this uncertainty. There are a variety of factors which determine the actual economic impacts of shortages, including antecedent conditions, local precipitation during and after the cutbacks, crop types, and the timing of the cutbacks with respect to the growing season.

Interviews with LOSA agricultural experts also suggest that farmers will not significantly modify their production activities during shortages. When shortages do occur, the water stress associated with irrigation cutbacks will result in yield reductions for the entire crop of sugarcane, since water stress will be uniform across the entire irrigated area. Because harvesting activities are entirely mechanized, the unit costs of crop production will not change significantly for different yield levels. Regardless of whether the crop is 100%, 80%, or 50% of potential yield, the costs of crop production will be nearly the same, resulting in a decrease in net farm income nearly equal to the decrease in crop revenues. As will be evident later in this report, this has important implications for estimating the NED impacts of agricultural water supply shortages resulting from the alternative restoration plans.

E.4.5 ECONOMIC POST PROCESSOR (EPP)

The EPP was originally developed to estimate the benefits of structural and/or operational improvements to the regional water supply system by monetizing the "value of unmet demand" for agricultural and M&I water supply. Understanding the concept of "value of unmet demand" is critical to properly interpreting the results of the agricultural water supply analysis. Unmet demand is not synonymous with actual crop loss and is not a direct measure of the impact of alternative plans on reduced crop yields. As stated previously, the AFSIRS model does not predict crop yields, but instead calculates the quantity and frequency of irrigation necessary to avoid water stress to crops.

Value of unmet demand is an estimate of the difference between actual crop yields and values and maximum crop yields and values. As such, the value of unmet demand represents the hypothetical increase in crop yields which could result if farmers were to obtain an amount of water that would not restrict yield. Obviously, such water supplies throughout the year are seldom, if ever, achieved, either in Florida, or in any other farming area throughout the country. The estimates of unmet demand for existing, future without-project, and future with-project conditions are based on a variety of factors, including normal climatic variations, soils conditions, farming practices, and water management system operations (as represented in the 31-year period of record contained in SFWMM). Therefore, the gross estimates of the value of unmet demand contain a variety of factors beyond the control of the C&SF Restudy alternatives, and should be viewed with caution. The proper comparison for this study is the net change in unmet demand between future without-project and future with-project condition, since it "nets out" all of the independent variables except changes resulting from implementation of the Restudy alternatives.

The agricultural element of the EPP was developed through a five-part process as illustrated in Figure 4.5-1 and described below.

E.4.5.1 Development of the AFSIRS Model

The Agricultural Field Scale Irrigation Requirement Simulation (AFSIRS) was developed at the Agricultural Engineering Department of the University of Florida (Smajstrla, 1990). This model predicts water requirements for maximum crop yields. It does not predict crop yields, but instead calculates the quantity and frequency of irrigation necessary to avoid water stress to crops. The program contains the data necessary to model the irrigation requirements of all of the commercially important crops in Florida under various irrigation schemes and with a wide variety of soil types.

AFSIRS calculates irrigation requirements and evapotranspiration rates as a function of crop type, soil type, irrigation system, growing season, and climatic conditions. The model assumes that irrigation requirements are met from the unsaturated zone through rainfall or supplemental irrigation. As illustrated in ***Figure 4.5-1***, the model draws upon four data files. The user specifies three sets of input parameters for the agricultural plot: soils, crops, and irrigation systems. These inputs are combined with time-series precipitation data and simulated potential and crop-specific evapotranspiration rates (PET and ET respectively). The model then calculates how much water is required by the selected crop at a particular point in its growing season under specific soil and climatic circumstances. AFSIRS has been successfully tested and applied in south Florida. The SFWMM contains an AFSIRS module that is used to estimate daily water requirements of irrigated agriculture in the LOSA and the LEC.

E.4.5.2 Modification of the AFSIRS Model for Drought Applications

Thompson and Lynne (1991,a) of IFAS modified the AFSIRS program to estimate changes in crop yield for drought impact analyses. Among the modifications made by Thompson and Lynne was the introduction of the Stewart equation into the model. The Stewart equation relates the difference between actual ET and potential ET (PET) to changes in crop yield. The logical basis for the Stewart equation is that plants reduce their transpiration when they are water stressed, and this reduction is an indicator of stress-induced effects on crop yield. The Stewart equation is as follows:

$$1-(Y_{act}/Y_{max}) = \beta(1-ET_{act}/PET)$$

where:

Y_{act} = actual crop yield per acre (simulated),

Y_{max} = maximum crop yield per acre,

β = crop specific output per irrigation level (Beta coefficient),

ET_{act}= actual evapotranspiration per acre (simulated), and

PET = potential evapotranspiration.

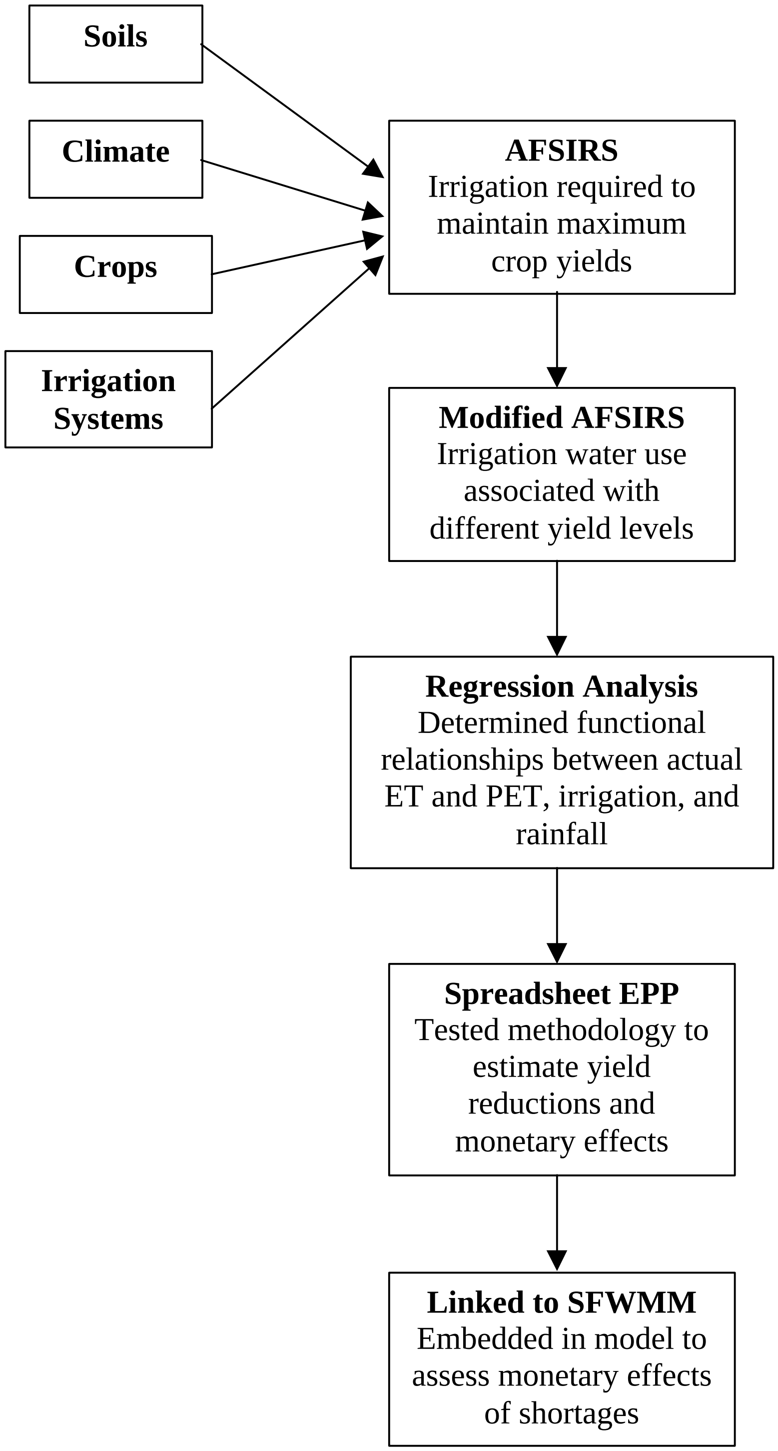


FIGURE 4.5-1
DEVELOPMENT OF THE AGRICULTURAL ELEMENT
SFWMM ECONOMIC POST-PROCESSOR

According to Thompson and Lynne, the Stewart equation is widely accepted. The crop-specific Beta coefficients (β), which relate water stress to crop yields, are based on research conducted for the Food and Agricultural Organization of the United Nations (Doorenbos and Kassam, 1979). The Beta coefficients depend on the crop type and growth stage being modeled. Thompson and Lynne caution users that the Beta coefficients contained in the program have been obtained from experimental data. For annual crops, single coefficients are included in the model for four growth stages: early vegetative, flowering, yield formation, and ripening. For perennials, it is more difficult to produce coefficients for specific growth periods. For example, it is well known that citrus is sensitive to water shortages during flowering. However, the actual flowering period will vary with climate and with soil moisture. This is problematic for AFSIRS, since it calculates irrigation requirements using the calendar date as a key to crop growth stage.

In the modified AFSIRS program, the user must specify actual yields (Y_{act}) as a proportion of the unconstrained yield (Y_{max}). The model uses the Stewart equation to simulate actual ET (ET_{act}). In the model, ET_{act} is drawn from moisture in the unsaturated zone supplied by rainfall or supplemental irrigation. Precipitation estimates contained in the climatic data file are used by the modified AFSIRS program to compute the supplemental irrigation required for the specified crop yields.

Thompson and Lynne (1991,a) attempted to validate the modified AFSIRS program. This was problematic however, since there were no subsequent agricultural droughts with which to compare the model's predictions. Instead, the model was tested against three crop-growth models which have been tested extensively in north Florida. The modified AFSIRS model generated results which were similar to the other models. Improvements were subsequently made to the model during the calibration process.

E.4.5.3 Regression Analysis

The SFWMD used the modified AFSIRS to determine the functional relationships between actual ET and PET, irrigation levels, and precipitation for a wide variety of crop and irrigation schemes (March, 1994). This was done by performing a series of model runs, specifying a range of different actual yields (Y_{act}): 100%, 75%, 60%, 50%, 40%, and 25%. This generated a series of simulated ET_{act} values. Regression equations were then computed to relate modeled monthly ET to monthly PET, rainfall, and net irrigation. The general functional form of the regression equations is double (natural) logarithmic:

$$\ln(ET_{ijkl}) = \alpha + \beta_1 \ln(PET_i) + \beta_2 * \ln(Raadj_i) + \beta_3 * \ln(Iradj_{ijkl})$$

where:

ET_{ijkl} = actual ET in month i of crop j on soil type k for yield level l
PET_I = Modified Penman-Monteith potential ET in month i
$Raadj_I$ = measured rainfall in month i
$Iradj_{ijkl}$ = simulated net irrigation in month i of crop j on soil type k at yield level l

(Note: In this equation, βi= regression coefficients, not the crop output factors in the Stewart equation)

E.4.5.4 Spreadsheet Prototype

The SFWMD developed a spreadsheet prototype of the EPP. During periods when available irrigation water supplies are less than what the AFSIRS model predicts is necessary to support maximum crop yields, the EPP estimates the potential reduction in agricultural revenues using the functions described above. The lower crop yields estimated using the regression functions are compared against maximum yields to determine changes in yield per acre. These values are then multiplied by the number of acres to estimate changes in total crop outputs. Crop outputs are multiplied by market prices to compute the potential revenue effects of water shortages.

E.4.5.5 Linkage to SFWMM

Once the spreadsheet prototype was successfully tested, the SFWMD embedded the EPP within the SFWMM. The SFWMM outputs of PET, irrigation water supply, and precipitation were combined with the agricultural land use profile for input to the EPP. ***Figure 4.5.5-1*** illustrates how the AFSIRS module determines the irrigation requirements for specific crops in particular locations. The EPP compares monthly PET for each grid cell (based on agricultural land use) with available water supply to estimate the monthly restricted ET and the monthly ET reduction from PET. The ET reductions can be used to estimate monthly shortages and crop yield reductions per acre. Reductions per acre are then multiplied by the number of acres and the per acre crop value to estimate the value of unmet demand for agricultural water supply.

According to USDA Natural Resources Conservation Service (NRCS) staff, there was only one drought year during this period, 1982, when there was a significant shortage of irrigation water in south Florida. During this year, crop yields were significantly lower than other years. However, during this year there was also a freeze that resulted in substantial crop damage. Unfortunately, it was not possible to distinguish the effects of the freeze from the effects of the drought. As a result, the results of the EPP have not been tested against historic drought conditions.

E.4.6 EPP ASSESSMENT

The EPP model has some theoretical and experimental components. When the NRCS was supporting the Corps in its attempt to estimate the effects of the alternative restoration plans on agricultural water supply, their staff considered using historical data to develop crop-specific relationships between crop yields and irrigation water shortages. The NRCS reviewed the past 25 years of agricultural water supply data available from the SFWMD and compared this information with historic data on crop yields in south Florida.

The EPP was reviewed to assess its suitability for estimating the NED effects of the alternative restoration plans on agricultural water supply. All five developmental elements illustrated in Figure 4.5.5-1 were examined. First, available AFSIRS documents were reviewed to determine the module's purpose, function, assumptions, strengths, and shortcomings (Thompson and Lynne, 1991,a,b). Second, a copy of the modified AFSIRS program for drought impact analysis was obtained from the SFWMD, including input data files, a copy of the computer code, and supporting documentation. Test runs of the modified program were performed to evaluate program inputs, function, and outputs. Third, the documentation of the regression analyses conducted to develop the functional relationships between simulated ET_{act} and PET, precipitation, and irrigation was reviewed. In addition, SFWMD personnel (Dr. Richard March) involved in developing the EPP were interviewed. Fourth, the spreadsheet prototype of the EPP was examined and tested to evaluate the logic underlying the calculation of the monetary effects of agricultural water shortages. Finally, the draft documentation for the SFWMM was reviewed to determine (1) which SFWMM outputs are used by the EPP and (2) how the AFSIRS module functions within the SFWMM. In addition, the output files from the EPP runs conducted for this investigation were scrutinized to determine how the EPP interacts with the SFWMM.

Based upon this review of the EPP-related materials, the post-processor seems to be a logical and practical approach to a difficult problem, i.e., estimating changes in crop yields and revenues associated with irrigation water shortages. However, there are four categories of issues that qualify the use of the economic post-processor. These issues do not preclude using the EPP to estimate the NED effects of the alternative restoration plans on agricultural water supply, but do qualify interpretation of the EPP outputs.

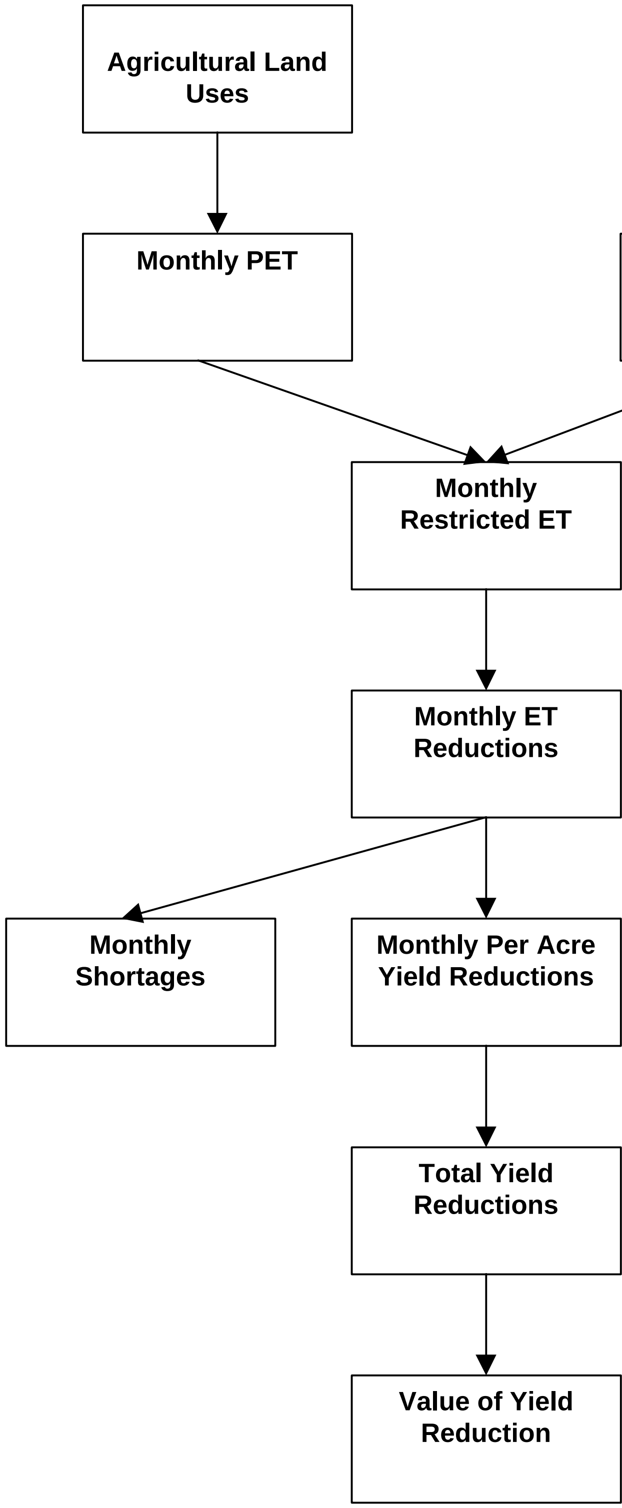


FIGURE 4.5.5-1
CONCEPTUAL FUNCTION OF THE EPP WITHIN THE SFWMM

E.4.6.1 Crop Response

The agricultural science that underlies the AFSIRS model is in its infancy. Although the program has been tested by the SFWMD, and calibrated for use in the SFWMM, the Beta coefficients (crop outputs per irrigation level) used in the Stewart equation are less evolved and should be considered experimental at this time. Additional research is needed to refine these coefficients. This research could determine the sensitivity of crop yields – and revenue effects – to changes in Beta coefficients. The most useful validation of the drought model would be to test it against empirical data from an actual drought event.

It is unclear whether the yield reductions predicted by the modified AFSIRS model imply crop mortality or, in the case of perennials (e.g., citrus), long-term damage that may affect future crop yields. Crop mortality would probably be limited to severe water shortages, but these events may comprise a significant share of potential revenue effects of water shortages. However, the SFWMD has a policy that commits Lake Okeechobee water supplies sufficient to meet at least one-third of the supplemental irrigation needs of EAA farmers. This minimum irrigation level may prevent extensive crop mortality in the EAA during droughts.

E.4.6.2 Growing Season

The timing of agricultural water supply shortages during the growing season is a critical factor in determining the extent and severity of potential crop losses. The difficulty of applying specific Beta coefficients to particular growth stages was mentioned previously. In the EPP, the user specifies the start and end months for the growing season for each crop. The simulation of revenue effects is based upon estimates of yield reductions that would result from water shortages during the specified months. If the actual growing seasons are not well aligned with the modeled growing seasons, the accuracy of the simulation could be compromised. The climate of south Florida is problematic in this regard, since it allows more flexibility in planting and harvesting than more northern climates.

There is an additional complication associated with crop rotation. As described previously, it has been estimated that approximately 12.5% of the land under sugarcane cultivation is fallow at any given time. If this is true, that would remove over 60,000 acres of sugarcane cultivation from vulnerability to water shortages. The EPP does not take crop rotation into consideration and therefore may overestimate the potential damages associated with water shortages. Land rotation considerations might also be important for other crops, as well.

E.4.6.3 SFWMM Constraints

The SFWMM provides tremendous analytical power for evaluating the alternative restoration plans by allowing multiple simulations to compare future with- and without-project conditions. However, there are some model-related constraints that affect its use in estimating the economic effects of agricultural water shortages. First, the land use categories in the SFWMM are broad relative to the complexity of agriculture in the LEC. For example, all of the vegetables grown with overhead irrigation systems are represented by tomato agriculture.

Second, the spatial resolution of the SFWMM is too coarse to accurately assess the agricultural impacts of the alternative restoration plans with great confidence. The grid cell represents only one agricultural use, the most dominant crop within that cell. For example, the SFWMM does not recognize crops other than sugar in the EAA, since none of the 4 square-mile grid cells are dominated by non-sugar crops. In actuality, there could be more than 30,000 acres of non-sugar crops in the EAA.

Third, the model presents a single value for soil depth in a grid cell. In the EAA, the depth of the soil is a critical factor in assessing the drought vulnerability of sugarcane. A single value (i.e., model node) for an area of 4 square miles may mask significant differences in drought vulnerability for the same crop.

Fourth, the full range of potential drought events in south Florida are not represented in the 31-year simulation period. The drought of 1980 and 1981 comprises a large share of the simulated drought effects. If the recurrence interval for this event is greater than once in 31 years, the average annual effects of agricultural water shortages are overstated.

Finally, the model must make assumptions about the behavior of farmers in the LOSA during extended dry periods. The ability of farmers to borrow water early in the dry season creates significant uncertainty regarding the timing and effects of water shortages.

E.4.6.4 Prolonged Water Shortages

The EPP calculates crop yield effects on a monthly basis. For shortages of several months in duration, the EPP may overestimate the effects on crop yield and revenue because each month is treated independently in the EPP. An example may best explain how an overestimation may occur. If there was a water shortage of 20% during the first month of the shortage, crop yields might be reduced by 10%. If the same shortage persisted to the following month, the crop yield effects would again be calculated at 10%. At the end of the year, the shortage would be tallied by the model as reducing crop yields by 20%. However, a 20% shortage sustained over two months might actually result in less than a 20% reduction in annual yield. Even if the 10% value for the second month was correct, it should probably be discounted (i.e., applied to the 90% of yield remaining after the first month of the shortage). One possible way to address this issue would be to treat shortages with durations of multiple months as a single event, evaluating the aggregate water shortage and applying that percentage to the maximum crop yield.

E.4.7 POTENTIAL NED EFFECTS ON AGRICULTURAL WATER SUPPLY

The NED account should reflect changes in net farm income that are associated with reduced agricultural water supply. According to the SFWMM analyses, the five alternative restoration plans will have different effects on agricultural water supply in the study area and thereby have different impacts on farm incomes. For the Restudy, estimating the NED effects of the alternative restoration plans on agricultural water supply requires a four-part analytical process:

- The available water supplies are estimated for each alternative plan.
- The supplies of the alternative plans are compared to water demand forecasts to identify potential shortfalls in water deliveries.
- Identified shortages are translated into yield reductions and then dollar-value reductions in net farm income.
- The monetary costs of water supply shortages of each alternative plan are compared to the costs anticipated in the absence of any action (i.e., comparing the with- and without-project conditions) to estimate the net economic effects of the alternative plans.

The first two steps have been accomplished in the SFWMM using the model's 31 years of daily simulations. The third and fourth steps are addressed below.

E.4.7.1 Revenue And Income Effects

The economic effects of changes in agricultural water supply can be registered in the NED account if there are resulting changes in either crop damages or land use. No land use effects are anticipated for the Restudy, since implementation of any of the alternative restoration plans is not expected to induce any changes in crop patterns. Therefore, the potential NED effects of changes in agricultural water supply are estimated based upon expected changes in net farm income during drought conditions. The NED account should include the net farm income effects associated with changes in both revenues and production costs resulting from plan implementation.

For sugarcane and non-sugar crops, the cost of crop inputs incurred over the course of the growing season would not change significantly during shortages. The potential income effects of water shortages on the cost side would therefore be derived from changes in harvesting and transportation (to processing facilities) costs. For sugarcane, harvesting and transportation in the EAA are conducted by the sugar mills, which then deduct these costs from their payments to the farmers for the cane. Sugarcane harvesting costs would not be expected to change during shortages for two reasons. First, while shortages would reduce sugarcane yields, it is likely that the SFWMD will provide sufficient irrigation water supplies to avoid crop mortality. As a result, the same area would be harvested during shortages as during non-shortage periods, since sugarcane is drought-tolerant. Second, since sugarcane harvesting is entirely mechanized, the combines would harvest the same areas during shortages with costs identical to non-shortage periods.

Under water stress, sugarcane yields in terms of biomass are reduced. Consequently, reductions in transportation costs to the sugar mills are expected. Given the relatively small shortage-induced changes in transportation costs anticipated for sugarcane and the inherent difficulty in quantifying them, it can be assumed for practical purposes that changes in farm revenues are approximately equal to changes in farm income. However, the exclusion of changes in sugarcane transportation costs during shortages may slightly exaggerate reductions in farm income associated with water shortages.

For vegetables and other non-sugar crops in the EAA, the assumption that changes in revenue equal changes in income is valid for other reasons. In the EAA, non-sugar crops such as rice, sod, and truck vegetables are raised by sugar farmers as supplemental crops. Based upon interviews with experts on EAA farm practices, it appears that during shortages, these crops would have irrigation priority over sugarcane. These crops are high-value relative to cane, and they are much more vulnerable to water shortages.

In the LEC, the assumption that changes in revenues would equal changes in income would not be applicable to non-sugar crops (row crops, citrus, etc). There would be some reductions in harvesting costs, as well as reductions in transportation costs. However, based upon a similar analysis conducted for the Lake Okeechobee Regulation Schedule Study, it appears that most of the effects of agricultural water shortages in the LEC are associated with urban landscaping and golf land uses, not commercial agriculture. Consequently, the assumption that changes in revenues equal changes in farm income remains valid for agriculture in the LEC, as well as in the EAA.

E.4.7.2 Crop Prices

Crop prices contained in the EPP come from a variety of sources. Representative prices for agricultural crops (rice, sugar, sod, tomatoes, citrus, avocado, and nurseries) were obtained from the Florida Agricultural Statistics Service (FASS). Representative values for the remaining categories (urban landscaping and golf turf) were derived from the 1992 Water Shortage Economic Impact Model (SFWMD,1990) study conducted for the SFWMD. Urban landscaping and golf turf values are better described as willingness-to-pay values (for green lawns and fairways), rather than market prices.

Corps planning guidance specifies that normalized prices developed by the U.S. Department of Agriculture (USDA) are to be used in water resources planning investigations whenever possible. If normalized prices are not available for a particular crop, average prices for a three-year period are to be used. As indicated in Table 4.7.2-1, the USDA normalized prices for 1997 include three of the EPP crop categories: sugarcane, rice, and citrus (oranges and grapefruit). The prices for rice and citrus were used to modify the EPP outputs. However, to account for significant interstate variability in sugarcane prices, a three-year average price for Florida sugarcane (1994-1996) was used to modify the EPP outputs. The price used for citrus was an average of the orange and grapefruit prices. For fall and spring tomatoes and avocados, three-year averages (1995-1997) were calculated using data from Florida Agricultural Statistics Service (FASS). Sod prices were problematic, since there are very little data available. The sod prices used in the EPP were developed in consultation with University of Florida Professor Haydu, a recognized expert in sod cultivation.

The EPP prices used for golf turf are dependent on the phase of the simulated water shortage. In a 1991 study prepared for the SFWMD by Apogee Research Inc., the costs for golf courses to implement operational changes in response to the shortages range from $9.95/acre (Phase I) to $210/acre (Phase IV). The EPP has the Phase IV value ($210/acre) programmed as the shortage value for all phases, but manual adjustments were made to apply the price appropriate to the shortage phase. Otherwise, there would be significant exaggeration of golf course effects.

TABLE 4.7.2-1
UNIT PRICES USED TO UPDATE EPP OUTPUT TO 1997 VALUES ($)

Crop	Units	EPP Unit Prices	Normalized Prices	Unit Prices Used	Comment
Sugarcane	Ton	$31.12	$28.26	$30.20	3 yr. Avg.
Rice	Cwt.	$10.00	$7.48	$ 7.48	Normalized
Sod	Acre	$3,600.00		$4181.76	Current Prices
Tomatoes – fall	Bushel	$9.35		$7.84	3-year average
Tomatoes– spring	Bushel	$9.35		$7.84	3-year average
Citrus	Box	$4.99-6.63	Oranges - $6.52 Grapefruit-$5.38	$5.95	Average of normalized
Avocado	Bushel	$1.74-41.80		$14.23	3-year average
Urban Landscape	Acre	$3,600.00		$2 per 1000 gallons	Phase I Residential Willingness to Pay
Golf	Acre	$182.00		Variable	Phase Dependent
Nursery	Acre	$7,597.00		$7,597.00	No Change

Sources:
Normalized Prices: U.S. Department of Agriculture. 1996.
Market Prices: Florida Agricultural Statistics Service. 1997.

Urban landscaping in the SFWMM includes lawns and landscaping for residential and commercial land uses (golf courses are treated as a separate category). The EPP was originally designed to assign the same unit price to landscaping as used for sod. This would be justifiable if a water shortage was sufficiently severe to extirpate the landscaping and require complete replacement. The SFWMM runs for the alternative restoration plans have not simulated water shortages in the LEC that are more severe than Phase I (moderate shortage). Phase I cutbacks on urban irrigation are modest. The SFWMD Water Shortage Plan (SFWMD, 1991) stipulates that irrigation of urban landscaping during Phase I shortages shall be limited to specific hours of the day and to specific days of the week, depending on the size of the irrigated area. The SFWMM estimates irrigation water uses for urban landscaping during Phase I shortages using maximum irrigation application rates of 20 inches per month. Given these modest effects, an adjustment of the unit price for urban landscaping effects was required. A revised unit price of $2 per 1000 gallons was selected for landscaping effects under Phase I shortages. This price was developed by the SFWMD to estimate the willingness of residential water users in the LEC to pay for water not received under Phase I shortages. For more information about the SFWMD's efforts to estimate LEC water users' willingness to pay for water during shortages, see Section 3 in this appendix on M&I water supply.

E.4.8 EVALUATION OF ALTERNATIVE RESTORATION PLANS

Evaluation of the effects of the five alternative restoration plans on agricultural water supply and revenues in the LOSA and in the LEC includes two principal components. First, the effects on agriculture in the EAA and in the LEC were estimated using the EPP. Second, the effects on agriculture in the Caloosahatchee and St. Lucie basins were estimated separately, using outputs from the SFWMM. These two sets of effects are discussed below.

E.4.8.1 Agricultural Water Supply in the EAA and LEC

Table 4.8.1-1 contains the simulated revenue (and income) effects on agriculture in the EAA and in the LEC associated with existing (1995) and future (2050) without-project conditions and the five alternative restoration plans (A, B, C, D, and THE RECOMMENDED PLAN). The values contained in this table represent the “value of unmet demand” for agricultural water supply estimated for the SFWMM’s 31-year simulation period.

In Table 4.8.1.1, the values of unmet agricultural water demands associated with the alternative restoration plans incorporate reductions in the crop area that are expected to result from plan implementation. For all of the alternative plans, it is anticipated that 60,000 acres in the EAA would be converted from crop land into one or more water supply reservoirs. As a result, in the SFWMM runs conducted for this investigation, the EAA with-project acreage under sugar cultivation was reduced from 491,520 to 431,520 acres.

Average annual values were calculated by distributing the total effects arithmetically over the 31 years. The value of unmet demand is defined as the difference between the normal value of yields under unconstrained water conditions and the value of yields predicted by the model for each restoration plan. As indicated in Table 4.8.1-1, all of the scenarios have unmet irrigation water demands over the simulation period. Considering the severity of some drought events contained in the simulation period (e.g., the 1980/1981 drought), it would be expected that all agricultural water users would receive less than the full amount of water desired from the C&SF system over the 31-year simulation period, except for landscape crops in the LEC. Therefore, the higher the values of unmet demand presented in this table, the greater the reduction in potential yields (and revenue losses) expected under each scenario. As indicated in Table 4.8.1-1, all of the alternative restoration plans have values of unmet demands that are well below those anticipated for the 2050 without-project (base) conditions. This suggests that the alternative plans would improve agricultural water supply conditions relative to future conditions expected with no restoration action. This table includes the effects on urban landscaping and golf turf, as well as agricultural crops.

Table 4.8.1-2 presents the sectoral and spatial distributions of values of unmet demands generated by the SFWMM for the with-project and without-project conditions. The simulated values of unmet irrigation water demand under the alternative plans are limited to golf courses in the LEC and sugarcane in the EAA. The sectoral percentages of total value of unmet demand for each scenario are also presented in this table. As indicated in Tables 4.8.1-1 and 4.8.1-2, sugarcane in the EAA is anticipated to be the agricultural sector most affected by shortages of irrigation water supply. However, all of the alternative plans are expected to represent significant improvements over the without-project future conditions.

Table 4.8.1-3 indicates the differences between the values of unmet agricultural water demand for the simulated with- and without-project futures. The positive (+) signs on the estimates reflect that the alternative plans are expected to be improvements over without-project future conditions. The average annual improvements would be expected to begin soon after project construction and increase up to the levels shown in the table over an assumed 20-year construction period. As indicated in Table 4.8.1-3, the five alternative restoration plans (Alternatives A, B, C, D and The Recommended Plan) have similar performance with respect to agricultural water supply. However, Alternative A is expected to produce the greatest improvement of the five alternative restoration plans with respect to agricultural water supply.

TABLE 4.8.1-1
VALUE OF UNMET DEMAND FOR AGR ICULTURAL WATER SUPPLY
EAA AND LEC, 1995, 2050 SCENARIOS ($1997)

Scenario	Area	Total	Average Annual
1995 Without-Project	EAA	$46,440,533	$1,498,082
	SA1	$253,516	$8,178
	SA2	$964,145	$31,101
	SA3	$5,063,061	$163,325
	North Palm Beach Co.	$74,635	$2,408
	Total	$52,795,890	$1,703,093
2050 Without-Project	EAA	$74,114,454	$2,390,789
	SA1	$965,200	$31,135
	SA2	$4,767,589	$153,793
	SA3	$226,363	$7,302
	North Palm Beach Co.	$820,639	$26,472
	Total	$80,894,244	$2,609,492
Alternative A (2050)	EAA	$17,330,507	$559,049
	SA1	$22,338	$721
	SA2	$370,508	$11,952
	SA3	$126,803	$4,090
	North Palm Beach Co.	$55,999	$1,806
	Total	$17,906,154	$577,618
Alternative B (2050)	EAA	$26,499,106	$854,810
	SA1	$22,338	$721
	SA2	$600,612	$19,375
	SA3	$86,535	$2,791
	North Palm Beach Co.	$55,999	$1,806
	Total	$27,264,589	$879,503
Alternative C (2050)	EAA	$20,219,681	$652,248
	SA1	$22,338	$721
	SA2	$180,851	$5,834
	SA3	$60,188	$1,942
	North Palm Beach Co.	$20,885	$674
	Total	$20,503,943	$661,418
Alternative D (2050)	EAA	$25,669,155	$829,037
	SA1	$22,338	$721
	SA2	$180,851	$5,834
	SA3	$62,645	$2,021
	North Palm Beach Co.	$20,885	$674
	Total	$25,955,874	$837,286
Recommended Plan (2050)	EAA	$21,944,171	$707,876
	SA1	$22,338	$721
	SA2	$180,851	$5,834
	SA3	$62,645	$2,021
	North Palm Beach Co.	$20,885	$674
	Total	$22,230,890	$717,125

TABLE 4.8.1-2
SECTORAL DISTRIBUTION OF
VALUES OF UNMET AGRICULTURAL WATER DEMAND
EAA AND LEC
1995, 2050 SCENARIOS ($1997)

Scenario	EAA	SA1	SA2	SA3	North P. B. County	Totals	% of Total
1995 Base							
Urban				$4,900,000		$4,900,000	9.3%
Golf		$253,516	$964,145	$163,061	$74,635	$1,455,357	2.8%
Other-cane	$46,440,533					$46,440,533	88.0%
Total	$46,440,533	$253,516	$964,145	$5,063,061	$74,635	$52,795,890	(100%)
(%)	(88.0%)	(0.5%)	(1.8%)	(9.6%)	(0.1%)		
2050 Base							
Urban					$496,000	$496,000	0.6%
Nursery (field)			$2,165,534			$2,165,534	2.7%
Golf		$965,200	$1,595,582	$226,363	$324,639	$3,111,783	3.8%
Other-sod			$1,004,359				1.2%
Other-cane	$74,114,454		$2,114.00			$74,116,568	91.6%
Total	$74,114,454	$965,200	$4,767,589	$226,363	$820,639	$80,894,244	(100%)
(%)	(91.6%)	(1.2%)	(5.9%)	(0.3%)	(1.0%)		
Alternative A							
Golf		$22,338	$370,508	$126,803	$55,999	$575,647	3.2%
Other-cane	$17,330,507					$17,330,507	96.8%
Total	$17,330,507	$22,338	$370,508	$126,803	$55,999	$17,906,154	(100%)
(%)	(96.8%)	(0.1%)	(2.1%)	(0.7%)	(0.3%)		
Alternative B							
Golf		$22,338	$600,612	$86,535	$55,999	$765,483	2.8%
Other-cane	$26,499,106					$26,499,106	97.2%
Total	$26,499,106	$22,338	$600,612	$86,535	$55,999	$27,264,589	(100%)
(%)	(97.2%)	(0.1%)	(2.2%)	(0.3%)	(0.2%)		
Alternative C							
Golf		$22,338	$180,851	$60,188	$20,885	$284,262	1.4%
Other-cane	$20,219,681					$20,219,681	98.6%
Total	$20,219,681	$22,338	$180,851	$60,188	$20,885	$20,503,943	(100%)
(%)	(98.6%)	(0.1%)	(0.9%)	(0.3%)	(0.1%)		
Alternative D							
Golf		$22,338	$180,851	$62,645	$20,885	$286,719	1.1%
Other-cane	$25,669,155					$25,669,155	98.9%
Total	$25,669,155	$22,338	$180,851	$62,645	$20,885	$25,955,874	(100%)
(%)	(98.9%)	(0.1%)	(0.7%)	(0.2%)	(0.1%)		
Recommended Plan							
Golf		$22,338	$180,851	$62,645	$20,885	$286,719	1.3%
Other-cane	$21,944,171					$21,944,171	98.7%
Total	$21,944,171	$22,338	$180,851	$62,645	$20,885	$22,230,890	(100%)
(%)	(98.7%)	(0.1%)	(0.8%)	(0.3%)	(0.1%)		

TABLE 4.8.1-3
DIFFERENCES BETWEEN SIMULATED
VALUES OF UNMET AGRICULTURAL WATER DEMANDS UNDER
2050 WITH- AND WITHOUT-PROJECT CONDITIONS
($1997)

Alternative	Total Value of Reduced Unmet Demand	Average Annual Value of Reduced Unmet Demands
A	$62,988,090	$2,031,874
B	$53,629,655	$1,729,989
C	$60,390,302	$1,948,074
D	$54,938,370	$1,772,205
Recommended Plan	$58,663,354	$1,892,366

Table 4.8.1-3 indicates that the value of unmet agricultural water demand is expected to increase significantly (from $52,795,890 to $80,894,244) between 1995 and 2050 under the without-project base conditions, respectively. In the absence of structural and management measures that comprise the alternative restoration plans, the performance of the C&SF system in terms of agricultural water supply can be expected to deteriorate over time. The substantial socio-economic and land use changes that are expected to occur in south Florida during the coming decades are among the explanations for this expected decline in system performance.

E.4.8.2 Agricultural Water Supply: St. Lucie and Caloosahatchee Basins

The EPP does not address the Caloosahatchee and St. Lucie basins, but the SFWMM does generate information which is relevant to the evaluation of the effects of the alternative restoration plans within these basins. The EPP was designed for evaluating irrigated agriculture in the EAA and in the LEC. It is directly dependent on the SFWMM for critical inputs, especially evapotranspiration. While the Caloosahatchee and St. Lucie basins are not included in the SFWMM grid cell network, these basins are incorporated in the SFWMM as single model nodes, much like large, individual grid cells. They are important components of the regional water management system for three reasons. First, these waterways provide outlets for regulatory releases from Lake Okeechobee. Second, the basins have water demands – particularly for agriculture – that draw upon the lake's water resources. Finally, the estuaries of these waterways are sensitive to salinity effects of fresh water releases from the lake and the local basins.

Since the EPP can not be used to estimate revenue effects of agricultural water shortages in the Caloosahatchee or St. Lucie basins, the best indicators of agricultural water supply effects of the alternative restoration plans are irrigation water demands and demands not met. The demands not met are presented for the Caloosahatchee or St. Lucie basins in ***Table 4.8.2-1***. These figures include consideration of Aquifer Storage and Recovery (ASR) and reservoirs in the Caloosahatchee basin. As indicated in Table 4.8.2-1, the simulated percentages of demands not met under the 2050 without-project conditions for the Caloosahatchee and St. Lucie basins are 22.4% and 31.6%, respectively. All alternatives appear to represent significant improvements over the future without-project conditions. The Recommended Plan is expected to have performance that is equivalent to Alternative D.

TABLE 4.8.2-1
SIMULATED IRRIGATION DEMANDS NOT MET
UNDER 2050 WITH- AND WITHOUT-PROJECT CONDITIONS

Basin	2050 Base	Alternative				
		A	B	C	D	RP
Caloosahatchee	22.4%	4.1%	6.5%	4.1%	3.1%	2.6%
St. Lucie	31.6%	9.2%	14.9%	9.0%	7.5%	6.7%

Note: RP = Recommended Plan (D13R + Other Project Elements)

E.5 MUNICIPAL AND INDUSTRIAL WATER SUPPLY

E.5.1 OVERVIEW

This chapter examines the potential economic effects of the alternative restoration plans on municipal and industrial (M&I) water supply. It is the first of six chapters that assess the potential National Economic Development (NED) effects of the alternative plans. These chapters examine economic implications of the hydrologic changes that are expected to result from the structural and operational changes to the C&SF project associated with the alternative plans. The hydrologic effects of the alternative plans have been simulated using the South Florida Water Management Model (SFWMM). The model incorporates the M&I water demand forecasts (discussed in the preceding chapter) into the with- and without-project future conditions. The focus of this and subsequent chapters is on the economic significance of hydrologic changes associated with the alternative plans, estimated as the differences between the with- and without-project future conditions.

During droughts, water demands may exceed available supplies. To manage water shortages and protect system reserves, the SFWMD may request and ultimately require water users in south Florida to reduce their water use. Consequently, during water shortages, water users in south Florida may not receive as much water as they would like. Voluntary and mandatory water use cutbacks have economic implications for urban and agricultural users. For urban water users, there may be direct costs associated with the unmet water demands. For example, residential and commercial water users may experience opportunity costs associated with active conservation measures (i.e., reducing water use during shortages). Urban water users may be willing to pay for water not received during shortages to avoid effects on water-related activities such as watering lawns, washing cars, etc. If shortages are frequent, there may be costs to M&I water users associated with: (1) new sources of supply, (2) additional water treatment, and/or (3) more aggressive water conservation. There may also be secondary effects, such as utility revenue losses that are experienced when M&I users reduce consumption during shortages.

This chapter focuses on M&I water use in the Lower East Coast (LEC), since most of the M&I water uses in the SFWMM coverage area portion of the C&SF study area are located in this region. The LEC includes Service Areas (SAs) 1, 2, and 3, which are primarily located within southern Palm Beach County, Broward County, and Miami-Dade County, respectively. Northern Palm Beach County comprises a fourth water supply area.

The discussions of M&I water use in this chapter do not include self-supplied irrigation of urban landscaping (i.e., watering urban and suburban lawns, shrubs, etc) or golf courses. These water uses are included in the discussions of agricultural water supply in the following chapter.

Estimates of the potential effects of the alternative restoration plans on M&I water supply were prepared using the economic post-processor (EPP) developed by the SFWMD. The EPP was designed to assess the economic effects on agricultural and urban water supply anticipated to result from structural and operational changes to the C&SF project.

The assessment of the M&I water supply impacts of the alternative restoration plans begins with a description of south Florida water management during water shortages followed by a discussion of alternative approaches to estimating the economic effects of M&I water shortages.

E.5.2 WATER MANAGEMENT DURING SHORTAGES

The SFWMD monitors hydrologic conditions throughout south Florida. Current hydrologic and water use data are compared to historic data to determine: (1) whether present and future water supplies will be sufficient to meet the needs of water users and (2) whether serious harm to the region's water resources can be expected, including saltwater intrusion into freshwater aquifers or adverse fish and wildlife effects. Factors considered in estimating present and future water supplies include:

- Historic, current, and anticipated levels in surface and ground waters,
- Historic, current, and anticipated flows in surface waters,
- The extent to which water may be transferred from one source to another,
- The extent to which water use restrictions might enhance supplies,
- Historic, current, and anticipated demands of natural systems, and
- Historic, current, and anticipated seasonal fluctuations in rainfall.

Factors considered in estimating present and anticipated water demands include:

- Estimated current and anticipated demands of permitted and exempt users,
- Demands of users whose water supply is established by federal law,
- Anticipated seasonal fluctuations in user demands, and
- The extent to which user demands may be met from other sources.

When current or future water supplies are not expected to meet water demands, the SFWMD may institute a series of progressively more severe demand management measures to conserve water supplies. The SFWMD developed a Water Shortage Plan in 1982 following a severe drought event. The plan provides specific guidelines for water restrictions which are based on the type of use and the severity of the drought. The SFWMD may initially request voluntary reductions, and later require mandatory cutbacks in water use commensurate with the anticipated balance of water supply and demand. Included within the plan is the following sequence of four mandatory water shortage phases:

- Phase I: Moderate Water Shortage,
- Phase II: Severe Water Shortage,
- Phase III: Extreme Water Shortage, and
- Phase IV: Critical Water Shortage.

Shortage declarations by the SFWMD can be triggered by salinity intrusion into coastal aquifers threatening utility wellfields or by low lake levels in Lake Okeechobee relative to seasonal goals. Water shortage declarations are typically made on a monthly basis. However, during the dry season it is likely that the declarations would be continued through the remainder of the dry season, avoiding to the extent possible an on/off whipsaw of shortage declarations that could occur due to short term variability in water supply conditions in South Florida

If droughts are localized, the SFWMD manages the regional water supply system to move water from areas of surplus to areas of deficit. The shortage phase declarations can be scaled to the municipal, utility, county, service area, or regional level, commensurate with the geographic extent of the water shortage. However, declarations are usually applied to entire service areas. For regional droughts such as those triggered by low Lake Okeechobee levels, the water shortage phases can be declared for the entire LEC to reduce water usage in all areas which Lake Okeechobee serves as a backup source of water. The specific use restrictions of the Water Shortage Plan have been invoked three times: in 1982, 1985, and 1989 (Hall, 1991).

The four phases of water supply shortages in the Water Shortage Plan stipulate cutbacks by water users in the LEC, including agricultural and urban water usage. For each phase, the plan stipulates the time of day, duration, and/or quantity of water usage by users in the following use categories:

Essential (e.g. fire fighting)
Domestic
Utility
Commercial
Agriculture
Nurseries
Urban irrigation
Recreation areas, and
Golf courses

The threat of salinity intrusion into the LEC's coastal aquifers is a major water management concern during water shortages. The salinity levels at key coastal monitoring wells are used as triggering mechanisms for declaration of LEC water shortages phases. The SFWMM does not model water quality, and groundwater levels are used as surrogate measures of salinity intrusion. In the model, hydraulic head (i.e., water level) is monitored at key trigger wells and canals. When modeled water levels fall below specific thresholds, water shortages are simulated with the following cutbacks in M&I water use expressed as a fraction of total pumpage: For the 1995 base condition - Phase I (15% cutback), Phase II (30% cutback), Phase III (45% cutback), and Phase IV (60% cutback): and for the 2050 base all alternative conditions – Phase I (10% cutback), Phase II (25% cutback), Phase III (40% cutback), and Phase IV (55% cutback). The latter cutback percentages are lower because of the assumption that conservation measures will have become a part of normal demands in the future.

In the LEC water supply service areas, the overwhelming share of M&I water is supplied to users by local utilities. The utilities draw upon local water resources – primarily groundwater – to meet their customers' needs. When utilities experience shortfalls of water supply, they can augment their supplies or take measures to reduce the demands of their customers.

Supply augmentation can be implemented as short-term or long-term measures. Water supplies can be augmented during short-term emergencies (e.g., large fires), via interutility transfers made possible by utility interconnections. To meet customer demands during water shortages, utilities can draw upon the regional water supply system to augment their supplies. To provide for long-term supply deficits, utilities must develop supplemental sources of water. In south Florida, supplemental water supply sources potentially include:

- Developing additional well fields to tap the relatively shallow Biscayne aquifer,
- Reverse osmosis treatment, or blending (for brackish water from the Biscayne and Floridan aquifers),
- Aquifer storage and recovery, and
- Making wastewater treatment plant effluent available for use after suitable treatment (e.g., advanced wastewater treatment or reverse osmosis).

M&I water demands can be reduced in the short term through active conservation measures during shortages and in the long term by passive conservation measures, such as low-flow plumbing fixtures

E.5.3 ALTERNATIVE APPROACHES TO M&I WATER SUPPLY EVALUATION

The alternative restoration plans could potentially affect the frequency, severity, and duration of M&I water shortages. The conceptual basis for evaluating the economic effects of changes in M&I water supply associated with alternative plans is society's willingness to pay (WTP) for the increase in the value of goods and services attributable to the water supplied. Corps of Engineers planning guidance stipulates that where the price of water reflects its marginal cost, that price should be used to calculate WTP for water supply – in this case, for the amount of water foregone in the supply shortfall. In the absence of such direct measures of WTP, the effects of water supply plans should instead be measured by the least cost alternative (LCA) to replace the shortfall in supply.

The LCA method is widely used in the Corps, given the difficulty of directly measuring WTP for water supply. However, as discussed below, the WTP approach has been selected as the primary method to estimate the M&I water supply impacts of the alternative restoration plans.

E.5.3.1 Problems in Applying the LCA Approach to the Lower East Coast

In the LEC, water supply planning and implementation takes place at the local (i.e., utility) and regional scales. For both scales, the use of the LCA approach in assessing the economic impacts of the alternative restoration plans on M&I water supply is problematic. At the regional scale, there is insufficient information at this time regarding the size and costs of alternative sources of water supply. ***Table 5.3.2-1*** presents a summary of recommendations prepared by the SFWMD for the Draft Lower East Coast Regional Water Supply Plan (1997). These recommendations illustrate the type of water supply measures that are considered to augment regional water supplies. The SFWMD has prepared preliminary cost estimates for some of these measures. Since no capacity estimates were prepared however, estimates of unit costs are not available.

The application of the LCA approach to the LEC at the utility scale is problematic for several reasons. First, the SFWMM-simulated declarations of shortages may not fully reflect the water supply situation of a given utility. Although a utility may have ample water supplies, in the model (and in fact) it could be subject to a simulated shortage declaration if regional monitoring of coastal aquifers indicated potential salinity intrusion. If a shortage was simulated for an entire service area due to salinity intrusion, utilities that effectively manage their water supplies can be penalized along with those utilities that are experiencing supply problems.

TABLE 5.3.2-1
RECOMMENDATIONS OF THE
DRAFT LOWER EAST COAST WATER SUPPLY MASTER PLAN

Regional:
Water Resource Partnerships/Basin Level Planning
Alternative Water Supply Development
Regional Storage Recommendation
Modifications to SFWMD Regulatory Program: Permit Duration
Modifications to SFWMD Regulatory Program: Level of Certainty
Saltwater Intrusion Management
Floridan Aquifer Regional Model Development
Aquifer Storage and Recovery Working Group
East Coast Buffer/Water Preserve Areas
Lake Okeechobee Restoration plans
Funding Strategy
Northern Palm Beach County:
North Palm Beach County Water Management Plan
L-8 Option
Discharges to Lake Worth Lagoon via C-17
LEC-SA1:
Southeastern Palm Beach County Integrated Water Resource Plan
Regional Groundwater Aquifer ASR Pilot Project
L-8 Option
Southeastern Lake Worth Drainage District Storage Feasibility Analysis
Site 1 Reservoir
Utility Well Field Expansion
LEC-SA2:
Coastal Broward County Integrated Water Resource Management Plan
Broward County Secondary Canals Recharge Network
Utility Well Field Expansion
LEC-SA3:
South Dade County Integrated Water Resource Management Plan
C-4 Structures
Utility Aquifer Storage and Recovery

Source: SFWMD. Draft Lower East Coast Water Supply Master Plan. 1997

Second, the determination of the LCA for an LEC utility during a particular shortage depends on the condition of the regional system. If the shortage is localized, a utility might be able to draw freely upon the regional system, and it may not need to develop supplemental sources of supply. However, if the water shortage is regional in nature, widespread shortages and institutional restrictions may limit access to regional water supplies and reduce supply options available to local water utilities.

Third, there are also practical considerations associated with the large number (29) of utilities in the LEC. Each utility has an array of short-term and long-term options to augment their water supplies. The potential combinations of utilities and options leads to hundreds of possible regional water supply scenarios, which makes the task of assessing the potential effects of the alternative restoration plans extremely difficult.

E.5.3.2 Opportunity Provided by the EPP

The EPP provides an opportunity to efficiently and effectively evaluate the alternative restoration plans using the WTP approach. The SFWMM estimates M&I water supply effects of the alternative restoration plans by comparing M&I water supply with demand. This requires a disaggregation/distribution procedure that accounts for spatial and sectoral uses, as well as groundwater pumpage. In its 31-year simulations, the SFWMM estimates the location, severity, and duration of M&I water supply shortages. It also simulates the frequency and phase of water shortage declarations based on: (1) Lake Okeechobee levels and (2) the salinity intrusion threat to coastal aquifers (estimated using water surface elevations in monitoring wells). These outputs from the SFWMM are then input to the EPP to calculate the economic effects of changes in the level of M&I water supply for each alternative restoration plan.

For each of the water shortage phases, the EPP estimates dollar damages from cutbacks based on the estimated WTP (in dollars per 1000 gallons) of regional M&I water consumers. The SFWMD developed these public water supply loss values on the basis of a 1992 survey of M&I water users in south Florida and also on utility charges for water and sewer services per unit of incremental water use.

E.5.3.3 SFWMD Willingness-to-Pay Survey

The SFWMD survey, which was conducted following regional water shortages in 1989, queried respondents' WTP for water under Phase III and Phase IV reductions. In the survey, residential water users were asked questions about their willingness to pay to avoid water shortages. The questions described in detail how water use behavior would be restricted during Phases III and IV water shortages, including shorter showers, early morning landscape watering, restricted toilet flushing, and possible landscape loss. Respondents asked if they would be willing to avoid these inconveniences and other losses. Specifically, they were told that the SFWMD had a plan that could do away with such shortages entirely, and they were then asked if they would vote for a referendum that would increase water bills to avoid these shortages which otherwise would occur every five years or every 10 years. Respondents were also told that agriculture and industry would pay their fair share.

Each of the Lower East Coast counties was surveyed separately. There were 1,260 respondents to the survey with approximately one-third of the responses each from Palm Beach, Broward, and Dade counties. County-level WTP estimates were developed for the three LEC counties.

SFWMD staff economists estimated WTP values for Phases I and II by subtracting the marginal costs, of M&I water in the LEC on the basis of chemical and power costs of producing and distributing additional water, from the changes in consumer surplus that would result from modest cutbacks in water supply.

Table 5.3.4-1 contains estimates of the WTP (in dollars per 1000 gallons) of M&I water users in the LEC to forgo curtailing water use during water shortages. In this table, the WTP values are presented in 1992 dollars, but for the evaluation of the alternative restoration plans, the WTP values have been updated to 1997 price levels.

E.5.4 ASSESSMENT OF ALTERNATIVE RESTORATION PLANS

The NED benefits of reducing M&I water demands not met are the differences in the consumer and producer surpluses of water use time between the with- and without-project conditions. The EPP calculates the economic value of unmet M&I water demand. The value of unmet demand is based on the amount that M&I customers would be willing to spend to have water that is unavailable during shortages. In the EPP, water supply shortfalls in a given shortage phase are multiplied by the WTP associated with that phase. The values of the unmet water demands during M&I shortages are the basis for comparing the alternative restoration plans against the without-project future conditions.

TABLE 5.3.4-1
WTP OF M&I WATER USERS TO FORGO CURTAILING WATER USE
LEC WATER SHORTAGE PHASES I-IV
($/1000 gallons); ($1992)

Service Area	Loss Value
Service Area 1	
Phase 1	$2.00
Phase 2	$3.00
Phase 3	$13.80
Phase 4	$26.00
Service Area 2	
Phase 1	$2.00
Phase 2	$3.00
Phase 3	$13.24
Phase 4	$22.36
Service Area 3	
Phase 1	$2.00
Phase 2	$3.00
Phase 3	$7.28
Phase 4	$17.40
N. Palm Beach Service Area	
Phase 1	$2.00
Phase 2	$3.00
Phase 3	$13.80
Phase 4	$26.00

Source: SFWMD. 1992.

The values of unmet M&I water demand for the alternative restoration plans and the 1995 and 2050 without-project (base) conditions are presented in ***Table 5.4-1***. As indicated in this table, it is anticipated that there will be unmet demand for M&I water supply under both with- and without-project future conditions. The larger the value of unmet demand, the greater the negative effects associated with water shortages. Average annual losses are included in this table, which were calculated as the arithmetic average over the 31-year simulation period. The values in Table 5.4-1 represent the estimated dollar amounts that M&I water users are willing to pay for water they want but do not receive during water shortages. [The expected value of unmet demand for the Recommended Plan is identical to that of Alternative D.]

The value of average annual unmet M&I demand under the without-project future (2050 base) condition ($31.8 million) is significantly higher than the values of unmet demands under existing without-project (1995 base) and with-project future conditions. The differences between the with- and without-project conditions are due to the number and severity of water shortages. ***Table 5.4-2*** presents the number of simulated Phase I water shortages declared during the 31-year simulation period. As indicated in this table, all of the alternative plans are expected to significantly reduce the number of Phase I shortages. The alternative plans have no simulated shortages that are more severe than Phase I. In contrast, the 2050 without-project (base) condition has eight simulated Phase II shortages and one simulated Phase III shortage in addition to the Phase I shortages depicted in the table.

Table 5.4-1 indicates that the average annual value of unmet M&I water demand is expected to increase significantly (from $11.3 million to $31.8 million) between 1995 and 2050 under the without-project (base) conditions, respectively. In the absence of the structural and operational measures that comprise the alternative restoration plans, the performance of the C&SF system in terms of M&I water supply can be expected to deteriorate over time. The substantial socio-economic and land use changes that are expected to occur in south Florida during the coming decades are one of the reasons for the expected decline in system performance.

As indicated in ***Tables 5.4-1*** and ***5.4-2***, the Recommended Plan is anticipated to have superior performance relative to the other alternative plans in reducing M&I water shortages. This superiority is also illustrated in ***Table 5.4-3***, which presents the net effects of the four alternative restoration plans on M&I water supply. Net effects are calculated as the difference between the value of unmet demand under without-project conditions (2050 base condition) and with-project conditions (Alternatives A, B, C, D, and the Recommended Plan). These differences represent the NED effects of the alternative restoration plans. All of the alternative plans have positive net effects, indicating that they would yield improvements in M&I water supply relative to the without-project future conditions. The Recommended Plan is expected to have the greatest positive effects of the alternative plans.

TABLE 5.4-1
VALUE OF UNMET DEMAND FOR M&I WATER SUPPLY (1995, 2010)
($1997)

Scenario	Service Area	Total	Average Annual
1995 Base	SA1	$58,229,583	$1,878,374
	SA2	$159,672,904	$5,150,739
	SA3	$120,222,851	$3,878,156
	North Palm Beach Co.	$13,105,403	$422,755
	Total	$351,230,741	$11,330,024
2050 Base	SA1	$202,363,845	$6,527,866
	SA2	$485,434,138	$15,659,166
	SA3	$259,289,294	$8,364,171
	North Palm Beach Co.	$39,296,761	$1,267,637
	Total	$986,384,038	$31,818,840
Alternative A	SA1	$56,761,860	$1,831,028
	SA2	$119,676,030	$3,860,517
	SA3	$126,176,108	$4,070,197
	North Palm Beach Co.	$12,527,694	$404,119
	Total	$315,141,693	$10,165,861
Alternative B	SA1	$58,965,160	$1,902,102
	SA2	$124,599,708	$4,019,345
	SA3	$122,026,903	$3,936,352
	North Palm Beach Co.	$13,007,021	$419,581
	Total	$318,598,792	$10,277,380
Alternative C	SA1	$42,745,852	$1,378,898
	SA2	$67,582,741	$2,180,088
	SA3	$78,394,469	$2,528,854
	North Palm Beach Co.	$9,411,500	$303,597
	Total	$198,134,562	$6,391,437
Alternative D & Recommended Plan	SA1	$29,857,805	$963,155
	SA2	$46,571,311	$1,502,300
	SA3	$60,795,524	$1,961,146
	North Palm Beach Co.	$6,557,277	$211,525
	Total	$143,781,917	$4,638,126

TABLE 5.4-2
NUMBER OF SIMULATED PHASE I WATER SHORTAGES
ALTERNATIVE RESTORATION PLANS AND 2050 BASE CONDITIONS

Service Area	2050 Base	Alternatives			
		A	B	C	D & RP
SA1	22	7	7	6	4
SA2	30	16	16	9	7
SA3	18	12	11	9	7
North Palm Beach County	19	7	7	6	4

Note: RP = Recommended Plan (D13R + Other Project Elements)

TABLE 5.4-3
SIMULATED VALUES OF DIFFERENCE IN UNMET M&I WATER DEMANDS 2050 WITH- AND WITHOUT-PROJECT CONDITIONS ($1997)

Alternative Plans	Total Value of Reduced Unmet Demand	Average Annual Value of Reduced Unmet Demands
A	$ 671,242,345	$21,652,979
B	$ 667,785,246	$21,541,460
C	$ 788,249,476	$25,427,402
D & RP	$ 842,602,120	$27,180,714

Note: RP = Recommended Plan (D13R + Other Project Elements)

E.6 FLOOD CONTROL IMPACTS OF SELECTED ALTERNATIVES

E.6.1 DESCRIPTION

The Central and Southern Florida (C&SF) Project is a multi-purpose project which provides flood control, water supply for municipal, industrial, and agricultural uses, prevention of saltwater intrusion, water supply for Everglades National Park, small boat navigation and protection of fish and wildlife resources. There have been 5 authorizations since 1948. The primary system encompasses approximately 18,000 square miles from Orlando to Florida Bay and includes about 1,000 miles of levees and canals, 150 water control structures and 16 major pump stations. The Central and Southern Florida (C&SF) Project is operated both by the Federal government and local sponsors. The Jacksonville District has operation and maintenance responsibilities for Lake Okeechobee and its main outlets and the main outlets of the Water Conservation Areas. The St. Johns River Water Management District operates and maintains project features in the upper St. Johns River Basin. The remainder of the project which includes the Kissimmee Basin, coastal canals, and project works in Southern Florida are operated and maintained by the South Florida Water Management District (SFWMD).

For hydrologic evaluation, the Central and Southern Project can be separated into five general subareas. These are the Kissimmee River Basin, Lake Okeechobee Service Area and Everglades Agricultural Area, Water Conservation Areas, Lower East Coast Canals, and Important Environmental Areas.

E.6.2 PURPOSE

The purpose of this section is to attempt to identify the beneficial and adverse flood impacts that might occur with each proposed project alternative. Some of this work has already been accomplished in the formulation of the alternatives. The evaluation in this chapter is limited due to the regional nature of the South Florida Water Management Model (SFWMM) and the resulting lists of impacted areas should be considered preliminary. Subsequent detailed studies will re-evaluate specific flood control aspects of the project alternatives in more detail and revise this list accordingly. In areas where flood hazards are identified or confirmed in this study or subsequent studies, full consideration will be given to improving areas and mitigating impacts by incorporating either design changes or land acquisition.

E.6.2.1 General Methodology

The task will be accomplished in two sections. The first section will describe existing flood damage potential in the basin without any improvements. This section has been developed by conducting interviews with knowledgeable people at the South Florida Water Management District (SFWMD), and the US Army Corps of Engineers. In addition, SFWMD and Corps of Engineers technical publications which describe historical flood events have been reviewed. Areas of concern have been mapped using the SFWMM 2X2 grid cell boundary. The conclusions in this section define existing flood problems and identify flood damage reduction opportunities. Second, information from the SFWMM is reviewed by grid cell for each alternative. Performance indicators for each of the alternatives, Alternative Evaluation Team (AET) concerns, and concerns of other interested parties are then examined to identify potential flooding conflicts. These areas of concern are also mapped using the SFWMM 2X2 grid cell boundary and identified by the appropriate basin. While this investigation will be not be conclusive or quantitative in nature, these areas will be identified for further evaluation in subsequent feasibility reports.

E.6.2.2 Flood Control Evaluation Limitations

The method selected to evaluate hydrologic impacts of alternatives is the South Florida Water Management Model (SFWMM). The SFWMM is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7,600 square miles using a mesh of 2 mile x 2 mile cells. In addition, the model includes inflows from Kissimmee River, and runoff and demands in the Caloosahatchee River and St. Lucie Canal basins. This model is regional in scope and allows for a regional level of evaluation never available before in the planning process. Its use in evaluating performance of alternatives using performance measures and targets has been indispensable for plan formulation. However, like most regional models, the ability to detect and evaluate detailed design problems, especially for flood control, is limited.

Damages to urban development include structural damages to buildings, as well as damages to personal property and associated lawns, pavement, shrubs, and streets. Depth of flooding is the determining factor for damages to structures and their contents. Duration of flooding is the determining factor for damages to lawns, pavement, shrubs, and streets. Flood damages to agricultural development are primarily related to flood duration. Losses to vegetable and fruit crops are very much dependent upon the duration of flooding in root zones. Properly calibrated topographic and stage-hydrograph information is required to compute depths of flooding to structures and duration of flooding to agriculture. Due to the regional design of the SFWMM, this information is not available by 2 X 2 grid cell.

The Central and Southern Florida Project encompasses approximately 18,000 square miles from Orlando to Florida Bay. Much of the area is outside the SFWMM. Areas excluded include the Kissimmee River Basin, and the Upper St. Johns River Basin. Also, the Caloosahatchee River and St. Lucie canal basins are not described spatially. These areas have been excluded from this evaluation.

E.6.3 HYDROLOGIC AND METEOROLOGIC BACKGROUND

In most of peninsular Florida about 60 percent of the annual rainfall normally falls during the four summer months of June through September. Along the southeast coast of Florida the wet season typically runs from June through October. Wet season rainfall is closely associated with convective activity. These rainfall events are normally of short duration and amounts are quite variable spatially. In general, the winter months constitute the dry season and rainfall is associated with mid-latitude systems (fronts and low-pressure centers) and is spatially distributed in a relatively uniform pattern. Even though annual average rainfall is relatively large and the dry season well defined, rainfall over the basin can be quite varied both in annual amount and seasonal distribution.

E.6.4 TROPICAL STORM AND HURRICANE HISTORY

During the typical wet season from May to October, South Florida receives approximately 70 percent of its annual rainfall. Rainfall in South Florida is greatly affected by tropical storms, hurricanes and slow moving low pressure areas which occur almost every year. A chronology of storms that have occurred in recent years is listed below. A publication list which was used to obtain this information is shown in ***Table 6.5.2-1***.

E.6.4.1 January, 1991

Multiple storm-fronts in January 1991 produced extremely heavy rainfall, 11"+ maximum, 6" in the Everglades Agricultural Area. The event happened in the dry season and local growers were keeping water levels high in the canals for irrigation purposes. Soil subsidence has severely affected the performance of the flood control infrastructure in the area.

E.6.4.2 November, 1994

A major rainfall after the 1994 hurricane season occurred during November by the movement of Tropical Storm Gordon up the east coast of Florida. The storm primarily affected the southern central portion of the state. Affected areas included the Kissimmee River Basin, the Upper St. Johns River Basin, the C-111 Basin, as well as the C-102, C-103, C-14, and C-12 basins. Also affected was the Bolles and Cross Canal Basin. Tropical Storm Gordon caused wide-spread flooding of streets and property in central Florida and on the east coast of Florida. The west coast of Florida had no flooding. There were numerous complaints of lake levels being too high in Orange and Osceola Counties with several inquiries as to the SFWMD structures operation. There were also large areas of agricultural land inundated in Central Florida. There were no known cases of residential homes being flooded.

E.6.4.3 December, 1994

A flood event during December 5-20, 1994, affected the east Everglades Agricultural Area (EAA). The area around S-7 received 14” of rain on December 5th. Widespread agricultural flooding occurred in the area. A sod farm was completely destroyed and Okeelanta sugar fields were severely inundated. Several local dikes breached on the Bolles and Cross canal. Alico farm in Hendry County was flooded and Flying Cow Road in western Palm Beach was under water for 3 months. There was flooding in Loxahatchee and C-100A, B, and C were out of banks in selected areas.

E.6.4.4 June, 1995

A severe rainfall event took place on June 18-26, 1995 in the South Dade area. Nine inches of rainfall fell over three days in Homestead, while Miami recorded 11 inches of rainfall over five days. Flows to S-18C prior to the storm were taking place at a rate of around 300 cubic feet per second (cfs). By June 17, flows had increased to 599 cfs. During the storm event, flow from S-18C ranged from 323 to 1,960 cfs. Discharges from S-197 ranged from no flow to 2,565 cfs. Corps projects located in the C-111 basin as well as the C-102, C-103, C-1, C-2, C-4, C-7, C-8, C-9, and C-100 basins were impacted and performed well.

E.6.4.5 Early August, 1995

Hurricane Erin developed in the Caribbean and affected Florida from August 2-5, 1995. Hurricane Erin passed through central and northwestern portions of Florida prior to entering the Gulf of Mexico. Although many portions of the state were affected by the heavy rainfall associated with the storm, they were primarily areas outside of the Central and Southern Florida Project.

E.6.4.6 Late August, 1995

Tropical Storm Jerry affected Collier, Broward, and Palm Beach counties during the period August 23-26, 1995. Over nine inches of rain fell over a period of two days in Palm Beach County. An average of 6.5 inches of rain was recorded in the surrounding areas. Some effects in St. Lucie County were recorded also as the storm came very close to overloading capacity of C-23, C-24, and C-25.

E.6.4.7 October, 1995

Hurricane Opal affected South Florida during October 5-7, 1995. Immediately after, the storm of October 14-19, 1995 affected the South Dade area. Flows at S-18C gradually increased after Hurricane Opal and reached a maximum of 1,540 cfs by October 18. On October 10, the culverts at S-197 were opened, discharging at a rate of 325 cfs. By October 19, the rate had increased to a maximum of 1,509 cfs. Flows then gradually decreased to 248 cfs by November 1, and the culverts at S-197 were closed on November 2nd.

E.6.4.8 September, 1996

Hurricane Fran began in the tropics in September, 1996. The storm traveled up the east coast of Florida and affected Wilmington, North Carolina on September 5, 1996. Hurricane Hortense began as a tropical storm in the Caribbean on September 7, 1996. Although Hortense did severe damage to Puerto Rico, St. Croix, and St. Thomas, the category three hurricane missed Florida and continued up the coast and affected Cape Hatteras, NC.

E.6.4.9 October, 1996

Josephine was an extra-tropical storm which originated about 50 miles southeast of Savannah, Georgia on October 8, 1996 and affected Kinston, North Carolina.

Hurricane Lili originated in the Caribbean on October 16, 1996. This storm made a direct hit on the central Bahamas and feeder bands caused 5” of rainfall in South Florida. However, the storm had no direct impact upon Corps projects. Although the rain was locally heavy, durations were brief and did not result in significant flood problems for the area. The major reason for this reduced impact was that the South Florida Water Management District (SFWMD) had drawn down coastal canals in advance of the hurricane. There were reports of some flooding problems in some low lying and poorly drained areas of Dade and Broward counties. Water levels were also high in the area known as the “8.5 Square Mile Area” located west of Levee 31 North adjacent to Everglades National Park.

E.6.4.10 November, 1996

Hurricane Marco developed in the Caribbean on November 19, 1996. The storm had no direct flooding impact upon Corps projects, but caused beach erosion and wind damage primarily south of Vero Beach.

E.6.4.11 January, 1997

South Florida Storm (January, 1997) - Caused beach erosion and wind damage.

E.6.4.12 July, 1997

Hurricane Danny began in the Caribbean in July, 1997. This storm originated southwest of Mobile and caused flooding primarily in Mississippi and the Florida Panhandle area.

E.6.4.13 September, 1997

Hurricane Erica began in the Caribbean in September, 1997. This storm went northeast of the United States.

E.6.5 EXISTING FLOOD DAMAGE POTENTIAL

E.6.5.1 General

The purpose of this section of the evaluation is to identify areas in the C&SF basin where a potential problem could occur without any project modifications or could occur if alternative plans increase stages or durations of storm events in the area. Generally speaking, the C&SF Project operates well for flood control purposes within the original design limitations that were formulated when the project was constructed. In addition, the Corps of Engineers, in partnership with the SFWMD, has re-evaluated many project components during the project life to reassess their effectiveness when changing needs have occurred. Federal funds for the modified components were proposed for construction when economic justification was demonstrated and allocated, subject to federal funding priorities. The SFWMD has assisted with non-federal funding, and has implemented discharge rules and other non-structural measures to limit runoff and decrease the need for future water resource modifications. Some of the project features that have been reevaluated include, but are not limited to, the Upper and Lower Kissimmee River Restoration, West Palm Beach Canal, The South Dade Conveyance Canals including C-111, and Modified Deliveries to Everglades National Park. Project features currently being evaluated include Bolles and Cross Canals, and Canals 7, 8, and 9. Rehabilitation to Corps of Engineers structures has also been authorized after severe storm events such as Hurricane Andrew.

Despite extensive efforts to keep the project current, operation of the project has become more difficult due to unexpected urbanization in some areas causing increased flows above design, urban encroachment into canal rights of way, regulatory problems with permitted discharge restrictions during long duration storm events, and conflicting environmental, urban, and agricultural issues. These sensitive areas where the potential for problems exist are the focus of this section. The identification of these areas without project modifications do not include areas where the problem is that secondary drainage is inadequate or not maintained. In addition, historical flood damages caused by storms that are greater than the project design in any of the C&SF basins are not considered a design problem.

E.6.5.2 Identification of Problem Areas

Areas of concern were identified primarily from the review of SFWMD technical publications listed in ***Table 6.5.2-1*** and discussions with Corps of

Engineers and SFWMD officials. Two sets of GIS maps at a scale of 1:100,000 were generated. Both sets include the C&SF basin outline, the 2X2 mile grid overlay, county overlays, hydrologic sub-basin overlays, roads, towns and railroads, lakes, water control structures and canals. In addition, one set of maps includes generalized 1995 land use information. The other set includes SFWMD water use permits for agriculture in the EAA. It was possible using these data to identify potential problem areas in the basin and identify the corresponding row and column co-ordinates of the 2X2 model to which they apply. General and specific conclusions about flood control in the C&SF project extracted from interviews are listed below. It should be noted that some of the existing problem areas may include sites for reservoirs contained in the alternative plans. Therefore, these cells may show damage potential when in fact none will exist.

E.6.5.2.1 General Conclusions About Flood Control

Most flood control issues can be attributed to four general concerns in the Central and Southern Florida Project area. These concerns are urban encroachment into agricultural areas, little or no buffer zone for urban construction on canals and lakes, inability of discharge in agricultural canals to reach primary systems, and institutional constraints and water management regulation.

Table 6.5.2-1
Technical Publication References

1. “WRE Publication #348 - Report of 1995 Wet Season Hydrologic Conditions.”, SFWMD, 1995.
2. Lin, Steve and Lane, Jim. “DRE Publication #141 - Preliminary Report on Rainstorm of March 28-29,1982.”,SFWMD, April, 1982.
3. Lin, Steve. “DRE 143 – Preliminary Report on Rainstorm of April 23-26, 1982”, SFWMD, May, 1982.
4. Water Resources Division, Resource Planning Department. “DRE 144 - Tropical Storm Dennis, August 16-18, 1981.”, SFWMD, June, 1982.
5. Khanal N. “DRE 158 – Technical Publication 82-7, Performance of District Structures During Critical Storm Events in West Miami, and Proposed Alternatives to Reduce Flooding”, SFWMD, October, 1982.
6. Water Resources Division, Resource Planning Department. “DRE 184 - Preliminary Report of Rainfall Event, May 22-31, 1984, Lower East Coast”, SFWMD, June, 1984.
7. Water Resources Division, Resource Planning Department. “DRE 203 - Preliminary Report of Rainfall Event, November 21-26, 1984, South Florida Coastal Area.”, SFWMD, December, 1984.
8. Water Resources Division, Resource Planning Department. “DRE 209 - Report of Tropical Storm Bob, July 22-24, 1985.”, SFWMD, July 22-24, 1985.
9. Cooper, Richard M. and Lane, Jim. “DRE 231 - An Atlas of Eastern Broward County Surface Water Management Basins”, SFWMD, November, 1987.
10. Cooper, Richard M. and Lane, Jim. “DRE-239 - Atlas of Eastern Dade County Surface Water Management Basins.”, October, 1987.
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12. Lin, Steve S.T. “DRE-260 - Flood Management Study of C-18 Basin, August, 1988.”, SFWMD, August, 1988.
13. Cooper, Richard M. and Ortel, Terry W. “DRE 265 - An Atlas of St. Lucie County Surface Water Management Basins”, SFWMD, November, 1988.
14. Cooper, Richard M. and Santee, Ray. “DRE 266 - An Atlas of Martin County Surface Water Management Basins”., SFWMD, November, 1988.
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16. Water Resources Division, Resource Planning Department. “DRE 297 - Storm Event of January 15-17, 1991.”, SFWMD, March, 1991.
17. Cooper, Richard M. and Roy, Joanne. “DRE 300 – An Atlas of Surface Water Management Basins in the Everglades: The Water Conservation Areas and Everglades National Park”, SFWMD, September, 1991.
18. Water Resources Division, Resource Planning Department. “DRE 304 – Storm Event of October 8-10, 1991.”, SFWMD, December, 1991.
19. Guardo, Mariano. “DRE 309- An Atlas of the Upper Kissimmee Surface Water Management Basins”, SFWMD, February, 1992.
20. Abtew, Wossenu. “DRE 313 – An Atlas of the Lower Kissimmee River and Lake Istokpoga Surface Water Management Basins”, SFWMD, April, 1992.
21. Department of Water Resources Evaluation, Department of Research, Operations and Maintenance Department, Regulation Department, Planning Department, Office of Government and Public Affairs. DRE 315 - “Preliminary Report on Rainstorm of June 23-30, 1992.”, SFWMD, December, 1992.

E.6.5.2.1.1. Urban Encroachment into Agricultural Areas

Most of the Lower East Coast (LEC) canal systems were designed in the 1960's. Areas that were urbanized or projected to be urbanized at the time of the study were designed at Standard Project Flood (SPF) capacity. Others that were thought to remain primarily agricultural were designed at 30% of SPF or approximately a 10 year storm. Since the 1960's the urbanization of the western portion of the LEC basins, particularly "Area B" in Miami, have lowered the design degree of flood protection, particularly in the western parts of the basins. Increased runoff due to urbanization in the west basin coupled with the lag times involved waiting for the eastern basin to drain has reduced protection in the western areas. This is the case in "Area B" and the Canal 7 basins. In addition, S-97 can no longer pass the design discharge simply because of unexpected urbanization in the St. Lucie Area.

E.6.5.2.1.2. Little or No Buffer Zone for Urban Construction on Canals and Lakes

Eastern basin urban flooding problems that have occurred (C-9 for example) are believed to be the result of urban development encroaching within the right of way of the channels. In addition, development on Lake Istokpoga presents a flooding problem since the development is so close to the lake that there is little effective room for lake regulation.

E.6.5.2.1.3. Inability of Discharge in Agricultural Canals to Reach Primary Systems

Primary flooding within a mile or two of the Bolles and Cross Canal is primarily due to inadequate conveyance and the failure of the canal bank. In addition, subsidence of the land surface has severely affected the ability to pump overland flow to the canals.

E.6.5.2.1.4. Institutional Constraints and Water Management Regulation

The preferred method of drainage in the EAA is to convey water through the North New River and Miami Canals to the Water Conservation Areas. However, actual discharge must be limited in order not to externalize flood problems in adjacent basins. Additional drainage by backpumping to Lake Okeechobee via S-2 and S-3 must be in compliance with the Interim Action Plan[1] for Lake Okeechobee.

[1] In 1979, the Department of Environmental Regulation limited the use of S-2 and S-3 pumping stations to protect the health of Lake Okeechobee. The goal was to pump as little runoff as possible into the Lake, while preserving the capability of major pumps for use in an emergency. The Lake Okeechobee Operating Permit was issued to the SFWMD which defined an objective process for deciding whether or not to pump, based on a number of factors related to how the pumps were operated in the 1970's. The rules governing the operation of these pumps, as stated in the permit, comprise the Interim Action Plan (IAP). The point system used to regulate usage of the pumps can be found on pages 24 and 25 of technical reference 21, listed in Table 6.5.2-1.

E.6.5.2.2 Specific Conclusions About Flood Control

The following information is listed by specific area in the applicable county. The affected areas pertain to row and column designations of the 2X2 grid cell overlay used by the SFWMM. The grid cell designations of the affected areas are shown in Plates 1 through 8 at the end of the chapter.

E.6.5.2.2.1. Miami-Dade County - Area B (Pennsuco/Lake Belt Area) Affected Area (R18-19,C27-28), (R20-24,C27-31), (R25,C27-32), (R26,C27-31), (R27,C27-30), (R28,C28) – Plate 1

There is significant flooding potential in West Miami, Area B, when moderate to high rainfall occurs due to low topographic elevations in the area. The problem is pronounced west of the Palmetto Expressway in Area B where there is much residential development. When the area west of West Miami was undeveloped, storm runoff from the developed eastern area was discharged before the storm runoff from the west reached the primary canals. Since the western area has now been highly urbanized, the western basin must wait for the eastern basin to drain. Observations indicate that flooding occurs more often from long durations of rainfall since these storms create larger volumes of water and it physically takes longer to drain the area. Even when structures are fully open, it takes many days for the groundwater to reach the canal and recede. As stated earlier, seepage problems at L-30 also affect the flood prone nature of Area B.

E.6.5.2.2.2. Miami-Dade County - C-4 (Tamiami Canal) Affected Areas (R22,C30), (R20,C30-31) – Plate 1

During the 1995 storm season, some of the most severe flooding occurred in the western C-4 basin. Three day rainfall peaks exceeded the 100 year rainfall event. Sweetwater (R22,C30) is situated in Area B in the general area of the Pennsuco/Lake Belt Area. Sweetwater is an area where drainage capacity is very limited and was the most heavily impacted during the 1995 storm season. Sweetwater is located at the intersection of the Florida Turnpike and US41 on the northeast corner across the street from Florida International University (FIU). A water elevation of 5.5 feet will cause flooding in the area east of SW 117th Avenue.

Another problem area includes the most western portion of the C-4 basin in Area B and the portion of the C-2 basin north of Sunset Drive (R20,C30-31). In addition to the localized runoff problems in Area B, seepage from L-30 aggravates the flooding problem.

C-4 has been designated as a critical project area with a primary purpose to restore the Pennsuco area. Additional structures proposed on C-4 to maintain higher elevations in the canal may create a flooding problem in the Pennsuco/Lake Belt Area.

E.6.5.2.2.3. Miami-Dade County - S-333 Affected Area (R22,C23-24) – Plate 1

Recommendations for future high water control discussed in 1994-1995 SFWMD publications indicated that better utilization of S-333 was necessary to reduce current operational flow limitation out of WCA-3A. This utilization is limited due to the fact that discharges from S-12A and S-12B have been limited to preserve Cape Sable Sparrow habitat. Therefore, S-12C and S-12D are the only structures which can fully discharge into the Slough. These limitations can compound problems on C-4.

Improvements to Tiger Tail Indian village North of US 41 and flooding mitigation for the East Everglades area are already in progress as a part of the Modified Water Deliveries to Everglades National Park. (R22,C23-24) This area will continue to be monitored in this evaluation.

E.6.5.2.2.4. Miami-Dade County - Miccosukee lands at C-4 Affected Area (R22,C15-17), (R22,C26-27) – Plates 1-2

In 1994 there were storm impacts on Miccosukee lands adjacent to Tamiami trail. The Miccosukee ownership is approximately 500 feet wide and about 5 miles long located south of US-41 at S-12B extending 5 miles west to approximately S-343A. (R22,C15-17). No additional problems are anticipated in the area since additional flood protection has already provided. However, the area between S-12B and L-28 could be susceptible to greater risk with greater discharges into Lostman's Slough. The tribe owns a casino within the triangle at S-335, S-336, and G-119 at (R22,C26-27). Additional development including gas stations and a prison are believed to also be in the area. The area used to be a wetland.

E.6.5.2.2.5. Miami-Dade County - C-7 (Little River Canal) Affected Area (R26-27,C32-33) – Plate 1

Tropical Storm Allison and the flood event of June 18-26, 1995, created some minor flooding problems in the western C-7 basin. Most of the development in the western end is high density residential development with low topographic elevations. The original project design for this channel was 75% of Standard Project Flood (SPF) with the secondary canals in place. This equates to approximately 10 year protection (R26-27,C32-33).

E.6.5.2.2.6. Miami-Dade County - C-111, Affected Area (R10,C25-26), (R11,C25-27), (R12-13,C25-26), (R14-15,C25), (R16,C26) – Plates 1 and 3

Events during the 1994 storm season affected this area. Since initial project construction in the 1960's, damage susceptibility has increased due to the increased value of crops and increased agricultural production which has taken place in the floodplain. Increased agricultural production has occurred since the system has been operated at lower water levels than originally authorized. Two forms of this increase in production are evident. First, highly damage susceptible vegetable crops are being planted earlier in the year, before the actual start of the winter dry season. Second, the amount of fruit tree crops and general horticultural activity have increased in the flood plain. Since these trees have longer root zones than other field crops, they are more susceptible to high water tables and to flooding. The purpose of the General Reevaluation Report for C-111, completed in 1994, was to formulate a plan of improvement that would restore more natural hydroperiods to Taylor Slough in Everglades National Park and maintain the flood protection provided by the existing project. Although stages in C-111 would be reduced when compared to the existing design stages shown in the 1961 report, they would be higher than the current regulation to accommodate increased deliveries to the Everglades National Park. However, higher stages during the winter months can adversely affect truck crops, and root zones of fruit trees can be affected year around. (R16,C26) (R14-15,C25).

E.6.5.2.2.7. Miami-Dade County - L-31N and 8.5 Square Mile Area, Affected Area: (R17-18,C25-26), (R19,C26) – Plate 1

The 8.5 square mile area is located west of L-31N north of the Rocky Glades Area. Flood mitigation for this area was formulated as part of the Modified Water Deliveries to Everglades National ParkThe SFWMD is planning to purchase this area. In 1994, flooding impacts northwest of South Miami Heights were in or around the 8.5 square mile area at (R16,C25-26), (R17,C26).

E.6.5.2.2.8. Miami-Dade County - Rocky Glades Area, Affected Area: (R17,C25-26) – Plate 1

The Rocky Glades area is located west of L-31N, south of the 8.5 square mile area. The area has historically been used for truck crops and citrus. The recommended plan for C-111 includes provision for the purchase of this land, and these purchases should take place before restudy alternatives are implemented. The SFWMD may extend leaseback arrangements to the local farmers with the stipulation that SFWMD will have the authority to vary canal stages at any time of the year regardless of the agricultural use of the land. Agriculture may or may not be in place in Rocky Glades when the restudy alternatives are constructed. However, if agriculture is in place, the farmers will farm totally at their own risk.

E.6.5.2.2.9. Dade and Broward County - C-9 (Snake Creek Canal), Affected Areas: (R28-29,C33-34) – Plates 1 and 4

Tropical Storm Allison and the flood event of June 18-26, 1995 created flooding problems for a small section of a low-lying coastal area in the eastern C-9 basin. This area becomes floodprone when tidal effects back up water from the eastern end. This affect is not discussed further in this report since alternative designs will not alleviate or worsen this type of flooding problem.

The western portion of the eastern subbasin is very prone to flooding because of low ground surface elevations relative to the eastern subbasin. Major storms can reverse flow in C-9 from east to west because of rapid runoff into the eastern reaches. Model results produced by the Miami-Dade County Department of Environmental Resources Management (DERM) indicate that under existing conditions, approximately 19 miles of bank along the canal would be overtopped during a 100 year storm event and any increases in stages from project alternatives may significantly increase flood potential in that area. The Stormwater Management Master Plan produced by DERM in September, 1997 suggests the highest ranked potential flood problems areas in the Canal 9 area are north of the canal and in the western end of the eastern C-9 basin in (R28-29,C33-34).

Observation of historical conditions in the Canal 9 basin suggests that peak stages from storms are becoming higher over time. Regulation of flows is becoming more difficult. The reason for implementation of the basin rule is to cut the peaks off the hydrographs to allow for slower and longer discharges. With wet antecedent conditions, it is more difficult to limit discharge. This regulatory issue could become a problem in the future but not at this time. Although the western area is presently urbanizing, the eastern portion design was 100% of SPF at the time of the project report in 1954.

E.6.5.2.2.10. Palm Beach County - C-18 Basin, Affected Area (R60-61,C34) – Plate 5

A Flood Management Study of the C-18 Basin[2] indicates that the western half of the west branch of the basin and the reach upstream of the C-18 weir lack the capacity to pass the 10 year discharge frequency used in the study. The sum of the permitted project runoff rates from all subbasins greatly exceeds the design capacity of the C-18 system.

This basin has had a significant increase in agricultural and urban development since construction. In 1956, the General Design Memorandum

[2] The study is technical reference 12 listed in Table 6.5.2-1.

predicted there would not be any urban development. There now exist 10,000 acres of agriculture and 6,900 acres of urban development in the basin. (R60-61,C84)

E.6.5.2.2.11. Palm Beach County - Indian Trails Water Control District, Affected Area: (R56,C33) – Plate 5

Indian Trails Water Control District was not a participant in the original C-51 construction. Therefore, the flood control system was not designed for additional flows during flood events to be discharged from the Water Control District into C-51. Currently, subject to SFWMD approval, C-51 receives off peak discharges from the M-1 basin of the Indian Trail Improvement District when such discharge can be received without causing flood impacts to the C-51 basin. When S-155A is placed into operation, a Memorandum of Agreement between the SFWMD and the Indian Trail Improvement District will govern discharge from the M-1 basin into C-51.

E.6.5.2.2.12. Palm Beach County – Levee 8 Conveyance, Affected Areas: (R56-57,C30), (R57-58,C29) – Plate 5

Infrequent major storm events cause problems in the L-8 basin. However, it is not uncommon for ponding problems to persist along the L-8 Tie-Back Levee as a result of long duration wet conditions. This is aggravated by the fact that by design, L-8 should discharge to either Lake Okeechobee or WCA-1. During wet years, stages in both of these regional storage areas are generally high and therefore, effective drainage of the L-8 is hampered. Under this scenario, S-5A(E) can be used during off-peak periods just before or immediately after the peak hydrograph stage has occurred in the C-51 canal, but its capacity is limited. S-5A(W) and S-5A are sometimes used when capacity exists. There is significant local pressure to continually operate S-5A(W) and S-5A as though L-8 were part of the S-5A drainage basin.

E.6.5.2.2.13. Palm Beach County - Everglades Agricultural Area--General

The entire Everglades Agricultural Area (EAA) is subject to severe drainage problems as indicated by the storm event of January 15-17, 1991. During that event, maximum rainfall totals were 11”+ , with an average of 6” falling over the entire EAA. Although the event occurred during the dry season, flood effects were more severe since local growers were keeping water levels high in the canals for irrigation purposes.

The EAA and other agricultural areas in South Florida are designed to remove 0.75 inches of rainfall each day. This level of flood protection is less than that normally provided to urban areas. A simple calculation indicates that it would take over nine days to remove a 7-inch rainfall if all project pumps were operating at full capacity. In addition, drainage in the EAA is greatly reduced due to the three following factors:

First, the drainage of the area for agriculture in the early 1900's has allowed the muck soils to oxidize and subside. Soil subsidence has reduced topographic elevations in the EAA by as much as 9 to 10 feet in some areas. As land elevations decrease and the canal elevations remain the same, it becomes increasingly difficult to move overland flow from the agricultural fields into the canals during a storm event.

Second, there are open channel connections to the North New River Canal and the Miami Canal via the Bolles Canal. Basin boundaries between S-5A, S-2, S-6, and S-7 can vary dependent upon the operation of the structures in the S-2, S-3, S-6, S-7, and S-8 basins. The preferred method of drainage is to utilize the North New River and Miami Canals to the Water Conservation Areas. However, actual discharge must be limited in order not to externalize flood problems in adjacent basins. Therefore, channel capacity becomes the limiting factor and the pumps operate at reduced capacity to prevent pump damage. This requires more time than many crops can survive inundation.

Third, the original operating level for the primary pumping stations that discharge through the Miami and North New River Canals to the WCA's was 13 feet MSL. However, the operating level of the pumping stations was later changed to 11 feet due to soil subsidence. The use of lakeshore pumps S-2 and S-3 to backpump into Lake Okeechobee is governed by the Interim Action Plan (IAP). Although operation of these structures is based upon a point system contained in the plan, usually the trigger is still at 13 feet MSL for these structures. The viable need to maintain water quality in Lake Okeechobee via restricted usage of these pumps reduces the Water Management District's flexibility in reducing flood damage in this area.

E.6.5.2.2.14. Palm Beach County - Bolles and Cross Canal (S-2, S-6, S-7, S-8), Affected Area: (R53,C18-22,R52,C18-22, R51,C18-24, R50,C18-25, R49,C18-25.) Plates 5 and 6

The Bolles and Cross Canal drainage area is located in the EAA. During the 1991 event described above, the area was severely flooded. Primary flooding at Bolles and Cross was located within a mile or two of the canal and was due to inadequate conveyance and the failure of the canal bank. The culverts on Bolles and Cross Canal do not effectively move water through the system and probably need to be replaced by bridges. Also, water pumped into the canal from adjacent fields would simply breech the canal and flood elsewhere. In addition, the conditions were aggravated due to the drainage restrictions listed above for the EAA.

The actual floodprone area of Bolles and Cross can vary considerably due to the rainfall distribution, duration of the storm, and how the system is operated.

Much of the area within two miles of the canal is 10.5 feet MSL. Although the remainder of the EAA is probably wet also, topographic elevations are higher than 10.5 feet MSL. Pre-subsidence information indicates the southern area can vary from 12 feet to about 20 feet MSL.

It is believed there is little or no problem in the area west of Miami Canal in S-3 since it is primarily pasture and incurs little or no flooding from Bolles and Cross. Also, the area east of Hillsboro Canal drains into the Ocean Canal and has less effect upon Bolles and Cross. Therefore the area of concern is defined to include the S-2 basin, excluding the area east of the Hillsboro Canal and the S-6 basin where there is permitted agricultural land use excluding the cells R49,C18-19 which are designated to be reservoir sites with project alternatives.

E.6.5.2.2.15. St. Lucie County - C-23, Affected Areas: (R69,C34), (R70,C33) (R72,C25-31) – Plate 7

S-97 was designed as part of C-23 for agricultural discharge. However, the entire area has urbanized, overloading the structure. Currently, S-97 (R72,C31) cannot pass the design discharge without opening the gates past the maximum designed level. During a flooding situation, it is felt the water would pond behind S-97 along C-23 and cover the area from (R72, C25-30). In addition the St. Lucie Settlement is located at South Fork on the St. Lucie River downstream of S-80 at (R69,C34) and (R70,C33). St. Lucie Settlement is an example of urban development building up to the edge of the canal. The area is affected by S-80 discharges and high tide. This area is noted as an area of concern but cannot be evaluated because the area is outside SFWMM grid.

E.6.5.2.2.16. St. Lucie County - C-25--General

C-25 and S-99 were designed to pass thirty percent of the Standard Project Flood, and to meet irrigation delivery requirements for the basin. However, much of the western part of the basin has limited flood protection. The area is on the Water Management Boundary between SFWMD and Upper St. John Water Management District (USJWMD). Landowners in this area rely on on-site retention for flood protection and drainage. The 1995 land use indicates almost all of the western basin is agricultural with some citrus. This area is noted as an area of concern but cannot be evaluated as the area is outside SFWMM grid.

E.6.5.2.2.17. Collier & Hendry County -- S-140 Seminole & Miccosukee Lands, Affected Area Seminole Lands(R40,C15), (R41-42,C9-14), Affected Area Miccosukee Lands (R36-39,C15-16) – Plate 8

Both tribal areas are located in the Big Cypress drainage area. The original flood control project for the area utilizes gravity drainage and was designed at approximately 30 percent of SPF in the early 1960's. The developed land use in the area is for cattle production. The land use was never expected to be intensified beyond its use as unimproved pasture. With this in mind, the capacity of S-140 was designed so that duration of flooding with a 10 year event would never exceed 10 days. This resulting capacity is 7/16 inch per day. This is less than the general agricultural design rate of ¾ inch per day used in much of the C&SF basin.

The Corps of Engineers is involved in a critical project at Big Cypress that will utilize impoundment areas to improve flooding conditions on the western portion of Seminole land. The Seminoles are also working with the Natural Resource Conservation Service (NRCS) to improve flooding conditions on the eastern portion. Several proposals for improving flood conditions on Miccosukee land have been discussed but none have been agreed upon. The affected areas listed include the Seminole and Miccosukee lands currently in agriculture. The Miccosukee lands South of I-75 and in WCA 3 are excluded since these areas are not capable of agricultural use. Seminole lands in Hendry County located in Row 49, Columns 7-13, are not currently in the model and are not evaluated.

E.6.6 EVALUTION OF ALTERNATIVES

E.6.6.1 General Information

This section is devoted to reducing the sensitive areas listed above that have existing flood hazard potential to a list of areas that are affected either favorably or adversely by the C&SF study alternatives. It should be noted that additional areas that do not have existing problems may also be beneficially or adversely affected by alternatives to the extent flood problems may be created or alleviated. The identification of these areas is beyond the scope of this study. Detailed topographic and stage-hydrograph information is required to compute depths of flooding to structures and duration of flooding to agriculture. Due to the regional design of the SFWMM, this information is currently not available. The evaluation of alternatives is conducted primarily using the output of the SFWMM. Numeric model results have been converted by the SFWMD to easily read charts and graphs called “performance indicators” and posted using the software Adobe Acrobat to the internet for public dissemination. The performance indicators used for the flood damage evaluation include average ponding depths, peak stage difference and stage-duration.

It must be emphasized that the SFWMM was not developed as a flood prediction or flood analysis model and is not intended for these purposes. The SFWMM can only be used as a general indicator of flooding risks on a subregional scale. Site-specific inferences about changes in flood risk will require more detailed investigation in subsequent studies.

E.6.6.1.1 Average Ponding Depth Maps

Maps of the SFWMM area grid cells are posted which describe average ponding depths for each alternative and the base conditions (1995 and 2050) during the summer (May) and winter (October). These maps have the advantage of being able to show actual ponding stages for each grid cell in the study area but also have the disadvantage of only showing this average monthly information for the simulation period for the two months. Nevertheless, they will be most useful in flagging situations in which there is a seasonal buildup of water levels through the wet season ending in October. This would indicate a problem in maintaining historical water levels.

E.6.6.1.2 Peak Stage Difference Maps

Maps of the SFWMM area grid cells showing the percentage of years during which the peak stage for an alternative differs from the peak stage for the 1995 or 2050 base by several fixed amounts are available. These maps show spatially where peak stages have either increased or decreased during the 31 year period of simulation possibly indicating areas subject to increased or decreased flood risk. These maps have the advantage of being able to show actual likelihood of impacts during the simulation period regardless of the month the event occurs. However, these maps have the disadvantage of only showing this information for selected target peak stage differences. Flood damage potential to agriculture is primarily a function of the duration of flooding. These maps give no indication of the duration of these stages, or whether the peak stage occurs above or below the ground surface.

E.6.6.1.3 Stage-duration Curves

Stage-duration curves are also available for selected grid cells in the SFWMM area. The advantage of this information is that a continual relationship between exceedence frequency and stage is displayed for the base conditions and each alternative for the 31 year simulation period. This information has the disadvantage of only being available for selected grid cells.

In addition to the performance indicators listed above, interviews with knowledgeable people and notes and memorandums provided by the Alternative Evaluation Team (AET) have been used to help evaluate alternative performance.

E.6.6.2 Evaluation Methodology and Results

E.6.6.2.1 Adversely Affected Areas

Average May and October ponding depths for base and alternative conditions are displayed for selected cells where concern has been identified during the initial stage of the evaluation. This information is shown in Table 6.6.2.1-1. From Table 6.6.2.1-1, four additional tables are created. Tables 6.6.2.1-2, 6.6.2.1-3, 6.6.2.1-4, and 6.6.2.1-5 display increases or decreases in depth expected with alternatives A, B, C, D, and D13R for May and October compared to the 1995 and 2050 base. It should be noted that some of the existing problem areas which show increases in depths may include sites for reservoirs contained in the alternative plans.

Tables ***6.6.2.1-2, 6.6.2.1-3, 6.6.2.1-4***, and ***6.6.2.1-5*** provide useful information for the periods May and October, but contain no additional information about possible adverse conditions that could occur during other months of the year. Therefore, *Table 6.6.2.1-6* and ***Table 6.6.2.1-7*** summarize peak stage differences to determine possible adverse effects. As discussed above, these tables taken from performance indicator maps have the disadvantage of only showing information for selected peak stage difference target elevations. A potential adversely affected area was defined as an area where the peak stage difference was at least 0.25 feet between an alternative the appropriate base condition for more than 0.0% of the years.

A consolidated list of adversely affected areas was then created. This was done by combining Tables 6.6.2.1-2, 6.6.2.1-3, 6.6.2.1-4, 6.6.2.1-5, 6.6.2.1-6 and Table 6.6.2.1-7 together. The information was then resorted by row and column and multiple records for each cell were examined. If any of the records indicated a problem for a given cell, the cell was considered possibly adversely affected. The results of this evaluation are shown in ***Table 6.6.2.1-8***. ***Table 6.6.2.1-9*** displays grid cells that are adversely affected for the Recommended Plan (D13R).

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TABLE 6.6.2.1-1
PONDING DEPTHS MAY AND OCTOBER

					Ponding Depths May, in feet							Ponding Depths October, in feet						
Row	**Column**	**Description**	**Basin**	**Stage Duration Curve**	**1995 Base Without Project**	**2050 Base Without Project**	**Alt. A**	**Alt. B**	**Alt. C**	**Alt. D**	**Alt. D13R**	**1995 Base Without Project**	**2050 Base Without Project**	**Alt. A**	**Alt. B**	**Alt. C**	**Alt. D**	**Alt. D13R**
10	25	Agricultural Area	C-111	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
10	26	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
11	25	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
11	26	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
11	27	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
12	25	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
12	26	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
13	25	Agricultural Area	C-111	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
13	26	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
14	25	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
15	25	Agricultural Area	C-111	Close	0.050	0.050	0.300	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
16	26	Agricultural Area	C-111	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
17	25	8.5 Sq Mi.Area/Rocky Glades	L-31N	No	0.050	0.050	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.750	0.750	0.750	0.750	0.750
17	26	8.5 Sq Mi Area/Rocky Glades	L-31N	Close	0.050	0.050	0.300	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
18	25	8.5 Sq Mi Area	L-31N	No	0.050	0.050	0.300	0.300	0.300	0.300	0.300	0.300	0.750	1.500	1.500	1.500	1.500	1.500
18	26	8.5 Sq Mi Area	L-31N	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
18	27	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
18	28	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
19	26	8.5 Sq. Mi. Area	L-31N	No	0.050	0.050	0.300	0.750	0.300	0.750	0.750	0.300	0.750	1.500	1.500	1.500	1.500	1.500
19	27	West Miami	Pennsuco/ Lake Belt Area	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
19	28	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
20	27	West Miami	Pennsuco/ Lake Belt Area	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.300	0.050	0.050	0.050	0.050	0.050
20	28	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
20	29	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
20	30	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
21	27	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.300	0.300	0.300	0.300	0.050	0.050	0.050	0.300	0.300
21	28	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.300	0.750	0.050	0.050	0.050	0.050	0.050	2.500	2.500
21	29	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
21	30	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
21	31	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
22	15	Miccosukee Lands	C-4/Forty Mile Bend	No	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.750	1.500	1.500	0.750	0.750	0.750	0.750
22	16	Miccosukee Lands	C-4/Forty Mile Bend	No	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.750	1.500	0.750	0.750	0.750	0.750	0.750
22	17	Miccosukee Lands	C-4/Forty Mile Bend	No	0.300	0.300	0.300	0.300	0.300	0.300	0.300	1.500	1.500	1.500	0.750	0.750	0.750	1.500
22	23	Tigertail Village	C-4	No	0.750	0.750	0.750	1.500	1.500	1.500	1.500	1.500	1.500	2.500	2.500	1.500	1.500	2.500
22	24	Tigertail Village	C-4	No	0.750	0.750	0.750	1.500	0.750	1.500	1.500	1.500	1.500	2.500	2.500	1.500	1.500	1.500
22	26	C-4/S-336	Miccosukee Casino	No	0.050	0.300	0.750	0.750	0.750	0.750	1.500	0.750	1.500	2.500	2.500	1.500	1.500	1.500
22	27	C-4/S-336	Miccosukee Casino	No	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.750	0.300	0.300	1.500	0.750	0.300
22	28	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.750	0.750
22	29	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.300	0.050	0.050
22	30	Sweetwater	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
22	31	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
23	27	West Miami	Pennsuco/ Lake Belt Area	No	0.300	0.300	0.750	0.750	0.750	0.750	0.750	1.500	1.500	1.500	1.500	1.500	1.500	1.500
23	28	West Miami	Pennsuco/ Lake Belt Area	No	0.300	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.300	0.300
23	29	West Miami	Pennsuco/ Lake Belt Area	No	0.300	3.000	3.000	3.000	3.000	3.000	3.000	0.050	3.000	3.000	3.000	3.000	3.000	3.000
23	30	West Miami	Pennsuco/ Lake Belt Area	No	0.300	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050

TABLE 6.6.2.1-1
PONDING DEPTHS MAY AND OCTOBER

					Ponding Depths May, in feet							Ponding Depths October, in feet						
Row	**Column**	**Description**	**Basin**	**Stage Duration Curve**	**1995 Base Without Project**	**2050 Base Without Project**	**Alt. A**	**Alt. B**	**Alt. C**	**Alt. D**	**Alt. D13R**	**1995 Base Without Project**	**2050 Base Without Project**	**Alt. A**	**Alt. B**	**Alt. C**	**Alt. D**	**Alt. D13R**
23	31	West Miami	Pennsuco/ Lake Belt Area	No	0.300	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
24	27	West Miami	Pennsuco/ Lake Belt Area	No	0.300	0.300	0.750	0.750	0.750	0.750	0.750	1.500	1.500	1.500	1.500	1.500	1.500	1.500
24	28	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.300	0.300
24	29	West Miami	Pennsuco/ Lake Belt Area	No	0.050	3.000	3.000	3.000	3.000	3.000	3.000	0.050	3.000	3.000	3.000	3.000	3.000	3.000
24	30	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
24	31	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
25	27	West Miami	Pennsuco/ Lake Belt Area	No	0.750	0.300	0.750	0.750	0.750	0.750	0.750	1.500	1.500	1.500	1.500	1.500	1.500	1.500
25	28	West Miami	Pennsuco/ Lake Belt Area	No	0.300	0.050	0.750	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.300	0.300	0.300	0.300
25	29	West Miami	Pennsuco/ Lake Belt Area	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
25	30	West Miami	Pennsuco/ Lake Belt Area	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
25	31	West Miami	Pennsuco/ Lake Belt Area	No	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
25	32	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
26	27	West Miami	Pennsuco/ Lake Belt Area	Yes	0.300	0.300	0.750	0.750	0.750	0.750	0.750	1.500	1.500	1.500	1.500	1.500	1.500	1.500
26	28	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
26	29	West Miami	Pennsuco/ Lake Belt Area	No	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
26	30	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
26	31	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
26	32	Western Basin	C-7	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
26	33	Western Basin	C-7	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
27	27	West Miami	Pennsuco/ Lake Belt Area	No	0.750	0.300	0.750	0.750	0.750	0.750	0.750	1.500	2.500	1.500	2.500	2.500	2.500	1.500
27	28	West Miami	Pennsuco/ Lake Belt Area	No	0.300	0.300	3.000	3.000	3.000	3.000	3.000	1.500	0.750	3.000	3.000	3.000	3.000	3.000
27	29	West Miami	Pennsuco/ Lake Belt Area	No	0.050	3.000	3.000	3.000	3.000	3.000	3.000	0.050	3.000	3.000	3.000	3.000	3.000	3.000
27	30	West Miami	Pennsuco/ Lake Belt Area	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
27	32	Western Basin	C-7	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
27	33	Western Basin	C-7	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
28	28	West Miami	Pennsuco/ Lake Belt Area	No	0.750	0.050	0.300	0.300	1.500	1.500	1.500	0.300	0.300	0.300	0.750	2.500	2.500	2.500
28	33	Eastern Subbasin	C-9	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
28	34	Eastern Subbasin	C-9	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
29	33	Eastern Subbasin	C-9	Yes	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
29	34	Eastern Subbasin	C-9	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
36	15	L-28	Miccosukee Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
36	16	L-28	Miccosukee Lands	No	0.050	0.300	0.300	0.300	0.300	0.300	0.300	0.750	0.750	0.750	1.500	0.750	0.750	0.750
37	15	L-28	Miccosukee Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
37	16	L-28	Miccosukee Lands	No	0.050	0.050	0.050	0.300	0.300	0.300	0.300	0.300	0.300	0.750	0.750	0.750	0.750	0.750
38	15	L-28	Miccosukee Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.005	0.005	0.005	0.005	0.050
38	16	L-28	Miccosukee Lands	No	0.050	0.050	0.300	0.050	0.300	0.300	0.300	0.750	0.750	0.750	0.750	0.750	0.750	0.750
39	15	L-28	Miccosukee Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
39	16	L-28	Miccosukee Lands	No	0.050	0.300	0.300	0.300	0.300	0.300	0.300	0.750	0.750	0.750	0.750	0.750	0.750	0.750
40	15	L-28	Seminole Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
41	9	L-28	Seminole Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
41	10	L-28	Seminole Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
41	11	L-28	Seminole Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
41	12	L-28	Seminole Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.300	0.300	0.300	0.050	0.050	0.050
41	13	L-28	Seminole Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
41	14	L-28	Seminole Lands	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.300	0.300	0.300	0.300	0.750	0.300	0.300
42	14	L-28	Seminole Lands	No	0.050	0.300	0.300	0.300	0.300	0.300	0.300	0.050	0.300	0.300	0.300	0.300	0.300	0.300

TABLE 6.6.2.1-1
PONDING DEPTHS MAY AND OCTOBER

					Ponding Depths May, in feet							Ponding Depths October, in feet						
Row	Column	Description	Basin	Stage Duration Curve	1995 Base Without Project	2050 Base Without Project	Alt. A	Alt. B	Alt. C	Alt. D	Alt. D13R	1995 Base Without Project	2050 Base Without Project	Alt. A	Alt. B	Alt. C	Alt. D	Alt. D13R
49	20	EAA	Bolles and Cross	No	0.050	0.050	2.500	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
49	21	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
49	22	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
49	23	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
49	24	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
49	25	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	18	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	19	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	20	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	21	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	22	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	23	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	24	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
50	25	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
51	18	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
51	19	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
51	20	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
51	21	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
51	22	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
51	23	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
51	24	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
52	18	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
52	19	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
52	20	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
52	21	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
52	22	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
53	18	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
53	19	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
53	20	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
53	21	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
53	22	EAA	Bolles and Cross	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
56	30	L-8	L-8	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
56	33	Indian Trails	C-51	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
57	29	L-8	L-8	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
57	30	L-8	L-8	No	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
58	29	L-8	L-8	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
60	34	C-18 Basin	C-18	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
61	34	C-18 Basin	C-18	No	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050

TABLE 6.6.2.1-2
MAY PONDING INCREASES COMPARED TO THE 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alt. A	Alt. B	Alt. C	Alt. D	Alt. D13R
10	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
10	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	27	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
14	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
15	25	Agricultural Area	C-111	0.25	0.00	0.00	0.00	0.00
16	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
17	25	8.5 Square Mile Area/Rocky Glades	L-31N	0.25	0.25	0.25	0.25	0.25
17	26	8.5 Square Mile Area/Rocky Glades	L-31N	0.25	0.00	0.00	0.00	0.00
18	25	8.5 Square Mile Area	L-31N	0.25	0.25	0.25	0.25	0.25
18	26	8.5 Square Mile Area	L-31N	0.00	0.00	0.00	0.00	0.00
18	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
18	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	26	8.5 Square Mile Area	L-31N	0.25	0.70	0.25	0.70	0.70
19	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
21	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.70
21	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	15	Miccosukee Lands	C-4/Forty Mile Bend	0.00	0.00	0.00	0.00	0.00
22	16	Miccosukee Lands	C-4/Forty Mile Bend	0.00	0.00	0.00	0.00	0.00
22	17	Miccosukee Lands	C-4/Forty Mile Bend	0.00	0.00	0.00	0.00	0.00
22	23	Tigertail Village	C-4	0.00	0.75	0.75	0.75	0.75

TABLE 6.6.2.1-2
MAY PONDING INCREASES COMPARED TO THE 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alt. A	Alt. B	Alt. C	Alt. D	Alt. D13R
22	24	Tigertail Village	C-4	0.00	0.75	0.00	0.75	0.75
22	26	C-4/S-336	Miccosukee Casino	0.70	0.70	0.70	0.70	1.45
22	27	C-4/S-336	Miccosukee Casino	0.00	0.00	0.00	0.00	0.00
22	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
22	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	30	Sweetwater	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
23	28	West Miami	Pennsuco/ Lake Belt Area	-0.25	-0.25	-0.25	-0.25	-0.25
23	29	West Miami	Pennsuco/ Lake Belt Area	2.70	2.70	2.70	2.70	2.70
23	30	West Miami	Pennsuco/ Lake Belt Area	-0.25	-0.25	-0.25	-0.25	-0.25
23	31	West Miami	Pennsuco/ Lake Belt Area	-0.25	-0.25	-0.25	-0.25	-0.25
24	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
24	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	29	West Miami	Pennsuco/ Lake Belt Area	2.95	2.95	2.95	2.95	2.95
24	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	28	West Miami	Pennsuco/ Lake Belt Area	0.45	-0.25	-0.25	-0.25	-0.25
25	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	32	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
26	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
26	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
27	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
27	28	West Miami	Pennsuco/ Lake Belt Area	2.70	2.70	2.70	2.70	2.70
27	29	West Miami	Pennsuco/ Lake Belt Area	2.95	2.95	2.95	2.95	2.95
27	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
27	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-2
MAY PONDING INCREASES COMPARED TO THE 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alt. A	Alt. B	Alt. C	Alt. D	Alt. D13R
27	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
28	28	West Miami	Pennsuco/ Lake Belt Area	-0.45	-0.45	0.75	0.75	0.75
28	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
28	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
36	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
36	16	L-28	Miccosukee Lands	0.25	0.25	0.25	0.25	0.25
37	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
37	16	L-28	Miccosukee Lands	0.00	0.25	0.25	0.25	0.25
38	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
38	16	L-28	Miccosukee Lands	0.25	0.00	0.25	0.25	0.25
39	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
39	16	L-28	Miccosukee Lands	0.25	0.25	0.25	0.25	0.25
40	15	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	9	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	10	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	11	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	12	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	13	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	14	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
42	14	L-28	Seminole Lands	0.25	0.25	0.25	0.25	0.25
49	20	EAA	Bolles and Cross	2.45	0.00	0.00	0.00	0.00
49	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-2
MAY PONDING INCREASES COMPARED TO THE 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alt. A	Alt. B	Alt. C	Alt. D	Alt. D13R
50	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
56	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
56	33	Indian Trails	C-51	0.00	0.00	0.00	0.00	0.00
57	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
57	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
58	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
60	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00
61	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-3
MAY PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
10	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
10	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	27	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
14	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
15	25	Agricultural Area	C-111	0.25	0.00	0.00	0.00	0.00
16	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
17	25	8.5 Square Mile Area/Rocky Glades	L-31N	0.25	0.25	0.25	0.25	0.25
17	26	8.5 Square Mile Area/Rocky Glades	L-31N	0.25	0.00	0.00	0.00	0.00
18	25	8.5 Square Mile Area	L-31N	0.25	0.25	0.25	0.25	0.25
18	26	8.5 Square Mile Area	L-31N	0.00	0.00	0.00	0.00	0.00
18	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
18	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	26	8.5 Square Mile Area	L-31N	0.25	0.70	0.25	0.70	0.70
19	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
21	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.70
21	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	15	Miccosukee Lands	C-4/Forty Mile Bend	0.00	0.00	0.00	0.00	0.00
22	16	Miccosukee Lands	C-4/Forty Mile Bend	0.00	0.00	0.00	0.00	0.00
22	17	Miccosukee Lands	C-4/Forty Mile Bend	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-3
MAY PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
22	23	Tigertail Village	C-4	0.00	0.75	0.75	0.75	0.75
22	24	Tigertail Village	C-4	0.00	0.75	0.00	0.75	0.75
22	26	C-4/S-336	Miccosukee Casino	0.45	0.45	0.45	0.45	1.20
22	27	C-4/S-336	Miccosukee Casino	0.00	0.00	0.00	0.00	0.00
22	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
22	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	30	Sweetwater	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
23	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
24	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
25	28	West Miami	Pennsuco/ Lake Belt Area	0.70	0.00	0.00	0.00	0.00
25	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	32	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
26	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
26	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
27	27	West Miami	Pennsuco/ Lake Belt Area	0.45	0.45	0.45	0.45	0.45
27	28	West Miami	Pennsuco/ Lake Belt Area	2.70	2.70	2.70	2.70	2.70
27	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-3
MAY PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
27	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
27	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
27	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
28	28	West Miami	Pennsuco/ Lake Belt Area	0.25	0.25	1.45	1.45	1.45
28	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
28	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
36	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
36	16	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
37	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
37	16	L-28	Miccosukee Lands	0.00	0.25	0.25	0.25	0.25
38	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
38	16	L-28	Miccosukee Lands	0.25	0.00	0.25	0.25	0.25
39	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
39	16	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
40	15	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	9	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	10	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	11	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	12	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	13	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	14	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
42	14	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
49	20	EAA	Bolles and Cross	2.45	0.00	0.00	0.00	0.00
49	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-3
MAY PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
50	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
56	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
56	33	Indian Trails	C-51	0.00	0.00	0.00	0.00	0.00
57	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
57	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
58	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
60	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00
61	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-4
OCTOBER PONDING INCREASES COMPARED TO 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
10	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
10	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	27	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
14	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
15	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
16	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
17	25	8.5 Square Mile Area/Rocky Glades	L-31N	0.45	0.45	0.45	0.45	0.45
17	26	8.5 Square Mile Area/Rocky Glades	L-31N	0.00	0.00	0.00	0.00	0.00
18	25	8.5 Square Mile Area	L-31N	1.20	1.20	1.20	1.20	1.20
18	26	8.5 Square Mile Area	L-31N	0.00	0.00	0.00	0.00	0.00
18	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
18	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	26	8.5 Square Mile Area	L-31N	1.20	1.20	1.20	1.20	1.20
19	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	27	West Miami	Pennsuco/ Lake Belt Area	-0.25	-0.25	-0.25	0.00	0.00
21	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	2.45	2.45
21	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	15	Miccosukee Lands	C-4/Forty Mile Bend	0.75	0.00	0.00	0.00	0.00
22	16	Miccosukee Lands	C-4/Forty Mile Bend	0.00	0.00	0.00	0.00	0.00
22	17	Miccosukee Lands	C-4/Forty Mile Bend	0.00	-0.75	-0.75	-0.75	0.00

TABLE 6.6.2.1-4
OCTOBER PONDING INCREASES COMPARED TO 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
22	23	Tigertail Village	C-4	1.00	1.00	0.00	0.00	1.00
22	24	Tigertail Village	C-4	1.00	1.00	0.00	0.00	0.00
22	26	C-4/S-336	Miccosukee Casino	1.75	1.75	0.75	0.75	0.75
22	27	C-4/S-336	Miccosukee Casino	0.00	0.00	1.20	0.45	0.00
22	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.45	0.45
22	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.25	0.00	0.00
22	30	Sweetwater	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
23	29	West Miami	Pennsuco/ Lake Belt Area	2.95	2.95	2.95	2.95	2.95
23	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
24	29	West Miami	Pennsuco/ Lake Belt Area	2.95	2.95	2.95	2.95	2.95
24	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.25	0.25	0.25	0.25
25	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	32	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
26	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
27	27	West Miami	Pennsuco/ Lake Belt Area	0.00	1.00	1.00	1.00	0.00
27	28	West Miami	Pennsuco/ Lake Belt Area	1.50	1.50	1.50	1.50	1.50
27	29	West Miami	Pennsuco/ Lake Belt Area	2.95	2.95	2.95	2.95	2.95
27	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-4
OCTOBER PONDING INCREASES COMPARED TO 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
27	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
27	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
28	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.45	2.20	2.20	2.20
28	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
28	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
36	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
36	16	L-28	Miccosukee Lands	0.00	0.75	0.00	0.00	0.00
37	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
37	16	L-28	Miccosukee Lands	0.45	0.45	0.45	0.45	0.45
38	15	L-28	Miccosukee Lands	-0.05	-0.05	-0.05	-0.05	0.00
38	16	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
39	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
39	16	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
40	15	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	9	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	10	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	11	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	12	L-28	Seminole Lands	0.25	0.25	0.00	0.00	0.00
41	13	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	14	L-28	Seminole Lands	0.00	0.00	0.45	0.00	0.00
42	14	L-28	Seminole Lands	0.25	0.25	0.25	0.25	0.25
49	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-4
OCTOBER PONDING INCREASES COMPARED TO 1995 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
50	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
56	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
56	33	Indian Trails	C-51	0.00	0.00	0.00	0.00	0.00
57	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
57	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
58	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
60	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00
61	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-5
OCTOBER PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative	Alternative D13R
10	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
10	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
11	27	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
12	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
13	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
14	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
15	25	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
16	26	Agricultural Area	C-111	0.00	0.00	0.00	0.00	0.00
17	25	8.5 Square Mile Area/Rocky Glades	L-31N	0.45	0.45	0.45	0.45	0.45
17	26	8.5 Square Mile Area/Rocky Glades	L-31N	0.00	0.00	0.00	0.00	0.00
18	25	8.5 Square Mile Area	L-31N	0.75	0.75	0.75	0.75	0.75
18	26	8.5 Square Mile Area	L-31N	0.00	0.00	0.00	0.00	0.00
18	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
18	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	26	8.5 Square Mile Area	L-31N	0.75	0.75	0.75	0.75	0.75
19	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
19	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	27	West Miami	Pennsuco/ Lake Belt Area	-0.25	-0.25	-0.25	-0.25	-0.25
20	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	27	West Miami	Pennsuco/ Lake Belt Area	-0.25	-0.25	-0.25	0.00	0.00
21	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	2.45	2.45
21	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
21	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	15	Miccosukee Lands	C-4/Forty Mile Bend	0.00	-0.75	-0.75	-0.75	-0.75
22	16	Miccosukee Lands	C-4/Forty Mile Bend	-0.75	-0.75	-0.75	-0.75	-0.75
22	17	Miccosukee Lands	C-4/Forty Mile Bend	0.00	-0.75	-0.75	-0.75	0.00

TABLE 6.6.2.1-5
OCTOBER PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative	Alternative D13R
22	23	Tigertail Village	C-4	1.00	1.00	0.00	0.00	1.00
22	24	Tigertail Village	C-4	1.00	1.00	0.00	0.00	0.00
22	26	C-4/S-336	Miccosukee Casino	1.00	1.00	0.00	0.00	0.00
22	27	C-4/S-336	Miccosukee Casino	-0.45	-0.45	0.75	0.00	-0.45
22	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.45	0.45
22	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.25	0.00	0.00
22	30	Sweetwater	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
22	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
23	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
23	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.25	0.25
24	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
24	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.25	0.25	0.25	0.25
25	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
25	32	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	27	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	31	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
26	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
26	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
27	27	West Miami	Pennsuco/ Lake Belt Area	-1.00	0.00	0.00	0.00	-1.00
27	28	West Miami	Pennsuco/ Lake Belt Area	2.25	2.25	2.25	2.25	2.25
27	29	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00
27	30	West Miami	Pennsuco/ Lake Belt Area	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-5
OCTOBER PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative	Alternative D13R
27	32	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
27	33	Western Basin	C-7	0.00	0.00	0.00	0.00	0.00
28	28	West Miami	Pennsuco/ Lake Belt Area	0.00	0.45	2.20	2.20	2.20
28	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
28	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	33	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
29	34	Eastern Subbasin	C-9	0.00	0.00	0.00	0.00	0.00
36	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
36	16	L-28	Miccosukee Lands	0.00	0.75	0.00	0.00	0.00
37	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
37	16	L-28	Miccosukee Lands	0.45	0.45	0.45	0.45	0.45
38	15	L-28	Miccosukee Lands	-0.05	-0.05	-0.05	-0.05	0.00
38	16	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
39	15	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
39	16	L-28	Miccosukee Lands	0.00	0.00	0.00	0.00	0.00
40	15	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	9	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	10	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	11	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	12	L-28	Seminole Lands	0.00	0.00	-0.25	-0.25	-0.25
41	13	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
41	14	L-28	Seminole Lands	0.00	0.00	0.45	0.00	0.00
42	14	L-28	Seminole Lands	0.00	0.00	0.00	0.00	0.00
49	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
49	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-5
OCTOBER PONDING INCREASES COMPARED TO 2050 BASE YEAR (IN FEET)

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative	Alternative D13R
50	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
50	25	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	23	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
51	24	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
52	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	18	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	19	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	20	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	21	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
53	22	EAA	Bolles and Cross	0.00	0.00	0.00	0.00	0.00
56	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
56	33	Indian Trails	C-51	0.00	0.00	0.00	0.00	0.00
57	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
57	30	L-8	L-8	0.00	0.00	0.00	0.00	0.00
58	29	L-8	L-8	0.00	0.00	0.00	0.00	0.00
60	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00
61	34	C-18 Basin	C-18	0.00	0.00	0.00	0.00	0.00

TABLE 6.6.2.1-6
PERCENT OF YEARS WHEN PEAK STAGE
IS AT LEAST 0.25 FEET GREATER THAN THE 1995 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
10	25	Agricultural Area	C-111	0.000%	0.000%	0.000%	0.000%	0.000%
10	26	Agricultural Area	C-111	0.000%	22.500%	22.500%	22.500%	22.500%
11	25	Agricultural Area	C-111	7.500%	37.500%	37.500%	37.500%	37.500%
11	26	Agricultural Area	C-111	0.000%	0.000%	0.000%	0.000%	0.000%
11	27	Agricultural Area	C-111	7.500%	7.500%	7.500%	7.500%	7.500%
12	25	Agricultural Area	C-111	0.000%	22.500%	22.500%	7.500%	7.500%
12	26	Agricultural Area	C-111	0.000%	0.000%	0.000%	0.000%	0.000%
13	25	Agricultural Area	C-111	22.500%	22.500%	22.500%	22.500%	22.500%
13	26	Agricultural Area	C-111	0.000%	0.000%	0.000%	0.000%	0.000%
14	25	Agricultural Area	C-111	22.500%	22.500%	22.500%	22.500%	22.500%
15	25	Agricultural Area	C-111	0.000%	7.500%	7.500%	7.500%	7.500%
16	26	Agricultural Area	C-111	7.500%	7.500%	7.500%	7.500%	7.500%
17	25	8.5 Square Mile Area/Rocky Glades	L-31N	82.500%	82.500%	82.500%	82.500%	82.500%
17	26	8.5 Square Mile Area/Rocky Glades	L-31N	0.000%	0.000%	0.000%	0.000%	0.000%
18	25	8.5 Square Mile Area	L-31N	95.000%	95.000%	95.000%	95.000%	95.000%
18	26	8.5 Square Mile Area	L-31N	7.500%	7.500%	7.500%	7.500%	7.500%
18	27	West Miami	Pennsuco/ Lake Belt Area	0.000%	52.500%	52.500%	52.500%	52.500%
18	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
19	26	8.5 Square Mile Area	L-31N	95.000%	95.000%	95.000%	95.000%	95.000%
19	27	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	7.500%	7.500%
19	28	West Miami	Pennsuco/ Lake Belt Area	7.500%	0.000%	0.000%	7.500%	7.500%
20	27	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	7.500%	7.500%
20	28	West Miami	Pennsuco/ Lake Belt Area	7.500%	0.000%	0.000%	7.500%	7.500%
20	29	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	22.500%	22.500%
20	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	7.500%	7.500%
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	22.500%	22.500%
21	27	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	7.500%	22.500%	22.500%
21	28	West Miami	Pennsuco/ Lake Belt Area	95.000%	95.000%	95.000%	95.000%	95.000%
21	29	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	37.500%	95.000%	95.000%
21	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	7.500%
21	31	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	7.500%
22	15	Miccosukee Lands	C-4/Forty Mile Bend	7.500%	0.000%	7.500%	7.500%	7.500%
22	16	Miccosukee Lands	C-4/Forty Mile Bend	7.500%	0.000%	0.000%	0.000%	7.500%
22	17	Miccosukee Lands	C-4/Forty Mile Bend	7.500%	7.500%	7.500%	0.000%	7.500%

TABLE 6.6.2.1-6
PERCENT OF YEARS WHEN PEAK STAGE
IS AT LEAST 0.25 FEET GREATER THAN THE 1995 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
22	23	Tigertail Village	C-4	95.000%	95.000%	95.000%	52.500%	95.000%
22	24	Tigertail Village	C-4	95.000%	95.000%	95.000%	52.500%	95.000%
22	26	C-4/S-336	Miccosukee Casino	95.000%	95.000%	95.000%	67.500%	95.000%
22	27	C-4/S-336	Miccosukee Casino	0.000%	7.500%	7.500%	22.500%	22.500%
22	28	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	67.500%	82.500%
22	29	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
22	30	Sweetwater	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	0.000%
22	31	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	0.000%
23	27	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	22.500%	22.500%	22.500%
23	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	52.500%	67.500%
23	29	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
23	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	22.500%	7.500%
23	31	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	22.500%	7.500%
24	27	West Miami	Pennsuco/ Lake Belt Area	22.500%	22.500%	22.500%	22.500%	22.500%
24	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	52.500%	52.500%
24	29	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
24	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	22.500%	22.500%
24	31	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	22.500%	22.500%
25	27	West Miami	Pennsuco/ Lake Belt Area	22.500%	22.500%	22.500%	22.500%	22.500%
25	28	West Miami	Pennsuco/ Lake Belt Area	52.500%	67.500%	82.500%	95.000%	95.000%
25	29	West Miami	Pennsuco/ Lake Belt Area	52.500%	52.500%	52.500%	52.500%	52.500%
25	30	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	22.500%	22.500%	22.500%
25	31	West Miami	Pennsuco/ Lake Belt Area	7.500%	37.500%	37.500%	37.500%	52.500%
25	32	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	22.500%	22.500%
26	27	West Miami	Pennsuco/ Lake Belt Area	22.500%	22.500%	22.500%	22.500%	22.500%
26	28	West Miami	Pennsuco/ Lake Belt Area	67.500%	82.500%	82.500%	82.500%	82.500%
26	29	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	52.500%	52.500%	52.500%
26	30	West Miami	Pennsuco/ Lake Belt Area	67.500%	67.500%	67.500%	82.500%	82.500%
26	31	West Miami	Pennsuco/ Lake Belt Area	95.000%	95.000%	95.000%	95.000%	95.000%
26	32	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
26	33	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
27	27	West Miami	Pennsuco/ Lake Belt Area	22.500%	95.000%	52.500%	67.500%	52.500%
27	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	95.000%	0.000%
27	29	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%

TABLE 6.6.2.1-6
PERCENT OF YEARS WHEN PEAK STAGE IS AT LEAST 0.25 FEET GREATER THAN THE 1995 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
27	30	West Miami	Pennsuco/ Lake Belt Area	22.500%	22.500%	22.500%	22.500%	22.500%
27	32	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
27	33	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
28	28	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	95.000%	95.000%	95.000%
28	33	Eastern Subbasin	C-9	0.000%	0.000%	0.000%	0.000%	0.000%
28	34	Eastern Subbasin	C-9	0.000%	0.000%	0.000%	0.000%	0.000%
29	33	Eastern Subbasin	C-9	0.000%	0.000%	0.000%	0.000%	0.000%
29	34	Eastern Subbasin	C-9	0.000%	0.000%	0.000%	0.000%	0.000%
36	15	L-28	Miccosukee Lands	0.000%	7.500%	7.500%	7.500%	0.000%
36	16	L-28	Miccosukee Lands	7.500%	82.500%	82.500%	82.500%	82.500%
37	15	L-28	Miccosukee Lands	0.000%	7.500%	7.500%	7.500%	7.500%
37	16	L-28	Miccosukee Lands	7.500%	67.500%	67.500%	52.500%	52.500%
38	15	L-28	Miccosukee Lands	0.000%	7.500%	7.500%	7.500%	7.500%
38	16	L-28	Miccosukee Lands	7.500%	22.500%	22.500%	22.500%	22.500%
39	15	L-28	Miccosukee Lands	0.000%	7.500%	7.500%	7.500%	7.500%
39	16	L-28	Miccosukee Lands	7.500%	22.500%	22.500%	22.500%	22.500%
40	15	L-28	Seminole Lands	0.000%	7.500%	7.500%	7.500%	7.500%
41	9	L-28	Seminole Lands	0.000%	0.000%	0.000%	0.000%	0.000%
41	10	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	11	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	12	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	13	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	14	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
42	14	L-28	Seminole Lands	95.000%	95.000%	95.000%	95.000%	95.000%
49	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	23	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	24	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	25	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%

TABLE 6.6.2.1-6
PERCENT OF YEARS WHEN PEAK STAGE
IS AT LEAST 0.25 FEET GREATER THAN THE 1995 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
50	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	23	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	24	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	25	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	23	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	24	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
56	30	L-8	L-8	67.500%	67.500%	67.500%	67.500%	67.500%
56	33	Indian Trails	C-51	82.500%	82.500%	95.000%	82.500%	82.500%
57	29	L-8	L-8	67.500%	67.500%	67.500%	67.500%	67.500%
57	30	L-8	L-8	0.000%	0.000%	0.000%	0.000%	0.000%
58	29	L-8	L-8	82.500%	82.500%	82.500%	82.500%	82.500%
60	34	C-18 Basin	C-18	7.500%	7.500%	7.500%	7.500%	7.500%
61	34	C-18 Basin	C-18	0.000%	0.000%	0.000%	0.000%	0.000%

TABLE 6.6.2.1-7
PERCENT OF YEARS WHEN PEAK STAGE
IS AT LEAST 0.25 FEET GREATER THAN THE 2050 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
10	25	Agricultural Area	C-111	7.500%	7.500%	7.500%	7.500%	7.500%
10	26	Agricultural Area	C-111	0.000%	37.500%	37.500%	37.500%	37.500%
11	25	Agricultural Area	C-111	0.000%	7.500%	7.500%	7.500%	7.500%
11	26	Agricultural Area	C-111	0.000%	0.000%	7.500%	7.500%	7.500%
11	27	Agricultural Area	C-111	0.000%	0.000%	7.500%	7.500%	7.500%
12	25	Agricultural Area	C-111	0.000%	7.500%	7.500%	7.500%	7.500%
12	26	Agricultural Area	C-111	0.000%	0.000%	0.000%	0.000%	0.000%
13	25	Agricultural Area	C-111	0.000%	7.500%	7.500%	7.500%	7.500%
13	26	Agricultural Area	C-111	0.000%	0.000%	7.500%	7.500%	7.500%
14	25	Agricultural Area	C-111	0.000%	7.500%	7.500%	7.500%	7.500%
15	25	Agricultural Area	C-111	0.000%	0.000%	7.500%	0.000%	7.500%
16	26	Agricultural Area	C-111	0.000%	7.500%	7.500%	7.500%	7.500%
17	25	8.5 Square Mile Area/Rocky Glades	L-31N	82.500%	82.500%	95.000%	67.500%	82.500%
17	26	8.5 Square Mile Area/Rocky Glades	L-31N	7.500%	7.500%	7.500%	7.500%	7.500%
18	25	8.5 Square Mile Area	L-31N	95.000%	95.000%	95.000%	95.000%	95.000%
18	26	8.5 Square Mile Area	L-31N	22.500%	22.500%	7.500%	7.500%	7.500%
18	27	West Miami	Pennsuco/ Lake Belt Area	0.000%	22.500%	22.500%	22.500%	22.500%
18	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
19	26	8.5 Square Mile Area	L-31N	95.000%	95.000%	95.000%	95.000%	95.000%
19	27	West Miami	Pennsuco/ Lake Belt Area	7.500%	0.000%	0.000%	0.000%	0.000%
19	28	West Miami	Pennsuco/ Lake Belt Area	7.500%	0.000%	0.000%	7.500%	7.500%
20	27	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	0.000%
20	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	7.500%	22.500%	22.500%
20	29	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	37.500%	95.000%	95.000%
20	30	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	67.500%	95.000%	95.000%
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	22.500%	22.500%	82.500%	95.000%	95.000%
21	27	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	7.500%
21	28	West Miami	Pennsuco/ Lake Belt Area	95.000%	95.000%	95.000%	95.000%	95.000%
21	29	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	95.000%	95.000%	95.000%
21	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	22.500%	22.500%
21	31	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	0.000%
22	15	Miccosukee Lands	C-4/Forty Mile Bend	0.000%	0.000%	0.000%	0.000%	0.000%
22	16	Miccosukee Lands	C-4/Forty Mile Bend	0.000%	7.500%	7.500%	7.500%	7.500%
22	17	Miccosukee Lands	C-4/Forty Mile Bend	0.000%	7.500%	7.500%	7.500%	7.500%

TABLE 6.6.2.1-7
PERCENT OF YEARS WHEN PEAK STAGE
IS AT LEAST 0.25 FEET GREATER THAN THE 2050 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
22	23	Tigertail Village	C-4	95.000%	95.000%	82.500%	82.500%	95.000%
22	24	Tigertail Village	C-4	95.000%	95.000%	82.500%	82.500%	82.500%
22	26	C-4/S-336	Miccosukee Casino	95.000%	95.000%	95.000%	95.000%	95.000%
22	27	C-4/S-336	Miccosukee Casino	0.000%	0.000%	0.000%	7.500%	7.500%
22	28	West Miami	Pennsuco/ Lake Belt Area	95.000%	95.000%	22.500%	82.500%	82.500%
22	29	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	7.500%	52.500%	52.500%
22	30	Sweetwater	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
22	31	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
23	27	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	7.500%	7.500%	7.500%
23	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	22.500%	82.500%	82.500%
23	29	West Miami	Pennsuco/ Lake Belt Area	7.500%	0.000%	37.500%	95.000%	95.000%
23	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	7.500%	52.500%	52.500%
23	31	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	7.500%
24	27	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	7.500%	7.500%
24	28	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	22.500%	52.500%	52.500%
24	29	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	67.500%	95.000%	95.000%
24	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	22.500%	52.500%	52.500%
24	31	West Miami	Pennsuco/ Lake Belt Area	0.000%	7.500%	7.500%	52.500%	52.500%
25	27	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	7.500%	7.500%
25	28	West Miami	Pennsuco/ Lake Belt Area	37.500%	37.500%	67.500%	95.000%	95.000%
25	29	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	52.500%	82.500%	82.500%
25	30	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	7.500%	7.500%
25	31	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	37.500%	67.500%	67.500%
25	32	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	7.500%	7.500%	0.000%
26	27	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	7.500%	7.500%	7.500%
26	28	West Miami	Pennsuco/ Lake Belt Area	7.500%	22.500%	22.500%	52.500%	52.500%
26	29	West Miami	Pennsuco/ Lake Belt Area	7.500%	7.500%	22.500%	52.500%	52.500%
26	30	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	7.500%	7.500%
26	31	West Miami	Pennsuco/ Lake Belt Area	82.500%	95.000%	95.000%	95.000%	95.000%
26	32	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
26	33	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
27	27	West Miami	Pennsuco/ Lake Belt Area	7.500%	82.500%	22.500%	22.500%	7.500%
27	28	West Miami	Pennsuco/ Lake Belt Area	0.000%	0.000%	0.000%	0.000%	0.000%
27	29	West Miami	Pennsuco/ Lake Belt Area	95.000%	95.000%	95.000%	7.500%	7.500%
27	30	West Miami	Pennsuco/ Lake Belt Area	37.500%	67.500%	37.500%	37.500%	52.500%

TABLE 6.6.2.1-7
PERCENT OF YEARS WHEN PEAK STAGE
IS AT LEAST 0.25 FEET GREATER THAN THE 2050 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
27	32	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
27	33	Western Basin	C-7	0.000%	0.000%	0.000%	0.000%	0.000%
28	33	Eastern Subbasin	C-9	0.000%	0.000%	0.000%	0.000%	0.000%
28	34	Eastern Subbasin	C-9	0.000%	0.000%	0.000%	0.000%	0.000%
29	33	Eastern Subbasin	C-9	7.500%	0.000%	0.000%	0.000%	0.000%
29	34	Eastern Subbasin	C-9	0.000%	0.000%	0.000%	0.000%	0.000%
36	15	L-28	Miccosukee Lands	0.000%	7.500%	0.000%	0.000%	0.000%
36	16	L-28	Miccosukee Lands	7.500%	67.500%	67.500%	67.500%	67.500%
37	15	L-28	Miccosukee Lands	0.000%	0.000%	0.000%	0.000%	0.000%
37	16	L-28	Miccosukee Lands	7.500%	37.500%	37.500%	22.500%	52.500%
38	15	L-28	Miccosukee Lands	0.000%	0.000%	0.000%	0.000%	0.000%
38	16	L-28	Miccosukee Lands	7.500%	7.500%	7.500%	7.500%	7.500%
39	15	L-28	Miccosukee Lands	0.000%	0.000%	7.500%	7.500%	7.500%
39	16	L-28	Miccosukee Lands	7.500%	7.500%	22.500%	22.500%	22.500%
40	15	L-28	Seminole Lands	7.500%	0.000%	7.500%	7.500%	7.500%
41	9	L-28	Seminole Lands	0.000%	0.000%	0.000%	0.000%	0.000%
41	10	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	11	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	12	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	13	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
41	14	L-28	Seminole Lands	0.000%	0.000%	7.500%	7.500%	7.500%
42	14	L-28	Seminole Lands	0.000%	0.000%	0.000%	0.000%	0.000%
49	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	23	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	24	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
49	25	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	23	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
50	24	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%

TABLE 6.6.2.1-7
PERCENT OF YEARS WHEN PEAK STAGE
IS AT LEAST 0.25 FEET GREATER THAN THE 2050 BASE YEAR

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
50	25	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	23	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
51	24	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
52	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	18	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	19	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	20	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	21	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
53	22	EAA	Bolles and Cross	0.000%	0.000%	0.000%	0.000%	0.000%
56	30	L-8	L-8	22.500%	22.500%	22.500%	22.500%	22.500%
56	33	Indian Trails	C-51	82.500%	82.500%	95.000%	82.500%	0.000%
57	29	L-8	L-8	22.500%	22.500%	37.500%	22.500%	22.500%
57	30	L-8	L-8	0.000%	0.000%	0.000%	0.000%	0.000%
58	29	L-8	L-8	37.500%	37.500%	37.500%	22.500%	22.500%
60	34	C-18 Basin	C-18	7.500%	7.500%	7.500%	7.500%	0.000%
61	34	C-18 Basin	C-18	0.000%	0.000%	0.000%	0.000%	0.000%

TABLE 6.6.2.1-8
CONSOLIDATED LIST OF POSSIBLE ADVERSELY AFFECTED INDICATOR AREAS

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
10	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
10	26	Agricultural Area	C-111	No	Yes	Yes	Yes	Yes
11	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
11	26	Agricultural Area	C-111	No	No	Yes	Yes	Yes
11	27	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
12	25	Agricultural Area	C-111	No	Yes	Yes	Yes	Yes
13	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
13	26	Agricultural Area	C-111	No	No	Yes	Yes	Yes
14	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
15	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
16	26	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
17	25	8.5 Square Mile Area/Rocky Glades	L-31N	Yes	Yes	Yes	Yes	Yes
17	26	8.5 Square Mile Area/Rocky Glades	L-31N	Yes	Yes	Yes	Yes	Yes
18	25	8.5 Square Mile Area	L-31N	Yes	Yes	Yes	Yes	Yes
18	26	8.5 Square Mile Area	L-31N	Yes	Yes	Yes	Yes	Yes
18	27	West Miami	Pennsuco/ Lake Belt Area	No	Yes	Yes	Yes	Yes
19	26	8.5 Square Mile Area	L-31N	Yes	Yes	Yes	Yes	Yes
19	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
19	28	West Miami	Pennsuco/ Lake Belt Area	Yes	No	No	Yes	Yes
20	27	West Miami	Pennsuco/ Lake Belt Area	No	Yes	Yes	Yes	Yes
20	28	West Miami	Pennsuco/ Lake Belt Area	Yes	No	Yes	Yes	Yes
20	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
20	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
21	27	West Miami	Pennsuco/ Lake Belt Area	No	No	Yes	Yes	Yes
21	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
21	29	West Miami	Pennsuco/ Lake Belt Area	No	No	Yes	Yes	Yes
21	30	West Miami	Pennsuco/ Lake Belt Area	No	No	No	Yes	Yes
21	31	West Miami	Pennsuco/ Lake Belt Area	No	No	No	Yes	Yes
22	15	Miccosukee Lands	C-4/Forty Mile Bend	Yes	No	Yes	Yes	Yes
22	16	Miccosukee Lands	C-4/Forty Mile Bend	Yes	Yes	Yes	Yes	Yes
22	17	Miccosukee Lands	C-4/Forty Mile Bend	Yes	Yes	Yes	Yes	Yes

TABLE 6.6.2.1-8
CONSOLIDATED LIST OF POSSIBLE ADVERSELY AFFECTED INDICATOR AREAS

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
22	23	Tigertail Village	C-4	Yes	Yes	Yes	Yes	Yes
22	24	Tigertail Village	C-4	Yes	Yes	Yes	Yes	Yes
22	26	C-4/S-336	Miccosukee Casino	Yes	Yes	Yes	Yes	Yes
22	27	C-4/S-336	Miccosukee Casino	No	Yes	Yes	Yes	Yes
22	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
22	29	West Miami	Pennsuco/ Lake Belt Area	No	No	Yes	Yes	Yes
22	30	Sweetwater	Pennsuco/ Lake Belt Area	No	No	No	Yes	No
22	31	West Miami	Pennsuco/ Lake Belt Area	No	No	No	Yes	No
23	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
23	28	West Miami	Pennsuco/ Lake Belt Area	No	Yes	Yes	Yes	Yes
23	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
23	30	West Miami	Pennsuco/ Lake Belt Area	No	No	Yes	Yes	Yes
23	31	West Miami	Pennsuco/ Lake Belt Area	No	No	No	Yes	Yes
24	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
24	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
24	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
24	30	West Miami	Pennsuco/ Lake Belt Area	No	Yes	Yes	Yes	Yes
24	31	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	31	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	32	West Miami	Pennsuco/ Lake Belt Area	No	Yes	Yes	Yes	Yes
26	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
26	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
26	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
26	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
26	31	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
27	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
27	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
27	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
27	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes

TABLE 6.6.2.1-8
CONSOLIDATED LIST OF POSSIBLE ADVERSELY AFFECTED INDICATOR AREAS

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
28	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
29	33	Eastern Subbasin	C-9	Yes	No	No	No	No
36	15	L-28	Miccosukee Lands	No	Yes	Yes	Yes	No
36	16	L-28	Miccosukee Lands	Yes	Yes	Yes	Yes	Yes
37	15	L-28	Miccosukee Lands	No	Yes	Yes	Yes	Yes
37	16	L-28	Miccosukee Lands	Yes	Yes	Yes	Yes	Yes
38	15	L-28	Miccosukee Lands	No	Yes	Yes	Yes	Yes
38	16	L-28	Miccosukee Lands	Yes	Yes	Yes	Yes	Yes
39	15	L-28	Miccosukee Lands	No	Yes	Yes	Yes	Yes
39	16	L-28	Miccosukee Lands	Yes	Yes	Yes	Yes	Yes
40	15	L-28	Seminole Lands	Yes	Yes	Yes	Yes	Yes
41	10	L-28	Seminole Lands	No	No	Yes	Yes	Yes
41	11	L-28	Seminole Lands	No	No	Yes	Yes	Yes
41	12	L-28	Seminole Lands	Yes	Yes	Yes	Yes	Yes
41	13	L-28	Seminole Lands	No	No	Yes	Yes	Yes
41	14	L-28	Seminole Lands	No	No	Yes	Yes	Yes
42	14	L-28	Seminole Lands	Yes	Yes	Yes	Yes	Yes
49	20	EAA	Bolles and Cross	Yes	No	No	No	No
56	30	L-8	L-8	Yes	Yes	Yes	Yes	Yes
56	33	Indian Trails	C-51	Yes	Yes	Yes	Yes	Yes
57	29	L-8	L-8	Yes	Yes	Yes	Yes	Yes
58	29	L-8	L-8	Yes	Yes	Yes	Yes	Yes
60	34	C-18 Basin	C-18	Yes	Yes	Yes	Yes	Yes

TABLE 6.6.2.1-9
CONSOLIDATED LIST OF POSSIBLE ADVERSELY AFFECTED INDICATOR AREAS, RECOMMENDED PLAN (D13R)

Row	Column	Description	Basin
10	25	Agricultural Area	C-111
10	26	Agricultural Area	C-111
11	25	Agricultural Area	C-111
11	26	Agricultural Area	C-111
11	27	Agricultural Area	C-111
12	25	Agricultural Area	C-111
13	25	Agricultural Area	C-111
13	26	Agricultural Area	C-111
14	25	Agricultural Area	C-111
15	25	Agricultural Area	C-111
16	26	Agricultural Area	C-111
17	25	8.5 Sq. Mi. Area/Rocky Glades	L-31N
17	26	8.5 Sq. Mi. Area/Rocky Glades	L-31N
18	25	8.5 Sq. Mi. Area	L-31N
18	26	8.5 Sq. Mi. Area	L-31N
18	27	West Miami	Pennsuco/ Lake Belt Area
19	26	8.5 Sq. Mi. Area	L-31N
19	27	West Miami	Pennsuco/ Lake Belt Area
19	28	West Miami	Pennsuco/ Lake Belt Area
20	27	West Miami	Pennsuco/ Lake Belt Area
20	28	West Miami	Pennsuco/ Lake Belt Area
20	29	West Miami	Pennsuco/ Lake Belt Area
20	30	West Miami	Pennsuco/ Lake Belt Area
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area
21	27	West Miami	Pennsuco/ Lake Belt Area
21	28	West Miami	Pennsuco/ Lake Belt Area
21	29	West Miami	Pennsuco/ Lake Belt Area
21	30	West Miami	Pennsuco/ Lake Belt Area
21	31	West Miami	Pennsuco/ Lake Belt Area
22	15	Miccosukee Lands	C-4/Forty Mile Bend
22	16	Miccosukee Lands	C-4/Forty Mile Bend
22	17	Miccosukee Lands	C-4/Forty Mile Bend
22	23	Tigertail Village	C-4
22	24	Tigertail Village	C-4
22	26	C-4/S-336	Miccosukee Casino
22	27	C-4/S-336	Miccosukee Casino
22	28	West Miami	Pennsuco/ Lake Belt Area

TABLE 6.6.2.1-9
CONSOLIDATED LIST OF POSSIBLE ADVERSELY AFFECTED INDICATOR AREAS, RECOMMENDED PLAN (D13R)

Row	Column	Description	Basin
22	29	West Miami	Pennsuco/ Lake Belt Area
23	27	West Miami	Pennsuco/ Lake Belt Area
23	28	West Miami	Pennsuco/ Lake Belt Area
23	29	West Miami	Pennsuco/ Lake Belt Area
23	30	West Miami	Pennsuco/ Lake Belt Area
23	31	West Miami	Pennsuco/ Lake Belt Area
24	27	West Miami	Pennsuco/ Lake Belt Area
24	28	West Miami	Pennsuco/ Lake Belt Area
24	29	West Miami	Pennsuco/ Lake Belt Area
24	30	West Miami	Pennsuco/ Lake Belt Area
24	31	West Miami	Pennsuco/ Lake Belt Area
25	27	West Miami	Pennsuco/ Lake Belt Area
25	28	West Miami	Pennsuco/ Lake Belt Area
25	29	West Miami	Pennsuco/ Lake Belt Area
25	30	West Miami	Pennsuco/ Lake Belt Area
25	31	West Miami	Pennsuco/ Lake Belt Area
25	32	West Miami	Pennsuco/ Lake Belt Area
26	27	West Miami	Pennsuco/ Lake Belt Area
26	28	West Miami	Pennsuco/ Lake Belt Area
26	29	West Miami	Pennsuco/ Lake Belt Area
26	30	West Miami	Pennsuco/ Lake Belt Area
26	31	West Miami	Pennsuco/ Lake Belt Area
27	27	West Miami	Pennsuco/ Lake Belt Area
27	28	West Miami	Pennsuco/ Lake Belt Area
27	29	West Miami	Pennsuco/ Lake Belt Area
27	30	West Miami	Pennsuco/ Lake Belt Area
28	28	West Miami	Pennsuco/ Lake Belt Area
36	16	L-28	Miccosukee Lands
37	15	L-28	Miccosukee Lands
37	16	L-28	Miccosukee Lands
38	15	L-28	Miccosukee Lands
38	16	L-28	Miccosukee Lands
39	15	L-28	Miccosukee Lands
39	16	L-28	Miccosukee Lands
40	15	L-28	Seminole Lands
41	10	L-28	Seminole Lands
41	11	L-28	Seminole Lands

TABLE 6.6.2.1-9
CONSOLIDATED LIST OF POSSIBLE ADVERSELY AFFECTED INDICATOR AREAS, RECOMMENDED PLAN (D13R)

Row	Column	Description	Basin
41	12	L-28	Seminole Lands
41	13	L-28	Seminole Lands
41	14	L-28	Seminole Lands
42	14	L-28	Seminole Lands
56	30	L-8	L-8
56	33	Indian Trails	C-51
57	29	L-8	L-8
58	29	L-8	L-8
60	34	C-18 Basin	C-18

E.6.6.2.2 Beneficially Affected Areas

The evaluation procedure in the preceding paragraphs is designed to show a worst case scenario, i.e., flag any potential adverse effect that might occur with the implementation of project alternatives and identify these areas so that detailed evaluations may be conducted in later studies. The procedure is not designed to make any judgements about the relative flood control merit or lack of merit of any of the alternatives. In addition to adverse effects, alternatives may also produce potentially positive effects. Table 6.6.2.2-1 displays a consolidated list of possible beneficially affected indicator areas**.** This table was constructed in a manner analogous to the preceding tables. ***Tables 6.6.2.1-2, 6.6.2.1-3, 6.6.2.1-4***, and ***6.6.2.1-5*** display decreases in depth expected with alternatives A, B, C, D, and D13R for May and October compared to the 1995 and 2050 base. In addition, peak stage difference maps were used. A potential benefited area was defined as an area where the peak stage difference for an alternative was at least 0.50 feet less than the appropriate base condition for more than 0.0% of the years. Table 6.6.2.2-2 displays grid cells that have potential beneficial effects for the Recommended Plan (D13R). It should be noted that many of the grid cells are duplicated in Table 6.6.2.1-9 and Table 6.6.2.2-2. This is to be expected since there are beneficial and adverse effects that occur under the Recommended Plan to the same areas at different times of the year or in different years of the project life (1995, 2050).

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TABLE 6.6.2.2-1
CONSOLIDATED LIST OF POSSIBLE BENEFICIALLY AFFECTED INDICATOR AREAS

Row	Column	Description	Basin	Alternative A	Alternative B	Alternative C	Alternative D	Alternative D13R
10	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
10	26	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
11	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
11	26	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
11	27	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
12	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
12	26	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
13	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
14	25	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
16	26	Agricultural Area	C-111	Yes	Yes	Yes	Yes	Yes
17	26	8 ½ Sq. Mile Area	L-31N	Yes	Yes	Yes	Yes	Yes
18	26	8 ½ Sq. Mile Area	L-31N	Yes	Yes	Yes	Yes	Yes
18	27	West Miami	Pennsuco/Lake Belt Area	Yes	Yes	Yes	Yes	Yes
18	28	West Miami	Pennsuco/Lake Belt Area	Yes	Yes	Yes	No	No
19	27	West Miami	Pennsuco/Lake Belt Area	Yes	Yes	Yes	Yes	Yes
19	28	West Miami	Pennsuco/Lake Belt Area	Yes	Yes	Yes	Yes	Yes
20	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
20	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
20	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
20	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
21	27	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
21	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	No	No	No
21	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
21	31	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
22	15	Miccosukee Lands	C-4/Forty Mile Bend	Yes	Yes	Yes	Yes	Yes
22	16	Miccosukee Lands	C-4/Forty Mile Bend	Yes	Yes	Yes	Yes	Yes
22	17	Miccosukee Lands	C-4/Forty Mile Bend	Yes	Yes	Yes	Yes	No
22	27	C-4/S-336	Miccosukee Casino	Yes	Yes	Yes	Yes	Yes
22	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
22	30	Sweetwater	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
22	31	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
23	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
23	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
23	31	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
24	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	28	West Miami	Pennsuco/ Lake Belt Area	No	Yes	Yes	Yes	Yes
25	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
25	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	No	No
26	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	No	Yes
26	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
27	27	West Miami	Pennsuco/ Lake Belt Area	Yes	No	Yes	Yes	Yes
27	29	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
27	30	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	Yes	Yes	Yes
28	28	West Miami	Pennsuco/ Lake Belt Area	Yes	Yes	No	No	No
29	33	Eastern Subbasin	C-9	Yes	Yes	Yes	Yes	Yes
36	15	L-28	Miccosukee Lands	No	No	Yes	Yes	Yes

TABLE 6.6.2.2-1
CONSOLIDATED LIST OF POSSIBLE BENEFICIALLY AFFECTED INDICATOR AREAS

36	16	L-28	Miccosukee Lands	No	Yes	Yes	Yes	Yes
37	16	L-28	Miccosukee Lands	No	Yes	Yes	Yes	Yes
38	15	L-28	Miccosukee Lands	Yes	Yes	Yes	Yes	No
38	16	L-28	Miccosukee Lands	No	Yes	No	No	No
39	15	L-28	Miccosukee Lands	Yes	Yes	Yes	Yes	Yes
39	16	L-28	Miccosukee Lands	Yes	Yes	Yes	Yes	Yes
40	15	L-28	Seminole Lands	No	No	Yes	Yes	Yes
41	12	L-28	Seminole Lands	No	No	Yes	Yes	Yes
56	30	L-8	L-8	No	No	No	Yes	Yes
56	33	Indian Trails	C-51	No	No	No	Yes	Yes
57	29	L-8	L-8	No	No	No	Yes	Yes
58	29	L-8	L-8	No	No	No	Yes	Yes
61	34	C-18 Basin	C-18	No	Yes	Yes	Yes	Yes

TABLE 6.6.2.2-2
CONSOLIDATED LIST OF POSSIBLE BENEFICIALLY AFFECTED INDICATOR AREAS---RECOMMENDED PLAN (D13R)

Row	Column	Description	Basin
10	25	Agricultural Area	C-111
10	26	Agricultural Area	C-111
11	25	Agricultural Area	C-111
11	26	Agricultural Area	C-111
11	27	Agricultural Area	C-111
12	25	Agricultural Area	C-111
12	26	Agricultural Area	C-111
13	25	Agricultural Area	C-111
14	25	Agricultural Area	C-111
16	26	Agricultural Area	C-111
17	26	8 ½ Sq. Mile Area	L-31N
18	26	8 ½ Sq. Mile Area	L-31N
18	27	West Miami	Pennsuco/ Lake Belt Area
19	27	West Miami	Pennsuco/ Lake Belt Area
19	28	West Miami	Pennsuco/ Lake Belt Area
20	27	West Miami	Pennsuco/ Lake Belt Area
20	28	West Miami	Pennsuco/ Lake Belt Area
20	29	West Miami	Pennsuco/ Lake Belt Area
20	30	West Miami	Pennsuco/ Lake Belt Area
20	31	Tamiami Trail	Pennsuco/ Lake Belt Area
21	27	West Miami	Pennsuco/ Lake Belt Area
21	30	West Miami	Pennsuco/ Lake Belt Area
21	31	West Miami	Pennsuco/ Lake Belt Area
22	15	Miccosukee Lands	C-4/Forty Mile Bend
22	16	Miccosukee Lands	C-4/Forty Mile Bend
22	27	C-4/S-336	Miccosukee Casino
22	29	West Miami	Pennsuco/ Lake Belt Area
22	30	Sweetwater	Pennsuco/ Lake Belt Area
22	31	West Miami	Pennsuco/ Lake Belt Area
23	28	West Miami	Pennsuco/ Lake Belt Area
23	30	West Miami	Pennsuco/ Lake Belt Area
23	31	West Miami	Pennsuco/ Lake Belt Area
24	30	West Miami	Pennsuco/ Lake Belt Area
25	28	West Miami	Pennsuco/ Lake Belt Area
25	29	West Miami	Pennsuco/ Lake Belt Area
26	29	West Miami	Pennsuco/ Lake Belt Area
26	30	West Miami	Pennsuco/ Lake Belt Area
27	27	West Miami	Pennsuco/ Lake Belt Area
27	29	West Miami	Pennsuco/ Lake Belt Area
27	30	West Miami	Pennsuco/ Lake Belt Area
29	33	Eastern Subbasin	C-9
36	15	L-28	Miccosukee Lands
36	16	L-28	Miccosukee Lands
37	16	L-28	Miccosukee Lands

TABLE 6.6.2.2-2
CONSOLIDATED LIST OF POSSIBLE BENEFICIALLY AFFECTED INDICATOR AREAS---RECOMMENDED PLAN (D13R)

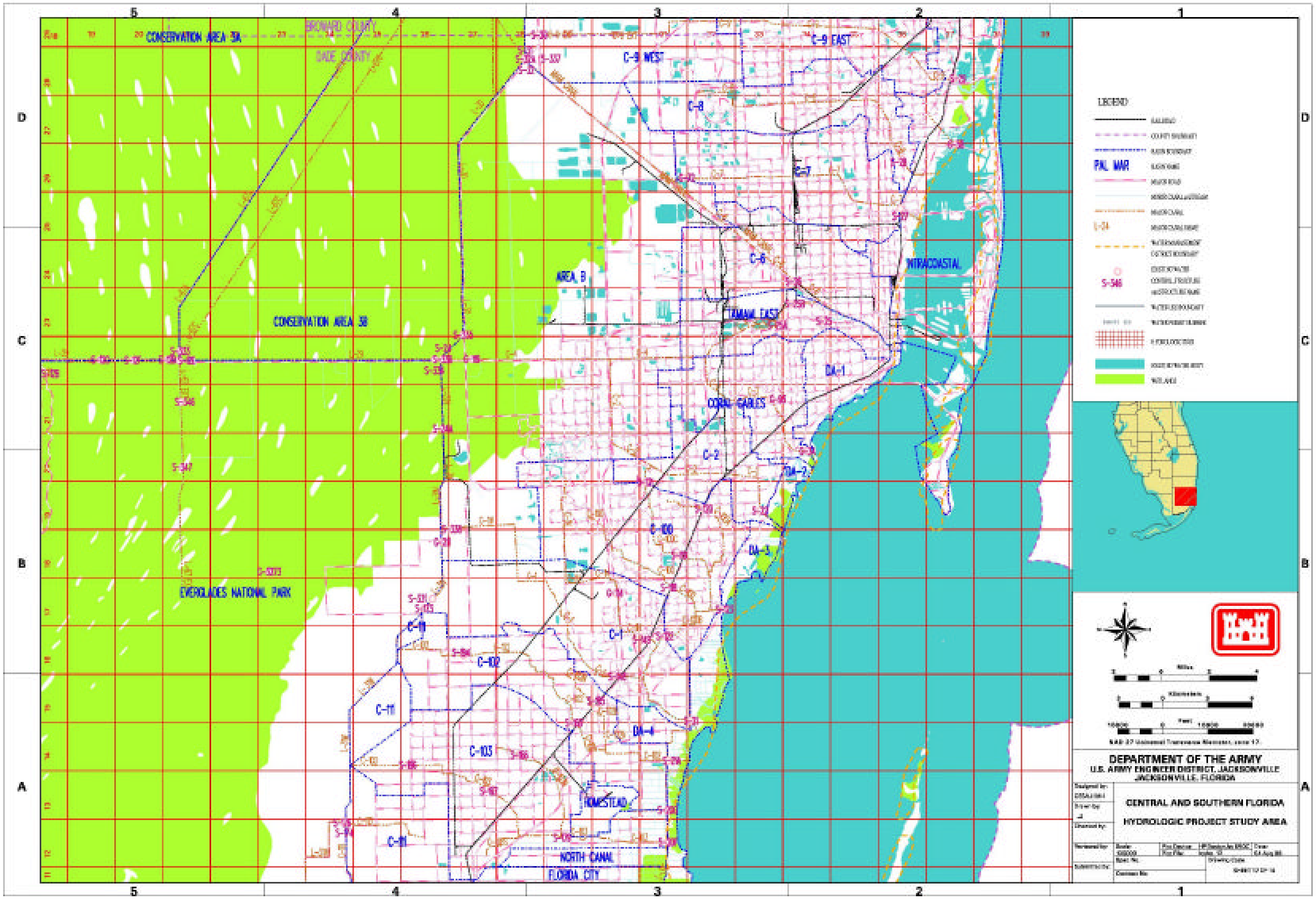
39	15	L-28	Miccosukee Lands
39	16	L-28	Miccosukee Lands
40	15	L-28	Seminole Lands
41	12	L-28	Seminole Lands
56	30	L-8	L-8
56	33	Indian Trails	C-51
57	29	L-8	L-8
58	29	L-8	L-8
61	34	C-18 Basin	C-18

Alternative plans were formulated with the intent of maintaining existing flood control protection. However, incidental increases in flood protection will be realized in areas where additional dynamic storage can be utilized. Additional retention or detention of flood waters during a storm event greater than the design of the system made possible by water supply reservoirs included in alternative plans will produce a greater degree of flood protection in the local area as long as the basin's existing outlet capacity is maintained.

E.6.6.3 Other Concerns

There is well deserved concern about the C-111 basin in South Miami-Dade County. It was noted that for cells R15C26 and R13C25 the results for Alternatives A,B,C,D, and D13R are comparable, and all are above the target by as much as 0.4 feet. In cell R13C25, the alternatives exceeded the two foot root zone almost 50% of the time. However, the 2050 base condition also violates the two foot root zone 40-50% of the time. The depth differences between alternatives and the base conditions for May and October are 0.0-0.1 feet msl., or minimal. However, the peak stage difference maps indicate that annual peak stages in this area are at least 0.25 feet higher for the alternatives than for the base conditions in approximately 7.5% of the years modeled. The alternatives might worsen conditions for an area that will already have water control problems under the future without project condition

PLATE 1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BROWARD COUNTY
DADE COUNTY
CONSERVATION AREA 3B
EVERGLADES NATIONAL PARK
C-9 WEST
C-9 EAST
C-8
C-7
C-6
AREA B
INTRACOASTAL
TAMIAMI EAST
CORAL GABLES
DA-1
C-2
DA-2
C-100
DA-3
C-1
C-102
C-103
C-111
DA-4
HOMESTEAD
NORTH CANAL
FLORIDA CITY
LEGEND
DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

PLATE 2

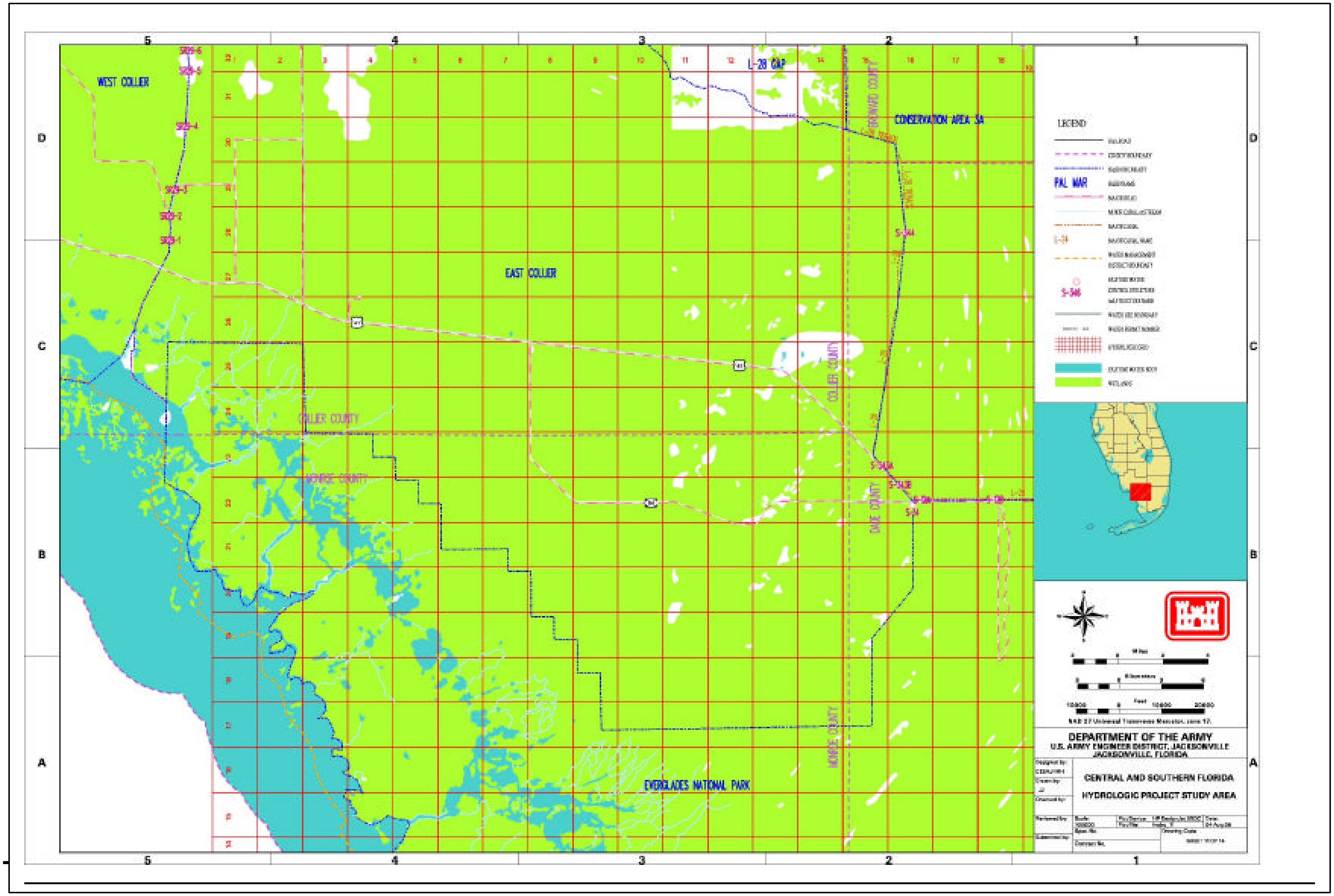

WEST COLLIER
EAST COLLIER
L-28 GAP
CONSERVATION AREA 3A
BROWARD COUNTY
COLLIER COUNTY
MONROE COUNTY
DADE COUNTY
EVERGLADES NATIONAL PARK
LEGEND
DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

PLATE 3

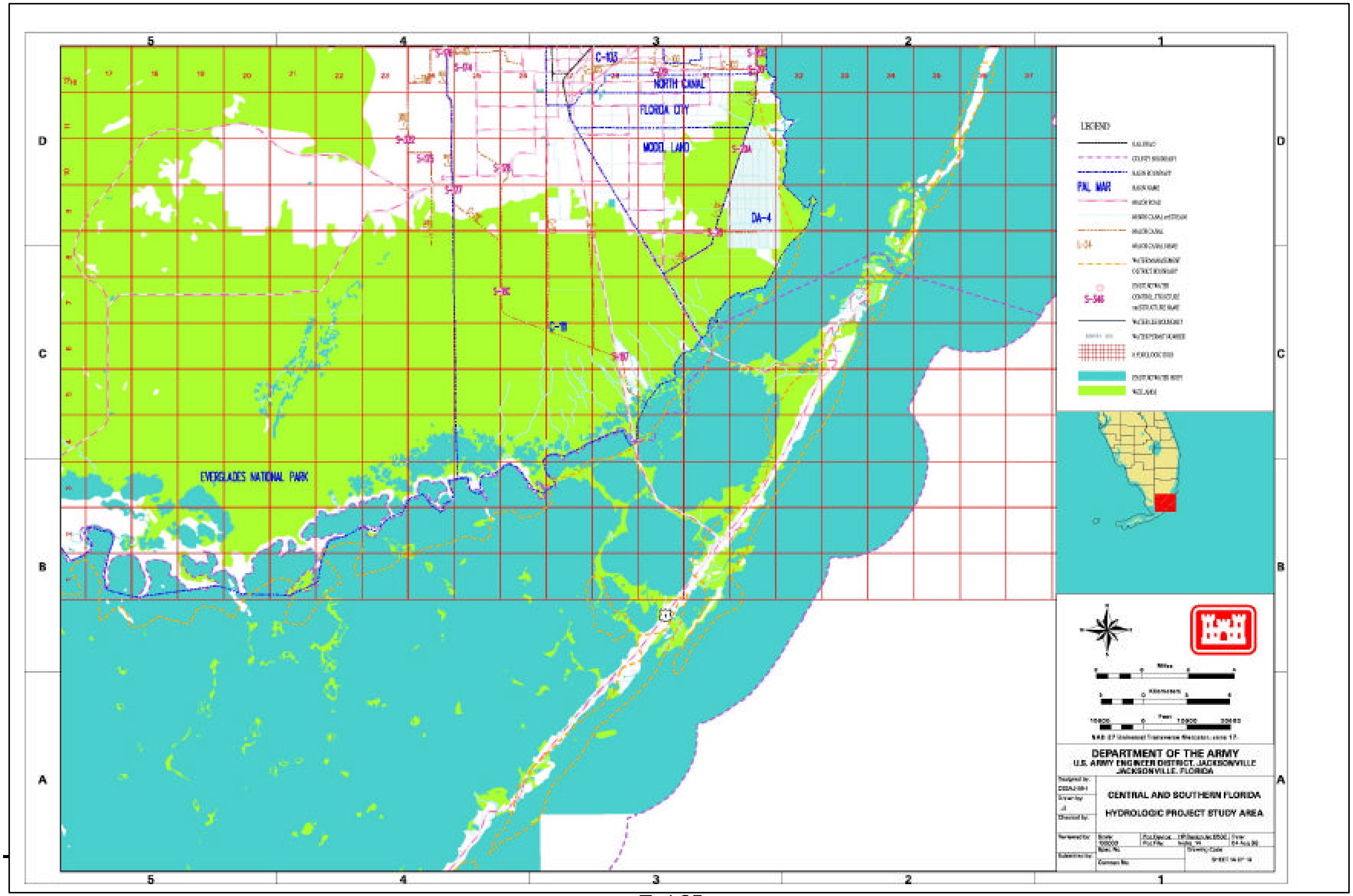

C-103
NORTH CANAL
FLORIDA CITY
MODEL LAND
DA-4
EVERGLADES NATIONAL PARK
LEGEND
DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

PLATE 4

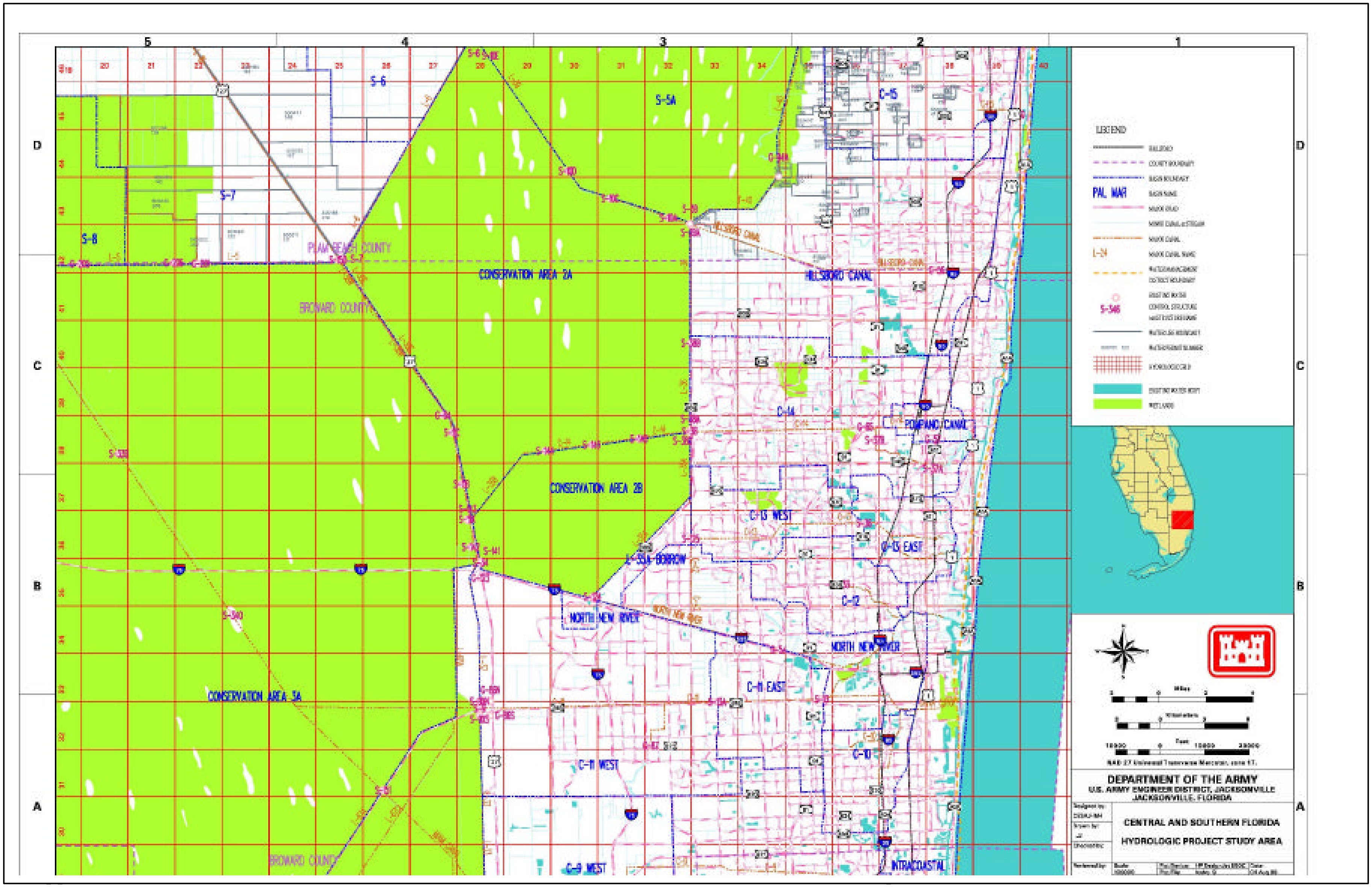

CONSERVATION AREA 2A
CONSERVATION AREA 2B
CONSERVATION AREA 3A
PALM BEACH COUNTY
BROWARD COUNTY
HILLSBORO CANAL
POMPANO CANAL
NORTH NEW RIVER
C-13 WEST
C-13 EAST
C-11 EAST
C-11 WEST
C-9 WEST
INTRACOASTAL
LEGEND
DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

PLATE 5

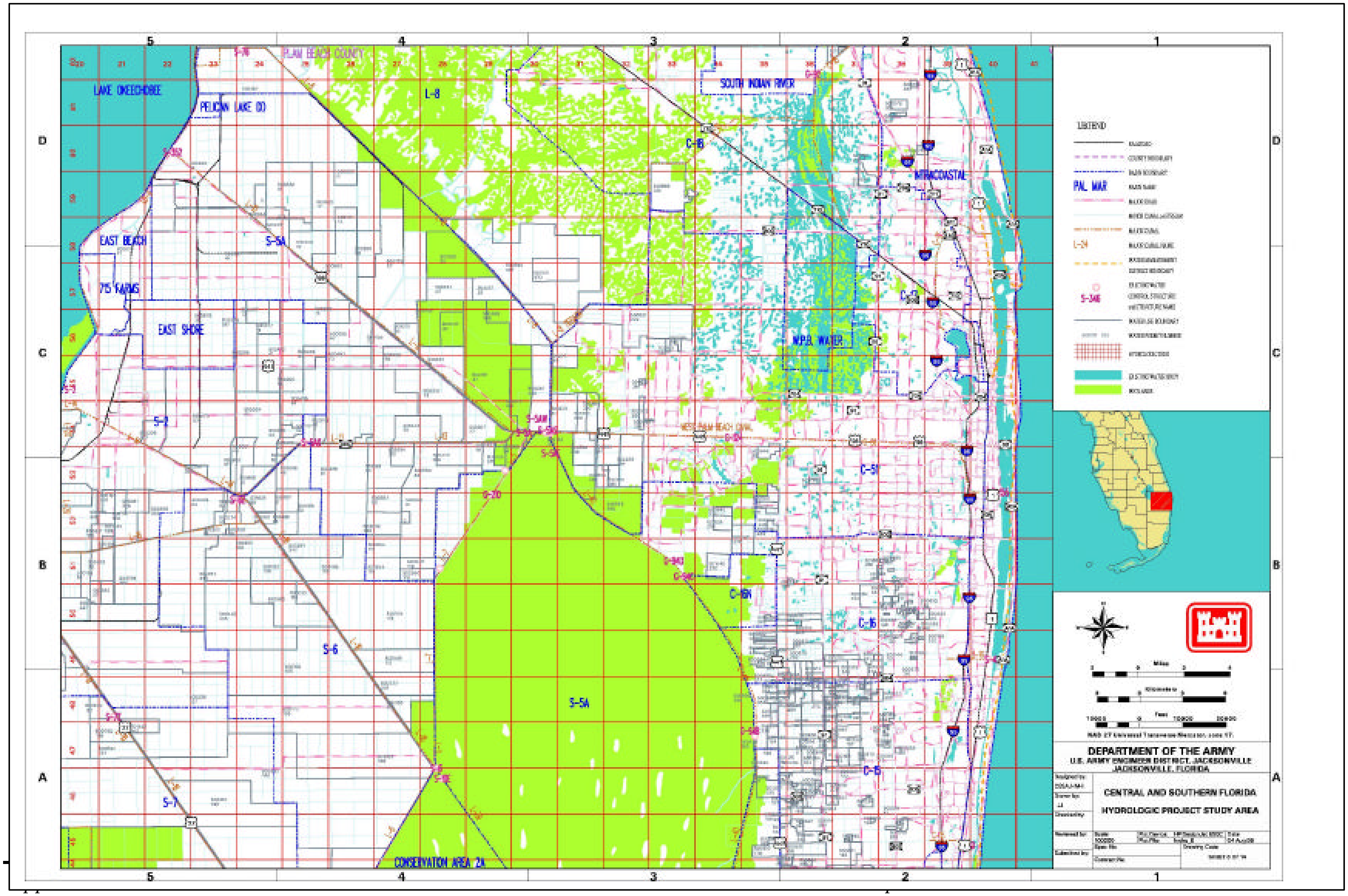

LAKE OKEECHOBEE
PELICAN LAKE
PALM BEACH COUNTY
L-8
SOUTH INDIAN RIVER
C-18
INTRACOASTAL
EAST BEACH
715 FARMS
EAST SHORE
S-5A
M.P.B. WATER
WEST PALM BEACH CANAL
S-2
C-51
S-6
C-16
S-5A
S-7
C-15
CONSERVATION AREA 2A
LEGEND
DEPARTMENT OF THE ARMY
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

PLATE 6

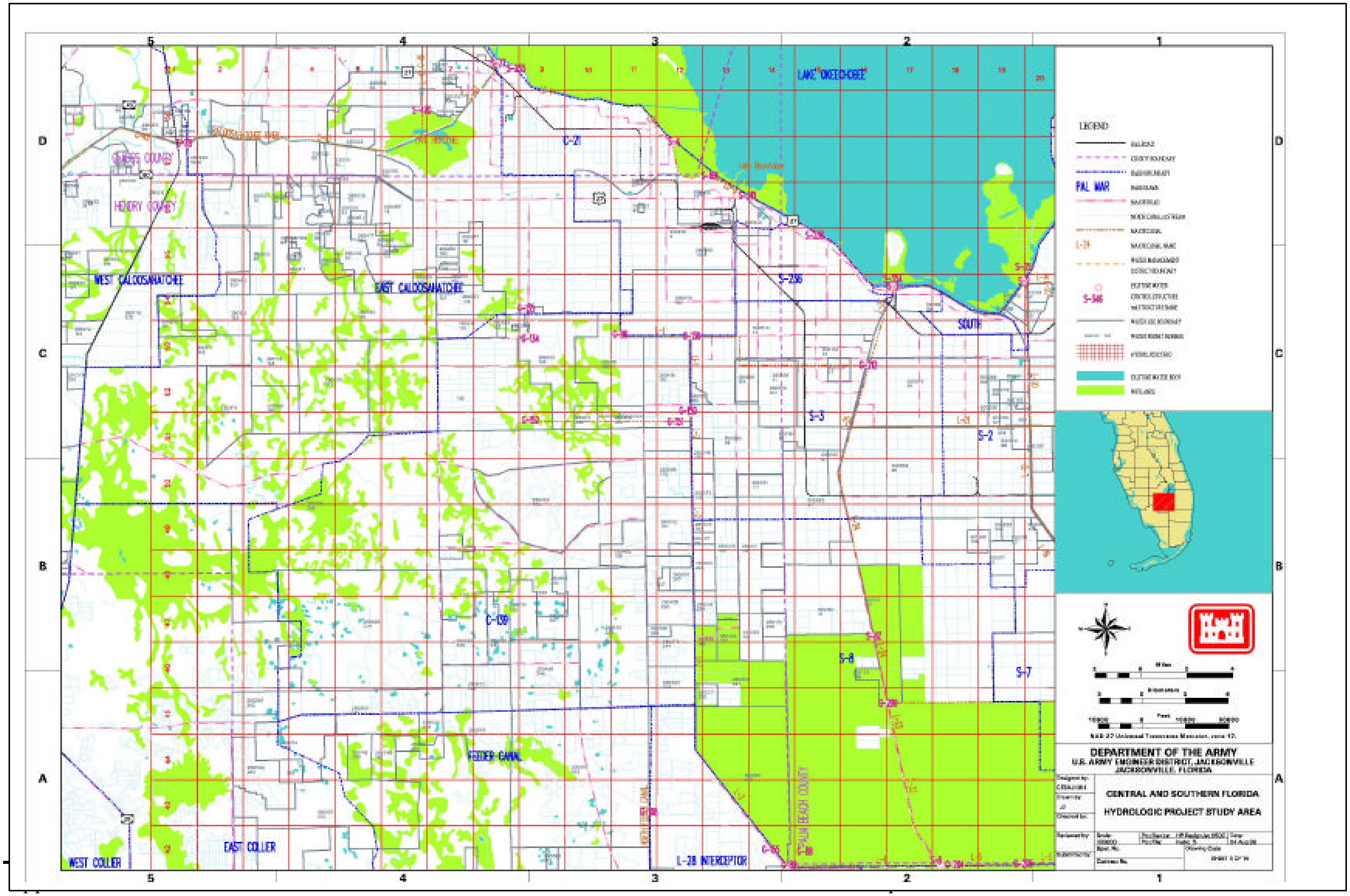
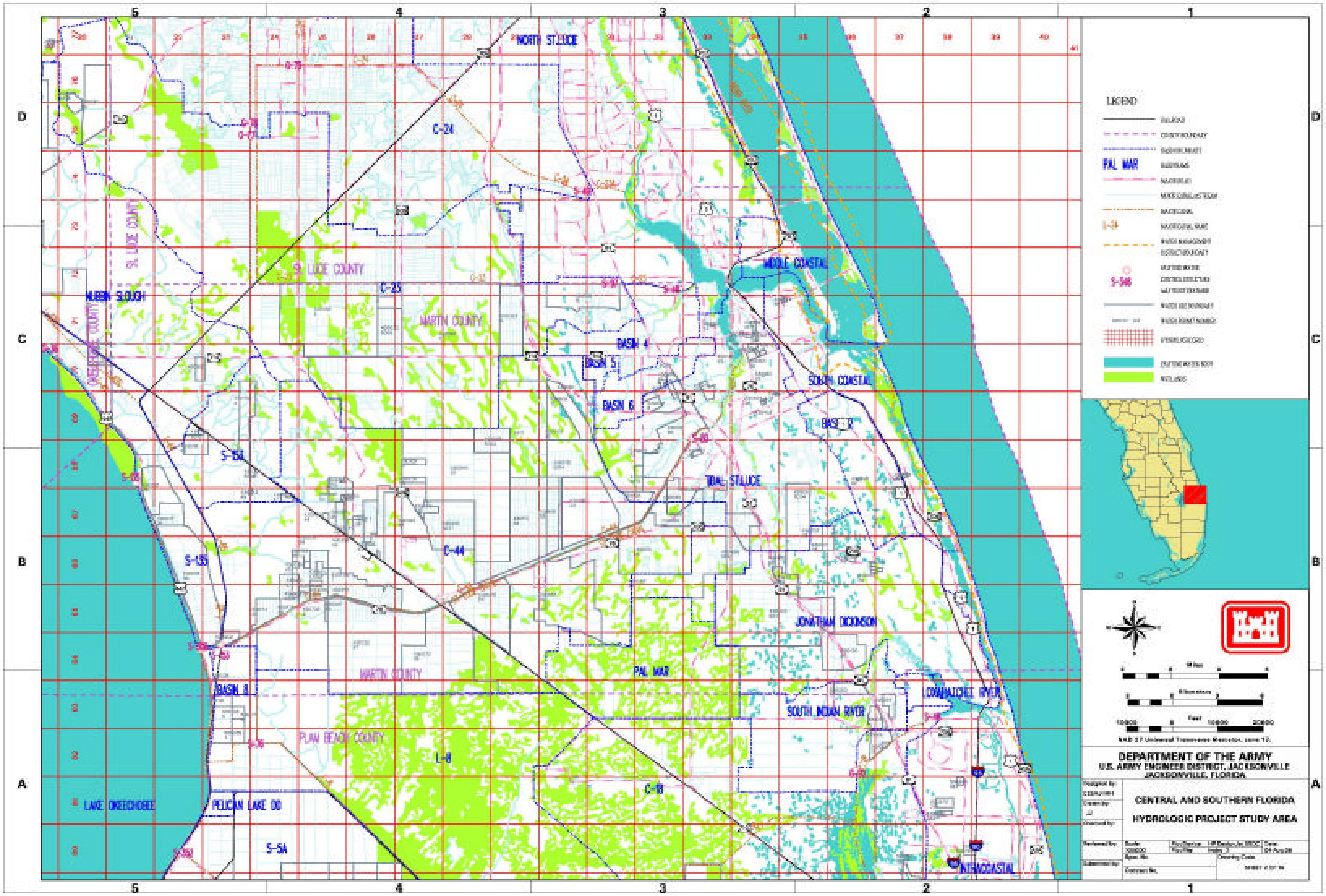
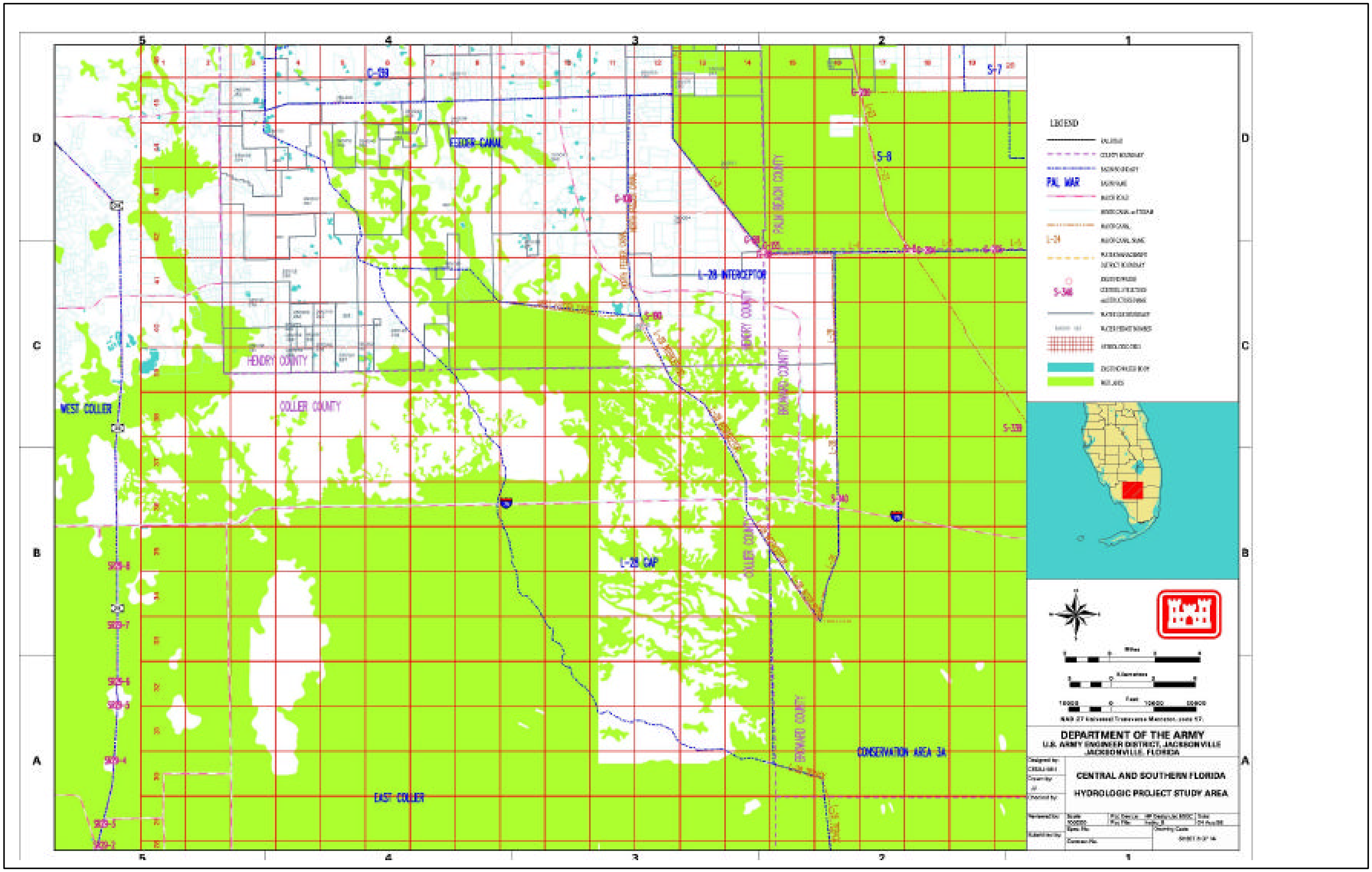

LAKE OKEECHOBEE
GLADES COUNTY
HENDRY COUNTY
WEST CALOOSAHATCHEE
EAST CALOOSAHATCHEE
SOUTH
C-21
S-236
S-3
S-2
C-139
S-8
S-7
FEEDER CANAL
EAST COLLIER
WEST COLLIER
L-28 INTERCEPTOR
PALM BEACH COUNTY
LEGEND
DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

PLATE 7



NORTH ST.LUCIE
C-24
C-23
ST. LUCIE COUNTY
MARTIN COUNTY
NUBBIN SLOUGH
MIDDLE COASTAL
BASIN 4
BASIN 5
BASIN 6
SOUTH COASTAL
TIDAL ST.LUCIE
S-154
S-135
C-44
BASIN 8
MARTIN COUNTY
PAL MAR
JONATHAN DICKINSON
LOXAHATCHEE RIVER
SOUTH INDIAN RIVER
PALM BEACH COUNTY
L-8
C-18
LAKE OKEECHOBEE
PELICAN LAKE DD
S-5A
INTRACOASTAL
LEGEND
DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

PLATE 8


FEEDER CANAL
L-28 INTERCEPTOR
HENDRY COUNTY
COLLIER COUNTY
WEST COLLIER
L-28 GAP
EAST COLLIER
CONSERVATION AREA 3A
PALM BEACH COUNTY
BROWARD COUNTY
DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA
HYDROLOGIC PROJECT STUDY AREA

E.7 COMMERCIAL NAVIGATION

E.7.1 OVERVIEW

This chapter evaluates the potential impact of the alternative restoration plans on commercial navigation on the Lake Okeechobee Waterway, which includes the lake, the Caloosahatchee River, and the St. Lucie Canal. This waterway has an authorized depth of eight feet and links Stuart on the Atlantic coast with Ft. Myers on the Gulf of Mexico. Commercial vessels, principally barge traffic, use this waterway to save the time and costs of passing around the tip of the Florida peninsula. Water levels – and channel depths – in the Caloosahatchee River and the St. Lucie Canal are regulated by a series of locks and dams on these waterways. However, channel depths in Lake Okeechobee fluctuate with lake stages. Very low lake levels reduce channel depths in the lake below the authorized navigation depth. This depth reduction could prevent passage, delay passage, or induce reductions in vessel loads for some commercial vessels that would pass through this waterway. These navigation impacts could have economic implications for the shippers and for the transportation costs of commodities carried by depth-constrained vessels.

Based on the South Florida Water Management Model (SFWMM) runs conducted for the Restudy, the alternative restoration plans are expected to have varying effects on water levels in Lake Okeechobee. Consequently, the alternative restoration plans will have varying impacts on commercial navigation. In general, the alternative plans are expected to result in a reduction in stage fluctuations on Lake Okeechobee. Of particular interest to commercial navigation is that the alternative plans are expected to reduce the frequency and duration of extremely low lake levels which affect vessel movements.

This analysis of the potential effects of the alternative restoration plans on commercial navigation will focus on the expected differences between the with- and without-project future conditions. The discussion of commercial navigation on the Lake Okeechobee Waterway begins with a physical description of the waterway, followed by a discussion of the operation and use of the waterway, and an evaluation of the potential effects of the alternative restoration plans.

E.7.2 PHYSICAL FEATURES OF THE WATERWAY

The Lake Okeechobee Waterway was completed in 1937 and includes 154 miles of navigation channel and five lock and dam structures. The five locks and dams, which are operated by the Corps of Engineers, are (from east to west): St. Lucie (river mile 15.3) and Port Mayaca (river mile 38.5) on the St. Lucie Canal; and Moore Haven (river mile 78.0), Ortona (river mile 93.6), and W.P. Franklin (river mile 122.0) on the Caloosahatchee River. The Moore Haven and Port Mayaca locks connect the lake with the Caloosahatchee River and St. Lucie Canal, respectively. Using the locks to designate waterway reaches, the channel dimensions of the Lake Okeechobee Waterway at lake elevation 12.56' NGVD are presented in ***Table 7.2-1***. The Lake Okeechobee Waterway has an authorized project depth of eight feet based upon a lake stage of 12.56 feet NGVD. As indicated in this table, there are two routes from Port Mayaca on the lake's eastern shore to Clewiston on the southwestern shore. Route 1, which cuts across the lake, has a deeper channel (8 feet). Route 2, which hugs the eastern shoreline, is known as the rim canal. This route has a shallower channel (6 feet) and is longer than Route 1, but is more sheltered. Lake Okeechobee is famous for its severe wave conditions which can arise rapidly even with modest wind velocities. During inclement weather, the rim canal is the preferred route between Clewiston and Port Mayaca.

TABLE 7.2-1
CHANNEL DIMENSIONS
LAKE OKEECHOBEE WATERWAY

Waterway Reach	Channel Dimensions	Length of Reach
Atlantic Intracoastal to St. Lucie Lock	Outside project limits	15.3 miles
St. Lucie Lock to Port Mayaca Lock	8' x 100'	23.7 miles
Route 1: Port Mayaca Lock to Clewiston (open lake)	8' x 100'	28.5 miles
Route 2: Port Mayaca Lock to Clewiston (rim canal)	6' x 100'	39.5 miles
Clewiston to Moore Haven Lock (rim canal)	8' x 180'	10.5 miles
Moore Haven Lock to Ortona Lock	8' x 90'	15.5 miles
Ortona Lock to W.P. Franklin Lock	8' x 90'	27.9 miles
W.P. Franklin Lock to Gulf Intracoastal	Outside project limits	33.2 miles
	TOTAL	154.4 miles (open lake) 165.4 miles (rim canal)

The depth of the Lake Okeechobee waterway is controlled by managing lake levels - no maintenance dredging is conducted for this waterway. Consequently, lake levels above (or below) 12.56 feet NGVD will result in a corresponding increase (or decrease) in channel depths. So, for example, at a lake level of 11 feet NGVD, the channel depth would be approximately 6.5 feet NGVD in the open lake and 4.5 feet NGVD in the rim canal.

Table 7.2-2 presents the lock dimensions for the five locks and dams on the Lake Okeechobee Waterway. The elevation of the bottom of Lake Okeechobee is approximately equal to sea level. As a result, with a lake elevation at 15.5 feet NGVD, the Caloosahatchee and St. Lucie locks would have a combined lift of approximately 15.5 feet and 14.5 feet, respectively. The difference is explained by the Caloosahatchee locks releasing further inland (upstream) from the coast than the St. Lucie locks. Three of the locks have head differences of several feet. However, two locks have significantly larger head differences. Ortona Lock has a head difference of approximately 8 feet, and St. Lucie typically has lift elevations in excess of 13 feet. The chamber depths of the five locks depend on the lock head. At their lowest operational levels, the chambers would have depths far in excess of the authorized project depths. Therefore, the lock chambers do not constitute depth constraints to waterway traffic under conceivable circumstances.

TABLE 7.2-2
LOCK DIMENSIONS
LAKE OKEECHOBEE WATERWAY

Lock	Dimensions (feet)
St. Lucie	50’ x 250’
Port Mayaca	56’ x 400’
Moore Haven	50’ x 250’
Ortona	50’ x 250’
W.P. Franklin	56’ x 400’

E.7.3 WATERWAY OPERATION

The Caloosahatchee River and the St. Lucie Canal are primary outlets for Lake Okeechobee. They are also critical components of the Lake Okeechobee Waterway. The locks and dams are operated in a manner that supports commercial navigation as well as other project objectives. Each of the locks and dams has a spillway that can be used for regulatory releases. The spillways and the locks release freshwater downstream and eventually into the Gulf of Mexico and the Atlantic Ocean. Releases are carefully controlled to regulate lake levels, maintain adequate depths for navigation in the two outlet waterways, and minimize salinity impacts on the two receiving estuaries.

Water is typically released through the Caloosahatchee River before the St. Lucie Canal for two reasons. First, freshwater releases to the St. Lucie Canal are limited due to greater ecological effects of freshwater releases on the estuary. Second, the water treatment facility for the town of Olga is located in the Caloosahatchee reach between the W.P. Franklin and Ortona locks. The plant is not allowed to discharge chloride-treated effluent to the river if chloride concentrations in the receiving waters are in excess of 250 parts per million (ppm). The three Caloosahatchee locks and dams are typically operated to keep salinity in this river reach low enough to receive the plant effluent. Since the Caloosahatchee River downstream of the W.P. Franklin lock is tidal, this involves a continual release of freshwater from the lake. In addition, the lock operators will occasionally flush the waterway to remove algae and to restore dissolved oxygen levels. In the

St. Lucie Canal, the St. Lucie Lock is the main interface between the lake and the Atlantic Ocean. When the lake level is below 14 feet NGVD, the Port Mayaca Lock is opened, and water levels for the reach from the lake to the St. Lucie lock are controlled by lake levels.

During water shortages, the operation of the Lake Okeechobee Waterway is altered. In all four phases of the SFWMD's Water Shortage Plan, lock operations can be restricted to conserve water in Lake Okeechobee and maintain acceptable salinity concentrations in the estuaries downstream of the locks. The operation of the W.P. Franklin Lock is a particular focus of the plan. Under the Plan, the SFWMD will request the Corps to limit lockages at W.P. Franklin to once every 4 hours if chloride concentrations at the lock exceed 180 ppm and a rainfall event in excess of 1 inch in 24 hours is not predicted in the surface water use basin within the next 48 hours. If these restrictions are insufficient to reach the salinity target at W.P. Franklin, the SFWMD can then request the Corps to restrict lockages to once every 4 hours, two days per week. If these additional measures are insufficient, the SFWMD can ask the Corps to prohibit lockages.

E.7.4 WATERWAY USE

As shown in ***Table 7.4-1***, the Lake Okeechobee Waterway was used to transport 430,000 tons of freight in 1995. This table, which contains statistics from Waterborne Commerce of the United States, 1997, indicates that petroleum products comprise the overwhelming majority of tonnage shipped. Petroleum products included distillate fuel oil, residual fuel oil, and liquid natural gas. As indicated in ***Table 7.4-2***, commercial navigation on this waterway has been relatively stable over the past ten years, with substantial interannual variability.

TABLE 7.4-1
FREIGHT TRAFFIC, 1995
LAKE OKEECHOBEE WATERWAY
(thousand tons)

Commodity	Total	Coastwise – Through		Internal		
		Upbound (east to west)	Downbound (west to east)	Inbound Upbound	Through Downbound	Intra-Upbound
All Commodities	430	8	1	415	6	1
Total Petroleum Products	423	7	0	411	5	0
Total Primary Manufactured						
Total Food & Farm Products	3			2		1
Total Manufactured Equipment & Machinery	3	1	1		1	
Ton-Miles (1000's)	9,758	1,187	179	8,265	125	1

Source: U.S. Army Corps of Engineers, 1996.

TABLE 7.4-2
FREIGHT TRAFFIC, 1986-1995
LAKE OKEECHOBEE WATERWAY
(thousand tons)

Year	Total Tons
1987	676
1988	696
1989	680
1990	665
1991	718
1992	753
1993	832
1994	662
1995	430

Source: U.S. Army Corps of Engineers, 1996.

The locks on the Lake Okeechobee Waterway play critical roles in movements of commercial vessels. The lock operators maintain records of the lock operations, including the general characteristics of vessels passing through the locks. These data are compiled in a national database, the Lock Performance Monitoring System

(LPMS). This database is maintained by the Corps of Engineers Water Resources Support Center in Ft. Belvoir, Virginia.

Data from the LPMS include characteristics of the commerce vessels used on the waterway. ***Table 7.4-3*** summarizes the LPMS vessel profiles for the Lake Okeechobee Waterway locks for 1996. The lock data contains information about recreational boats passing through the locks, as well as commercial traffic.

The number of tows passing through the locks range from 97 to 226 for W.P. Franklin and the St. Lucie locks, respectively. The average number of barges per tow is small, ranging from 1.1 to 1.5 for St. Lucie and Port Mayaca locks, respectively. The light volume of traffic and small tow sizes indicated by the LPMS data indicate that there are minimal delays at the five locks and dams.

Additional data on the commercial vessels using the Lake Okeechobee Waterway is provided in ***Table 7.4-4***, which presents Florida state vessel registrations for the counties surrounding the lake. This table includes commercial and recreational vessels by length class. The vessels in this table are primarily small, recreational craft. However, there are larger commercial vessels as well. There is a small but viable fleet of day/dinner cruise vessels that operate during the tourist season from Pahokee on the eastern shore of the lake, and from Ft. Myers. These vessels have relatively shallow drafts, in the range of four to five feet. The smaller commercial craft may be fishing boats associated with marinas or fish camps on the lake. These operations will rent fishing boats, and also offer guide services. The vessel registration information in Table 7.4-4 must be interpreted with caution for two reasons. First, Palm Beach and Martin Counties are coastal counties with potential vessel registrations for the Lake Okeechobee Waterway and the Atlantic Ocean. Second, the county of registration may not necessarily be the same as the county of operation.

E.7.5 ANTICIPATED EFFECTS OF ALTERNATIVE PLANS

The potential effects of the alternative restoration plans on commercial navigation are based on the anticipated changes in the frequency and duration of low stage events in Lake Okeechobee. As shown in Table 7.5-1, the 31-year SFWMM simulations suggest that in the absence of restoration action (i.e., under without-project future conditions), lake stages are expected to be below 12 feet National Geodetic Vertical Datum (NGVD) for 30% of the time. As indicated in this table, the alternative plans are expected to significantly reduce the percent of time when lake stages are below 12 feet NGVD. The Recommended Plan is expected to have similar performance to Alternative D.

E.7.6 IMPLICATIONS FOR COMMERCIAL NAVIGATION

Economic effects on commercial navigation are defined as the changes in the value of resources required to transport commodities and/or the change in the value of output from these goods and services. Changes in transportation costs may stem from changes in: (1) the vessel fleet used on the waterways, (2) efficiency in the use of existing vessels, (3) transit time, (4) origin-destination patterns, (5) cargo handling, (6) tug assistance, and (7) use of waterborne transportation, rather than competing modes. The national economic development (NED) effects include the costs of resources, impacts on net income, and operating costs.

The statistics on waterborne commerce and vessels on the Lake Okeechobee Waterway were complemented by extensive field research. This research included interviews with: (1) lockmasters of each lock, (2) waterway users, (3) waterway interest groups, and (4) Corps operations personnel involved with the Lake Okeechobee Waterway project. These interviews solicited opinions regarding the potential navigation impacts from changes associated with the alternative restoration plans. In addition, the waterway was traversed as part of this field research to identify the sensitivity of commercial navigation to changes in lake levels. This included taking spot soundings to assess channel conditions and evaluate aids to navigation. The findings of this field research are highlighted below.

TABLE 7.4-3
VESSEL PROFILES
LAKE OKEECHOBEE WATERWAY LOCKS
JANUARY – DECEMBER 1996

	Vessels				Barges			Bottoms	Tonnage
	Total	Recreation	Tows	Other	Total	Loaded	Empty	Total	(1000's tons)
St. Lucie									
Upbound	4500	3859	116	525	134	82	52	4634	8
Downbound	4444	3759	110	575	122	95	27	4566	15
Total	8944	7618	226	1100	256	177	79	9200	23
Port Mayaca									
Upbound	4420	3448	54	918	67	34	33	4487	5
Downbound	4348	3349	49	950	89	69	20	4437	8
Total	8768	6797	103	1868	156	103	53	8924	13
Moore Haven									
Upbound	5287	5054	70	163	84	65	19	5371	9
Downbound	5441	5220	73	148	84	48	36	5525	7
Total	10728	10274	143	311	168	113	55	10896	16
Ortona									
Upbound	3925	3744	54	127	70	57	13	3995	9
Downbound	4090	3921	54	115	70	37	33	4160	4
Total	8015	7665	108	242	140	94	46	8155	13
W.P. Franklin									
Upbound	8115	7872	46	197	66	47	19	8181	8
Downbound	8362	8141	51	170	75	36	39	8437	5
Total	16477	16013	97	367	141	83	58	16618	13

Source: U.S. Army Corps of Engineers, 1997.

TABLE 7.4-4
VESSEL REGISTRATIONS
LAKE OKEECHOBEE COUNTIES
FY 1996-1997

Class	Length	Type	Glades	Hendry	Martin	Okeechobee	Palm Beach	Total
Class A-1	<12'	Pleasure	72	349	1,785	297	6,415	8,918
		Commercial	12	13	70	11	108	214
Class A-2	12'-15'11'	Pleasure	371	832	2,270	1,603	6,405	11,481
		Commercial	70	58	71	115	88	402
Class 1	16'-25'11'	Pleasure	577	1,328	7,141	2,624	15,372	27,042
		Commercial	65	115	262	141	430	1,013
Class 2	26'-39'11"	Pleasure	30	213	1,876	73	3,187	5,379
		Commercial	4	33	132	1	196	366
Class 3	40'-64'11"	Pleasure	7	49	343	8	735	1,142
		Commercial	2	9	79	3	109	202
Class 4	65'-109'11"	Pleasure	0	1	14	0	58	73
		Commercial	0	1	3	0	19	23
Class 5	>110'	Pleasure	0	0	0	0	6	6
		Commercial	0	0	0	0	0	0
Canoes		Pleasure	14	22	126	15	241	418
		Commercial	0	2	1	0	0	3
Dealers			5	14	285	20	270	594
	Sub-total	Pleasure	1,071	2,794	13,555	4,620	32,419	54,459
	Sub-total	Commercial	153	231	618	271	950	2,223
TOTAL			1,229	3,039	14,458	4,911	33,639	57,276

Source: Bureau of Vessel Titles and Registrations, 1997.

TABLE 7.5-1
SIMULATED EFFECTS OF ALTERNATIVE RESTORATION PLANS
ON LOW LAKE OKEECHOBEE STAGES

PERFORMANCE MEASURE	2050 Base	ALTERNATIVE PLAN			
		A	B	C	D & RP
Percent of time lake stage < 12 feet NGVD	30%	16%	20%	16%	11%

Note: RP = Recommended Plan (D13R + Other Project Elements)

E.7.6.1 Commercial Traffic

Based on conversations with representatives of the Florida Inland Navigation District, the current and former presidents of the Lake Okeechobee Waterway Association, and the lockmasters, there are no commercial shipping lines with regularly scheduled traffic through the Lake Okeechobee Waterway. The commercial traffic consists of special barge shipments that are taking advantage of the shortcut across the peninsula, which can save 3 to 5 days of travel. In some cases, deep-draft tugs transfer the tows to shallow-draft tugs for passage through the Lake Okeechobee Waterway.

In the absence of an established fleet of vessels using the waterway, the analysis of commercial navigation must depend on records of the shipments collected as part of the waterborne commerce statistics and the LPMS.

The absence of regular vessel traffic through the Lake Okeechobee Waterway combined with the historic profile of vessel and commodity movements suggests that commercial navigation on this waterway will continue at its current level with the same high year-to-year variability experienced over the last decade. It is not possible to estimate if and how the fleet of commercial vessels using the waterway might change with the alternative restoration plans. However, given the low level of existing commercial usage and the absence of any significant restrictions or delays, very little change (if any) would be expected between with- and without-project conditions.

E.7.6.2 Groundings

Interviews held with the lockmasters and Corps operations personnel suggested that when lake levels are below 14 feet NGVD, the frequency of vessel groundings increases. While the problem is most severe for recreational vessels, commercial traffic is subject to groundings as well. In general, groundings occur when vessels do not stay in the channel. Since most commercial vessels will endeavor to remain in the channel, groundings are less of a problem for them than recreational craft. However, at very low lake levels, the authorized channel depths cannot be maintained. Under these circumstances, the Coast Guard will install temporary markers to keep vessels in deep water within the channels. The Coast Guard will also issue a Notice to Mariners warning commercial and recreational navigators about the reduced channel depths.

Of particular concern are two shoal areas that pose hazards to vessels that have drafts close to the authorized channel depth. During average and high lake levels these shoals are not a threat to commercial navigation, but during low lake stages they can be problematic. In particular, there is a rock shelf on Route 2 near Port Mayaca lock and a rocky reef on Route 1 near Clewiston that are hazardous. At Port Mayaca, the shoal allegedly has only 4.5 feet of clearance at lake level 12.56

feet NGVD, and the Clewiston entrance allegedly has less than 8 feet of clearance at the same lake level.

As lake levels decline, there is less margin for pilot error or adverse weather conditions. If commercial vessels stray outside of the channel for any reason, they can run aground. Rocky Reef on Route 1 near Clewiston is particularly unforgiving of errors. Much of the lake bottom is soft, but running aground at this location could cause severe damage to vessels. For commercial traffic, it can be particularly challenging to stay in the smaller channel during low lake levels due to the wave and wind action for which Lake Okeechobee is famous. The lower lake levels compound problems with waves, since the shallower depths exacerbate wave formation.

If vessels run aground, the Coast Guard at Ft. Pierce is contacted, and a tow from Ft. Meyers is requested. If there is danger to life or property, the Corps project operations office in Clewiston, on the southwestern edge of the lake, will provide assistance. The Corps keeps records of such assistance, but only for the past two years. As a result, information about groundings on the lake is primarily anecdotal.

E.7.6.3 Aids To Navigation

Based upon a detailed inspection of the Lake Okeechobee Waterway, it appears there are some problems with aids to navigation that may pose hazards to commercial and recreation vessels. Route 1 across the lake is particularly problematic in this regard. Specifically, the channel markers appear to be spaced too far apart for safe navigation. In particular, offshore from Clewiston, Route 1 turns sharply northward to pass through Rocky Reef at the "Hole in the Wall." There are three buoys that mark the channel through this turn: one for the approach, one for the pivot point, and one for exit. The problem is that inexperienced mariners might be tempted to cut across the hypotenuse of what is almost a right triangle, moving directly from the approach to the exit buoy. Unfortunately, this would be a path directly over the reef. This path might not be problematic during average or high lake levels, but at low lake levels groundings would result.

In addition, waterway users indicate that in some locations the spacing between waterway buoys exceeds the channel dimensions significantly. Again, during average or high water, this may not be a problem, but during low lake levels, shallow water could be encountered, as evidenced by the Coast Guard's placement of temporary markers.

Finally, the channel marker buoys on Route 1 seem to be spaced too far apart. While compass headings for this route are provided in navigational charts for the lake, visual cues (i.e., confirmation) using the channel markers are not possible at some points along this route, particularly offshore of Port Mayaca.

E.7.6.4 Lockage Restrictions During Water Shortages

Restrictions on lockages during water shortages cause delays to commercial and recreational waterway traffic. Delays are offset to some degree by the opening of the Port Mayaca lock during low lake levels. However, there are economic effects associated with these delays, particularly for commercial traffic. Although the restriction of lockages as a result of water shortages is uncommon, the restrictions are perceived by the lockmasters as unnecessarily rigid. The lockmasters report that lockages have been restricted at the same time water releases over the dam spillways were being conducted to control salinity in the waterways and the estuaries. During normal operations, the locks are operated on demand. The lockmasters acknowledge that lockages should be restricted during water shortages, but they suggest that they be given more flexibility to manage lock operations with open-ended performance measures, such as requirements not-to-exceed a specified number of lockages over a given time period.

E.7.7 ASSESSMENT

Based upon field research and database searches regarding commercial navigation on the Lake Okeechobee Waterway, it can be concluded that the effects of the alternative restoration plans on the NED account would be very small. All of the alternative restoration plans are expected to lead to reductions in the frequency of low lake stages relative to the 2050 without-project condition. However, the economic effects of these improvements for commercial navigation are expected to be small. There are some commercial navigation issues on this waterway, all of which are directly or indirectly related to lake levels. However, it is not possible to quantify the impacts of the alternative restoration plans without extensive research to identify the waterway fleet and commodity flows. In addition, the infrequent and irregular nature of navigation on the waterway raises the question of whether shipments through the waterway could be deferred until lake levels increase, with little ill effect. In addition, those shippers who use this waterway may already have adjusted to the fluctuations in lake levels. Revisions in lock management practices during drought conditions, as suggested by the lock masters, could also reduce the impacts of the alternative restoration plans on commercial traffic. Finally, the combination of the minor difference in the frequency of extreme low lake levels among the alternative schedules and relatively light commercial traffic on the waterway supports the conclusion that the impacts of the alternative restoration plans on commercial navigation will be negligible.

E.8 RECREATION

E.8.1 OVERVIEW

This chapter examines the potential effects of the Restudy's five alternative restoration plans (Alternatives A, B, C, D, and the Recommended Plan) on the value of outdoor recreation in south Florida. Florida residents and domestic and international tourists enjoy the state's numerous recreation amenities. At the state level, residents and tourists participated in over 493 million outdoor recreation user occasions in Florida during 1992 (Florida Department of Environmental Protection, 1994). Tourists accounted for over 250 million of these occasions, or 51% of all outdoor recreation in Florida. In 1996, approximately one half of all air travelers to Florida (12,002,961 of 23,510,157) had destinations in south Florida (Florida Tourism Industry Marketing Corporation, 1997).

Most visitors to Florida come to enjoy the pleasant climate and participate in a wide variety of opportunities for outdoor recreation. In 1996, Florida hosted more than 43 million domestic and international visitors (Florida Tourism Industry Marketing Corporation, 1997). The expenditures of these visitors make tourism Florida's largest industry. Tourism directly employs more than 781,000 persons and generates more than $37 billion in annual taxable spending. Outdoor recreation plays a significant role in this industry. Visitors are attracted to the state's recreation amenities, and most recreation activities require significant participant expenditures for preparation, travel, and participation. Since the state's parks and preserves are popular visitor attractions, tourists account for a significant portion of the approximately five million annual visitors to the Everglades-related recreation areas in south Florida.

Outdoor recreation in Florida includes many different activities. A common way of differentiating outdoor recreation activities is to classify them based as "user-oriented" or "resource-based" activities. User-oriented activities, such as individual and team sports, are not dependent on any natural resource setting and can be located, space permitting, on any open site. These facilities are provided for the convenience of the user. For example, a basketball court can be added to a playground. Resource-based activities, such as hunting and fishing, depend on the existence and quality of supporting natural or historical resources.

Recreation on Florida's coastal beaches provides an excellent illustration of resource-based recreation in the state. In addition to its beaches, south Florida has the tremendous resource-based recreation potential provided by the unique and nationally significant natural resources of the Everglades. These resources include the diverse ecosystems within the Everglades and related ecosystems, such as Lake Okeechobee, Biscayne Bay, and Florida Bay.

The economic value of resource-based recreation is determined by the users' willingness to pay for a recreation occasion. The willingness of current and potential users to pay for resource-based recreation of specific quantity and quality constitutes the demand for that type of recreation. The interaction of demand with the quantity and quality of recreation resources available determines the recreation use or "participation" levels for that resource-based activity. When the quantity or quality of recreation resources is modified by a project, such as the alternative restoration plans, the change in value of resource-based recreation is based on the difference in the willingness of users to pay under the with- and without-project conditions.

The restoration of the Everglades ecosystems could potentially have significant impacts on the value of outdoor recreation in south Florida. The hydrologic changes associated with the Restudy's alternative restoration plans have been designed to improve the structure and function of the Everglades ecosystems. These improvements can be expected to result in increases in the quantity and quality of Everglades-related recreation resources. Many tourists and residents recreate in the natural areas of south Florida. If the alternative restoration plans improve the ecology of the Everglades, the quality of the Everglades-related recreation and/or the number of people who participate in Everglades-related recreation could increase significantly. Consequently, the value of outdoor recreation in south Florida could increase as well.

Estimating the future value of Everglades-related recreation in south Florida is problematic, and anticipating the incremental changes in value associated with Everglades restoration is even more challenging. There are four principal uncertainties which challenge forecasting the future quantity and quality of outdoor recreation under with- and without project conditions. Perhaps the most important uncertainty concerns the timing and character of the ecological changes that are expected to result from the alternative restoration plans. At this time the outcomes of the restoration actions can not be predicted. Consequently, secondary effects, such as associated changes in recreation patterns, can not be accurately anticipated.

A second uncertainty is the marketing of tourism and Everglades-related recreation. If the restored Everglades is used to market tourism and recreation in south Florida, the value of recreation could change dramatically relative to the without-project future conditions.

A third uncertainty is the degree to which recreational facilities and recreational access would be developed as part of a restoration plan. Recreation facilities and access, such as visitor centers, scenic overlooks, nature trails, and roads, can greatly affect participation levels.

Finally, there are a variety of economic factors at the national level which can influence tourist and resident recreation demand. These factors include the health of the national economy, levels of disposable income, and the availability and costs of competing recreation opportunities. As described in the 1994 Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP): "Florida tourism and its economic implications are sensitive to national economic and energy policies. The dynamic nature of the industry causes uncertainty in tourism forecasting, making it difficult to accurately project visitation levels for more than one or two years at a time" (Florida Department of Environmental Protection, 1994). As evidence of the challenges of tourism and recreation forecasting, the Florida Tourism and Industry Marketing Corporation limits its tourism forecasts to three years, and the most recent SCORP (1994) used a six-year forecast horizon (to the year 2000).

This chapter explores the potential effects of the alternative restoration plans on the value of recreation in south Florida. Given the above challenges, it is beyond the scope of this analysis to quantify the value of Everglades-related recreation under the with- and without-project future conditions throughout the 50-year planning period. This chapter, however, identifies the principal Everglades-related recreational resources, anticipates future recreation demand using available information, and assesses the potential changes in the value of Everglades-related recreation that could result from the alternative restoration plans.

As part of this investigation, a series of telephone interviews was conducted with experts on Florida's tourism industry, including: (1) representatives of the Division of Recreation and Parks of the Florida Department of Environmental Protection, (2) tourism professionals at the Florida Tourism Industry Marketing Corporation, the state's recently formed public/private partnership to promote tourism, and (3) academic recreation and tourism specialists at the University of Florida Center for Tourism Research and Development and at Florida State University. In particular, the methodology was discussed with Dr. Stephen Holland, Director of the Center for Tourism at the University of Florida. Dr. Holland was a principal author of the Florida SCORP. He concurred that Everglades restoration could significantly affect recreation patterns in south Florida and that the above uncertainties preclude quantitative estimates of the change in the value of Everglades-related recreation.

This chapter is concerned with outdoor recreation in Florida that is: (1) land-based, (2) resource-based, and (3) Everglades-related. The principal focus of the recreation analysis is on nonconsumptive Everglades-related recreation, particularly wildlife watching. In this chapter, hunting is discussed to a limited degree, since some areas of south Florida support significant levels of hunting. As examples, Big Cypress National Preserve allows big game hunting, primarily white-tailed deer and feral hogs, and Lake Okeechobee supports significant levels of waterfowl hunting. Recreational fishing is discussed in a separate chapter with commercial fishing. The recreation discussions begin with a profile of regional recreation resources.

E.8.2 RECREATION RESOURCES

The SCORP is the best source of information on recreation demand and supply at the state and regional scales. It divides the state into 11 planning regions, each with clusters of counties. As indicated in ***Table 8.2-1***, there are three planning regions which encompass south Florida. The three regions contain 13 counties. The alternative restoration plans are not expected to have recreation-related impacts in all of these counties. In particular, Charlotte, Sarasota, and Indian River would be expected to experience insignificant recreation-related effects. Sarasota and Indian River Counties are not within the SFWMD boundaries which define the study area, but they are part of the relevant SCORP Planning Regions and are therefore mentioned in that context.

TABLE 8.2-1
COUNTIES WITHIN SCORP PLANNING REGIONS
POTENTIALLY AFFECTED BY ALTERNATIVE RESTORATION PLANS

Region	Counties
Region IX	Collier
	Glades
	Hendry
	Lee
	Charlotte
	Sarasota
Region X	Martin
	Palm Beach
	St. Lucie
	Indian River
Region XI	Broward
	Dade
	Monroe

Source: Florida Department of Environmental Protection, 1994.

Within the three SCORP regions are a variety of Federal, state, and local recreation resources. ***Table 8.2-2*** contains selected Federal and state recreation resource areas in south Florida.

There are five principal areas in south Florida that support the majority of Everglades-related recreation: Everglades National Park, Biscayne National Park, Big Cypress National Preserve, Arthur R. Marshall Loxahatchee National Wildlife

Refuge, and Lake Okeechobee. The recreation resources of these five areas are described briefly below.

TABLE 8.2-2
SELECTED FEDERAL AND STATE RECREATION RESOURCES
C&SF STUDY AREA

	Recreation Area	County
FEDERAL	Everglades National Park	Monroe, Dade, Collier
	Biscayne National Park	Dade
	Big Cypress National Preserve	Collier
	Arthur R. Marshall Loxahatchee National Wildlife Refuge	Palm Beach
	Lake Okeechobee Waterway	Palm Beach, Martin, Hendry, Glades, & Okeechobee
	Florida Panther National Wildlife Refuge	Collier
	Caloosahatchee National Wildlife Refuge 1/	Lee
STATE	John Pennekamp Coral Reef State Park	Monroe
	Water Conservation Areas 2A and 3A	Broward & Palm Beach
	Rotenberger Wildlife Management Area	Palm Beach
	Holey Land Wildlife Management Area	Palm Beach

Source: Florida Department of Environmental Protection, 1994.
1/ J.N. "Ding" Darling NWR

Everglades National Park, created in 1947, occupies over 1.5 million acres in the heart of the Everglades. One-third of this area is covered by water, either the freshwater of the Everglades or the estuarine waters of the park, including Cape Sable, Ten Thousand Islands, and Florida Bay. There are five visitor centers: main entrance (Homestead), Royal Palm, Flamingo, Shark Valley, and Gulf Coast (Everglades City). Park recreation facilities and activities include: ranger-led nature walks, boat tours, hiking trails, tram, overlook towers, fishing, canoe trails, overnight lodging, campgrounds, and backcountry camping. All keys and beaches in Florida Bay are closed to protect wildlife habitat.

Biscayne National Park, established in 1968, lies 21 miles east of Everglades National Park, and occupies 181,500 acres, with over 95 percent of its area covered by water. Visitors must use boats to access most of the park. The park headquarters and visitor center are located at Convoy Point. Popular recreation activities in the park include: glass bottom boat tours, snorkeling, diving, and fishing. There are no campgrounds, but there are a variety of nearby visitor services outside of the park.

Big Cypress National Preserve, which is located on the northern boundary of the Everglades National Park, was established in 1974 to protect the Big Cypress watershed for the park. The preserve occupies over 728,000 acres. Few services are provided to the general public in Big Cypress. Most of the use is by hunters and off-road vehicle enthusiasts. There are two scenic drives through the preserve and a visitor center. The preserve contains 31 miles of the Florida (hiking) Trail and has eight primitive campgrounds.

Loxahatchee National Wildlife Refuge is the only remnant of the northern Everglades. The 146,000-acre refuge is leased from the state by the U.S. Fish and Wildlife Service and is one of three large water conservation areas within the C&SF project. Together, the three areas comprise 850,000 acres of marshlands that are designed and managed for flood protection and water supply. Recreation facilities and activities at the refuge include: a visitor center, nature walks, hiking trails, canoe trails, and fishing.

Lake Okeechobee is one of the largest recreational resources in south Florida. The lake and its associated waterways and shoreline provide a wide variety of land-based and water-based recreation activities for local residents and out-of-state visitors, including: fishing, boating, picnicking, sightseeing, camping, swimming, hunting, air boating, and hiking. The western side of the lake is relatively shallow, with an extensive littoral zone. This area provides important habitat for the lake's popular sport fishery. It also attracts thousands of waterfowl, which lure hunters during the fall migration season.

There are other important (state-managed) lands that are used for recreation (managed by the FGFWFC). These include the Lake Harbor Waterfowl Area and Terrytown (both in the EAA), Rocky Glades WEA, and the Everglades WMA (WCAs 2 and 3), and comprise significant recreational resources, specifically for hunting and fishing (e.g., the L-67 canals, which support fishing tournaments). Further information can be found on this subject in the F&W Coordination Act Report, which is in Section A2 of Annex A. Another recreation resource area that deserves mention is the Florida Keys National Marine Sanctuary.

The SCORP organizes outdoor recreation in Florida into 47 categories that encompass a wide variety of recreation activities including team sports (e.g., basketball and baseball), individual sports (e.g., golf and tennis), hunting, fishing, swimming, and boating. ***Table 8.2-3*** presents descriptive information on the recreation facilities in SCORP Regions IX, X, and XI for 21 recreation categories. These resource-based categories were selected as those which could potentially be affected by the hydrologic changes or ecological changes associated with the alternative restoration plans. This table also includes percentages of the statewide totals for the recreation categories and a summary for the three-region recreation impact area. As indicated in this table, the three-region recreation impact area contains 39 percent of Florida's outdoor recreation acres, 32 percent of the state's hunting acreage, and 40 percent of the state's nature trails.

TABLE 8.2-3
REGIONAL OUTDOOR RECREATION FACILITIES
SOUTH FLORIDA, 1992

Resource / Facility	Region IX	% of State Total	Region X	% of State Total	Region XI	% of State Total	Three-Region Recreation Area	% of State Total	State Total
Outdoor Recreation Areas	1,001	9%	1,086	9%	2,038	18%	4,125	35%	11,637
Outdoor Recreation Acres	750,068	7%	472,045	5%	2,676,334	27%	3,898,447	39%	10,094,713
Land Acres	720,721	8%	409,999	5%	1,789,611	20%	2,920,331	33%	8,789,490
Water Acres	29,347	2%	62,045	5%	886,722	68%	978,114	75%	1,305,388
Hunting Acres	1,050,072	16%	241,879	4%	837,405	13%	2,129,356	32%	6,683,054
Land Acres	1,049,658	16%	212,876	3%	833,504	13%	2,096,038	32%	6,580,662
Water Acres	414	0%	29,003	28%	3,901	4%	33,318	32%	104,294
Camping									
RV / Trailer Camp Sites	18,857	15%	6,081	5%	11,218	9%	36,156	29%	125,427
Tent Camp Sites	356	4%	392	4%	927	10%	1,675	18%	9,552
Trails									
Hiking Trails (miles)	123	7%	118	7%	200	12%	441	26%	1,721
Horseback Riding Trails (miles)	30	8%	32	8%	16	4%	78	20%	394
Multipurpose Trails (miles)	425	44%	11	1%	289	30%	725	75%	963
Nature Trails (miles)	32	5%	34	5%	181	30%	246	40%	612
Freshwater Catwalks	22	3%	18	3%	35	5%	75	11%	667
Boating									
Canoe Trails (miles)	60	4%	13	1%	131	10%	203	15%	1,355
Freshwater Boat Ramp Lanes	80	4%	91	5%	196	11%	367	20%	1,817
Freshwater Marinas	13	4%	12	4%	3	1%	28	8%	342
Freshwater Slips / Moorings	647	6%	535	5%	154	1%	1,336	12%	11,417

Source: Florida Department of Environmental Protection. 1994.

E.8.3 RECREATION DEMAND

Profiles of existing and future recreation demand in south Florida can be developed by drawing on a variety of information at the national, state, regional, and local levels. The discussions begin with the results of two national surveys on outdoor recreation. These illustrate the participation and expenditures of participants in outdoor recreation activities that could potentially be affected though Everglades restoration. These surveys have relevance for resident and tourist recreation in south Florida.

E.8.3.1 National Recreation Trends

National trends in recreation may help to identify potential or expected changes in the demand for Florida recreation as the result of ecosystem restoration. Two recent national surveys of outdoor recreation have particular relevance for this investigation.

E.8.3.1.1 National Survey of Recreation and the Environment

A National Survey of Recreation and the Environment was conducted in 1994 and 1995 by the Outdoor Recreation Coalition of America. Approximately 17,000 Americans were interviewed in a random sample telephone survey, providing information regarding their participation in 62 recreational activities organized into 13 broad categories.

Table 8.3.1.1-1 presents 1994-1995 participation rates for 26 of the 62 surveyed recreational activities. The activities in this table were selected as those that potentially could be affected by the alternative restoration plans. Of the selected activities, the three most popular groups of activities were outdoor viewing, fitness activities, and outdoor social activities which had participation rates of 76.2 percent, 68.3 percent and 67.8 percent, respectively. Walking was identified as the most popular activity with approximately 134 million participating (66.7 percent of the population). Approximately 124 million recreationists (62.1 percent) enjoy visiting a beach or other waterside and gathering outdoors with family. Sightseeing also had a high level of participation (56.6 percent). Other very popular activities include hiking and backpacking, fishing, boating and camping.

The Outdoor Recreation Coalition conducted a similar national survey of recreation and the environment in 1983-1984. ***Table 8.3.1.1-2*** compares the results of the two surveys. The categories are somewhat different than in ***Table 8.3.1.1-1*** due to differences in the surveys.

TABLE 8.3.1.1-1
PARTICIPATION RATES FOR SELECTED RECREATIONAL ACTIVITIES BY U.S. POPULATION 16 YEARS OR OLDER, 1994-1995

Recreational Activity	Participants (millions)	Percent of U.S. Population
Fitness	136.9	68.3%
Walking	133.7	66.7%
Viewing / Studying	152.6	76.2%
Nature Centers	93.1	46.5%
Visitor Centers	69.4	34.6%
Bird Watching	54.1	27.0%
Wildlife Viewing	62.6	31.3%
Fish Viewing	27.4	13.7%
Other Wildlife Viewing	27.5	13.7%
Sightseeing	113.4	56.6%
Visiting Beach / Waterside	124.4	62.1%
Water-based Nature Study	55.4	27.7%
Camping	52.8	26.4%
Developed Area	41.5	20.7%
Primitive Area	28	14.0%
Hunting	18.6	9.3%
Big Game	14.2	7.1%
Small Game	13	6.5%
Migratory Bird	4.3	2.1%
Fishing	57.8	28.9%
Freshwater	48.8	24.4%
Saltwater	19	9.5%
Warmwater	40.8	20.4%
Anadromous	9.1	4.5%
Catch and release	15.5	7.7%
Boating	58.1	29.0%
Canoeing	14.1	7.0%
Kayaking	2.6	1.3%
Rowing	8.4	4.2%
Outdoor Adventure	73.6	36.7%
Hiking	47.8	23.9%
Off-Road Vehicle Driving	27.9	13.9%
Horseback Riding	14.3	7.1%

Source: Outdoor Recreation Coalition of America, 1997.

This table contains numbers of participants, not participation rates. As indicated in this table, there has been an increase in the number of participants for almost all activities. The 11.4% increase in U.S. population during this period explains some of the change in number of participants. However, some activities are clearly undergoing an increase in participation rates. For example, birdwatching has the largest increase (155 percent) in number of participants from 1984 to 1995. Hiking and backpacking also experienced large increases in participation, 93.5 and 72.7 percent respectively. Walking activity increased 42 percent from 94 million to 134 million participants. Also, since 1984 there has been an increasing interest in specialized outdoor adventure activities such as orienteering, mountain climbing, rock climbing, caving, and special types of wildlife viewing.

In general, the variety of recreational interests in the U.S. appears to be increasing along with recreational participation rates. As future recreation needs and interests develop, it is important to recognize that participation in specific types of recreational activities is often linked to demographic factors such as age and income. For example, participation in activities requiring vigorous exercise is considerably higher for young people than for senior citizens. However, the elderly population has increasing recreation participation because of the growing awareness of the importance of physical fitness. Participation in most activities is low for those with family incomes below $25,000 per year. Interestingly, participation is also low for those with family incomes greater than $100,000 per year. Most outdoor recreational activities appear to be enjoyed largely by the middle class, those with family incomes between $25,000 and $75,000 per year.

E.8.3.1.2 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation

The U.S. Fish and Wildlife Service conducted the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation in 1996. As part of this survey, 22,578 anglers and hunters and 11,759 wildlife watchers were interviewed. The purpose of the survey was to gather information regarding participation and expenditures for wildlife-related activities, including: fishing, hunting, and wildlife watching. National participation and expenditure data for sportsmen and wildlife watchers are presented in ***Table 8.3.1.2-1***. The survey revealed that 77 million Americans aged 16 or older (40 percent of the adult population) enjoyed some form of wildlife-related recreation in 1996 with total expenditures exceeding $101 billion.

TABLE 8.3.1.1-2
TRENDS IN U.S. RECREATION PARTICIPATION, 1982-1994

Recreational Activity	1983-1984 (millions)	1994-1995 (millions)	% Change
U.S. POPULATION	**234,868** (January '84)	**261,575** (January '95)	**11.4%**
Fitness			
Walking	93.6	133.7	42.8%
Viewing Studying			
Bird watching	21.2	54.1	155.2%
Sightseeing	81.3	113.4	39.5%
Camping (overall)	42.4	52.8	24.5%
Camping, developed	30	41.5	38.3%
Camping, primitive	17.7	28	58.2%
Hunting	21.2	18.6	-12.3%
Fishing	60.1	57.8	-3.8%
Boating	49.5	58.1	17.4%
Swimming			
Pool Swimming	76	88.5	16.4%
River/lake/ocean Swimming	56.5	78.1	38.2%
Outdoor Adventure			
Hiking	24.7	47.8	93.5%
Backpacking	8.8	15.2	72.7%
Off-Road Driving	19.4	27.9	43.8%
Horseback Riding	15.9	14.3	-10.1%

Source: Outdoor Recreation Coalition of America, 1997.

Wildlife watching activities primarily included observing, photographing and feeding wildlife for two types of participants: residential and nonresidential. The residential category included those whose activities occurred within one mile of their home, while the nonresidential group included those who took trips or outings for the primary purpose of observing, photographing, or feeding wildlife. Based on the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, in 1996 over 62.9 million people in the U.S. participated in wildlife watching. This figure is consistent with the 1995 participation of 62.6 million wildlife watchers reported in the National Survey of Recreation and the Environment.

TABLE 8.3.1.2-1
TOTAL U.S. WILDLIFE WATCHING PARTICIPATION, 1996

Category	Participants	Expenditures
Residential	60.8 million	
Nonresidential	23.7 million	
Total*	**62.9 million**	**$29 billion**

Source: U.S. Fish and Wildlife Service, 1996.
* The sum of residential and nonresidential subcategories does not equal the total due to an overlap in participation.

Table 8.3.1.2-2 presents residential and nonresidential participation in various wildlife-watching activities. Among all wildlife-watching participants, 97 percent (60.8 million) watched wildlife within 1 mile of their home (residential). The most popular residential activities included feeding and observing wildlife, 54.1 and 44.1 million participants, respectively. Approximately 23.7 million people (38 percent of all wildlife-watchers) spent 314 million days in 1996 taking trips for the primary purpose of enjoying wildlife. Of all nonresidential wildlife watchers, 68 percent participated only within their home state, 13 percent traveled only to other states and 19 percent took wildlife watching trips in both their state of residence as well as in other states. Survey results indicated that wildlife-watching trips were evenly distributed among male and female participants. The types of sites visited by nonresidential wildlife watchers included woodlands (77 percent), lakes or streamside (69 percent), open field (63 percent), brush covered (59 percent), wetland marsh or swamp (44 percent), manmade area (39 percent) and oceanside (27 percent). Of the 23.7 million nonresidential participants 22.9 million enjoyed observing wildlife. Observing birds and land mammals was favored by 75 percent of wildlife observers.

Table 8.3.1.2-3 presents a profile of wildlife observed by nonresidential participants by type. Waterfowl and songbirds were among the most popular species watched.

TABLE 8.3.1.2-2
U.S. WILDLIFE-WATCHING ACTIVITY, 1996

Category	Participants (millions)	Average Days / Year (millions)	Average Days / Participant
Total Wildlife Watching*	**62.9 (100%)**		
Residential*	**60.8 (97% of total)**		
Observed Wildlife	44.1		
Photographed Wildlife	16.0		
Fed Wildlife	54.1		
Maintained Plantings/Natural Areas	13.4		
Visited Public Areas	11.0		
Nonresidential*	**23.7 (38% of total)**	**314**	**13.2**
Observed Wildlife	22.9	279	12.2
Photographed Wildlife	12.0	79	6.6
Fed Wildlife	10.0	90	9.0

Source: U.S. Fish and Wildlife Service, 1996.
* The sum of subcategories may not equal the category total due to an overlap in participation.

The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation also contains state-level information on recreation participation and expenditures. In 1996, approximately 3,642,000 of Florida's 11,239,000 residents (32 percent) participated in wildlife-related recreation with the following distribution: 2,840,000 wildlife watching (25 percent of the state population) and 1,988,000 hunting/fishing (18 percent of the state's population). According to the survey, 79 percent of the time spent wildlife watching by Florida residents is spent within the State of Florida.

As indicated in ***Table 8.3.1.2-4***, there were an estimated 1,846,000 participants in wildlife-watching activities in Florida in 1996. Approximately 1,050,000 (57 percent) of these participants were Florida residents and the remainder (796,000 or 43 percent) were from outside the state. Together, the in-state and out-of-state participants spent a total of 14,658,000 days watching wildlife in Florida.

TABLE 8.3.1.2-3
U.S. NONRESIDENTIAL WILDLIFE-WATCHING BY SPECIES, 1996

Category	Participants (millions)	% of Total
Nonresidential	**23.7**	
Birds	17.7	75%
Waterfowl	14.3	
Songbirds	12.9	
Birds of Prey	10.6	
Other Shorebirds	9.5	
Other Birds	6.5	
Land Mammals	17.7	75%
Fish	8.4	35%
Marine Mammals	3.5	15%
Other	11.5	49%

Source: U.S. Fish and Wildlife Service, 1996.

Table 8.3.1.2-5 presents estimated expenditures associated with wildlife watching in Florida during 1996. As indicated in this table, in-state and out-of-state participants spent over $1.6 billion in 1996 on wildlife watching. This includes trip-related expenditures and equipment expenditures. Wildlife watching equipment includes binoculars, film, bird food, and special clothing. Auxiliary equipment expenditures accounted for items such as tents and backpacking equipment. Other expenditures include magazines and books, membership dues and contributions, land leasing and ownership, and plantings.

TABLE 8.3.1.2-4
PARTICIPANTS IN WILDLIFE-RELATED RECREATION IN FLORIDA, 1996

Participant	Residents	% of Total	Non-residents	% of Total	Total
Anglers	1,878,000	(66%)	986,000	(34%)	2,864,000
Hunters	170,000	(92%)	14,000	(8%)	184,000
Wildlife Watchers	1,050,000	(57%)	796,000	(43%)	1,846,000

Source: U.S. Fish and Wildlife Service, 1996.

TABLE 8.3.1.2-5
FLORIDA WILDLIFE-WATCHING EXPENDITURES, 1996

Expenditure Category	Total Expenditures (millions)	% of Total
TOTAL EXPENDITURES	**$ 1,677.2**	**100%**
Trip-Related Expenditures	**$ 754.7**	**45%**
Food and Lodging	$ 439.7	26%
Transportation	$ 189.4	11%
Other Trip Costs	$ 125.6	7%
Total Equipment Expenditures	**$ 767.6**	**46%**
Wildlife-Watching Equipment	$ 286.9	17%
Auxiliary Equipment	$ 65.4	4%
Other Expenditures	**$ 154.8**	**9%**

Source: U.S. Fish and Wildlife Service, 1996.

E.8.3.2 State Recreation Trends

The Florida SCORP supplements the results of the two national recreation surveys described above with estimates of current and future recreation demand at the state and regional scales. Recreation demands were developed for the SCORP through surveys of residents and tourists. The recreation participation information obtained from the 1992-1993 surveys was extrapolated to total number of 1992 Florida residents (13,412,190) and tourists (36,611,280). Participation in outdoor recreation activities is expressed in terms of user-occasions, which occur each time an individual participates in a single outdoor recreation activity. The number of user-occasions was calculated for each planning region as well as the entire state by type of activity. Demand was estimated for 1995 and 2000 by applying the per capita participation rates to population projections.

Table 8.3.2-1 presents 1992 state-wide resident and tourist demand in Florida for selected outdoor recreation activities. The activities were chosen on the basis of their potential for being affected by the alternative restoration plans. As indicated in this table, over 45 million residents and tourists participated in these activities in 1992. Hiking, recreational vehicle (RV) camping, and nature study were popular with residents and tourists. With the exception of RV camping, participation by residents outnumbered tourist participation.

TABLE 8.3.2-1
DEMAND FOR SELECTED RECREATION ACTIVITIES IN FLORIDA
USER-OCCASIONS (thousands), 1992

Activity	Resident	Tourist	Resident & Tourist	% of Total
Hunting	1,656	34	1,690	4%
RV Camping	2,992	5,659	8,651	19%
Tent Camping	1,260	825	2,086	5%
Hiking	5,220	3,668	8,887	20%
Horseback Riding	3,155	491	3,647	8%
Nature Study	4,645	2,215	6,859	15%
Canoeing	846	555	1,401	3%
Total	**27,235**	**18,271**	**45,506**	**100%**

Source: Florida Department of Environmental Protection, 1994.

Table 8.3.2-2 presents participation rates for the same set of recreation activities during 1985 and 1992. In general, residents have higher participation rates than tourists, and participation rates for both groups have declined from 1985 to 1992.

TABLE 8.3.2-2
PARTICIPATION RATES FOR SELECTED RECREATION ACTIVITIES
1985, 1992

	% of Residents Participating		% of Tourists Participating	
Activity	**1985**	**1992**	**1985**	**1992**
Hunting	11%	2%	0%	0%
RV / Trailer Camping	8%	3%	4%	5%
Tent Camping	10%	3%	1%	1%
Hiking	10%	6%	3%	3%
Horseback Riding	8%	3%	0%	0%
Nature Study	17%	5%	4%	3%
Canoeing	10%	3%	1%	1%

Source: Florida Department of Environmental Protection, 1994.

Tables 8.3.2-3 and ***Table 8.3.2-4*** present age and income characteristics of resident and tourist participants in the same set of recreation activities as in the preceding tables. For residents and tourists, the 25-44 year age group comprised most of the participants in the selected recreation activities. Regarding income characteristics, the middle incomes in general had higher participation rates than the highest income category, and upper income tourist participants in general had higher participation relative to resident participants with similar incomes.

TABLE 8.3.2-3
AGE CHARACTERISTICS OF PARTICIPANTS IN SELECTED RECREATION ACTIVITIES, FLORIDA 1992

Activity	0-24 Years	25-44 Years	45-64 Years	65+ Years
Hunting				
Resident	35%	40%	23%	2%
Tourist	0%	67%	33%	0%
RV / Trailer Camping				
Resident	8%	34%	40%	18%
Tourist	0%	8%	76%	15%
Tent Camping				
Resident	25%	55%	17%	3%
Tourist	15%	70%	15%	0%
Hiking				
Resident	7%	52%	26%	16%
Tourist	6%	35%	40%	19%
Horseback Riding				
Resident	23%	54%	14%	10%
Tourist	0%	64%	36%	0%
Nature Study				
Resident	12%	46%	21%	21%
Tourist	10%	33%	42%	16%
Canoeing				
Resident	19%	57%	19%	6%
Tourist	16%	42%	34%	8%

Source: Florida Department of Environmental Protection, 1994.

TABLE 8.3.2-4
INCOME CHARACTERISTICS OF PARTICIPANTS IN SELECTED RECREATION ACTIVITIES IN FLORIDA, 1992

Activity	<$20,000	$20,000-$29,000	$30,000-$39,000	$40,000-$49,000	>$50,000
Hunting					
Resident	23%	30%	14%	7%	26%
Tourist	0%	0%	67%	0%	33%
RV / Trailer Camping					
Resident	16%	16%	26%	9%	35%
Tourist	2%	4%	7%	15%	73%
Tent Camping					
Resident	23%	16%	14%	18%	30%
Tourist	30%	0%	5%	35%	30%
Hiking					
Resident	27%	15%	19%	14%	26%
Tourist	10%	10%	16%	13%	51%
Horseback Riding					
Resident	6%	20%	20%	10%	43%
Tourist	0%	9%	0%	36%	55%
Nature Study					
Resident	24%	13%	19%	15%	29%
Tourist	12%	17%	16%	12%	44%
Canoeing					
Resident	18%	20%	21%	5%	36%
Tourist	3%	21%	21%	13%	42%

Source: Florida Department of Environmental Protection, 1994.

Tables 8.3.2-5, 8.3.2-6, and ***8.3.2-7*** present 1992 and projected 2000 demands for the selected recreation activities in SCORP Planning Regions IX, X, and XI, respectively. These tables include user-occasions as well as facility/resource needs. As part of the without-project conditions, all of the regions are expected to have significant increases in demands for the selected recreation activities with a commensurate need to increase development of the regions' recreation resources and facilities.

TABLE 8.3.1.2-5
DEMAND AND FACILITY NEEDS (1992 and 2000)
SELECTED RECREATION ACTIVITIES
SOUTHWEST FLORIDA (SCORP REGION IX)

Activity	Units	Demand (user-occasions)		Resources / Facility Needs	
		1992	2000	1992	2000
Hunting	Acres	96,867	120,692	0	0
RV / Trailer Camping	Camp Sites	976,501	1,304,857	0	0
Tent Camping	Camp Sites	315,343	415,226	35	158
Hiking	Linear Miles	888,604	1,173,019	98	168
Horseback Riding	Linear Miles	107,714	138,672	0	0
Nature Study	Linear Miles	1,671,055	2,142,340	20	34
Canoeing	n.a.	106,211	137,916	n.a.	n.a.

Source: Florida Department of Environmental Protection, 1994.

TABLE 8.3.1.2-6
DEMAND AND FACILITY NEEDS (1992 and 2000)
SELECTED RECREATION ACTIVITIES
TREASURE COAST (SCORP REGION X)

Activity	Units	Demand (user-occasions)		Resources / Facility Needs	
		1992	2000	1992	2000
Hunting	Acres	6,226	7,603	0	0
RV / Trailer Camping	Camp Sites	388,148	506,088	0	0
Tent Camping	Camp Sites	115,337,	153,187	0	0
Hiking	Linear Miles	1,138,013	1,434,238	164	237
Horseback Riding	Linear Miles	535,001	653,038	79	103
Nature Study	Linear Miles	679,856	859,893	0	0
Canoeing	n.a.	108,405	142,253	n.a.	n.a.

Source: Florida Department of Environmental Protection, 1994.

TABLE 8.3.1.2-7
DEMAND AND FACILITY NEEDS (1992 and 2000)
SELECTED RECREATION ACTIVITIES
SOUTH FLORIDA (SCORP REGION XI)

Activity	Units	Demand (user-occasions)		Resources / Facility Needs	
		1992	2000	1992	2000
Hunting	Acres	622,179	692,465	57,344	157,981
RV / Trailer Camping	Camp Sites	1,811,356	2,134,501	0	0
Tent Camping	Camp Sites	711,854	848,837	0	124
Hiking	Linear Miles	988,197	1,199,496	125	177
Horseback Riding	Linear Miles	1,530,484	1,768,027	300	349
Nature Study	Linear Miles	1,019,259	1,296,006	0	0
Canoeing	n.a.	242,264	304,650	n.a.	n.a.

Source: Florida Department of Environmental Protection, 1994.

E.8.3.3 State Tourism Trends

As described in the SCORP, 43 million domestic and international visitors to Florida per year comprise a significant portion of the overall demand for outdoor recreation resources in Florida. Their participation in resource-based recreation and their relatively high incomes (compared to resident recreationists) make tourists a significant component of Everglades-related recreation in south Florida. Additional insight to the links between tourists and outdoor recreation in south Florida is provided by the 1997 Florida Visitor Study prepared by Florida Tourism Industry Marketing Corporation. The findings of this study are based on interviews with Florida visitors conducted at major entry points to the state (airports and interstate highways). Some of the information developed by the visitor survey applies to the state as a whole; other aspects of the study have direct relevance for Everglades-related recreation in south Florida.

Table 8.3.3-1 contains visitation data for Florida for 1995 and 1996, including travel mode. As indicated in this table, of the 43 million visitors to Florida in 1996, approximately 23.5 million (55 percent) arrived by air travel, and the remaining 19.5 million (45 percent) arrived by automobile. Tourism increased by 4.2 percent between 1995 and 1996 with a significant increase in air travel and a small decrease in automobile travel.

TABLE 8.3.3-1
NUMBER OF FLORIDA VISITORS
1995, 1996

Travel Mode	1995	1996	% of 1996 Total	% Change (1995-1996)
Air Visitors	21,518,096	23,510,157	54.7%	+9.3%
Auto Visitors	19,764,218	19,491,583	45.3%	-1.4%
Total	**41,282,314**	**43,001,740**	**100%**	**+4.2%**

Source: Florida Tourism Industry Marketing Corporation, 1997.

The top ten states of residence of the visitors are presented in ***Table 8.3.3-2*** for air and auto visitors. The top ten states account for the origins of 58 percent of Florida air visitors and 60 percent of auto visitors. As expected, the auto visitors originate in more proximal states than air visitors.

TABLE 8.3.3-2
ORIGINS OF FLORIDA VISITORS
1996

Air Visitors	%	Auto Visitors	%
New York	11.5%	Georgia	17.6%
California	6.2%	Ohio	6%
Ohio	6%	Tennessee	5.5%
Texas	5.7%	North Carolina	5.1%
New Jersey	5.6%	Michigan	4.6%
Illinois	5.3%	South Carolina	4.3%
Pennsylvania	5.1%	Illinois	4.3%
Georgia	4.4%	Alabama	4.2%
Massachusetts	4.1%	Ontario	4.2%
Michigan	4.1%	Pennsylvania	3.8%
Total	**58.0%**		**59.6%**

Source: Florida Tourism Industry Marketing Corporation, 1997.

The visitor survey asked tourists about their county destination. Many of the visitors had destinations in south Florida. For air visitors, Miami-Dade County is the most popular county with over 17 percent of Florida air visitors bound for this destination. Broward County is third with over 15 percent, and Palm Beach County is fourth with over 9 percent. Lee County accounts for 4.6 percent of the destinations, and Monroe is the destination of over 4 percent of air visitors. Together, these south Florida counties comprise 48% of the county destinations for Florida air travelers.

For auto visitors, Disney World (in Orange and Osceola counties) is the premier destination. In south Florida, Broward County is the destination of 4.1 percent of auto visitors, and Palm Beach County is the destination of 4.0 percent.

Many visitors to Florida come for a vacation (air visitors – 35 percent; auto visitors – 58 percent). For air travelers, business is second, accounting for 30 percent of visits, followed by visiting friends/relatives with 28.3 percent. For auto travelers, visiting friends/relatives is second, accounting for 31.2 percent of auto visitors, followed by business visits which account for only 7.9 percent of auto visits. If the numbers of visitors who are vacationing or visiting friends/relatives are combined, an estimated 63.3 percent of air travelers and 89.2 percent of auto travelers come to Florida for non-business travel.

The visitor survey found that parks and preserves of Florida are a significant attraction to air and auto visitors. For air visitors, parks and preserves are ranked second as an attraction with 7.9 percent (after Walt Disney World's 23.8 percent). This percentage represents those respondents who describe parks and preserves as their premier attraction. For auto visitors, parks and preserves were a less significant attraction with a sixth place ranking and 4.3 percent.

The Florida visitor study ranks the top ten activities enjoyed by air travelers and auto travelers. For air travelers, visitor survey respondents ranked "attractions" (including parks and preserves) sixth with 7.8 percent. For auto travelers, "attractions" were ranked fifth with 8.5%, and fishing ranked eighth with 3.1 percent.

Visitation to Florida varies with the seasons. ***Table 8.3.3-3*** presents 1996 Florida air and auto visitation by month and by quarter. As expected, for air and auto visitors, the greatest visitation occurs during the winter months, and the least visitation takes place during the summer months.

TABLE 8.3.3-3
AIR AND AUTO VISITORS BY MONTH
1996

	Air Visitors per Month	% of Total	Auto Visitors per Month	% of Total
January	2,155,081	9.2%	1,144,648	5.9%
February	2,257,974	9.6%	1,284,263	6.6%
March	2,752,740	11.7%	2,349,003	12.1%
QuarterI	**7,165,795**	**30.5%**	**4,777,914**	**24.5%**
April	2,363,529	10.1%	2,392,696	12.3%
May	1,952,157	8.3%	1,556,972	8.0%
June	1,766,742	7.5%	1,810,612	9.3%
QuarterII	**6,082,428**	**25.9%**	**5,760,280**	**29.6%**
July	1,751,997	7.5%	1,992,117	10.2%
August	1,903,621	8.1%	1,747,460	9.0%
September	1,253,024	5.3%	1,208,274	6.2%
QuarterIII	**4,908,642**	**20.9%**	**4,947,851**	**25.4%**
October	1,743,425	7.4%	1,117,633	5.7%
November	1,774,862	7.5%	1,241,351	6.4%
December	1,835,005	7.8%	1,646,554	8.4%
QuarterIV	**5,353,292**	**22.8%**	**4,005,538**	**20.6%**
Total	**23,510,157**	**100%**	**19,491,583**	**100%**

Source: Florida Tourism Industry Marketing Corporation, 1997.

Table 8.3.3-4 contains 1996 estimates of air visitor traffic through south Florida airports. As indicated in this table, over 12 million visitors to Florida passed through a south Florida airport in 1996. These visitors accounted for 51% of all air travelers to Florida in 1996. Miami International Airport accounted for more than 60 percent of the air travel to south Florida.

TABLE 8.3.3-4
AIR VISITOR ESTIMATES FOR SOUTH FLORIDA AIRPORTS, 1996

Airport	Air Visitors	% of Total
Fort Lauderdale	2,178,605	18%
Fort Myers	1,346,315	11%
Miami	7,273,431	61%
West Palm Beach	1,204,610	10%
Total (South Florida)	**12,002,961**	**100%**

Source: Florida Tourism Industry Marketing Corporation, 1997.

Florida also receives significant numbers of international visitors. Canadians lead international visitation with 1,913,200 visitors to Florida in 1996. In addition, in 1995, there were 4,161,526 international visitors to Florida, comprising 20.4 percent of all international U.S. visitation.

The 1996 Florida Visitor Study recognizes the importance of marketing activities in developing and maintaining Florida's tourist industry. In 1997, Florida was ranked sixth among states in marketing expenditures for tourism with an estimated $17 million.

E.8.3.4 Trends at Everglades-Related Recreation Areas

As described above, the five principal recreation areas associated with the Everglades are: the Everglades National Park, Biscayne National Park, Big Cypress National Preserve, Loxahatchee National Wildlife Refuge, and Lake Okeechobee. Recreations demands at these five locations are discussed below.

E.8.3.4.1 Everglades National Park

Table 8.3.4.1-1 presents visitation to the Everglades National Park for the 1989-1996 period. During this eight-year period, visitation has ranged from 1,340,988 in 1991 to 909,363 in 1995 (the year which experienced a Federal government shutdown). During this period, the average annual visitation was 1,040,561. ***Figure 8.3.4.1-1*** illustrates the history of visitation to the park. As indicated in this figure, visitation rose steadily from its creation in 1948 to 1972, when the park received 1.8 million visitors. Visitation to the park fell through the mid-1980s and rebounded into the early 1990s. National and international economic and recreation trends underlie some of these changes. The impacts of the decline in the ecological condition of the park on park visitation is not known at this time.

TABLE 8.3.4.1-1
EVERGLADES NATIONAL PARK VISITORS
1989-1996

Year	Visits
1989	979,261
1990	1,002,109
1991	1,340,988
1992	1,064,357
1993	961,643
1994	981,944
1995	909,363
1996	984,825

Source: Littlejohn, 1996.

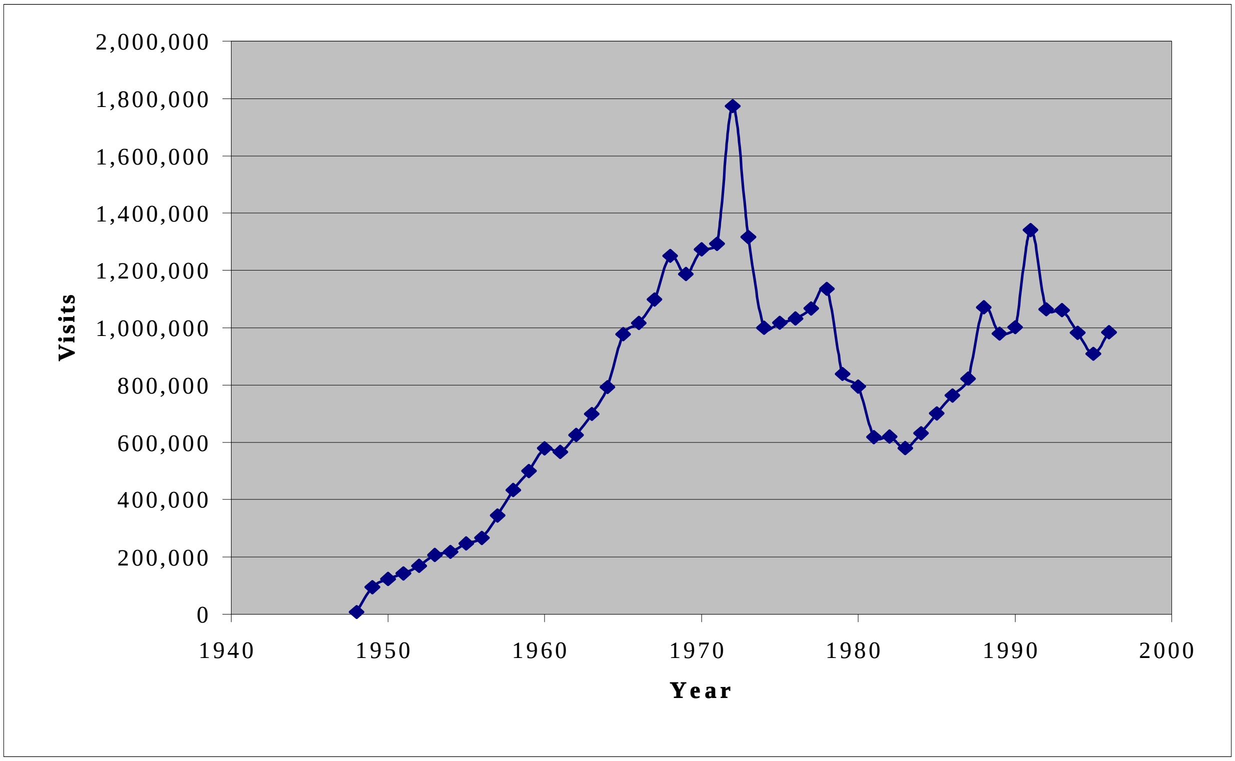


FIGURE 8.3.4.1-1
EVERGLADES NATIONAL PARK VISITATION
1948-1996

The 1996 Everglades National Park Visitor Study provides insights regarding the characteristics of park visitors and their activities while in the park (Littlejohn, 1996). Most of the visitors come in small groups with family (61 percent) and friends (18 percent). Only 12 percent of the visitors indicated that they were part of a guided tour. Many of the visitors to the park were coming for the first time. Of the survey respondents, 60 percent indicated that they had not been to the park within the last five years. The respondents cited many reasons for visiting the park, including:

View wildlife (82 percent),
Experience wilderness (63 percent),
Visit a wetland (59 percent),
Birdwatching (58 percent),
Park is an International Biosphere Reserve (25 percent),
Experience solitude (24 percent),
Fish/power boat (10 percent), and
Canoe/kayak (7 percent).

Most of the park visitors (29 percent) are from Florida. Illinois leads other states with 5 percent, followed by Michigan (4 percent), and New York (4 percent). International visitors are a significant portion (21 percent) of Everglades National Park visitors. Germans constitute 52 percent of the international visitors, followed by British (13 percent) and Canadians (10 percent).

Most of the visitors (75 percent) stay less than one day. Based on the responses of the visitor survey, the average stay in the park is 4.5 hours. Recreation activities during visits include:

Birdwatching (73 percent),
Hike/walk (59 percent),
Ranger-led programs (33 percent),
Picnic (26 percent),
Bicycle (12 percent),
Power boat (11 percent),
Campground (9 percent),
Canoe/kayak (7 percent),
Salt-water fish (7 percent),
Fresh-water fish (6 percent), and
Back-country camping (3 percent)

The visitor survey also queried park visitors about their visit-related expenditures inside and outside the park. Survey responses indicate that 39 percent spent up to $50 in visit-related expenses and that 20 percent spent between

$50 and $100 to visit the park. As indicated in this table, an estimated 76 percent of park visitors spend less than $150 to visit the park.

TABLE 8.3.4.1-2
TOTAL VISITOR EXPENDITURES PER VISIT
EVERGLADES NATIONAL PARK, 1996

Year	Percent of Visitors
>$351	6%
$301-350	1%
$251-300	3%
$200-250	6%
$151-200	7%
$101-150	11%
$51-100	20%
$1-50	39%
No money spent	6%

Source: Littlejohn, 1996.

E.8.3.4.2 Biscayne National Park

Table 8.3.4.2-1 contains visitation information for Biscayne National Park for the 1992 to 1997 period. This information includes visitation to the visitor center, the landside portion of the park, boat tours, visits, and visitor hours. The low visitation to the park in 1993 and 1994 reflect the impact of Hurricane Andrew, which passed directly over the park and devastated park facilities and the nearby City of Homestead.

TABLE 8.3.4.2-1
VISITATION TO BISCAYNE NATIONAL PARK
1995, 1996

	Visitor Center	Outside	Boat Tours	Boat Visitors	Total Visits
1992	n.a.	n.a.	n.a.	n.a.	307,512
1993	16,255	1,753	2,011	n.a.	19,950
1994	17,095	4,674	3,568	n.a.	25,147
1995	18,814	5,605	4,454	559,494	584,519
1996	21,352	4,250	2,894	314,058	338,603
1997	29,192	4,695	3,549	365,586	392,069

Source: Biscayne National Park, 1998.

E.8.3.4.3 Big Cypress National Preserve

Big Cypress National Preserve had 1995 and 1996 visitation levels of 365,500 and 424,920, respectively. Most of these visitors were involved in hunting and off-road vehicle recreation.

E.8.3.4.4 Loxahatchee National Wildlife Refuge

Table 8.3.4.4-1 presents a summary of recreation at Loxahatchee National Wildlife Refuge for the 1992 to 1997 period. As indicated in this table, visitation to the refuge has ranged from 105,581 to 132,549 during this period. Participation levels for the specific refuge recreation activities listed in the table have ranged widely over this five year period.

TABLE 8.3.4.4-1
RECREATION AT LOXAHATCHEE NATIONAL WILDLIFE REFUGE
FY 1992 – FY1997

Year	Visits	Hunting	Fishing	Canoeing
1993	132,549	183	49,586	997
1994	106,264	270	29,215	370
1995	105,581	165	32,270	845
1996	109,032	235	32,185	116
1997	116,300	152	19,633	247

E.8.3.4.5 Lake Okeechobee

Table 8.3.4.5-1 contains information on recreation in the Lake Okeechobee Waterway, which includes the lake, the Caloosahatchee River, and the St. Lucie Canal. The table contents were extracted from the Natural Resource Management System (NRMS), a database that contains visitation information for Corps of Engineers recreation projects. While the visitor hours have varied somewhat over time, the number of visitors to Lake Okeechobee has risen steadily. Sightseeing, fishing, and boating are among the most popular recreational activities on this waterway.

TABLE 8.3.4.5-1
RECREATION ON LAKE OKEECHOBEE WATERWAY
FY 1992 – FY1997

	FY 96	FY 95	FY 94	FY 93	FY 92
Total Visitors	**6,695,300**	**6,589,700**	**5,507,600**	**5,693,400**	**5,130,018**
Visitor Hours	**64,503,500**	**71,470,600**	**34,201,300**	**34,623,800**	**32,847,600**
Picnicking %	12%	13%	12%	12%	12%
Camping %	5%	5%	3%	3%	3%
Swimming %	2%	2%	8%	8%	8%
Water Skiing %	1%	1%	1%	1%	1%
Boating %	23%	23%	19%	19%	20%
Sightseeing %	45%	45%	49%	49%	47%
Fishing %	27%	27%	24%	24%	23%
Hunting %	1%	1%	2%	0%	0%
Other Use %	9%	8%	9%	9%	9%

Source: U.S. Army Corps of Engineers, Natural Resource Management System, 1998.

E.8.3.4.6 Aggregate Visitation to Principal Recreation Areas

In 1996, the five principal Everglades-related recreation areas had a total of 5,637,605 visitors. Several simplifying assumptions can be made to estimate the total number of visitors who participate in wildlife watching activities. First, while the proportions of participation in recreation activities in Big Cypress National Preserve are not known, its is assumed that most of the visitors participate in other activities, such as hunting and off-road vehicle recreation. Consequently, visitors to the preserve are not included in the wildlife watching subtotal. Second, the hunting and fishing participants in Lake Okeechobee recreation also were not included. As a result, there were an estimated 5.2 million wildlife watching visitors to the principal Everglades-related recreation areas in south Florida.

E.8.4 POTENTIAL CHANGES IN VALUE OF RECREATION

The information presented in the preceding section provides a profile of recreation at the five principal areas that support Everglades-related recreation. However, in order to estimate the effects of restoration on the value of Everglades-related recreation, the value of a project's recreation resources should be measured in terms of willingness to pay, as specified in Corps guidance (ER 1105-2-100). The best estimates of recreation resource value come from survey-based studies using primary data collected from users and potential users of the recreation resource. For this investigation, the time and budget did not permit the primary data collection required of survey-based methodologies. However, the results of a previous study (Waddington et al., 1994) which estimated the value of non-consumptive recreation in Florida give a perspective on the value of Everglades-related recreation resources. Expenditure data on Everglades-related recreation is also presented to give as complete a picture of the recreation impact of Everglades restoration as existing information would allow.

To estimate the incremental changes in recreation value associated with each of the alternative restoration plans would require an understanding of how a plan's effects on the quantity and quality of recreation resources would modify the demand for that resource. This would require extensive survey-based data collection, as indicated above. Even though the data collection and analysis needed to adequately estimate the recreation effects of the alternative restoration plans are beyond the scope of this report, an analysis of existing data can provide insight to the potential magnitude of the effects of restoration action. This perspective on the economic value of Everglades-related recreation is presented in terms of recreation expenditures and willingness to pay for non-consumptive recreation.

The estimation of expenditures on Everglades-related recreation can be conducted at the regional and local scales. As indicated in ***Table 8.4-1***, the SCORP can be used to estimate expenditures on wildlife-watching recreation in south Florida at the regional scale. The SCORP estimated year 2000 user-occasions for five selected recreation categories used in the SCORP: recreational vehicle camping, tent camping, hiking, horseback riding, nature study, and canoeing. Expenditures per user occasion ($36) are based on the national estimate of expenditures per trip for wildlife watching from the National Survey of Fishing, Hunting, and Wildlife Associated Recreation. Based on this expenditure per user occasion, the year 2000 total expenditures for wildlife watching in the three-region area would be approximately $600 million.

TABLE 8.4-1
ESTIMATED EXPENDITURES: SOUTH FLORIDA WILDLIFE WATCHING BY SCORP REGION--YEAR 2000 (estimated)

SCORP Region	User Occasions*	Expenditures / User-Occasion**	Total Expenditures
Region IX (Southwest Florida)	5,312,030	$36	$191,233,080
Region X (Treasure Coast)	3,749,067	$36	$134,966,412
Region XI (South Florida)	7,551,517	$36	$271,854,612
Total	**16,612,614**	**$36**	**$598,054,104**

* From Florida DEP, 1994.
** From U.S. Fish and Wildlife Service, 1997.

A similar analysis can be conducted using the visitation information for the five principal Everglades-related recreation areas. ***Table 8.4-2*** contains the estimated expenditures for wildlife watching in the five areas. The table includes current visitation levels, expenditures per visit, and total expenditures. Expenditures per visit ($64) are based on average trip-related expenditures from the Everglades National Park visitor survey. As described above, visitation to Big Cypress National Preserve was not included in the estimate of wildlife watching visits, and visitation to Lake Okeechobee was adjusted to subtract hunting and fishing activities. Based on these assumptions, the estimated expenditures for wildlife watching at the principal Everglades-related recreation areas in 1996 was approximately $404 million.

TABLE 8.4-2
ESTIMATED EXPENDITURES: EVERGLADES-RELATED WILDLIFE WATCHINGBY RECREATION RESOURCE AREA

	Wildlife-Watching Visits*	Expenditures per Visit**	Total Expenditures
Everglades National Park	984,825	$64	$63,028,800
Biscayne National Park	392,069	$64	$25,092,416
Loxahatchee National Wildlife Refuge	116,300	$64	$7,443,200
Lake Okeechobee	4,820,616	$64	$308,519,424
Total	**6,313,810**	**$64**	**$404,083,840**

* From Park/Refuge visitation data.
** From Littlejohn, 1996.

Expenditures represent the minimum value of the recreation resources, since participants are willing to pay more than they actually expend. Waddington et al. (1994) conducted CVM studies to estimate the willingness to pay of recreationists beyond the willingness revealed in their expenditures. Economists refer to this additional willingness to pay as consumer surplus. For outdoor recreation in Florida, Waddington et al. (1994) estimated the consumer surplus at $46 (in $1997) per user occasion. This estimate of consumer surplus can be applied to Everglades-related recreation at the regional and local scales in a manner similar to the expenditure estimates above. ***Tables 8.4-****3* and ***8.4-4*** present the regional and local estimates of non-consumptive recreation, respectively. The year 2000 regional estimate is $763.5 million, and the local estimate for 1996 is $290.2 million.

TABLE 8.4-3
ESTIMATED CONSUMER SURPLUS: SOUTH FLORIDA WILDLIFE WATCHING BY SCORP REGION
YEAR 2000 (estimated)

SCORP Region	User Occasions*	Consumer Surplus / User Occasion**	Total Consumer Surplus
Region IX (Southwest Florida)	5,312,030	$46	$244,131,070
Region X (Treasure Coast)	3,749,067	$46	$172,300,183
Region XI (South Florida)	7,551,517	$46	$347,053,749
Total	**16,612,614**	**$46**	**$763,485,002**

* From Florida DEP, 1994.
**From Waddington et al., 1994.

The preceding tables present estimates of the expenditures and consumer surplus for Everglades-related recreation. The estimates contained in the tables provide insight to the value of the Everglades-related recreation resources, but they should not be interpreted as estimates of that value. As described above, this would require survey-based primary research. The regional and local estimates of the expenditures and consumer surplus of Everglades-related wildlife watching are based on secondary sources of information. While the regional and local estimates of expenditures and consumer surplus differ significantly, much of the difference is explained by: (1) the regional approach contains counties that are not in south Florida, (2) the five recreation areas do not represent all of the Everglades-related recreation in the region, and (3) there are four years separating the estimates.

TABLE 8.4-4
ESTIMATED CONSUMER SURPLUS: EVERGLADES-RELATED WILDLIFE WATCHING BY RECREATION RESOURCE AREA
($1997)

Recreation Resource Area	Wildlife-Watching Visits*	Expenditures per Visit**	Total Expenditures
Everglades National Park	984,825	$46	$45,260,735
Biscayne National Park	392,069	$46	$18,018,766
Loxahatchee National Wildlife Refuge	116,300	$46	$5,344,933
Lake Okeechobee	4,820,616	$46	$221,546,592
Total	**6,313,810**	$46	$290,171,026

* From Parks/Refuge visitation data.
** From Waddington et al., 1994.

The estimates of expenditures and consumer surplus describe existing conditions using available information. The true expenditures and consumer surplus of Everglades-related recreation probably lie somewhere between the regional and local estimates. Regarding future conditions, the differences between the with- and without-project future conditions were not estimated as part of this investigation. As described in the beginning of this chapter, the estimation of the without-project recreation values is problematic, and the assessment of the differences between the with- and without-project conditions are even more challenging. Among the challenges in forecasting future recreation value are difficulties in predicting: (1) the ecosystem changes that will occur as a result of restoration action, (2) differences in marketing activities if restoration occurred, (3) identifying changes in recreation access and facilities as part of the with-project conditions, and (4) broad trends in the economy, tourism, and outdoor recreation.

In addition to these larger issues, there are other area-specific issues that complicate estimating the value of recreation under with- and without-project future conditions. First, the sensitivity of Everglades-related recreation to changes in the ecological condition of the Everglades is uncertain. The quality of a recreation resource is not the only determinant of participation or of value. Second, all of the Everglades-related recreation resources may not be affected by restoration action. For instance, recreation on Lake Okeechobee may experience relatively small effects from restoration, since an important factor affecting lake recreation is that of lake levels, and lake levels are largely determined by the lake's regulation schedule which is assumed to be the same under the with- and without-project conditions. Nevertheless, there are some effects other than lake levels which could impact lake recreation.

More definitive estimates of the value of Everglades-related recreation and the potential economic effects of the alternative restoration plans could be developed through an economic study focusing on the demand for Everglades-related recreation. An original economic study for this purpose would be based on a survey of recreationists to: (1) identify the determinants of demand and (2) estimate the effect of environmental change on the demand for Everglades-related recreation with and without restoration action. The Florida Keys recreation studies conducted by Leeworthy and Wiley (1997,a,b) of the National Oceanic and Atmospheric Administration provide an example of the type of effort that would be required. Available methodologies for this economic study include the Contingent Valuation Method, Conjoint Analysis, and the Travel Cost Method.

Any study estimating the incremental changes in the value of Everglades-related recreation due to the alternative restoration plans would necessarily be conditioned upon multiple assumptions concerning hydrological, ecological, and economic relationships. There are too many uncertainties involved in estimating and differentiating the with- and without-project future conditions to provide a definitive single value of restoration. However, the survey could be structured to query the hypothetical participation and valuation for recreation in the Everglades under various conditions, including ecological conditions, recreation access and facilities, and level of recreation marketing. Survey questions could be constructed to assess the sensitivity of the value of Everglades-related recreation to changes in the quantity and quality of recreation associated with diverse restoration outcomes and recreation features in the alternative restoration plans.

In sum, the Everglades ecosystems support a significant amount of outdoor recreation in south Florida. Currently, there are over six million visitors annually to the Everglades-related parks and preserves and over 16 million annual user occasions of wildlife watching in the region. Estimates of current annual Everglades-related recreation expenditures range from approximately $404 million (for parks and preserves) to $598 million (for the region). The estimated annual consumer surplus for Everglades-related recreation ranges from $290 million (for parks and preserves) to $763 million (for the region). A significant portion of the expenditures come from tourists who in some cases are spending a substantial portion of their disposable incomes in south Florida. It is not possible at this time to anticipate how expenditures and consumer surplus associated with Everglades-related recreation would change if restoration occurred. Given the potential levels of expenditures and consumer surplus in the future, a small percentage increase in the quantity or quality of Everglades-related recreation could represent a large change in recreation value.

E.9 RECREATIONAL AND COMMERCIAL FISHING

E.9.1 OVERVIEW

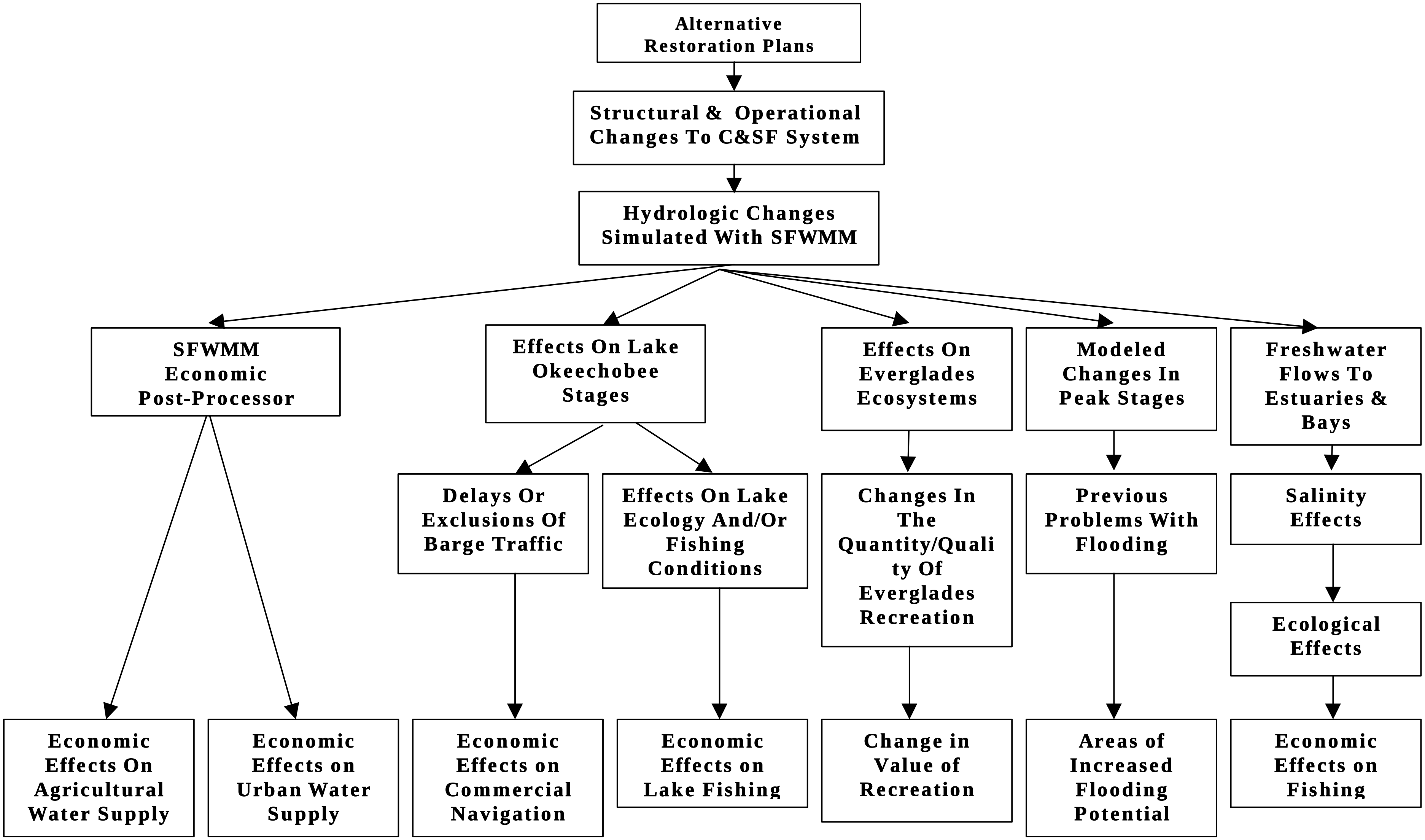
This chapter addresses the likely economic effects of the five alternative restoration plans (Alternatives A, B, C, D, and the Recommended Plan) on commercial and recreational fishing in south Florida. The alternative plans have the potential to affect recreational and commercial fishing throughout south Florida by modifying the hydrologic regime in the region's waterways and estuaries. There are five principal fishing impact zones that would experience the majority of the potential economic effects on fishing in the region: Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, and Biscayne and Florida Bays.

Both recreational fishing and commercial fishing are discussed in this chapter. Recreational fishing is most often represented by sportsmen who fish from their boats or from the shore; while commercial fishing is generally represented by watermen who earn their living from the sale of the fish they harvest. In some cases, the effects of the alternative restoration plans are evaluated separately for these two groups. In other cases, the distinction between commercial and recreational fishing is less clear and the two are evaluated together. For example, guided sportfishing and commercial headboats occupy intermediate positions between recreational and commercial fishing.

As illustrated in ***Figure 9.1-1***, the linkages between hydrologic changes that are expected to result from the alternative restoration plans and the economic effects on commercial and recreational fishing in the five impact zones differ. Economic effects on commercial fishing are estimated based on a net income approach. Increases or decreases in the net income of commercial fishermen can result from either changes in the size of the catch (i.e., revenues) or from changes in the cost of fishing operations (i.e., expenses). For recreational fishing, economic effects are measured based on changes in both the quality of the fishing experience, as well as changes in the frequency of fishing in a given area (e.g., number of fish caught per trip, number of trips, number of fishermen, or hours fished per trip).

In the case of Lake Okeechobee, the potential effects of the alternative plans on fishing result from changes in the extent or timing of lake elevations (i.e., stages) and changes in water quality. Changes in the frequency of extremely high or low lake stages may impact the lake's commercial and/or recreational fishery by affecting the quantity of fish in the lake, the mix of species, and/or the fishing conditions.

FIGURE 9.1-1
SOURCES OF ECONOMIC EFFECTS



For the St. Lucie and Caloosahatchee estuaries, the alternative plans are expected to change the quantity and timing of water releases from Lake Okeechobee and local basins to the St. Lucie Estuary (Indian River Lagoon north to Port St. Lucie Inlet on the Atlantic coast) and to the Caloosahatchee Estuary (on the Gulf coast). Releases are made to reduce high stages in Lake Okeechobee and to maintain a minimum level of freshwater inputs to the estuaries. Modification of freshwater releases from the lake would yield a sequence of effects on these estuaries, including: (1) changes in salinity levels, (2) consequent ecological effects, and (3) resultant economic impacts on commercial and recreational fishing. In general, these estuaries receive too much freshwater during the wet season and too little freshwater during the dry season. The result is an oscillation in salinity levels in the estuaries that exceeds the natural fluctuations that occurred prior to implementation of the regional water management system.

For Biscayne and Florida bays, the cause-and-effect relationship between hydrologic changes and economic impacts are similar to the Caloosahatchee and St. Lucie estuaries. However, there are also a number of important differences between the bays and estuaries. First, both bays are significantly larger than the St. Lucie and Caloosahatchee estuaries. Second, groundwater inputs to Biscayne and Florida Bays have greater significance than in the two smaller estuaries. Third, freshwater inputs to the bays are generally lower throughout most of the year than had occurred prior to modification of the natural system. Fourth, freshwater inputs to Biscayne and Florida Bays are not characterized by the significant seasonal fluctuations experienced in the St. Lucie and Caloosahatchee estuaries. Fifth, Biscayne and Florida Bays are designated as National Parks and contain fish and wildlife resources of national and international significance. Finally, the bays are at the downstream terminus of the Everglades ecosystem, and the amount and timing of freshwater flows to these bays are less certain than the regulatory releases to the St. Lucie and Caloosahatchee estuaries.

For each of the five fishing impact zones, the level of understanding and availability of data characterizing the cause-and-effect relationship between hydrologic effects of the alternative restoration plans and the associated economic impacts on fishing differ. As a result, the ability to accurately estimate the economic effects on fishing in these areas varies. In general, it is not possible to adequately assign economic values to the anticipated hydrologic and ecological effects of the alternative restoration plans if these precursor effects cannot be accurately quantified.

The economic analysis methodology used in this investigation consists of four components:

1. Quantification of commercial and recreational fishing activities (without-project condition);

2. Identification of the linkages (cause-and-effect relationships) between hydrologic changes, ecological impacts; and economic effects;
3. Quantification of the economic impacts, given current understanding and available data; and,
4. Recognition of the limitations of the analysis and identification of gaps in data or knowledge and future research needs.

Monetary economic impacts are quantified in those instances where adequate hydrologic and ecological information is available to determine the physical impacts of the alternative restoration plans on the fisheries. At a minimum, the hydrologic information generated for the alternative restoration plans has been analyzed to determine the potential magnitude of economic effects. The inability to quantify the potential economic effects on fishing at particular locations does not diminish the significance of the potential impacts on commercial and recreation fishing. In these locations, baseline information on the value of the fisheries is presented to characterize the economic significance of fishing in the local and regional economy. Qualitative analysis is then used to evaluate the relative importance of potential changes; and future research needs and data gaps that can be addressed in subsequent studies are identified. The discussions of the five fishing impact zones begin with Lake Okeechobee.

E.9.2 POTENTIAL EFFECTS ON FISHING IN LAKE OKEECHOBEE

Lake Okeechobee is a broad shallow lake with an area of approximately 730 square miles and an average depth of approximately nine feet. The assessment of potential effects of the alternative restoration plans on commercial and recreational fishing in Lake Okeechobee includes: (1) a profile of the commercial and recreational fisheries on the lake, (2) an evaluation of the potential hydrologic and associated ecological changes brought about by the alternative plans, and (3) an economic assessment of the consequences of these changes on commercial and recreational fishing.

E.9.2.1 Profile of Fishing In Lake Okeechobee

Lake Okeechobee contains an extensive commercial and recreational fishery that supports a number of water-based economic activities, including: commercial fishing, guided sportfishing, and recreational angling. Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. The fishery is extremely large and productive, due an extensive, shallow littoral zone (approximately one-quarter of the lake) that provides abundant habitat for juvenile and adult fish.

The potential effects of the alternative restoration plans on these fisheries are associated with changes in the extent and duration of extreme lake stages (high and low) which can impact this littoral zone. As discussed below, these changes could have short-term and/or long-term impacts on the number of fish, the species mix, and fishing conditions on the lake. The assessment of the potential effects of the alternative plans on the lake's commercial and recreational fisheries begins with a description of the fishery.

E.9.2.1.1 Commercial Fishing

Large scale commercial fishing began in Lake Okeechobee around 1900 with the use of haul seines as the primary gear type, although trotlines, pound nets, and wire traps were also utilized. Catfish were the most commonly sought species by commercial fishermen at that time. Other species such as bluegill, redear sunfish, and black crappie, as well as largemouth bass and mullet were also harvested.

In 1916, the Florida legislature imposed the first regulation on the commercial fishing industry, which included a four-month closed season on haul seines, a maximum haul seine length, and a minimum haul seine mesh. Despite these initial regulatory efforts, commercial catches in Lake Okeechobee waned, due in part to over-fishing, and in part to development activities in the lake's zone of influence. For example, the flood control levee constructed on the southern shore of the lake prevented fish from entering adjacent marshes to spawn. In addition, the emerging sportfishing industry began to push for increased regulation of commercial fishing, claiming that commercial harvesting of gamefish, particularly using haul seines, was detrimental to sportfish populations. As a result, commercial fishing became increasingly regulated throughout the 1950's. Stronger restrictions were placed on both the size of the commercial harvest of gamefish and on the use of various types of commercial fishing gear.

In 1976, the Florida Game and Freshwater Fish Commission (GFWFC) authorized a commercial fishing program with the joint goals of improving lake water quality and restoring the sportfishery. The GFWFC recognized that commercial fish harvests are a practical means to improve the structure of gamefish populations, as well as to remove nutrients (nitrogen and phosphorus) from the lake which had accumulated in the fish. The commercial harvest and sale of freshwater gamefish (except black bass and chain and redfin pickerel) and the use of haul seines and trawls were approved. Initially, 40 haul seine permits and 200 trawl permits were issued. To avoid conflicts with popular sportfishing areas, haul seines and trawls were prohibited from operating within one mile of emergent (shoreline) vegetation.

In 1981, a severe drought resulted in historically low water levels in Lake Okeechobee. The lake's littoral zone was almost entirely drained, forcing fish populations from the shallows into deeper, open water. There was widespread concern among sportfishermen that the commercial fishing industry would over-harvest the dislocated fish populations. This concern induced the GFWFC to temporarily suspend the use of haul seines and trawls for the harvest of gamefish.

In November 1982, the harvest and sale of some gamefish and the operation of 10 haul seines were re-authorized. Trawl permits and the commercial harvest and sale of black crappie were not re-authorized.

Regulation of the commercial fishery has remained unchanged since 1982, except for a 1995 state-wide ban on the commercial harvest of striped mullet. Commercial fishing activity is prohibited on weekends and holidays, but otherwise occurs year-round. The three primary gear types utilized on Lake Okeechobee are haul seines, trot lines, and wire traps. Haul seines are used primarily for bream (bluegill and redear sunfish), although the incidental catch (i.e., catfish, bullhead, shad and gar) must also be kept. Most of the current haul seiners operate out of Clewiston, although one operator is located in Pahokee. Daily haul seine harvests are accepted at four local fish markets. Haul seine fishermen are responsible for filing weekly harvest reports with the GFWFC.

During the course of this investigation, interviews were conducted with haul seiners on Lake Okeechobee to: (1) evaluate the operations and economics of commercial fishing on the lake and (2) determine the sensitivity of commercial fishing to changes in lake levels associated with the alternative regulation schedules. Questions about commercial fishing with trotlines and wire traps were answered by local representatives of the GFWFC at their Okeechobee field office.

The total number of haul seine permits is limited to 10 in order to maintain the sustainability of fish yields. The profitability of the haul seine operations on Lake Okeechobee is indicated by the long waiting list for permits. Although some of the vessels are larger, most of the haul seine operations use vessels with lengths of approximately 35 feet. These vessels generally draw four to five feet of water, depending on the vessel and the weight of the catch in the hold.

Haul seiners prefer low lake levels to high lake levels based on the characteristics of their equipment. The seines are set by driving a metal pole into the lake bottom with one end of the seine attached. The fishing boat then motors away, laying the seine in a large arc. The boat slowly completes the circle as it returns to the pole. Another pole is driven adjacent (approximately one foot distance) to the first. The net is pulled through the space between the poles, slowly closing it around the fish. The fishermen report that deeper waters are problematic for haul seines, because they require larger poles which are more difficult to drive into the lake bottom. Haul seiners also indicated that they do not like to fish in deep waters of the lake, since the nets sink into the muddy bottom. It is possible for haul seines to be used at depths over 20 feet, but some fishermen would need to purchase new nets, and the additional costs are compounded by the physical challenge of using haul seines in deeper water.

Haul seiners prefer lake levels that are in the range of 13 to 14 feet National Geodetic Vertical Datum (NGVD). Lower lake levels constrain their movements around the lake. Higher lake levels make their gear more difficult to use and induce the fish to move into shallow waters that are inaccessible to commercial fishermen.

The haul seiners operate year-round. Haul seine licenses require that they fish at least 120 days per year. Haul seiners apparently do not fish much more frequently than the minimum, due to adverse weather conditions on the lake. If winds are in excess of 15 knots, haul seiners generally do not leave port. Lake Okeechobee is famous for its dangerous wave conditions. With even moderate winds, the long fetches and shallow depth of the lake can produce hazardous wave conditions.

Trotline fishermen using trotlines or wire traps on Lake Okeechobee primarily for catfish. Gear regulations do not restrict the length of trotlines; however, each line is limited to a maximum of 500 hooks. Wire trap designs are restricted to two funnels at one end. Maximum trap dimensions must not exceed 7 feet in length or 32 inches in width. Additionally, the minimum mesh size for wire traps is one inch, and all wire traps must be submerged a minimum of three feet. Fishermen using either wire traps or trotlines on Lake Okeechobee must have a state commercial fishing license. Because commercial fishing licenses are not specific to a particular fishery, the number of trotliners and wire trappers on Lake Okeechobee cannot be determined from license data. However, catch by gear type is recorded for Lake Okeechobee through reports that must be filed by each fish house with the GFWFC. Annual commercial fish harvests by species and gear type from 1986 to 1991 and from 1995-1996 are contained in Table 9.2-1. Data from 1992 through 1994 were unavailable. In the 1995-1996 season, haul seines accounted for 67percent of the total commercial harvest in Lake Okeechobee by weight, followed by trotline (33 percent, and wire traps (>1 percent). Catfish (white and channel) accounted for 49 percent of the total catch by weight, followed by shad (26 percent) and bluegill (10 percent) with the other six species together accounting for the remaining 15 percent.

Fishermen who use trotlines and wire nets prefer high water conditions since catfish are generally found in the deeper waters of Lake Okeechobee (Bull et al., 1995). The catfish utilize crevices, natural cavities, and deeper areas during daylight hours, and emerge at night to feed. In Lake Okeechobee, the open water areas are deeper and more turbid, reducing light penetration and providing better catfish habitat.

Lake Okeechobee's commercial fishing industry includes several different types of fishing operations and landside support activities, such as marinas and fish houses, which purchase the catch from the watermen for wholesale and retail distribution. In his study of the economic effects of commercial fishing on Lake Okeechobee, Bell (1987) estimated that there were approximately 80 trotline fishermen operating on the lake. According to GFWFC, there are only a few fishermen who use wire nets, and they are required by their fishing licenses to have at least five feet of water overhead. They generally prefer water depths around 8 feet.

Bell (1987) estimated that there were a total of 230 jobs associated with commercial fishing in Lake Okeechobee. These included 190 jobs for fishermen using all types of gear and 40 landside jobs in local fish houses. As part of this investigation, several fish houses were interviewed to determine current market prices (wholesale) in order to estimate commercial fishing revenues. The following average market prices were obtained from the fish houses: catfish ($.40/lb.), bream ($.90/lb.), shad ($.25/lb.), and tilapia ($.25/lb.). Based upon these prices the current annual value of the wholesale commercial fishery in terms of revenue to the fishermen is approximately $2.3 million ($1997).

There is a continuing controversy in the Lake Okeechobee region regarding the compatibility of commercial fishing and sportfishing. Some sportfishermen accuse the commercial fishermen of degrading the sportfishery by over-harvesting. GFWFC has conducted a variety of studies that suggest that commercial fishing actually benefits sportfishing by removing non-sportfish species and reducing nutrient levels in the lake that these species have absorbed. In general, the sportfishermen seem skeptical, but the GFWFC maintains that the sportfishery has thrived in recent years despite commercial fish harvesting.

E.9.2.1.2 Recreational Fishing

Fishing on Lake Okeechobee attracts recreational fishermen from all over Florida and various locations around the country. Recreational fishermen use the seven commercial marinas on the lake, which provide a variety of services to boaters and fishermen. In addition, there are approximately one dozen fish camps along the lake that rent fishing boats, offer guide services, and provide lodging and other amenities.

For its national recreation database (Natural Resource Management System), the Corps estimated that in FY 1996 over 6,695,300 visitors recreated on Lake Okeechobee. Of these, an estimated 27% (or 1,807,731 visitors) were involved in fishing. The 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation conducted by the U.S. Fish and Wildlife Service estimates that the national average expenditure per person for a freshwater fishing trip is $371. Assuming that the national average is representative of fishing expenditures at Lake Okeechobee, direct expenditures for fishing on Lake Okeechobee would be approximately $671 million annually.

TABLE 9-1
COMMERCIAL FISH HARVEST (POUNDS)
LAKE OKEECHOBEE, 1986-1996

		White Catfish	Channel Catfish	Brown Bullhead	Yellow Bullhead	Bluegill	Redear Sunfish	Shad	Gar	Striped Mullet	Tilapia	Total
Trotline	1986-87	2,061,860	266,814	34,058	0							2,362,732
	1987-88	1,993,339	30,896	20,816	1,367							2,046,418
	1988-89	2,174,885	160,837	27,159	247							2,363,128
	1989-90	1,666,426	223,882	38,267								1,928,575
	1990-91	1,495,038	350,641	45,448								1,891,127
	1995-96	1,504,830	372,966	84,443	2,293							1,964,532
Haul Seines	1986-87	202,399	78,527	133		532,361	178,005	588,232	70,788	119,390		1,769,835
	1987-88	386,633	27,489	1,664		386,498	205,563	499,374	97,485	264,222		1,868,928
	1988-89	320,384	22,362	9,647		700,300	119,218	361,834	86,803	176,294		1,796,842
	1989-90	295,981	162,051	72,497		717,250	272,364	521,245	100,766	167,388		2,309,542
	1990-91	430,064	251,862	25,970		875,319	265,253	409,061	252,407	164,257		2,674,193
	1995-96	877,047	138,433	107,161		625,329	276,735	1,557,969	295,190		136,308	4,014,172
Wire Trap	1986-87	38,751	188,033	33,310								260,094
	1987-88	208,076	135,536	43,563	85							387,260
	1988-89	62,182	11,173	17,353	1,792							92,500
	1989-90	34,700	22,349	6,109	23							63,181
	1990-91	52,732	7,189	2,094								62,015
	1995-96	20,467	8,509	4,401								33,376
All Gear	1986-87	2,303,010	533,374	67,501		532,361	178,005	588,232	70,788	119,390		4,392,661
	1987-88	2,588,048	193,921	66,043	1,452	386,498	205,563	499,374	97,485	264,222		4,302,606
	1988-89	2,557,451	194,372	54,159	2,039	700,300	119,218	361,834	86,803	176,294		4,252,470
	1989-90	1,997,107	408,282	116,873	23	717,250	272,364	521,245	100,766	167,388		4,301,298
	1990-91	1,977,834	609,692	73,512		875,319	265,253	409,061	252,407	164,257		4,627,335
	1995-96	2,402,343	519,908	196,005	2,293	625,329	276,735	1,557,969	295,190		136,308	6,012,080

Source: Florida Game and Freshwater Fish Commission (data from 1991-1994 were unavailable)

Recreational fishermen generally come to Lake Okeechobee to fish for largemouth bass, black crappie, and other bream (bluegill and redear sunfish). A creel (i.e., fish catch) survey of lake fishermen conducted by the GFWFC during the 1990-91 season indicated that largemouth bass and black crappie fisheries are thriving. During the survey period, there was a record high of 151,915 largemouth bass caught with a record low angling effort of 264,764 hours. The resulting success rate was 0.58 bass per hour. The black crappie fishery also exhibited record levels during the survey period with 2,084,749 fish taken over 735,795 hours, with a record angler success rate of 2.79 fish per hour. Field discussions with lake anglers suggest that in recent years, the black bass fishing has declined somewhat, and many bass fishermen have started to fish for crappie. Nonetheless, by all accounts the sportfishery on the lake remains healthy at this time. Black crappie are fished most heavily on the north end of the lake and are fished year round by local residents. Black crappie generally prefer the deep waters and only move into shallow, vegetated areas during spawning season (Bull et al., 1995). The season peaks from December to May with an influx of black crappie anglers. Peak bass season begins in December and lasts through March. Bass are fished with even pressure from the northern, western, and southern regions of the lake. The bream season peaks from March through July. Bream are fished primarily on the western side of the lake.

There are 34 boat launching sites which provide fishermen access to the lake. Ramps were of particular interest in this investigation, since ramp access to the lake could be affected by fluctuations in lake levels that result from the implementation of the alternative restoration plans. Only those facilities on the lake that could be affected by changes in lake levels were evaluated. For example, the ramps and marinas along the Caloosahatchee River were not examined in detail. The water levels in this waterway would not fluctuate with changing lake levels, since stages in the river are controlled by the three Caloosahatchee locks. Under most circumstances, the St. Lucie Canal would also not be affected by changing lake levels. However, when the lake levels fall below 14 feet NGVD, the Port Mayaca Lock is opened and the canal fluctuates with lake levels. For this reason, the recreation facilities on the St. Lucie Canal, as well as boat launching facilities on the lake, were examined in detail.

Site visits were conducted to boat launch ramps, marinas, and fish camps on the Lake Okeechobee Waterway (including the lake, the Caloosahatchee River, and the St. Lucie Canal) to evaluate their sensitivity to lake level fluctuations. At each of the marinas and boat launching ramps, spot soundings were taken at the entrance channels and end of ramps to determine whether use of and access to these facilities could be affected by changes in lake levels. In addition, dockmasters were interviewed to determine the depths of their access channels and boat slips.

Lake levels determine where fishermen can go on the lake. Since the littoral zone occupies approximately 25% of the lake area (primarily on the west side of the lake), access to much of the lake is sensitive to fluctuating lake levels. According to discussions with lake fishermen and GFWFC representatives, access to many fishing locations is not possible when lake levels are extremely low (e.g., below 12 feet NGVD). However, the difficulties faced by boat fishermen during very low lake levels are somewhat offset by increased wading opportunities for shore anglers. As an indicator of the sensitivity of recreation to lake levels, the levels are posted daily on the front pages of local newspapers measured to two decimal places. For example, on 22 November 1997 – the day the boat launch sites were surveyed – the Clewiston News reported that the lake level was 15.24 feet (NGVD).

Some of the boat ramps on Lake Okeechobee would be inoperable at extremely low lake levels (i.e., below 10 feet NGVD). However, the depths of the lake at these extremely low lake stages would probably curtail boating activity before lake access via the ramps became a problem, particularly on the western side of the lake. The ramps at Corps recreation sites along the waterway typically extend from 9’ to 21.5’ NGVD. In addition, these specifications are recommended to state and local governments when they construct or rehabilitate boat ramps on the waterway. Discussions with boaters launching from the ramps on this waterway indicated that two feet of water is required at the bottom of the ramp to launch the small (bass) fishing boats that are typically used on Lake Okeechobee. This sets the effective lower limit for fishing boat access from boat ramps at 11’ NGVD.

The spot soundings of 21 boat ramps on Lake Okeechobee were conducted as part of this study, and some of these boat ramps were found to be sensitive to lake levels. Soundings were taken at the lower end of the ramps. Four of the ramps have terminus depths below 5 feet; nine ramps had terminus depths between 5 and 7.5 feet; and five ramps had depths in excess of 7.5 feet. The lake stage at the time of the soundings was 15.2 feet NGVD. Therefore, some of the ramps would be inoperable at the lowest lake levels (below 10 feet NGVD). However, in general, substitute ramps are available for much of the lake, and the economic effects would be limited to the inconvenience of accessing the lake via the next nearest useable ramp.

E.9.2.2 Potential Economic Effects On Fishing In Lake Okeechobee

As part of the field investigations for this study, interviews with commercial fishermen, fish houses, and the GFWFC were conducted to determine the scope of commercial and recreational fishing on Lake Okeechobee and assess their economic sensitivity to the potential changes in lake levels resulting from the alternative regulation schedules. The economic effects of the alternative restoration plans on these fisheries depend on how the hydrologic changes to the lake stages could impact: (1) the ecology of the lake and the number and mix of fish in the lake and (2) physical access to the fishery.

E.9.2.2.1 Potential Hydrologic and Ecological Effects

Prior to 1900, Lake Okeechobee was clear with a sandy bottom (Furse and Fox, 1994). Lake stages varied with the season as overflow from the lake fed the southward sheetflow into the Everglades. However, construction of the levee system around the lake eliminated lake overflow and facilitated backpumping of nutrient-rich water from the Everglades Agricultural Area. In the last 30 years, rising nutrient levels have degraded water quality in the lake, and the lake has become increasingly eutrophic. More than one-half of the lake bottom is now covered with mud (Furse and Fox, 1994). In addition, periodic increases in lake stages – made possible by the levee system – have diminished the habitat quality of the littoral zone.

Understanding the natural history of the lake is an important first step in evaluating the potential ecological effects of the alternative restoration plans. Under natural conditions, lake stages fluctuated. The variations in lake stages supported a diversity of plant communities in the littoral zone, providing high-quality fish and wildlife habitat. Under any given lake level, fishery effects can be viewed as positive or negative, depending on one's perspective. Low lake stages have both positive and negative effects on fish and wildlife habitat. On the positive side, low lake stages:

- Allow muck to consolidate on the exposed lakebed thereby improving water quality and benthic habitat;
- Permit emergent vegetation to extend further into the lake, cleansing the water column; and, Enable the GFWFC to conduct controlled burning of exotic (i.e., non-native) species such as torpedo grass, hydrilla, and cattails, allowing native plants to recolonize the area.
- Would cause dryouts following which native seeds would be expected to germinate regardless of controlled burning

On the negative side, low lake stages can:

- Reduce access of fishermen to the lake, and
- Damage desirable aquatic vegetation, such as bullrush and eelgrass (although undesirable exotics are also damaged when their habitat is drained).

High lake stages also have mixed effects. On the positive side, high lake stages are desirable since they kill undesirable exotic vegetation, such as hydrilla. On the negative side, desirable aquatic vegetation are also adversely impacted by high lake stages.

The ecological effects of changes in lake stages must be evaluated from both the short-term and long-term perspectives. For example, recreational fishing may suffer in the short term when lake stages are low, since the water is warmer and many gamefish are forced from shallow to deep water. However, longer term benefits to fishing from the drawdown can be realized the following year as fish stocks increase due to habitat improvements. Similarly, high lake stages may increase fishing in the short term by allowing better access to the lake, but the inundation of the littoral zone may have adverse effects on fishing the following year as a result of its diminished function as a fish nursery.

The SFWMD has established a Lake Okeechobee Littoral Zone Technical Group to monitor and assess the ecological condition of the lake's littoral zone, specifically the plant communities and their attributes as fish and wildlife habitat. The Group consists of aquatic scientists from the federal, state, and private sectors. The Group has been evaluating the decline in the habitat quality of the littoral zone as manifested by: (1) loss of habitat for wading birds and waterfowl feeding, (2) decline in spikerush and beakrush communities that serve as nursery areas for young gamefish, (3) reduction in number of willows, which serve as rookery sites for wading birds and endangered snail kites, and (4) increase in torpedo grass and cattails which form dense monotypic stands that preclude foraging by birds and (when inundated) support low dissolved oxygen levels.

Among the causal factors for the ecological decline of the littoral zone are excessive fluctuations in lake stage, including the extent and duration of the fluctuations. From an ecological perspective, Lake Okeechobee lake stages are generally higher than desirable during the wet season (June through August) and generally lower than desirable during the dry season (October through March). While some lake stage fluctuations are desirable for purposes of fish and wildlife habitat, the net positive effects begin to erode when the fluctuations inundate or expose the littoral zone to the point of causing short-term and long-term stress on desirable fish and wildlife habitat.

Table 9.2.2.1-1 presents the simulated effects of the alternative restoration plans on Lake Okeechobee stages. The Recommended Plan is expected to produce effects equivalent to Alternative D. The first hydrologic performance measure, percent of time lake stages fell below 12 feet, indicates that all four alternative plans exceed (i.e., improve upon) the performance of the 2050 without-project (base) future condition. Alternative D has the best performance of the alternatives, and Alternative B has the worst. The second performance measure, number of times lake stage was greater than 17 feet for more than 50 days, showed no difference between the alternative restoration plans and the without-project future condition, except for Alternative B. Alternative B showed a slight increase (i.e., negative effect) of one additional occurrence.

TABLE 9.2.2.1-1
SIMULATED EFFECTS OF ALTERNATIVE RESTORATION PLANS ON LAKE OKEECHOBEE STAGES

PERFORMANCE MEASURE	2050 Base	ALTERNATIVE PLAN			
		A	B	C	D/ Rec Plan
Percent of time lake stage < 12' NGVD	30%	16%	20%	16%	11%
Number of times lake stage > 17' NGVD for > 50 days	2	2	3	2	2

E.9.2.2.2 Commercial Fishing

The NED account registers changes in net income from commercial fishing operations. Net income changes can result from either (1) changes in the size of the catch (net revenues) and/or (2) changes in net operating costs of commercial fishermen. In general, commercial fishing on Lake Okeechobee does not appear to be sensitive to the magnitude of the hydrologic changes (i.e., changes in lake levels) that are expected to result from implementation of the alternative restoration plans. This includes potential ecological effects, which could induce changes in the sizes of fish stocks or fish catch, and physical effects, which could affect access to the commercial fishery.

In terms of the size of fish stocks, the ecological effects of the alternative restoration plans could potentially affect the number of fish and mix of species in Lake Okeechobee. The alternative restoration plans are all expected to improve habitat conditions in the lake's littoral zone by reducing the extent and duration of extreme lake stages relative to the future without-project condition. This would probably translate into an increase in the size of commercial fish stocks. The commercial fishermen interviewed indicated that very high or very low lake levels inundate or drain the littoral zone which is important for fish spawning. The higher water temperatures during low water periods were also cited as adversely impacting spawning.

Despite the positive ecological effects of the restoration plans, it is unlikely that resulting marginal increase in fish stocks will significantly affect the size of the sustainable commercial fish catch. The single greatest determinant of the size of the fishing catch (and net fishery revenues) is the complex series of operational restrictions placed on the fishery by GFWFC to promote a sustainable commercial harvest. These regulations are not expected to change between the with- and without-project conditions. It is unlikely that the GFWFC will allow a significant increase in the commercial harvest following implementation of the restoration plans.

In terms of physical access to the fishery, the operating drafts of commercial fishing vessels on Lake Okeechobee are sufficiently shallow to access commercial stocks throughout the range of lake levels anticipated with the alternative restoration plans. However, there may be some marginal benefits realized by reducing the costs of fishing operations, since fishermen seem to prefer lake levels in the intermediate range and the restoration plans are anticipated to moderate lake stage fluctuations.

Regulation of the fishery by the GFWFC appears to be the most significant determinant of both the size of the commercial catch and the net income of commercial fishermen. While the GFWFC has shown in the past (e.g., 1981) that it will modify the restrictions on the fishery in response to extreme changes in lake levels, it is not anticipated that any similar action would be taken in the foreseeable future. Commercial fishing on the lake currently appears to be at sustainable levels. Therefore it is unlikely that any regulatory changes would be made in response to the modest effects anticipated from implementation of any of the proposed restoration alternatives.

E.9.2.2.3 Recreational Fishing

The alternative restoration plans should have a positive effect on gamefish stocks by modulating the fluctuations in lake stages (relative to the without-project condition) and by improving the habitat quality of the lake's littoral zone. There are also short-term considerations regarding whether the fish are "biting". Some local fisherman report that the quality of the fishing declines significantly when lake levels get low, water temperatures rise, and dissolved oxygen levels fall. Others see little change in the quality of the fishing during low lake stages. Discussions with sportfishermen on Lake Okeechobee yield a variety of opinions regarding the critical threshold when lake levels begin to affect the quality of fishing. In general, this threshold was reported to be approximately 14 feet NGVD.

There could be a small increase in the value of recreational fishing through improved access and increased quality of the fishing experience (larger fish and more catch). These improvements can be expected to cause current fishermen to fish more often and new fishermen to enter the fishery. However, as in the case of commercial fishing, recreational fishing on Lake Okeechobee appears to be relatively insensitive to the minor hydrologic and ecological changes that are expected to accompany the alternative restoration plans.

The relationship between quality of fishing and lake levels has several qualifying factors. First, the timing of low lake levels is important relative to the quality of fishing for particular sportfish. The quality of fishing for particular species varies with the seasons. If low water levels occurred at a time during the year when fishing is not normally good, the effects on fishing would be less, relative to peak fishing periods during the year. A second qualifying factor is that low lake levels do not affect the quality of fishing for all sportfish species.

E.9.2.2.4 Summary of Economic Effects on Fishing in Lake Okeechobee

The alternative restoration plans are expected to have positive effects by moderating the extent and duration of extreme lake stage fluctuations. This could improve the habitat quality of the lake's littoral zone, which provides important habitat for the lake's commercial and recreational fish stocks. The commercial fishery is not expected to benefit significantly from this effect however, since neither the size of the catch nor the cost of the catch are expected to change. The recreational fishery might marginally benefit from the anticipated habitat improvements, but the sportfishery is already quite healthy and therefore relatively insensitive to the magnitude of the expected hydrologic and ecological changes. In terms of physical movement around the lake, the commercial fishermen would be unaffected, but the recreational fishermen might experience some improvement in access to the fishery through the reduction of extremely low lake stages.

E.9.2.2.5 Aquatic Vegetation Control

An issue that is related to commercial and recreational fishing on Lake Okeechobee is the control of exotic plants in and around the lake. The Corps of Engineers and the SFWMD have engaged in a cooperative program to control exotic aquatic and emergent species around the lake. From FY1992 to FY1997 the average expenditures on this program were $784,000 annually.

According to the program managers, it is not possible to estimate the potential economic effects of implementation of the alternative restoration plans on the aquatic plant control program, for several reasons. First, there are multiple species targeted by the aquatic plant control program. High and low lake stages can have counterbalancing positive and negative effects on different exotic species. On a year-to-year basis, the problems with exotic plants depend on a complex interaction of climatic conditions, water temperature, and water levels. When water levels are high, exotic emergent vegetation is inundated and killed. When water levels are low, exotic emergent and aquatic vegetation is exposed and the plants dry and can be cleared using controlled burning. Low lake levels also improve access to the exotic melaleuca trees in the lake for "hack and squirt" control using a combination of cutting and pesticide treatment.

E.9.3 LAKE OKEECHOBEE RELEASES TO ST. LUCIE AND CALOOSAHATCHEE ESTUARIES

Stages in Lake Okeechobee are managed to keep lake levels from being too high at the beginning of the wet season (June) to provide flood and hurricane protection; and to keep levels from dropping during the dry season (November to

May) for water supply purposes. The lake has four principal outlets for discharging inflows received from its tributary waterways: (1) evaporation, which in the south Florida climate accounts for 70% of the lake's water loss, (2) the distributary canals that convey water southward to the LEC and the Everglades, (3) the Atlantic Ocean via the St. Lucie canal, and the (4) the Gulf of Mexico via the Caloosahatchee River. The quantity, quality, and timing of the releases to the St. Lucie and Caloosahatchee estuaries are critical determinants of the diversity and productivity of those ecosystems. Management of the lake and the ecological effects on the estuarine ecosystems resulting from the hydrologic changes induced by the alternative restoration plans are described below. The purpose of this discussion is to aid in interpreting the economic consequences of the alternative restoration plans.

E.9.3.1 Management of Lake Okeechobee

Water levels in Lake Okeechobee are managed through regulatory (flood control) and nonregulatory releases. Regulatory releases are made according to the regulation schedule established by the Corps in conjunction with the SFWMD to ensure that the integrity of the levee system surrounding the lake is not compromised by high water levels. Under the current regulation schedule, the lake level will be dropped by releasing water so that elevations do not exceed 15.65 feet NGVD in late May and 16.75 feet NGVD at the beginning of October.

Nonregulatory releases are made to meet: (1) environmental water supply requirements of the Everglades ecosystem, (2) water supply requirements of the LEC, (3) agricultural irrigation water demands in the LOSA, and (4) environmental needs in the St. Lucie and Caloosahatchee estuaries. Nonregulatory releases from the lake to the two estuaries are made in response to particular circumstances throughout the year. In general, releases are made during low flow periods to provide sufficient freshwater inflows into the estuaries to maintain ecologically desirable salinity levels.

As described in Hall (1992), the regulatory releases from Lake Okeechobee are intended to control high lake stages. The releases are controlled by the regulation schedule, which has management zones that specify outlets and release rates according to the time of year and prevailing lake stage (see Figure 9.3.1-1).

Although the regulatory discharges can have negative effects on the St. Lucie and Caloosahatchee estuaries due to excessive freshwater flows into these ecosystems, the releases are necessary during high lake stages to avoid loss of life and property associated with hurricane-generated rainfall and waves. The current regulation schedule (Run25) provides for pulse releases (Levels I, II, and III) to these estuaries during periods of rising lake stage. The pulse releases are designed to avoid the adverse ecological effects of higher releases over more concentrated periods. Pulse releases mimic natural hydrology following rainfall events. The receiving estuaries are able to absorb the pulses without prolonged salinity or ecological effects. While the pulses are effective for moderate regulatory releases, the prospect or occurrence of prolonged high lake stages can necessitate continuous releases from the lake into the estuaries.

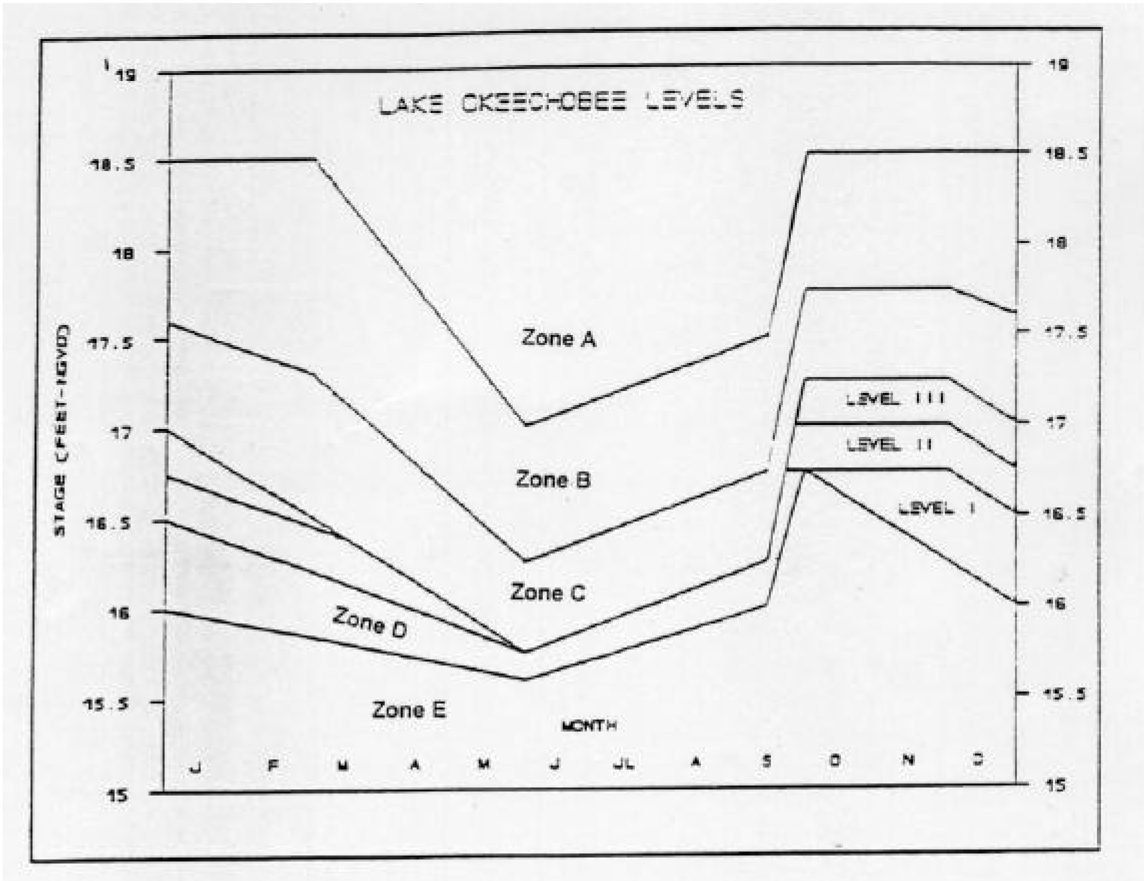
As indicated in ***Figure 9.3.1-1***, the regulatory releases from the lake are directed southward toward the Water Conservation Areas (and the Everglades ecosystem) to the fullest extent possible. When the need for regulatory releases exceeds the receiving capacity of the Water Conservation Areas, releases are made to the two estuaries. In Zone D, maximum non-harmful releases will be made to the St. Lucie and Caloosahatchee estuaries when the lake stage is rising. Based upon field discussions with operators of the water control structures on the Lake Okeechobee Waterway, when moderate releases are required, they will be made first to the Caloosahatchee River and then to the St. Lucie Canal, if necessary. The reason is that the St. Lucie is a much smaller estuary with greater sensitivity to the freshwater releases. When larger releases are required, water must be discharged down both waterways.

E.9.3.2 Effects on Estuarine Ecology

The Caloosahatchee and St. Lucie estuaries are highly productive ecosystems that exist at the interface between freshwater and seawater. The St. Lucie Estuary is a small estuary of approximately 6,000 acres located in Martin and St. Lucie counties. The North and South Forks, which constitute the inner estuary, converge at the City of Stuart where the river widens to one mile after passing beneath the Roosevelt Bridge. Approximately three miles east, the river bends to the south, extending to the southernmost extension of Sewall Point, a spit of land separating the St. Lucie River from the Indian River Lagoon to the east. At this point, both bodies of water empty into the Atlantic Ocean at the St. Lucie Inlet.

The Caloosahatchee Estuary is part of the southern portion of Charlotte Harbor, which includes the estuary, San Carlos Bay, Pine Island Sound, and Matlacha Pass. The estuary extends 29 miles from the W.P. Franklin Lock and Dam near Alva to Shell Point at its mouth in San Carlos Bay. San Carlos Bay, which is bounded by Sanibel Island and Pine Island, is located at the confluence of the river, Pine Island Sound, Matlacha Pass, and the Gulf of Mexico. The freshwater releases into the estuary are controlled by the Franklin Lock and Dam, which also serves as a barrier to salinity and tidal influences upstream.

FIGURE 9.3.1-1
RUN25 REGULATION SCHEDULE



Source: Hall, C.A. Guide for the Management of High Stages of Lake Okeechobee. SFWMD. 1992.

The quantity, timing, and quality of freshwater inputs to estuaries are critical determinants of the structure and function of these ecosystems (Bulger et al., 1990). Freshwater flows provide critical functions and materials for estuaries, including:

- Nutrients for estuarine biota;
- Protection from predation by mature life stages that are intolerant of lower salinities or that are unable to find prey in naturally turbid estuarine waters;
- A range of salinity conditions for a variety of organisms with different requirements for growth and development; and,
- Transportation of many estuarine-dependent larvae.

Relative to natural conditions, the releases from Lake Okeechobee and changes in their watersheds have adversely affected the structure and function of these sensitive ecosystems. In general, the peak flows from the lake to these estuaries are higher than those under natural conditions, and the low flows are lower.

The changes in freshwater inputs to the estuaries have short-term and long-term effects on these ecosystems. The most immediate effect of these changes is the magnification of the natural fluctuations of salinity in these estuaries. Estuarine species evolved under conditions of naturally fluctuating salinity levels, but excessive fluctuations can stress these ecosystems. As described by Bulger et al. (1990), excessive salinity fluctuations can keep estuarine biota in constant flux between organisms which favor higher salinity and those which favor lower salinity. If the fluctuations are extreme, appropriate salinity conditions do not last long enough for organisms to complete their life cycle, and the diversity of organisms is reduced to those few species which can tolerate the dramatic salinity fluctuations.

Even moderate releases (such as in Zone B of the regulation schedule) can transform these estuarine systems into freshwater habitats after a few weeks of sustained releases. The estuarine species are displaced or expire during extended periods of low or high salinity. In addition, continuous flow releases tend to create critically low benthic oxygen levels at the transition zone between freshwater and seawater. These ecosystem perturbations affect more than just estuarine species, since estuaries provide important nursery habitat for marine (offshore) finfish and invertebrate species. These adverse effects provided the impetus for instituting the pulse releases contained in Regulation Zone C.

In general, when regulatory releases are terminated, the salinity levels in these estuaries return to the normal range, and the ecosystems begin to recover. The estuarine species that were displaced or extirpated return or are replaced. The recovery period is commensurate with the rate and duration of the freshwater inputs to the estuaries.

Other longer-term effects of the regulatory releases from the lake on the St. Lucie and Caloosahatchee estuaries include sediment and nutrient effects. Both effects are related to the quality of the water releases from Lake Okeechobee, which contain suspended silt, clay, and organic material. Much of the suspended material settles onto the bottom of the St. Lucie Canal and the Caloosahatchee River during modest, nonregulatory releases. However, during regulatory releases – particularly the high release levels of Zone B and Zone A – this material is resuspended and carried into the estuaries during the first few days of the release period.

Suspended material increases the turbidity of the water in the estuaries and blocks sunlight to seagrass communities in these estuaries. Some seagrass communities are smothered by the suspended material as it settles in the low-energy environment of the estuaries. Other seagrass communities are affected by the reduction in sunlight that results from increased turbidity. Nutrient effects result from the nitrates and phosphorus contained in the lake water which are resuspended by the release flows and stimulate primary production in the estuaries. Releases can imbalance nutrient cycling in these ecosystems, leading to algae blooms and subsequent declines in dissolved oxygen and further increases in turbidity.

The short-term and long-term ecological problems in these estuaries are not entirely attributable to the regulatory releases from Lake Okeechobee, however. These estuaries have perturbations from other sources that contribute to the stresses on these ecosystems. For instance, other estuarine tributaries deposit freshwater, sediments, and nutrients in these ecosystems, including heavy metals that are associated with agricultural pesticide use in the contributing watersheds. These are also being addressed by the recommended plan.

E.9.3.3 Fishing and Other Economic Effects on the Estuaries

The ecological effects of the freshwater releases to the estuaries can lead to commercial and recreational fishing impacts. These potential economic effects are discussed below. There are other potential (non-fishing) economic effects from freshwater releases which are also associated with changes in estuarine water quality. These effects could include changes in (1) waterfront property values if water quality degradation is severe or sustained, (2) the quantity or quality of recreation (and tourism) if the releases discolor the water at beaches or if the releases contribute to algae blooms that limit beach access. These nonfishing effects are beyond the scope of this investigation, but they are current sources of concern to local residents and businesses who enjoy the estuaries and depend on tourists who come to use them. For example, in the spring of 1998 the City of Sanibel received complaints from residents and tourists about the water quality effects of freshwater releases down the Caloosahatchee River and into San Carlos Bay and the Gulf of Mexico.

E.9.3.4 Regulatory Release Targets for St. Lucie and Caloosahatchee Estuaries

In response to the desire to promote the health of the St. Lucie and Caloosahatchee estuaries, through the Restudy salinity distribution targets for these estuaries with associated high and low release, expressed in cubic feet per second (cfs), comprise one set of performance measures used to evaluate the alternative restoration plans (see ***Table 9.3.4-1***). The measures are the number of months that SFWMM-simulated releases exceed target release levels. The low flow targets for the two estuaries are similar. High flow targets for the St. Lucie are significantly lower than for the Caloosahatchee, since the St. Lucie estuary is a much smaller receiving water body and therefore is more effected by high freshwater releases. For both estuaries, two performance measures for large releases from the lake have also been developed, incorporating quantity thresholds and duration criteria.

TABLE 9.3.4-1
LOW FLOW & HIGH FLOW PLANNING TARGETS
ST. LUCIE AND CALOOSATCHEE ESTUARIES

ESTUARY	LOW FLOW		HIGH FLOW	
	Measure	**Target**	**Measure**	**Target**
St. Lucie	Number of Months Mean Flow < 350 cfs	50	Number of Times Mean Flow > 1600 cfs for > 14 days	13
			Number of Times Mean Monthly Flow > 1600 cfs	9
			Number of Times Mean Monthly Flow > 2500 cfs	3
Caloosahatchee	Number of Months Mean Flow < 300 cfs	60	Number of Months Mean Flow > 2800 cfs	22
			Number of Months Mean Flow > 4500 cfs	6

E.9.4 POTENTIAL EFFECTS ON FISHING IN ST. LUCIE ESTUARY

The potential economic effects of the alternative restoration plans on fishing in the St. Lucie estuary depend on how the hydrologic changes affect the ecology of the estuary and on how the ecological changes translate into changes in commercial and recreational fishing. The economic effects on commercial fishing might include changes in the size of the catch or the cost of fishing operations. For guided sportfishing, the economic effects might include changes in the income of the professional fishing guides. For recreational anglers, economic effects could result from changes in the quantity or quality of recreational fishing experiences. As evident in the discussions below, the linkages between the hydrology, ecology, and economics of fishing in the St. Lucie Estuary are highly uncertain. Nevertheless, the hydrologic information generated through the SFWMM simulations does have economic implications for fishing in the estuary.

As part of this investigation, a variety of individuals, organizations, and institutions were contacted to identify pertinent studies and individuals with expertise on the effects of Lake Okeechobee releases on the St. Lucie Estuary. Contacts included:

Florida Oceanographic Society

St. Lucie Initiative

Harbor Branch Oceanographic Institute

Marine Research Council

Indian River Lagoon National Estuary Program

Treasure Coast Regional Planning Council

St. Lucie River Coalition

Florida Marine Research Insititute

Florida Sea Grant

SFWMD

Martin County

E.9.4.1 Profile of Commercial and Recreational Fishing in the St. Lucie Estuary

A profile of commercial and recreational fishing in the St. Lucie Estuary can be constructed using field information and data from state and national fishing databases. Unfortunately, much of the available information about commercial and recreational fishing in the estuary is contained in studies and data sets for much larger geographic areas.

There is very little, if any, commercial fishing in the St. Lucie Estuary. The use of gill nets in Florida coastal waters was banned in 1994. Interviews with local fish houses (i.e., retailers) indicate that their supplies do not come from the estuary. However, there may be low levels of commercial fishing for finfish (using rod and reel or cast nets) and for crabs. In Martin County, there are 271 saltwater products licenses and 44 permits for blue crab fishing. Crabbing activity in the estuary is believed to be small.

Although there is little commercial fishing within the estuary proper, the St. Lucie Estuary has important ecological connections with offshore commercial fish stocks. As explored in Nelson et al. (1991), some commercial species of finfish and invertebrates inhabit estuaries year-round; however, a large number of species only use estuaries during portions of their life cycle. Most of these latter species fall into four general categories:

- Diadromous species, which use estuaries as migration corridors and, in some instances, nursery areas;
- Species that use estuaries for spawning, often at specific salinity levels;
- Species that spawn in marine waters near the mouths of estuaries and depend on tidal- and wind-driven currents to carry eggs, larvae, or early juveniles into estuary nursery areas; and,
- Species that enter into estuaries during certain times of the year to feed on abundant prey and/or utilize preferred habitats.

In 1990, the Indian River Lagoon, which adjoins the St. Lucie Estuary, was included in the National Estuary Program (NEP). The NEP targets nationally significant estuaries for assessment and development of management plans that will substantially enhance their ecological quality. While the NEP studies on Indian River Lagoon suggest that the freshwater flows from the St. Lucie Estuary may not significantly affect the lagoon, they do provide insight to the ecology of the St. Lucie Estuary. In particular, the Indian River Lagoon studies identified 20 species of commercial finfish and 3 species of shellfish (blue crab, hard clam, and oyster) in the lagoon that are estuarine dependent. The estuarine-dependent finfish include:

Atlantic sheephead
Bluefish
Croaker
Drum, black
Drum, red
Flounders
Jack, crevalle
King whiting
Mackerel, spanish
Menhaden
Mullet, silver
Mullet, striped
Permit
Pompano
Snapper, mangrove
Snapper, mutton
Snapper, yellowtail
Seatrout, spotted
Spot
Tripletail

Nelson et al. (1991) note that the estuaries on Florida's east coast include large numbers of tropical Caribbean fauna. In addition, they determined that the number of species – including adults, juveniles, and larvae – in southeastern estuaries varies by season and by salinity zone. Estuarine utilization for all life stages is highest in summer and lowest in winter. The number of species present as larvae reaches a peak in April in the tidal freshwater, mixing, and seawater zones. In contrast, the numbers of juveniles and adults in the three zones peak during the summer months. In any given month, more species utilize these estuaries as juveniles than at any other life stage. Some common species, such as bluefish and gray snapper, are primarily found in the estuary as juveniles and adults, with spawning, eggs, and larval development occurring offshore. Other species, such as snook and tarpon, are tolerant of a wide range of salinity levels. Seasonal variations in species composition implies that the timing – as well as the quantity – of freshwater releases to the St. Lucie Estuary are critical determinants of their potential effects on the estuarine ecology.

The Florida Department of Environmental Protection (FDEP) maintains the Florida Marine Fisheries Information System, a database of commercial fish landings. In this database, the St. Lucie Estuary is located within the Ft. Pierce fishing area, which extends approximately from Jupiter to Melbourne. Summaries of the 1993-1997 inshore commercial landings for this fishing area are presented in ***Table 9.4.1-1***. Inshore is defined as within three miles of the coast. The summaries include finfish, invertebrates, and bait shrimp. No shrimp landings were reported. The poundage, trips, and value of finfish have varied widely over the last five years, with values ranging from one-half million dollars to more than one million dollars. In contrast, the invertebrate landings showed a steady increase in all three categories.

TABLE 9.4.1-1
COMMERCIAL LANDINGS
FT. PIERCE INSHORE WATERS
1993-1997

YEAR	CATEGORY	POUNDS	TRIPS	VALUE
1993	Finfish	1,766,741	5,045	$793,107
	Invertebrates	41,066	496	$84,809
	Bait Shrimp	1,022	13	$2,452
1994	Finfish	2,077,588	6,353	$984,043
	Invertebrates	72,815	1,443	$208,860
	Bait Shrimp	0	0	$0
1995	Finfish	1,065,894	4,860	$664,367
	Invertebrates	86,301	2,671	$640,030
	Bait Shrimp	0	0	$0
1996	Finfish	843,586	6,063	$613,413
	Invertebrates	76,811	2,630	$862,998
	Bait Shrimp	0	0	$0
1997	Finfish	772,355	4,787	$523,118
	Invertebrates	93,778	1,393	$1,168,742
	Bait Shrimp	0	0	$0

Source: Florida DEP, Marine Fisheries Information System, 1997.

The Ft. Pierce inshore waters landings data is complemented by ***Table 9.4.1-2***, which contains the top ten commercial landings (by weight) in Martin County during 1997. The ten listed species each account for at least two percent of the total county catch by weight (2,054,136 pounds). Together, they account for 82% of the total catch. Most of the species on this list reside in estuarine habitat for at least part of their life cycle.

TABLE 9.4.1-2
RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT
MARTIN COUNTY 1997

SPECIES	POUNDS	PERCENT OF TOTAL CATCH
Thread Herring	529,447	26%
Mackerel, Spanish	274,702	13%
Sardines	272,368	13%
Mackerel, King	134,820	7%
Shark	123,687	6%
Scad, Bigeye	88,975	4%
Mullet, Black	88,795	4%
Spot	76,135	4%
Bluefish	51,257	2%
Porgies	37,310	2%

Source: Florida DEP, Marine Fisheries Information System, 1997.

The 1997 commercial invertebrate landings for Martin County were relatively small. They included 5,245 pounds of blue crabs, 6,174 pounds of stone crabs, and 11,105 pounds of spiny lobsters. There were no shrimp landings reported in Martin County for 1997.

The St. Lucie Estuary also supports guided sportfishing and recreational fishing. According to interviews with local professional sportfishing guides, there are approximately 12 guides who operate in this estuary on a full-time basis. Charters typically fish for tarpon, spotted seatrout, snook, and red drum. Assuming that the guides charge an average of $300 per day, guided sportfishing in the estuary would have an approximate annual value in excess of $800,000. The guides indicate that while the majority of their charters consist of tourists, there are also a significant number of charters by Florida residents. Cited percentage ratios of resident/tourist charters were 40/60 for much of the year and 20/80 during the tourist season (i.e., winter and early spring).

Fishing in the St. Lucie Estuary is also popular with local anglers. Bell et al. (1982) have estimated that the overall economic value of recreational fisheries to a region can be as much as six times that from commercial fisheries. Unfortunately, no current participation rates for recreational fishing in the estuary could be identified during this investigation. However, a general impression of recreational fishing in the St. Lucie Estuary can be constructed using the following studies of recreational fishing in areas that include the estuary.

1. In a 1979 creel census of recreational anglers in the St. Lucie Estuary, Van Os et al. (1980) estimated that 338,797 fish were caught (446,820 pounds). The most abundant fish were sea catfish, but bluefish dominated the catch by weight.

2. The National Survey of Recreational Fishing conducted by the National Oceanic and Atmospheric Administration (NOAA) has collected recreational fishing data for the east and west coasts of Florida. The 1996 recreational landings for the east coast of Florida are presented in ***Table 9.4.1-3*** for those species that account for at least one percent of the total catch. Since the survey is for creeled fish, catch-and-release statistics are not available. For some gamefish, such as tarpon, catch-and-release accounts for the entire recreational fishery.

3. Bell et al. (1982) estimate 61.5% of recreational fishing trips are within brackish coastal waters or within 3 miles of shore, where fisheries stocks are largely dependent on estuaries

4. Nelson et al. (1991) describe bluefish, gray snapper, spotted seatrout, spot, black drum, red drum, and gulf flounder as among the species that are abundant in the adjacent Indian River Lagoon, and by inference, in the St. Lucie Estuary.

5. Milon and Thunberg (1993) conducted a state-wide survey of resident anglers. They estimated that, on a statewide basis, resident anglers make 8.7 fishing trips per year and that 56% of trips involved private boats. For Florida Marine Fisheries Commission Region 6, which includes the St. Lucie Estuary, Milon and Thunberg estimated over 65% of the total fishing effort was expended in near-shore waters or within the estuary or lagoon complex. Their findings suggest that over 90% of the recreational fishing by Florida residents in Region 6 is done by people who reside in the lagoon watershed. In addition, their surveys indicate that sea trout, snook, and red drum are the most popular species with anglers, pursued by 48% of the anglers who expressed species preference. The survey results suggest average statewide daily expenditures by resident anglers of $114.81, with annual expenditures of $576.49 per fisherman. This is consistent with Bell’s estimate of $508.97 spent per fisherman on recreational fishing during 1982.

6. Bell (1993) investigated fishing by tourists to Florida. He estimated that of those tourists visiting Florida, 16.5% had engaged in saltwater fishing in the last year. However, 90% of the tourist anglers do not come primarily to fish, and two-thirds of these anglers have no target species. The tourists spend approximately $110 per day while fishing.

7. Bell (1992) investigated the potential changes in tourist visitation resulting from adverse effects on recreational beaches and fisheries. He noted a statewide decline in catch per trip from 5.8 to 4.5 fish/trip from 1979-1990. However, during the same

period, he found no relationship between changes in tourism and changes in the catch rates of recreational saltwater fishing in the state.

TABLE 9.4.1-3
RECREATIONAL LANDINGS
EAST COAST OF FLORIDA 1996

Species	Landings	Percent
Saltwater catfishes	1,016,102	4%
Spot	878,155	3%
Jack, crevalle	840,862	3%
Mullets	752,765	3%
Other fishes	696,490	3%
Snapper, gray	584,592	2%
Drum, red	385,577	1%
Pinfishes	358,850	1%
Kingfishes	355,793	1%
Sheepshead	350,996	1%
Other grunts	205,466	1%
Herrings	188,775	1%
Bluefish	131,526	1%

Source: NOAA. National Survey of Recreational Fishing. 1997.

E.9.4.2 Hydrologic Changes Associated With Alternative Restoration Plans

The SFWMM-simulated hydrologic effects of the alternative restoration plans on the St. Lucie Estuary are presented in ***Table 9.4.2-1***. The Recommended Plan is expected to produce effects equivalent to Alternative D. As indicated in this table, all of the alternative plans are expected to significantly improve upon the future without-project conditions with respect to the performance measures for low and high freshwater releases into the St. Lucie Estuary. However, none of the alternatives is expected to meet the targets for low or high water releases. In particular, the simulated high water releases of the alternative significantly exceed the performance targets for releases over 1600 cfs and over 2500 cfs.

Regarding the second performance measure in Table 9.4.2.1 (the number of times mean flow exceeds 1600 cfs for at least 14 days), the SFWMM provides insight into the source of the flows which violate the target for this measure. For each scenario, the model differentiates the inflows from the estuary's watershed from Lake Okeechobee releases. The Lake Okeechobee releases account for a relatively small percentage of the total number of times that the flow target is exceeded for each scenario: 2050 base (29 of 110: 26%); Alternatives A, C, and D (2 of 51: 4%); and Alternative B (1 of 49: 2%).

TABLE 9.4.2-1
SIMULATED HYDROLOGIC PERFORMANCE OF ALTERNATIVE PLANS
ST. LUCIE ESTUARY

PERFORMANCE MEASURE	2050 Base	ALTERNATIVE A	B	C	D & RP
Number of Months Mean Flow < 350 cfs (target: 50)	163	61	64	60	51
Number of Times Mean Flow > 1600 cfs for ≥ 14 days (target:13)	110	51	49	51	51
Number of Times Mean Monthly Flow > 1600 cfs (target: 9)	71	35	34	35	15
Number of Times Mean Monthly Flow > 2500 cfs (target: 3)	36	11	9	12	8

Note: RP = Recommended Plan (D13R + Other Project Elements)

E.9.4.3 Potential Ecological and Economic Effects of Hydrologic Changes

There has been long-standing concern about the effects of regulatory releases on the St. Lucie Estuary. More than 20 years ago, conferences were sponsored by the Florida Oceanographic Society to discuss the ecological impacts of the regulatory releases. Over the years, the level of local awareness of the issues surrounding the ecological effects of the releases has varied in accordance with the release levels.

In 1998, a number of local interests expressed concern regarding the effects of the regulatory releases. Following the extremely wet spring induced by a strong El Nino event, high lake levels required Zone A releases into the St. Lucie Estuary, reaching as high as 7,500 cfs. The brackish estuary was quickly transformed into a freshwater estuary, and the accumulated sediment on the canal bottom was quickly transported and deposited on the estuary benthos. Concern was heightened when deformed mullet and gamefish with lesions were observed in the estuary. Water samples revealed the presence of *Cryptoperidiniopsis*, a marine algae, in the estuary. *Cryptoperidiniopsis* is being investigated by FDEP as the potential cause of the lesions on fish in the estuary. However, at this time *Cryptoperidiniopsis* has not been linked to the lesions in the St. Lucie Estuary or to human health effects anywhere.

Based on available literature, some aspects of the relationship between regulatory releases and ecological effects on fishing are relatively clear. In general, the St. Lucie Estuary ecosystem is stressed by magnified oscillations in freshwater inputs to the estuary and other ecosystem perturbations. The stressors include Lake Okeechobee releases and other influences from the estuary's watershed. The variability in freshwater inputs to the estuary creates an unstable salinity environment (Chamberlain and Hayward, 1996). The turbidity and sedimentation impacts on seagrass communities may be the principal long-term concern regarding freshwater inputs to the estuary (Haunert and Startzman, 1985). However, there are also concerns about the effects of low-flow periods, particularly with regard to dissolved oxygen levels. While in some instances the effects of releases may be difficult to distinguish from watershed effects, it appears that regulatory releases do affect commercial and recreational fisheries in the estuary (Haunert and Startzman, 1980; Van Os et al., 1980).

Unfortunately, there is a great deal of uncertainty regarding the effects of the freshwater releases from Lake Okeechobee on the St. Lucie Estuary. Estuarine ecosystems are complex, and the linkages between causes (e.g., ecosystem perturbations) and effects (e.g., changes in the structure or function of the ecosystem) are often unclear. There are multiple research topics that need to be explored to fully understand these linkages. These topics include distinguishing between: (1) the impacts of regulatory releases and runoff from the watershed, (2) short-term and long-term effects of the releases, (3) the few high level releases and the more numerous smaller events, and (4) low and high flow violations of the desired salinity targets.

Ecological uncertainties compound the economic uncertainties regarding commercial and recreational fishing. An example of the relationship between uncertainties in ecological and economic response to the regulatory releases is provided by the regulatory releases which occurred during the spring of 1998. During the Spring 1998 releases, gamefish disappeared due to the salinity effects, and the commercial and recreational fishery was severely impacted. However, by June of 1998, gamefish had returned to the estuary and guided sportfishing and recreational fishing rebounded.

The economic effects would seem to be clearly bounded by the effects on fishing, since adult gamefish relocate during release periods (Van Os et al., 1980). However, the loss of juveniles and loss of habitat due to sedimentation effects on seagrass may not affect fishing and the economics of fishing for years to come. In addition, for those offshore commercial species that reside in estuarine waters during their larval or juvenile stages, the economic effects of changes in the estuarine ecology could be manifested in offshore commercial or recreational landings or in the landings of another county.

The challenge in determining the economic impacts on commercial and recreational fishing in the St. Lucie Estuary is further complicated by the need to differentiate between the with- and without-project future conditions in order to isolate the effects of the alternative restoration plans. Given these considerations, the determination of an actual dollar estimate of the effects of the alternative plans on commercial and recreational fishing is beyond the limits of this investigation. However, the hydrologic effects of the alternative plans simulated in the SFWMM can be interpreted from the perspective of the fishing industry by combining the profile of commercial and recreational fishing with the current understanding of the ecological effects of regulatory releases on the estuary.

As indicated in Table 9.4.2-1, the alternative restoration plans are all expected to result in significant improvements over the without-project future condition. However, they are not expected to meet the performance targets. The relative performances of the alternative restoration plans allow the plans to be compared, but the monetary estimation of the economic effects on the commercial and recreational fishery will require additional research into the ecology and economics of the estuary.

E.9.4.4 Further Research to Fill Data and Knowledge Gaps

The SFWMD is currently attempting to fill some of the information gaps that exist in the hydrology-ecology-economics chain of cause-and-effect as regards freshwater releases from Lake Okeechobee. In June 1998, the SFWMD sponsored a series of focus groups in Martin and St. Lucie counties that were intended to assemble local businesses affected by the large regulatory releases to the St. Lucie Estuary in the spring of 1998 and to identify the economic impacts on these businesses and the regional economy.

In general, the understanding of the hydrology/ecology/economics linkages need to be strengthened. The hydrology of regulatory and non-regulatory releases from Lake Okeechobee and the ecological effects on the estuary are an active area of research by the SFWMD, the Corps, and other agencies through the Indian River Lagoon Feasibility Study and the Lake Okeechobee Regulation Schedule Study. The focus groups will provide an effective entry point for additional studies regarding the potential economic effects of the alternative restoration plans on commercial and recreational fishing in the St. Lucie Estuary. The focus groups can help guide further economic research into the potential effects of lake releases on commercial fishing (inshore and offshore), guided sportfishing, recreational fishing, and the indirect and induced effects on the local economy. It may eventually be determined that additional research is not warranted. However, the following additional studies are identified as potential avenues to clarify the particular categories of economic effects.

Estuarine Ecology

- Continue research to differentiate effects of Lake Okeechobee freshwater releases from perturbations attributable to the watershed.

Commercial Fishing

- Inshore: Monitor the estuary for commercial fishing activities, including crab traps and cast nets.
- Offshore: analyze commercial landings of estuarine-dependent finfish and invertebrates following periods of high and low releases to determine lag effects.

Guided Sportfishing

- Survey professional guides to help determine short-term and lag effects of freshwater releases.

Recreational Fishing

- Monitor recreational catch to determine short-term and lag effects of freshwater releases.
- Survey anglers to determine willingness to pay for fishing experience.
- Conduct Boat Census: boat count, ramp count, and/or aerial surveys.

Indirect and Induced Economic Effects

- Survey local businesses to determine indirect and induced effects of changes in the number of resident and tourist fishermen.

E.9.5 POTENTIAL EFFECTS ON FISHING IN CALOOSAHATCHEE ESTUARY

While the issues regarding Lake Okeechobee releases to the Caloosahatchee Estuary are similar to the St. Lucie Estuary, there are several important differences as well. Similarities include: (1) the purposes and timing of the regulatory and non-regulatory releases from Lake Okeechobee and (2) the uncertainties in the causal relationship between hydrologic changes in the releases, the consequent ecological effects, and the economic impacts on commercial and recreational fishing. The differences include: (1) the larger size of the Caloosahatchee Estuary relative to the St. Lucie Estuary, (2) the larger releases from the lake down this waterway, and (3) the ecological distinctions between the Caloosahatchee and St. Lucie estuaries.

As part of this investigation, a variety of individuals, organizations, and institutions were contacted to identify pertinent studies and individuals with expertise regarding the impacts of the freshwater releases from Lake Okeechobee on the Caloosahatchee Estuary. Contacts included:

Harbor Branch Oceanographic Institute	Caloosahatchee River Citizens Committee
Lee County Professional Guides Association	Florida Bureau of Seafood and Aquaculture
Florida Marine Research Institute	Florida Sea Grant
City of Sanibel	Lee County
Gulf of Mexico Program	Gulf of Mexico Foundation
Charlotte Harbor National Estuary Program	Southwest Florida Regional Planning Council
Florida Center for Environmental Studies, Tarpon Bay Research Center	SFWMD

In 1995, Charlotte Harbor, which adjoins the Caloosahatchee Estuary, was included in the National Estuary Program (NEP). The Charlotte Harbor NEP effort included two studies with direct relevance for this investigation. The first is a review of the physical setting in the Caloosahatchee Estuary. The second is an estimate of the economic value of resources in the Charlotte Harbor study area, which includes the Caloosahatchee River.

Goodwin (1996) modeled the currents in the area of San Carlos Bay and concluded that much of the regulatory discharges from the Caloosahatchee River pass southward under the Sanibel Causeway and enter the Gulf of Mexico. However, under certain conditions, some of this freshwater can be transported into Pine Island Sound and Matlacha Pass. The extent of the effects of regulatory releases from the lake are variable, depending on the release rate and the wind and tidal conditions in the estuary. Based on discussions with some of the previously listed organizations, the effects of large freshwater releases, such as those experienced in the spring of 1998, extend into San Carlos Bay, Matlacha Pass, Pine Island Sound, and Estero Bay. According to local residents, the tanin-colored waters from Lake Okeechobee are quite apparent as they darken the waters of San Carlos Bay.

It appears that the sedimentation effects of the releases on the Caloosahatchee Estuary are less problematic than the nutrient effects of the releases, relative to the St. Lucie Estuary. Red tides (i.e., marine algae blooms) were consistently described during interviews as a more significant ecological and economic threat than freshwater releases from Lake Okeechobee. Red tides kill fish, ruin fishing, and close beaches with the stench of dead fish and the effects of algae on bathers' respiratory systems (e.g., throat and sinus irritation). The two issues may be interconnected, since algae blooms have been linked to nutrient inputs to coastal waters. However, there are significant sources of nutrients in these coastal waters other than water released from the lake. Phosphate mining, agriculture, and wastewater discharges contribute to the nutrient levels in the coastal waters of Lee County.

E.9.5.1 Profile of Commercial and Recreational Fisheries

As in the case of the St. Lucie Estuary, a profile of commercial and recreational fishing in the Caloosahatchee Estuary can be constructed using field information and data in national and state fishing databases. Again, much of the available information about commercial and recreational fishing in the estuary is contained in studies and data sets for larger geographic areas.

There is some commercial fishing in the Caloosahatchee Estuary. The use of cast nets in the estuary is reported to be common. In addition, there is reported to be substantial crabbing activity in the estuary. In Lee County, there are 638 saltwater products licenses and 267 permits for blue crab fishing.

The Caloosahatchee Estuary has important ecological connections with offshore commercial fish stocks. As described in Nelson (1992), many commercial finfish and invertebrate species use estuaries for critical stages of their development. Table 9.5.1-1 presents commercial landings, trips, and value data collected by the Florida DEP for the Pine Island Sound/San Carlos Bay area. As indicated in this table, in 1997 the value of the commercial landings from this area were approximately $1.7 million. The finfish and bait shrimp fisheries account for most of the landings and value. Although the shrimp landings in Table 9.5.1-1 are small, there is a significant offshore pink shrimp fishery that is based on Sanibel Island. This fishery is reflected in 1997 pink shrimp landings data for Lee County, which totaled 4,033,537 pounds. The Caloosahatchee Estuary and the area affected by freshwater releases from Lake Okeechobee comprise part of the nursery habitat for this fishery. The finfish and bait shrimp poundage, trips, and value data vary widely from year to year. This is due to changes in the fish population dynamics, fishing conditions, and fishing effort.

The data in ***Table 9.5.1-1*** are complemented by the information in ***Table 9.5.1-2*** and ***Table 9.5.1-3***. Table 9.5.1-2 contains 1997 landings data from nearby Charlotte Harbor (to the north) and Estero Bay (to the south). As indicated in Table 9.5.1-2, the finfish fishery in Charlotte Harbor is substantially larger than that of the Pine Island/San Carlos Bay area.

TABLE 9.5.1-1
COMMERCIAL LANDINGS
PINE ISLAND SOUND/SAN CARLOS BAY 1993-1997

YEAR	CATEGORY	POUNDS	TRIPS	VALUE
1993	Finfish	1,084,476	4,853	$629,297
	Invertebrates	1,484	11	$1,435
	Shrimp	2,017	9	$6,250
	Bait Shrimp	89,165	1,762	$213,630
1994	Finfish	174,582	783	$134,862
	Invertebrates	1,864	13	$1,299
	Shrimp	0	0	$0
	Bait Shrimp	114,982	1,961	$265,397
1995	Finfish	260,175	1,682	$274,862
	Invertebrates	32,583	111	$31,560
	Shrimp	0	0	$0
	Bait Shrimp	118,009	2,105	$369,182
1996	Finfish	479,160	2,745	$492,314
	Invertebrates	410,203	1,391	$219,301
	Shrimp	26,126	7	$3,914
	Bait Shrimp	136,356	2,735	$513,383
1997	Finfish	1,036,342	3,881	$867,150
	Invertebrates	196,409	1,373	$247,464
	Shrimp	215	1	$927
	Bait Shrimp	147,564	2,749	$556,705

Source: Florida DEP, Marine Fisheries Information System, 1997.

TABLE 9.5.1-2
COMMERCIAL LANDINGS
CHARLOTTE HARBOR; ESTERO BAY 1997

AREA	CATEGORY	POUNDS	TRIPS	VALUE
Charlotte Harbor	Finfish	1,787,612	6,103	$1,293,085
	Invertebrates	748,850	4,446	$701,355
	Shrimp	14,609	141	$40,562
	Bait Shrimp	0	0	$0
Estero Bay	Finfish	100,947	428	$70,768
	Invertebrates	2,766	25	$11,236
	Shrimp	0	0	$0
	Bait Shrimp	0	0	$0

Source: Florida DEP, Marine Fisheries Information System, 1997.

Table 9.5.1-3 contains ranked landings of the top nine commercial species in Lee County, by weight. Each of these nine species account for at least one percent of the total county catch by weight (2,599,308 pounds). Together, they account for

95% of the total catch. Most of these species reside in estuarine habitat for at least part of their life stage. The 1997 commercial invertebrate landings for Lee County include blue crabs (1,409,015 pounds) and stone crabs (151,330 pounds). In addition, the 1997 shrimp landings for Lee County were 4,224,879 pounds.

TABLE 9.5.1-3
RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT
LEE COUNTY 1997

SPECIES	POUNDS	PERCENT OF TOTAL CATCH
Mullet, Black	1,714,122	66%
Grouper, Red	270,762	10%
Pompano	134,932	5%
Mojarra	80,428	3%
Jack, Mixed	71,064	3%
Grouper, Gag	39,989	2%
Jack, Crevalle	33,991	1%
Ladyfish	30,758	1%
Grouper, Black	22,737	1%

Source: Florida DEP, Marine Fisheries Information System, 1997.

The Caloosahatchee Estuary also supports guided sportfishing and recreational fisheries. Nelson (1992) described the following recreational species as "highly abundant", "abundant", or "common" in the Caloosahatchee Estuary: tarpon, sea catfish, snook, crevalle jack, silver perch, pinfish, spotted seatrout, red drum, black drum, and stripped mullet.

According to interviews with the Lee County Professional Guides Association, there are approximately 60 guides who operate in Lee County, mostly on a full-time basis. Many of the guides fish in the Caloosahatchee River at least some of the time. An even larger number of guides fish in the area that is potentially subject to the effects of the lake releases. It appears that guides will frequently take charters into the Caloosahatchee River to fish for tarpon or to escape windy conditions on the coast. Guides in the area typically pursue tarpon, spotted seatrout, snook, and red drum. Assuming that the guides charge an average of $350 per day, guided sportfishing in the area would have an approximate annual revenue of $4.8 million. The guides indicate that while the majority of their charters consist of tourists, there are also significant numbers of charters by Florida residents. The ratio of resident/tourist charters of 40/60 was considered representative for much of the year, changing to 20/80 during the tourist season.

Recreational fishing in the Caloosahatchee Estuary is also popular with local anglers. Bell et al. (1982) estimated that the overall economic value of recreational fisheries to a region can be as much as six times that of commercial fisheries.

Unfortunately, no current participation rates for recreational fishing in the estuary were identified as part of this investigation. However, a representative picture of recreational fishing in the Caloosahatchee Estuary can be constructed using studies of recreational fishing that include the estuary.

1. The 1996 National Survey of Recreational Fishing conducted by the NOAA for the west coast of Florida is presented in ***Table 9.5.1-4*** for those species which account for at least one percent of the catch. Many of those species spend much of their lives in estuarine waters.

TABLE 9.5.1-4
RECREATIONAL LANDINGS
WEST COAST OF FLORIDA 1996

SPECIES	LANDINGS	PERCENT
Seatrout, spotted	2,762,297	11%
Pinfishes	2,486,234	10%
Sheepshead	896,605	3%
Saltwater catfishes	866,782	3%
Snapper, gray	818,934	3%
Drum, red	732,176	3%
Jack, crevalle	663,931	3%
Mullets	278,833	1%
Groupers	263,856	1%
Perch, silver	236,575	1%
Grunt, white	221,545	1%
Pigfish	194,270	1%
Seatrout, sand	183,686	1%

Source: NOAA. National Survey of Recreational Marine Fishing. 1996.

2. Bell et al. (1982) estimated that 61.5% of recreational fishing trips are within brackish coastal waters or within 3 miles of shore, where fish stocks are largely dependent on estuaries

3. The state-wide survey of resident anglers by Milon and Thunberg (1993) estimated that for the Florida Marine Fisheries Commission Region 3, which includes the Caloosahatchee Estuary, over 65% of the total fishing effort was expended in near-shore waters or within the estuary or lagoon complex. Their findings suggest that 88% of the recreational fishing by Florida residents in the lagoon is done by people who reside in the region. In addition, their surveys indicate that sea trout, snook, and red drum are the most popular species with anglers, pursued by 48% of the anglers who expressed species preference.

4. Bell's (1993) study of fishing by Florida tourists estimated that 16.5% of tourists visiting Florida engaged in saltwater fishing in the last year. However, 90% of

the tourist anglers do not come primarily to fish, and two-thirds of these anglers have no target species.

Lee County is also home to an emerging aquaculture industry. Since the State of Florida instituted the gill net ban in 1994, it has encouraged aquaculture to mitigate the economic effects on watermen and coastal communities and to meet the growing demand for seafood. In Lee County, there are over 10 aquaculture farms, which primarily raise hard clams. The Harbor Branch Oceanographic Institute has received a state grant to provide technical support for clam aquaculture. Some of these operations raise seed clams for sale to other aquaculture farmers; others raise mature clams for commercial sale. The seed clam operations typically use a closed (recycling) water system. The clam farms which are raising mature clams in Lee County are located in Pine Island Sound near the midpoint of Pine Island. It is anticipated that the releases from Lake Okeechobee will not have a significant effect on aquaculture operations in Lee County for two reasons: (1) the seed clams, which are potentially vulnerable to sudden and drastic salinity changes, are not exposed to the freshwater releases from the Caloosahatchee River and (2) the clam farms that raise clams to maturity are sufficiently removed from the more extreme effects of the freshwater releases.

E.9.5.2 Hydrologic Changes Associated With Alternative Restoration Plans

The SFWMM-simulated hydrologic effects of the alternative restoration plans on the Caloosahatchee Estuary are presented in ***Table 9.5.2-1***. The Recommended Plan is expected to produce effects equivalent to Alternative D. As indicated in this table, all of the alternative plans are expected to significantly exceed (improve upon) the future without-project conditions with respect to the performance measures for low and high freshwater releases into the Caloosahatchee Estuary. Each of the alternative plans also meets the performance targets, and even improves on them. The extreme high and low flow rates are exceeded fewer times than the targets allow in all cases.

Regarding the second performance measure in Table 9.5.2-1 (the number of months when the mean flow exceeds 2800 cfs), the SFWMM provides insight into the source of the flows which exceed the maximum flow rate for this measure. For each scenario, the model differentiates the inflows from the estuary's watershed from Lake Okeechobee releases. The Lake Okeechobee releases account for a relatively small percentage of the total number of times that the flow target is exceeded in the SFWMM scenarios: 2050 base (17 of 61: 28%) and Alternatives A, B, C, and D (1 of 11: 9%).

TABLE 9.5.2-1
SIMULATED HYDROLOGIC PERFORMANCE OF ALTERNATIVE PLANS
CALOOSAHATCHEE ESTUARY

PERFORMANCE MEASURE	2050 Base	ALTERNATIVE			
		A	B	C	D & RP
Number of Months Mean Flow < 300 cfs (target: 60)	111	36	36	36	36
Number of Months Mean Flow > 2800 cfs (target: 22)	61	11	11	11	11
Number of Months Mean Flow > 4500 cfs (target: 6)	26	4	2	3	3

Note: RP = Recommended Plan (D13R + Other Project Elements)

E.9.5.3 Potential Ecological and Economic Effects On Fishing In Caloosahatchee Estuary

Based on available literature, some aspects of the relationship between the regulatory releases and effects on fishing are relatively clear. In general, the Caloosahatchee Estuary ecosystem is stressed by the magnified oscillations in freshwater inputs to the estuary and other ecosystem perturbations. The stressors include the Lake Okeechobee releases and other influences from the estuary's contributing watershed. As in the St. Lucie Estuary, the variability in freshwater inputs to the Caloosahatchee Estuary creates an unstable salinity environment. The work of Doering and Chamberlain (1997) suggests that turbidity and dissolved oxygen levels are comparable to other Florida estuaries, but nitrogen concentrations are relatively high. They also note that, in general, water quality deteriorates with distance upstream from the mouth of the estuary. While in some instances the effects of the releases may be difficult to distinguish from effects of the Caloosahatchee River's relatively large watershed, it appears that the regulatory releases affect the commercial and recreational fisheries in the estuary.

Unfortunately, as in the case of the St. Lucie Estuary, there is a great deal of uncertainty regarding the effects of the freshwater releases from Lake Okeechobee on the Caloosahatchee Estuary. Estuarine ecosystems are complex, and the linkages between causes (e.g., ecosystem perturbations) and effects (e.g., changes in the structure or function of the ecosystem) are often unclear. There are multiple research topics that need to be explored to fully understand these linkages. These topics include distinguishing between the effects of: (1) the impacts of lake releases and freshwater inflow from the watershed, (2) short-term and long-term effects of the releases, (3) the few high level releases and the more numerous smaller events, and (4) low and high flow violations of the desired salinity envelope.

The ecological uncertainties compound the economic uncertainties regarding commercial and recreational fishing. As in the St. Lucie Estuary, the return of gamefish following a period of large releases to the estuary may not fully reflect the impacts on the fisheries. The economic effects would seem to be clearly bounded by the effects on fishing, since adult gamefish relocate during release periods (Van Os et al., 1980). However, the loss of juveniles and loss of habitat due to impacts on seagrass communities may not affect fishing and the economics of fishing for years to come.

The challenge in estimating the economic effects on commercial and recreational fishing in the Caloosahatchee Estuary is further complicated by the need to differentiate between the with- and without-project future conditions in order to isolate the effects of the alternative restoration plans. Given these considerations, the determination of a dollar value of the effects of the alternative plans is beyond the scope of this investigation. However, the simulated hydrologic effects of the alternative plans can be interpreted from the perspective of the economics of commercial fishing by combining the profile of commercial and recreational fishing with current understanding of the ecological effects of regulatory releases on the estuary.

As indicated in Table 9.5.2-1, the alternative restoration plans are expected to result in significant improvements over the without-project future condition with respect to low and high water inputs to the Caloosahatchee Estuary. They are also expected to meet, and even improve upon, the performance targets. The relative performances of the alternative restoration plans allow the plans to be ranked, but the monetary estimation of the economic effects on the commercial and recreational fishery will require additional research into the ecology and economics of the estuary.

E.9.5.4 Further Research to Fill Data and Knowledge Gaps

As in the case of economic effects in the St. Lucie Estuary, understanding of the causal linkages between hydrology/ecology/economics needs to be strengthened for the Caloosahatchee Estuary. The SFWMD is currently attempting to fill some of the information gaps that exist in describing the sequence of hydrology-ecology-economics effects of freshwater releases from Lake Okeechobee. In particular, the SFWMD is conducting research on the ecological effects of the freshwater releases on the Caloosahatchee estuary. It appears that the economic effects need to be further explored. One avenue would be to hold a similar series of focus groups in Lee County as are being conducted for the St. Lucie Estuary. The regulatory releases in the spring of 1998 provide timely opportunity to explore the economic impacts of these releases.

The following recommendations are offered to further understanding of the economic impacts of the freshwater releases from Lake Okeechobee into the

Caloosahatchee Estuary. Many of these recommendations coincide with suggestions for the St. Lucie Estuary. All of this research must consider the area potentially impacted by the releases, not just the physical limits of the estuary.

Estuarine Ecology

- Continue research to differentiate effects of Lake Okeechobee freshwater releases from perturbations attributable to the watershed.

Commercial Fishing

- Inshore: Monitor the estuary for commercial fishing activities, including crab traps and cast nets.

- Offshore: analyze commercial landings of estuarine-dependent finfish and invertebrates following periods of high and low releases to determine lag effects.

Guided Sportfishing

- Survey professional guides to determine short-term and lag effects of freshwater releases.

Recreational Fishing

- Monitor recreational catch to determine short-term and lag effects of freshwater releases.

- Survey anglers to determine willingness to pay for fishing experience.

- Conduct Boat Census: boat count, ramp count, and/or aerial surveys.

Indirect and Induced Economic Effects

- Survey local businesses to help determine indirect and induced effects of changes in the number of resident and tourist fishermen.

E.9.6 FRESHWATER FLOWS TO BISCAYNE AND FLORIDA BAYS

For commercial and recreational fishing in Biscayne Bay and Florida Bay, the sequence of effects of the alternative restoration plans also depends on how the hydrologic changes affect the ecology of the bays and how the ecological changes translate into changes in commercial and recreational fishing. However, the bays have several important differences relative to the St. Lucie and Caloosahatchee estuaries. First, the bays lie at the downstream terminuses of the C&SF system where water flowing through the Everglades enters the sea. Second, the bays, which primarily lie within the Biscayne National Park and Everglades National Park, are recognized as estuaries of national and international significance. Third, the bays are much larger than the St. Lucie and Caloosahatchee estuaries. As a result, they play a much more significant role in south Florida's commercial and recreational fishing.

The bays support a variety of recreation activities, including fishing, spearfishing, boating, diving, and snorkeling. In addition to their ecological roles in supporting in-shore and off-shore commercial and recreational fishing, the bays provide non-fishing recreation activities, such as boating, snorkeling, and diving. The economic values of these activities are potentially significant. These recreation activities could be affected by short-term and long-term ecological changes associated with modifying freshwater releases to the bays. However, estimating the economic effects of restoration-related impacts on the quantity and quality of these non-fishing activities in the bays is problematic. For this reason the discussions of recreation in the bays focuses on sportfishing. Nevertheless, it is assumed that ecological impacts of restoration on the bay fisheries will have associated effects on snorkeling and diving activities.

As in the cases of the St. Lucie and Caloosahatchee estuaries, the quantity and timing of freshwater flows into Biscayne and Florida bays are critical determinants of the structure and function of the bay ecosystems. The bays differ from the two smaller estuaries, since they do not experience the magnified fluctuations of high and low freshwater inputs and resultant salinity levels. Instead, the bays in general receive less water throughout the year than they would under natural conditions. Another distinction of the bays is the greater significance of groundwater flows as freshwater inputs to these estuaries.

The sizes, locations, and protected status of Biscayne Bay and Florida Bay make them critical components of the marine ecosystem in the Florida Keys and south Florida. The waters surrounding the Florida Keys are recognized as one of the nation's most significant and most stressed marine resources (Ault et al., forthcoming). Many ecologically and economically important tropical marine fish and invertebrates recruit over protracted periods of the year to avoid predation or take advantage of prey (Ault et al, forthcoming). However, many economically important south Florida fishes (including groupers, snappers, grunts) and invertebrates (lobsters and shrimp) spawn offshore at the shelf edge and their larvae are then advected inshore into nearshore and coastal bay nursery areas (Lee et al., 1992). As described by Ault et al. (1997), the potential effects of the alternative restoration plans encompass the entire Keys ecosystem:

> *Hydrologic (Everglades Restoration) projects of historic proportions are expected to make a substantial change in the timing, volume, and location of freshwater outflows into the coastal marine environment. These changes could affect the survivorship of juvenile reef fishes in important shallow nursery areas of Florida Bay and Biscayne Bay and ultimately affect the productivity of the entire coral reef ecosystem.*

E.9.7 POTENTIAL EFFECTS ON FISHING IN BISCAYNE BAY

Biscayne Bay is a shallow subtropical estuary that is approximately 38 miles long and 11 miles wide at its broadest. The northern part of the bay is a state-designated aquatic preserve. The southern part of the bay includes Biscayne National Park. The extreme southern portion of the bay, which includes Card Sound and Barnes Sound, lies outside of the park. Less than five miles east of the park lies the northern boundary of the Florida Keys coral reef tract. The park consists of 180,000 acres of which 95% is water. While there is a visitor center, visitors must use a boat to access most of the park.

As in the case of the two preceding estuaries, the quantity and timing of freshwater inputs to Biscayne Bay are critical determinants of the ecosystem structure and function. In its natural condition, Biscayne Bay was fed by overland sheetflow and groundwater discharges through permeable rock formations. The urbanization of Miami-Dade County and the modification of the hydrology of south Florida have significantly impacted the ecology of Biscayne Bay by focusing surface water inputs to canal outlets and reducing groundwater discharges to the bay. The current surface discharges are greater than under natural conditions, and the canal discharges are irregular pulses that quickly and drastically change salinity levels inconfined portions of the bay (Serafy et al, 1997). Rapid salinity fluctuations can represent significant – even lethal – stress for marine organisms, reducing available energy for growth, development, and resistance to other stressors, such as high temperature. Serafy et al. (1997) found that areas of the bay that are subject to the low salinity pulses from the canals have significantly less ecological diversity and productivity, since species that are intolerant to rapid salinity fluctuations must expend energy to respond to the stress or relocate to areas with more stable salinity.

E.9.7.1 Profile of Commercial and Recreational Fishing in Biscayne Bay

A profile of commercial and recreational fishing in Biscayne Bay can be constructed using a variety of information from Biscayne National Park, FDEP, and estuarine ecologists at the Rosenstiel School of Marine and Atmospheric Sciences at the University of Miami, such as Dr. Jerald Ault. As in the cases of the previous two estuaries, Biscayne Bay supports commercial and recreational fisheries on-site and serves as important nursery habitat for offshore fisheries as well. The bay includes a variety of habitats that support extensive fisheries, including bay, seagrass flats, reef, and pelagic.

In their survey of estuaries on the southeastern coast of the U.S., Nelson et al. (1991) describe the following species as among those that are “highly abundant”, “abundant”, or “common” in Biscayne Bay.

Snapper, gray	Seatrout, spotted
Flounder, gulf	Mullet, striped
Ladyfish	Crab, blue
Pinfish	Shrimp, pink
Mackerel, spanish	Shrimp, grass
Spot	

In contrast to the St. Lucie and Caloosahatchee estuaries, there is commercial landings information that specifically apply to Biscayne Bay. Table 9.7.1-1 presents commercial landings data for Biscayne Bay, Card Sound, and Barnes Sound, including annual poundage, trips, and value for the 1993-1997 period. The 1997 value of the commercial fishery was in excess of $1.5 million. The bait shrimp fishery accounted for the dominant share of this value with 73%, as compared to invertebrates (21%), finfish (4%), and shrimp (2%). The value of the bait shrimp fishery has been growing in value during the 1993-1997 period. In contrast, the value of the pink shrimp fishery has been declining steadily during the same period.

The 1997 commercial landings data for Miami-Dade County provide additional insight into commercial fishing in Biscayne Bay. ***Table 9.7.1-2*** contains 1997 commercial landings for the twelve species in Miami-Dade County each of which accounts for at least two percent of the total catch by weight. The percentages of total county catch by weight (696,882 pounds) are also included in this table. Together, these twelve species account for 83% of the total catch. As indicated in ***Table 9.7.1-2***, king mackerel is the dominant commercial species by weight, followed by ballyhoo, yellowtail snapper, shark, and amberjacks. Most of the species in Table 9.7.1-2 spend part of their life in coastal estuaries such as Biscayne Bay or depend on the shrimp stocks that thrive in the seagrass beds of these estuaries and support the coastal and offshore food chains.

In addition to the commercial finfish landings, Miami-Dade County had invertebrate landings that included: blue crabs (104,248 pounds), stone crabs (85,050 pounds), and spiny lobsters (399,598 pounds). The 1997 commercial shrimp landings for the county were 349,271 pounds.

TABLE 9.7.1-1
COMMERCIAL LANDINGS
BISCAYNE BAY/CARD SOUND/BARNES SOUND
1993-1997

YEAR	CATEGORY	POUNDS	TRIPS	VALUE
1993	Finfish	56,797	269	$27,954
	Invertebrates	44,931	519	$42,524
	Shrimp	32,982	93	$71,827
	Bait Shrimp	134,902	1,742	$323,414
1994	Finfish	60,128	151	$38,212
	Invertebrates	33,252	546	$39,185
	Shrimp	24,959	120	$41,816
	Bait Shrimp	205,680	2,821	$462,968
1995	Finfish	51,608	162	$40,493
	Invertebrates	68,439	661	$158,847
	Shrimp	30,574	183	$53,537
	Bait Shrimp	251,974	3,428	$717,452
1996	Finfish	67,915	222	$59,337
	Invertebrates	115,300	1,571	$239,280
	Shrimp	56,694	141	$68,354
	Bait Shrimp	335,118	4,046	$1,011,372
1997	Finfish	64,740	270	$55,195
	Invertebrates	133,542	1,479	$316,009
	Shrimp	56,379	99	$36,338
	Bait Shrimp	358,609	4,764	$1,095,279

Source: Florida DEP, Marine Fisheries Information System, 1997.

TABLE 9.7.1-2
RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT
DADE COUNTY 1997

SPECIES	POUNDS	PERCENT OF TOTAL CATCH
Mackerel, king	112,058	16%
Ballyhoo	105,663	15%
Snapper, yellowtail	74,909	11%
Shark	65,940	9%
Amberjacks	59,079	8%
Drum, black	37,323	5%
Grunts	27,209	4%
Mackerel, spanish	21,410	3%
Tunny, little (Bonito)	20,661	3%
Snapper, mutton	20,418	3%
Mullet, silver	17,887	3%
Snapper, gray	15,371	2%

Biscayne Bay supports an extensive guided sportfishery. Inshore species that are pursued by guided anglers include: bonefish, red drum, snook, black drum, tarpon. Bonefish are a particularly large and valuable fishery for professional fishing guides. No permits from Biscayne National Park are required for a guide to operate in Biscayne Bay. Therefore, the exact number of guides is not known, but discussions with guides who regularly operate in Biscayne Bay suggest that there are approximately 20 guides who operate in Biscayne Bay on a full time basis. At approximately $300 per day, the guided sportfishery would have an approximate annual value of $1.4 million.

In the annual fisheries report for Biscayne National Park, Lockwood and Perry (1997) describe the size and diversity of the park's recreational fishery. In 1996, over 55,000 boats used park waters. Of these boats, 59% (32,875) were engaged in recreational fishing. Most of the fishermen were residents of Homestead (44%) or Miami (39%). Less than 0.5% were from north Florida or from out of state. Surveys with bay fishermen suggest that 45% have no species preference, while others target specific species: dolphin (18.4%), bonefish (5.8%), lobster (5.5%), and snapper (4.1%).

Table 9.7.1-3 presents the annual number of boats, total catch, and total harvest for groupers, snapper, grunts, and other species during the 1996-1997 period. Grunts dominated the catch and harvest in terms of number of fish. Lockwood and Perry (1997) report no change in abundance of recreational catch from 1992-1996. The top three species by catch in the "other" species category are blue runner (36.4%), barracuda (16.4%), and pinfish (4.7%). Based on their recreational creel survey, Lockwood and Perry (1997) estimate the following species composition for inshore waters in the park: grunt (41.2%), snapper (28.6%), lobster (7.2%), jacks (7.1%), grouper (6.0%), barracuda (2.8%), hogfish (1.6%), and others (5.5%).

TABLE 9.7.1-3
ANNUAL RECREATIONAL CATCH AND HARVEST
BISCAYNE NATIONAL PARK
1996-1997

SPECIES	FISHING BOATS (% of total)	TOTAL CATCH (fish)	TOTAL HARVEST (fish)
Groupers	17,470 (53%)	37,327	4,320
Snappers	20,057 (61%)	145,005	34,455
Grunts	19,307 (59%)	220,960	108,665
Other	24,817 (75%)	145,005	34,455

Source: Lockwood and Perry (1997)

If each of the 32,875 boats which visited Biscayne Bay in 1996 had an average of 2.3 fishermen per boat (consistent with the Everglades National Park recreational fishery), there were approximately 74,087 fishermen involved in the bay's recreational fishery. If the estimated daily expenditures per fishing trip by Florida resident ($114.81) from Milon and Thunberg (1993) is applied to these fishermen, the recreational fishery in 1996 had an approximate value of $8,505,928.

Biscayne National Park is a sanctuary for lobster from commercial trapping. However, recreational lobster catch is permitted. For the 1996-1997 period, Lockwood and Perry (1997) present an annual estimate of 11,455 man-hours for sport lobstering in the park involving 4,552 boats. The estimated harvest was 44,710 lobsters.

Spearfishing is also permitted in Biscayne National Park. For the 1996-1997 period, Lockwood and Perry (1997) present an annual estimate of 8,316 man-hours for spearfishing involving 5,398 boats. The estimated catch was 16,729 fish, and the estimated harvest was 15,370 fish.

E.9.7.2 Hydrologic Changes Associated With Alternative Plans

The SFWMM simulates freshwater inputs to Biscayne Bay using flows at five different discharge points: Snake Creek, North Bay, Miami River, Central Bay, and South Bay. For four of these discharges, the Restudy team has established targets for wet and dry season releases into the bay. These targets and the results of the simulations for the with- and without-project future conditions are contained in ***Table 9.7.2-1***. The Recommended Plan is expected to produce effects equivalent to

Alternative D. In general, the 2050 base conditions and the alternative restoration plans fall short for the target discharges (wet and dry seasons). In addition, three of the alternative restoration plans are expected to have less desirable performance than the without-project conditions. The exception is Alternative D.

TABLE 9.7.2-1
SIMULATED HYDROLOGIC PERFORMANCE OF ALTERNATIVE PLANS
SURFACE WATER FLOWS TO BISCAYNE BAY
(1000 acre-feet)

SURFACE DISCHARGES	SEASON	TARGETS	2050 BASE	ALTERNATIVES			
				A	B	C	D & RP
Snake Creek	Dry	93	43	14	29	31	28
	Wet	67	114	57	83	87	83
North Bay	Dry	None	37	21	38	38	38
	Wet	None	95	51	96	97	97
Miami River	Dry	None	39	24	27	22	19
	Wet	None	82	72	51	43	44
Central Bay	Dry	83	73	24	41	49	63
	Wet	161	152	86	105	120	140
South Bay	Dry	68	52	39	41	89	104
	Wet	158	152	122	125	175	208

Note: RP = Recommended Plan (D13R + Other Project Elements)

E.9.7.3 Potential Ecological and Economic Effects On Fishing In Biscayne Bay

The potential shortfall of the with- and without-project conditions relative to the targets for freshwater inputs to Biscayne Bay suggest a continued salinity stress on the bay ecosystem. This stress may have ecological effects that infer economic consequences for commercial and recreational fishing in the bay. From an ecological point of view, the response of seagrass communities to continued salinity stress will be critical, since these communities support juvenile pink shrimp which are critical to the health of the inshore and offshore fisheries.

The relatively stable abundance of economically valuable species suggests that the ecosystem has some resilience to the continued salinity stress from low freshwater inputs. However, the sustainability of this abundance under continued stress is not known.

Alternative D is clearly the most preferable of the alternative restoration plans. It is the only alternative plan that provides more freshwater inputs to Biscayne Bay than the without-project conditions.

E.9.7.4 Further Research to Fill Data and Knowledge Gaps

Biscayne Bay is the subject of ongoing research regarding the structure and function of this ecosystem. This research will help link the changes in hydrology associated with the alternative restoration plans with the potential economic effects on commercial and recreational fishing. The economics of recreational fishing and guided sportfishing appear to be the least understood links in the sequence of effects from hydrologic to ecological to economic. Surveys of professional guides, their charters, and recreational anglers could be directed toward determining the value and satisfaction of their fishing experience.

E.9.8 POTENTIAL EFFECTS ON FISHING IN FLORIDA BAY

Florida Bay is a triangularly-shaped subtropical lagoonal estuary that is approximately 700 square miles in area. To the north is the Florida mainland; to the southeast is the Florida Keys. Over 80% of the bay lies within the Everglades National Park. The bay is shallow with an average depth of less than one meter. There are over 200 small islands in the bay which are rimmed with mangroves and have interior, irregularly flooded flats.

As in the cases of the preceding estuaries, the quantity and timing of freshwater inputs to Florida Bay are critical determinants of the ecosystem structure and function. At the northern edge of the bay lies the interface of the bay with the Everglades. Freshwater inputs to the bay occur via: (1) sheetflow across the marl prairies of the southern Everglades, (2) creeks fed by Shark River Slough and Taylor Slough, and (3) groundwater flow through porous rock formations (McIvor et al., 1997). Some areas within the bay become hypersaline when evaporation exceeds freshwater inputs to the bay (via rainwater and surface and groundwater flow from the Everglades). The hypersalinity is reinforced by circulation patterns within the bay that limit flushing of hypersaline water.

Based on Restudy model results, freshwater flow to Florida Bay has been decreasing in recent years. For instance, it is estimated that flows of Shark River Slough into Florida Bay have decreased 59% relative to natural conditions (McIvor et al., 1997). Banding of bay coral formations is one example of available biological evidence. The reduced freshwater inputs to the bay diminish the diversity and productivity of this estuary, since many species found in Florida Bay are not well adapted to hypersaline conditions.

The reduction in freshwater flows into the bay may be related to the widespread dieoff of seagrass in the bay which began in 1987 and continues today. Prior to that time, seagrass covered more than 80% of the bay, supporting shrimp populations that comprise critical elements of the inshore and offshore food chains. In some areas, vegetative cover has been re-established by the original species or by other species. However, in other areas, re-colonization has been slow, and large areas of the bottom are devoid of vegetation. The seagrass dieoff may be attributable to causes other than changes in the quantity or timing of freshwater inputs to the bay, but the long-term salinity stress may have exacerbated their vulnerability to other perturbations (e.g., high water temperature, reduced frequency of hurricanes, pathogens). In addition to the seagrass dieoff, increases in sponge mortality and algae blooms also indicate that the ecology of this estuary is under stress.

E.9.8.1 Profile of Commercial and Recreational Fishing in Florida Bay

Florida Bay supports large commercial and recreational fisheries inshore and offshore. Commercial fishing in the Everglades National Park portion of the bay was banned in 1985. In the 10 years prior to the ban (1976-1985), the commercial harvest in the bay had averaged over two million pounds per year (Centaur Associates, 1986). Currently, the bay is heavily used as a recreational fishery for Florida residents and tourists, many of whom hire professional sportfishing guides. In their survey of estuaries on the southeastern coast of the U.S., Nelson et al. (1992) describe the following species as among those that are “highly abundant”, “abundant”, or “common” in Florida Bay. McIvor et al. (1997) add grunts, lobster, and barracuda to this list of species that are common in Florida Bay, either as juveniles or adults.

Pink shrimp
Grass shrimp
Blue crab
Stone crab
Bull shark
Tarpon
Hardhead Catfish
Silversides
Snook
Bluefish
Jack, crevalle
Gulf flounder
Pompano
Snapper, gray
Sheepshead
Pinfish
Silver perch
Spotted seatrout
Spot
Drum, black
Drum, red
Mullet, striped
Mackerel, spanish

Florida Bay provides important habitat for many offshore commercial species, especially pink shrimp and stone crabs. Table 9.8.1-1 presents commercial landings information for Florida Bay and oceanside waters of the Keys, including annual poundage, trips, and value for 1993-1997. Since commercial fishing is not permitted in Everglades National Park, the commercial landings data in this table apply to those areas of the bay which lie outside of the park. In 1997, the value of commercial fishing in Florida Bay was approximately $10.8 million. As indicated in ***Table 9.8.1-1***, the value of the invertebrate fishery, which is dominated by lobsters and stone crabs, far exceeds the value of the commercial finfishery. In 1997, the finfish landings dropped well below 1993-1996 levels.

Table 9.8.1-2 presents 1997 commercial finfish landings data for the 13 species in Monroe County that account for at least two percent of the county landings by weight. Together, these 13 species account for 87% of the total catch. As indicated in this table, yellowtail snapper is the dominant commercial species by weight in Monroe County, followed by king mackerel, ballyhoo, and dolphin. Most of the species in Table 9.8.1-2 spend part of their life in coastal estuaries such as Florida Bay or depend on the shrimp stocks that thrive in the seagrass beds of the bay and support the coastal and offshore food chains.

The 1997 commercial invertebrate landings for Monroe County include: stone crabs (2,410,204 pounds) and spiny lobster (64,441,159 pounds). Total 1997 shrimp landings for Monroe County were 3,693,854 pounds.

TABLE 9.8.1-1
COMMERCIAL LANDINGS
FLORIDA BAY AND KEYS OCEANSIDE

1993-1997

YEAR	CATEGORY	FLORIDA BAY			KEYS OCEANSIDE			TOTAL		
		POUNDS	TRIPS	VALUE	POUNDS	TRIPS	VALUE	POUNDS	TRIPS	VALUE
1993	Finfish	84,827	561	$151,784	430,651	3,193	$678,216	515,478	3,754	$830,000
	Invertebrates	796,558	4,411	$2,399,465	466,413	2,881	$1,260,308	1,262,971	7,292	$3,659,773
	Shrimp	0	0	$0	0	0	$0	0	0	$0
	Bait Shrimp	486	1	$1,166	0	0	$0	486	1	$1,166
1994	Finfish	148,946	516	$133,760	517,347	3,804	$862,294	666,293	4,320	$996,054
	Invertebrates	939,094	4,504	$3,485,620	627,199	2,863	$2,454,756	1,566,293	7,367	$5,940,376
	Shrimp	0	0	$0	395	1	$158	395	1	$158
	Bait Shrimp	0	0	$0	0	0	$0	0	0	$0
1995	Finfish	225,400	529	$143,271	685,226	5,211	$1,020,979	910,626	5,740	$1,164,250
	Invertebrates	1,035,245	5,253	$4,261,036	919,574	5,245	$3,979,000	1,954,819	10,498	$8,240,036
	Shrimp	0	0	0	64	1	$261	64	1	$261
	Bait Shrimp	19,421	203	$77,614	0	0	0	19,421	203	$77,614
1996	Finfish	183,084	250	$111,492	443,971	4,092	$794,604	627,055	4,342	$906,096
	Invertebrates	1,724,758	7,619	$6,158,169	1,231,156	6,315	$4,690,493	2,955,914	13,934	$10,848,662
	Shrimp	2,204	4	$2,572	1,530	5	$2,012	3,734	9	$4,584
	Bait Shrimp	24,413	264	$94,721	0	0	$0	24,413	264	$94,721
1997	Finfish	116,516	278	$77,913	49,575	651	$69,244	166,091	929	$147,157
	Invertebrates	1,855,215	8,808	$7,089,668	847,157	5,235	$3,499,591	2,702,372	14,043	$10,589,259
	Shrimp	0	0	0	0	0	$0	0	0	$0
	Bait Shrimp	18,983	201	$75,867	0	0	$0	18,983	201	$75,867

Source: Florida Marine Fisheries Information System

TABLE 9.8.1-2
RANKED COMMERCIAL FINFISH LANDINGS BY WEIGHT
MONROE COUNTY 1997

SPECIES	POUNDS	PERCENT OF TOTAL CATCH
Snapper, yellowtail	1,521,467	24%
Mackerel, king	639,477	10%
Ballyhoo	593,083	9%
Dolphin	584,203	9%
Amberjacks	488,963	8%
Swordfish	354,127	6%
Shark	337,269	5%
Snapper, gray	252,051	4%
Grouper, red	200,269	3%
Mackerel, spanish	169,402	3%
Snapper, mutton	164,876	3%
Grouper, black	146,455	2%
Grunts	122,466	2%

Guided sportfishing is extremely popular in Florida Bay. The guides are required to have a permit from Everglades National Park to operate within the park's bay jurisdiction. In 1996, the park issued 202 guide permits. Discussions with representatives of the Florida Keys Fishing Guides Association suggest that there are approximately 170 guides operating in the Florida Keys, most of which fish in Florida Bay at least some of the time. Most of the Keys guides operate from Islamorada. Most of the non-Keys guides that operate in Florida Bay are based in Everglades City. The guide anglers typically pursue bonefish, tarpon, snook, and snapper. Bonefish and tarpon are particularly large and valuable fisheries for professional fishing guides. These species are of little food value and are generally not highly sought by non-guide anglers.

In the 1996 annual fisheries report for Everglades National Park, Schmidt et al. (1997) estimated that there were 26,279 fishing boats with an average of 2.3 fishermen per boat for a total of 61,354 anglers. There were an estimated 351,163 hours of fishing in the Florida Bay portion of the park in 1996. The average trip lasted a total of 7.2 hours (with 5.8 hours of fishing) and caught 20 fish. In the park, Flamingo is the most popular access point to Florida Bay used by 50 to 60 percent of park anglers. Most of the anglers fishing in the park are from south Florida. The Flamingo survey suggests that 84% of fishermen are from south Florida with only 1% from out of state. Many of the Florida Bay anglers (45%) do not have any target species when they go fishing. In general, recreational anglers pursue the "Big Four" species: sea trout, red drum, snook, and gray snapper.

As in the case of Biscayne Bay, the estimated daily expenditures of a Florida resident per fishing trip ($114.81) from Milon and Thunberg (1993) can be used to estimate the value of the recreational fishery in the Everglades National Park portion of Florida Bay. Based on the park's estimate of 61,354 fishermen, the recreational fishery in the park portion of the bay in 1996 had an approximate value of over $7 million.

The 1996 recreational catch and harvest for the most popular gamefish species are presented in ***Table 9.8.1-3***. This table includes guide and non-guide anglers. Spotted seatrout led the 1996 catch and harvest. Schmidt et al. (1997) indicate that catch rates for seatrout, red drum, snook, and snapper were nearly as high or higher than during the 1986-1990 period (1991-1994 estimates were not available). The catch rates for bonefish and tarpon are also relatively stable.

In 1996, the professional guides conducted 3,378 fishing trips with an average of 2.1 persons fishing. As a result, the guide anglers catch and harvest estimates in Table 9.8.1-3 represent the effort of approximately 13,965 fisherman. At approximately $300 per day, the guided sportfishery in 1996 had an approximate value of $1.0 million.

TABLE 9.8.1-3
ESTIMATED FLORIDA BAY RECREATIONAL CATCH AND HARVEST
EVERGLADES NATIONAL PARK 1996

	NON-GUIDE ANGLERS		GUIDE ANGLERS		TOTAL	
SPECIES	CATCH	HARVEST	CATCH	HARVEST	CATCH	HARVEST
Snook	18,688	3,189	8,674	1,882	27,362	5,071
Drum, red	43,003	6,588	16,155	1,824	59,158	8,412
Seatrout, spotted	102,406	23,366	41,635	7,094	144,041	30,460
Snapper, gray	83,776	21,637	22,317	5,640	106,093	27,277
Tarpon	2,636	0	2,633	4	5,269	4
Bonefish	n.a.	n.a.	1,060	2	1,060	2
Other Species	138,035	14,674	37,980	3,337	176,015	18,011
Total	502,124	79,925	130,454	19,783	632,578	99,708

Source: Schmidt et al. (1997)

E.9.8.2 Hydrologic Changes Associated With The Alternative Plans

The SFWMM simulates freshwater inputs to Florida Bay using wet season (June – October) and dry season (November - May) flows at four different discharge transects: Shark River Slough into Whitewater Bay and Craighead Basin, Taylor Slough, and Eastern Panhandle into Florida Bay. The SFWMM simulates overland and groundwater flows for the three discharge points into Florida Bay. The benchmarks for these discharges are the flows that were simulated in the Natural System Model (NSM). For some measures in ***Table 9.8.2-1***, such as overland flow through Shark River Slough, the alternative restoration plans are expected to provide more freshwater inputs to Florida Bay than the 2050 without-project (base) conditions, but less than the amount estimated in the NSM. In other cases, such as southward flows via Craighead Basin, the with- and without-project conditions are expected to provide greater freshwater inputs to the bay than under natural conditions. While the hydrologic performance of the individual restoration plans are mixed, it appears that for most of the hydrologic measures, Alternative A is superior to the other restoration plans and to the future without-project conditions. The Recommended Plan is expected to produce effects equivalent to Alternative D.

TABLE 9.8.2-1
SIMULATED HYDROLOGIC PERFORMANCE OF ALTERNATIVE PLANS
FLORIDA BAY AVERAGE ANNUAL FLOWS
(1000 acre-feet)

AVERAGE ANNUAL FLOWS	FLOW TYPE	SEASON	NSM	2050 BASE	ALTERNATIVES A	B	C	D & RP
Westward via Shark River Slough	Overland	**Wet**	808	489	688	642	596	593
		Dry	711	337	528	487	444	453
Southward via Craighead Basin	Overland	**Wet**	27	27	32	31	30	30
		Dry	9	8	12	11	10	10
	Groundwater	**Wet**	0.8	0.9	0.9	0.9	0.9	0.9
		Dry	0.7	1.0	0.9	0.9	1.0	1.0
Southward via Taylor Slough	Overland	**Wet**	62	55	59	59	58	59
		Dry	21	14	16	15	15	15
	Groundwater	**Wet**	2.6	2.7	2.7	2.7	2.7	2.7
		Dry	3.1	2.9	3.0	3.0	3.0	3.0
Southward via Eastern Panhandle	Overland	**Wet**	44	52	59	37	33	34
		Dry	14	15	17	14	11	11
	Groundwater	**Wet**	1.5	1.9	2.1	1.8	1.6	1.6
		Dry	1.7	1.9	2.0	2.2	1.9	1.9

Note: RP = Recommended Plan (D13R + Other Project Elements)

E.9.8.3 Potential Ecological and Economic Effects On Fishing In Florida Bay

The importance of commercial and recreational fishing in Florida Bay to the economies of the Florida Keys and south Florida have been previously documented by Leeworthy and Wiley (1996 a, b; 1997 a, b) and Gorte (1994). The complex hydrologic effects of the alternative restoration plans challenge estimation of (1) the potential ecological effects on Florida Bay and (2) the potential economic impacts on commercial and recreational fishing.

For commercial fishing, the nursery function of Florida Bay for the offshore fisheries would be enhanced if freshwater inputs to the bay resembled those under the natural system. From an ecological perspective, the quantity of water is not the only important aspect of the freshwater inputs. The timing and routes of the freshwater inflows are also critical determinants of the diversity and productivity of the bay ecosystem.

The best available economic linkages between Florida Bay and the offshore commercial fisheries is provided by the pink shrimp fishery on the Tortugas grounds. Based on the work of Browder (1985) and others, pink shrimp catch rates and landings on the Tortugas grounds are influenced by freshwater inflows to Florida Bay, which provideS nursery habitat for juvenile pink shrimp. Browder's efforts to directly link the freshwater inflows and pink shrimp catch rates on the Tortugas grounds implicitly includes the intermediate salinity effects of the inflows and the consequent ecological impacts. Pink shrimp catch rates (in pounds per vessel per day) were adopted as a performance measure by the Restudy team to evaluate the economic effects of the alternative restoration plans. The team used a historic catch of 134 pounds per vessel per day. In recent years, this fishery has experienced a significant decline in landings from 17.6 million pounds from 1971-1985 to 12.2 million pounds (1986-1990), a decline of more than 30% (Gorte, 1994). For additional treatment of the pink shrimp fishery, see Sheridan, P., 1996. For the 2050 future conditions, the SFWMM simulations generate the following results for average daily pink shrimp catch rates per vessel per year: 2050 Base conditions (88 pounds), Alternative A (128 pounds), Alternative B (122 pounds), Alternative C (137 pounds), and Alternative D (137 pounds). The Recommended Plan is expected to produce effects equivalent to Alternative D. All of the alternative restoration plans are expected to result in improvements in pink shrimp catch rates compared to the without-project future condition.

Although Alternative A appears to have a strong hydrologic performance in terms of freshwater inputs to Florida Bay (see Table 9.8.2-1), Alternatives C and D are expected to produce the highest pink shrimp catch rates of the alternative restoration plans. The reason is that the statistical relationship used by the SFWMM to predict pink shrimp catch rates and freshwater inputs includes Key West air temperature as well as freshwater flows into the bay. Key West air temperature serves as a proxy for water temperature in the bay. The simulated superiority of Alternatives C and D provide a cautionary illustration regarding ecological and economic interpretation of hydrologic information.

Regarding the recreational fishery, the increases in freshwater inputs to Florida Bay that could accompany the alternative restoration plans would be expected to improve the ecology of the bay and the abundance of gamefish. Rutherford et al. (1989) found a positive correlation between catch rates of spotted seatrout in Florida Bay and rainfall in prior years (2 and 3 years). Tilmant et al. (1989) found that recreational fishermen caught significantly more red drum in Florida Bay when the preceding year had experienced high rainfall. As with the bay ecology, the degree of improvement in gamefish abundance would depend on the quantity, timing, and routes of the freshwater inputs, as well as other environmental factors. It must be recognized that cause and effect relationships in estuarine ecology are complex. The freshwater inputs are one factor in the complex interaction of environmental influences on the ecology of Florida Bay.

E.9.8.4 Further Research To Fill Data and Knowledge Gaps

Florida Bay is the subject of wide-ranging ecological and economic research. The ecological research is coordinated by the Florida Bay Program Management Committee, an interagency committee of federal and state agencies with jurisdictional or scientific interest in Florida Bay. In its annual Strategic Science Plan, the committee prioritizes Florida Bay research needs and identifies information gaps. In addition, the committee draws upon the experience of a national scientific oversight panel and sponsors an annual Florida Bay Science Conference. In cooperation with the Program Management Committee, the Everglades National Park is developing a marine monitoring network for temperature and salinity, dividing the bay into zones where recorders can correlate catch with conditions in the bay.

The economic significance of Florida Bay has also been the subject of several investigations in recent years (Gorte, 1994; Leeworthy and Wiley, 1996 a, b and 1997 a, b). As a result of these studies and ongoing efforts by the Everglades National Park to monitor recreational fishing in the bay, the economics of fishing in Florida Bay are relatively well defined. The most important knowledge gap regarding the potential economic effects of the Everglades restoration plans seems to be the variation of fish abundance with freshwater inputs to the bay. This is the subject of ongoing research, and additional data collection and analysis is required to strengthen understanding of the hydrologic/ecological/economic sequence of effects.

E.9.9 SUMMARY OF POTENTIAL ECONOMIC EFFECTS ON FISHING

The potential effects of the Restudy's alternative restoration plans are summarized in ***Table 9.9-1***. This table presents estimates of current annual revenues for each of the fisheries under consideration. As described in the above discussions, these estimates were generated using a variety of approaches and data sources. Consequently, the estimates should be considered approximate, and comparisons of the revenues of one fishery with another should be made with caution. Table 9.9-1 also contains information on the anticipated hydrologic performance of the alternative restoration plans. In general, the alternative plans are expected to comprise improvements over the without-project (base) future conditions. As indicated in the table, Alternative D is expected to have the most desirable hydrologic performance among the alternative plans. The Recommended Plan is expected to produce effects equivalent to Alternative D. However, the plans are not expected to provide inputs to the St. Lucie Estuary that meet the Restudy planning targets or NSM flows. The economic interpretation of this hydrologic information suggests that the alternative plans could result in significant improvements in the economics of commercial and recreational fishing relative to the existing and without-project future conditions. The quantification of the expected economic impacts is not possible at this time given knowledge and data gaps in the sequence of hydrologic, ecological, and economic effects that determine economic impacts of the alternative restoration plans.

TABLE 9.9-1
SUMMARY OF ECONOMIC EFFECTS OF ALTERNATIVE PLANS ON COMMERCIAL AND RECREATIONAL FISHING

Area	Approximate Annual Revenues of Fishery ($ million)			Hydrologic Performance Of Alternative Plans			Economic Interpretation of Hydrologic Performance
	Commercial	Guided	Recreational	Performance Relative to 2050 Base	Ranking	Performance Relative to Targets/NSM	
Lake Okeechobee	$2.3	n.a.	$671	A,B,C, & D exceed 2050 Base conditions	A – 2 B – 3 C – 2 D – 1	n.a.	Minor positive economic impacts expected with alternative plans.
St. Lucie Estuary	$1.7	$0.8	n.a.	A,B,C, & D exceed 2050 Base conditions	A – 4 B – 2 C – 3 D – 1	A,B,C, & D do not meet flow targets	Significant positive economic impacts expected with alternative plans.
Caloosahatchee Estuary	$1.7	$4.8	n.a.	A,B,C, & D exceed 2050 Base conditions	A – 3 B – 1 C – 2 D – 2	A,B,C, & D meet flow targets	Significant positive economic impacts expected with alternative plans.
Biscayne Bay	$1.5	$1.4	$8.5	Only D exceeds 2050 Base conditions	A – 4 B – 3 C – 2 D – 1	A,B,C, & D do not meet flow targets	With the exception of Alternative D[1/] significant negative economic impacts expected with alternative plans
Florida Bay	$10.8	$1.0	$7.0	A,B,C, & D exceed 2050 Base conditions	A – 1 B – 2 C – 4 D – 3	A,B,C, & D do not meet NSM flows	Significant positive economic impacts expected with alternative plans.

Note: Recommended Plan effects expected to be equivalent to D.

[1/] Biscayne Bay is expected to have positive impacts with Alternative D and the Recommended Plan (the only alternatives to do so), although there are multiple performance measures, and the results are mixed.

E.10 COSTS

Data for initial construction/implementation, land acquisition, monitoring, and periodically recurring costs for OMRR&R (operation, maintenance, repair, replacement, and rehabilitation), have been developed through engineering design and cost estimation, and real estate appraisal efforts. Details of that data development are explained and discussed elsewhere in this report. The main issues requiring economic evaluation attention include present worth calculations, price levels, and timing of project spending.

Costs represent the difference between conditions without any plan (the "base condition", or "without-project condition") and with a plan or alternative. For purposes of this report and analysis, NED costs (National Economic Development Costs, as defined by Federal and Corps of Engineers policy), are expressed in 1999 price levels, and are based generally on costs estimated to be incurred over a 50 year period of analysis. Costs of a plan represent the value of goods and services required to implement and operate/maintain the plan.

The timing of a plan's costs is important. Construction and other initial implementation costs cannot simply be added to periodically recurring costs for project operation, maintenance, and monitoring. Also, construction costs incurred in a given year of the project can't simply be added to construction costs incurred in other years if meaningful and direct comparisons of the costs of the different alternatives are to be made. A common practice of equating sums of money across time with their equivalent at an earlier single point in time is the process known as discounting. Through this mathematical process, which involves the use of an interest rate (or discount rate) officially prescribed by Federal policy for use in water resource planning analysis (currently set at 6.875% per year), the cost time streams of each alternative are mathematically translated into a present worth value. This present worth value, calculated for this study as of the beginning of the period of analysis, can then be directly and meaningfully compared between the plans being considered in this study. An annual value, equivalent to the present worth, can also be computed for the 50 year period of analysis. This average annual value represents an equivalent way of expressing the costs of a plan. The various costs estimated to be incurred over time to put each plan into place and keep it going will be computed and expressed as both a present worth value and an average annual equivalent value.

There is some admitted uncertainty as to how any of the plans, if approved and adopted, would be implemented. It is recognized that any of the plans would likely be implemented over a considerable period of time, little by little. For purposes of this evaluation, construction and land costs are assumed to be incurred on an equal annual basis during the first 20 years of the 50 year period of analysis (i.e., for each of the first 20 years of the period of analysis, 1/20th of the construction and land totals is the estimated amount to be spent).

OMRR&R costs, which have been estimated as an annual amount for a fully implemented, fully functioning plan, would begin only after implementation of project features have reached completion. For purposes of this analysis, these costs are assumed to begin to be incurred after the initial two years of construction activity have passed. Calculation of the present worth and average annual equivalent values of the OMRR&R costs are based on the assumption that the annual costs would grow by an equal amount each year (i.e., linear growth through time), reaching 100% of the full OMRR&R estimated amount 19 years later, in the 2nd year following completion of project implementation.

An important feature of all alternatives is that of monitoring programs, needed to acquire knowledge of project effectiveness. Such information can then be used to make needed changes and adjustments in the future. The costs of such programs must be accounted for and are part of the costs of alternatives. For purposes of this analysis, the annual estimated monitoring cost for each alternative is estimated to be incurred at 100% of the same estimated level starting with the first year of the period of analysis, and continuing at that level throughout the 50-year period of analysis.

Present worth calculations assume that costs are incurred at mid-year. The calculations convert all costs from the middle of the year in which they are spent to an equivalent amount at a common time reference point. For purposes of this study, this common time reference point is the beginning of project construction.

A summary of NED project implementation, OMRR&R, and monitoring costs for Plans A, B, C, and D, and their derived present worth and average annual equivalent values, is outlined in ***Tables10-1*** and ***10-2***.

Table 10-1
Summary of Costs of Plans A-D

Plan	**Cost (millions)**			
	Initial		**Periodically Recurring**	
	Land	**Construction**	**OMRR&R**	**Monitoring**
A	$1,444	$3,785	$70	$10
B	$1,645	$4,378	$72	$10
C	$1,673	$5,052	$126	$10
D	$1,709	$5,626	$162	$10

Note: Initial cost represents total cost of project; periodically recurring cost represents 100% of full annual amount. Costs reflect estimated 1999 prices.

Table 10-2
Present Worth and
Average Annual Equivalent Costs of Plans A-D

Plan	Costs (Millions)	
	Present Worth	**Average Annual Equivalent**
A	$3,524	$251
B	$3,979	$284
C	$4,746	$338
D	$5,333	$380

Note: 1999 prices, annual discount rate = 6.875%, 50 year period of analysis; all plans have 20 year construction period, with all implementation costs spread uniformly over the 20 year period; OMRR&R starts following the 2nd year of implementation (which is also the 2nd year of the period of analysis), initially = 1/20th of the full OMRR&R estimate, growing by 1/20th of the full OMRR&R each year until the full level of OMRR&R is reached, after which OMRR&R remains at that level for the remainder of the period of analysis; monitoring costs are constant each year throughout the period of analysis; all costs assumed to be incurred at mid-year. E.g., present worth = [$(1.06875)^{-.5}$ + $(1.06875)^{-1.5}$ + $(1.06875)^{-2.5}$ + … + $(1.06875)^{-19.5}$] x (land + construction costs)/20 + [$(1.06875)^{-2.5}$ x (1/20) + $(1.06875)^{-3.5}$ x (2/20) + $(1.06875)^{-4.5}$ x (3/20) + … + $(1.06875)^{-21.5}$ x (20/20)] x (full annual OMRR&R estimate) + [$(1.06875)^{-22.5}$ + $(1.06875)^{-23.5}$ + $(1.06875)^{-24.5}$ + … + $(1.06875)^{-49.5}$] x (full annual OMRR&R estimate) + [$(1.06875)^{-.5}$ + $(1.06875)^{-15}$ + $(1.06875)^{-2.5}$ + … + $(1.06875)^{-49.5}$] x (annual monitoring cost estimate). Average annual equivalent = (present worth) x [.06875 x $(1.06875^{50})/(1.06875^{50} - 1)$].

A summary of NED project implementation, OMRR&R, and monitoring costs for the Recommended Plan and their derived present worth and average annual equivalent values, is outlined in the ***Table 10-3***. The Recommended Plan is a modification of Plan D above. It has been "fine-tuned" to improve its overall performance and acceptability, and contains a number of "other project elements" ("OPE's"), most of which are separable, stand-alone projects which could be undertaken with or without any of the basic plans, and which would contribute to environmental improvements in the overall study area. The summary cost data for the Recommended Plan is presented separately because its costs are not comparable with the costs of Plans A through D, mainly because of the inclusion of the OPE costs.

Table 10-3
Present Worth and
Average Annual Equivalent Costs of Recommended Plan

Category	Costs (Millions)		
	Amount	**Present Worth**	**Average Annual Equivalent**
Land	$2,221	$1,292	$92
Construction	$5,598	$3,031	$216
Total Initial	**$7,820**	**$4,323**	**$308**
OMRR&R	$173	$1,209	$86
Monitoring	$10	$145	$10
Total Recurring	**$183**	**$1,354**	**$96**
TOTAL		**$5, 677**	**$404**

Note: Recommended Plan = D13R + Other Project Elements

As mentioned previously, there is uncertainty as to how long it would take to complete project implementation, and the 20 year construction period assumption used in the above calculations has been used as a potential most likely scenario. It is important to recognize the sensitivity of present worth and average annual equivalent values of the costs of alternatives to variations in this assumption. To this end, a second set of calculations was performed based on the general assumption of a 50 year, instead of a 20 year implementation period. The relative differences between the present worth values of the alternatives is almost exactly the same for the 50 year implementation period assumption, as for the 20 year assumption. The same holds true for the average annual equivalent costs of the alternatives. Using the 50 year assumption, the present worth values are about half of what they are using the 20 year assumption. The same holds true for the average annual equivalent costs.

E.11 REGIONAL ECONOMIC IMPACTS

E.11.1 INTRODUCTION

The purpose of this section is to evaluate and quantify the economic consequences of the restoration plans on the economy of South Florida. Primary and secondary consequences of the proposed structural and operational modifications of the C&SF system will be considered. Primary consequences include the economic activities stimulated by the purchases of materials and services required in the construction of the project, the purchases of real estate, operation and maintenance of the system and monitoring costs. Secondary consequences are the changes outlined in Section E.1.5.4 and in Figure 1.5.4-1 above, such as the effects on agricultural and urban areas, commercial navigation, fishing, recreation, and flooding. Of these, only the consequences of changing agricultural land use and of altered water deliveries to agriculture will be estimated at this time.

The study region of the impact analysis is defined in Section E.11.2. Five types of economic impacts are defined and quantified in Section E.11.3. The general methodology used in the evaluation of regional impacts with simple numerical examples drawn from South Florida is explained in Section E.11.4. The results of the computations are presented in Section E.11.5.

E.11.2 DEFINING THE STUDY AREA

The study area for the restoration plan coincides with boundaries of the South Florida Water Management District (SFWMD), which is composed of ten full counties and parts of six other counties. However, the national and state statistical systems that provide the data for the regional economic analysis make it impractical to isolate the economic activities of *parts* of counties. Therefore, if a significant share of a "partial" county's economic activity falls within the SFWMD, the entire county is included in the study area, while those counties with only a small share of economic activity falling within the SFWMD will be excluded. Using these criteria, two of the "partial" counties –Okeechobee and Osceola-- are included in the study area along with the ten "full" counties of Broward, Collier, Dade, Glades, Hendry, Lee, Martin, Monroe, Palm Beach, and St. Lucie. The four partial counties that are excluded are Charlotte, Highlands, Orange, and Polk.

The twelve counties that fall within the study region account for 87.9% of the area, 97% of the population, and 96% of the water demand of the total SFWMD. (See Table 11.2-1, lines 1b,2b, & 3b.) The counties in the study area account for 26.2% of the state's total area, 39.2% of the state's

TABLE 11.2-1
ECONOMIC CHARACTERISTICS OF THE STUDY AREA

	1995		2010	
	Estimate	Region as % of Total	Estimate	Region as % of Total
	[1]	[2]	[3]	[4]
1. Area (square miles)				
a. Study Area (12 full counties)	14,164	100.0		
b. SFWMD (10 full & 6 partial counties)	16,114	87.9		
c. Total Florida	53,997	26.2		
2. Population (million)				
a. Study Area (12 full counties)	5.556	100.0	6.880	100.0
b. SFWMD (10 full & 6 partial counties)	5.729	97.0	7.110	97.8
c. Total Florida	14.184	39.2	17.836	38.6
3. Total Water Demands (billion gals/year)*				
a. Study Area (12 full counties)	1,236	100.0	1,657.00	100.0
b. SFWMD (10 full & 6 partial counties)	1,285	96.1	1,725.00	96.1
c. Total Florida	2,768	44.6	n.a.	n.a.
4. Regional Economic Characteristics	% of State			
a. Employment (millions)	2.935	38.7		
b. Numer of Housholds (millions)	2.346	39.3		
c. Total Personal Income (billion $)	$142.53	43.6		
d. Income per household ($)	$60,750	111.1		

12 Counties included in the Impact Study Area: Broward, Collier, Dade, Glades, Hendry, Lee, Martin, Monroe, Okeechobee, Osceola, Palm Beach, and St. Lucie.
4 Counties excluded from Study Area but partially within SFWMD: Charlotte, Highlands, Orange, Polk.
*Note: Lines 3a-c refer to 1990.
Sources:
Data for the partial counties in col.1of lines 1b & 2b were computed by multiplying the shares of the area and population that fall within the SFWMD by their respective total county population & area.
Shares for the partial counties are from SFWMD, Water Supply Needs and Sources 1990-2010, (July 1992). County totals are IMPLAN data.
Line 2 for 2010 are medium projections from Florida Bureauof Economic and Business Research (BEBR), 1997 Florida Statistical Abstract, Table 1.84.
Line 3 from SFWMD, Water Supply, Table A.1. All Florida totals from BEBR, 1997 Fl.Stat.Abst., Table 8.40.

population, and 44.6% of the state's total demand for water. (See lines 1c, 2c, & 3c of Table 11.2-1.)

Over 5.6 million people with a total personal income of $142.5 billion live in the study area. This corresponds to 2.3 million households with an average income of $60,750 per family, which is 11.1% higher than the state-wide average.[3] (See Table 11.2-1, lines 4a & b, cols. 1 & 2.)

No attempt has been made to identify economic impacts of the restoration plan on subregions or on groups of counties within the study area for two reasons. First, the present plan is unable to pinpoint the exact location of construction and the annual maintenance expenditures. Second, the actual locations of direct effects of changes in the agricultural and urban water supplies are based on the 4-square mile grid cells defined in the SFWMM model and their effects on households or industries cannot be separated. Therefore, only the impacts on the entire region will be evaluated.

While the location of the various impacts will eventually depend on the exact placement of the components, the magnitude of the economic impacts on the total region may be evaluated in relation to their causes. These cover a range of anticipated effects, each of which will be investigated in some depth. First are the impacts due to the actual construction costs of all the components of each alternative. Second are the impacts due to the costs of the land purchases required by the components for each alternative. Next are two categories of impacts associated with the changes in use of the acquired lands. In the case of agricultural land, there will be a reduction in agricultural produce as the land is put into the alternative use of water storage. There will also be improvements in productivity on other agricultural lands due to more regular water deliveries. Two additional categories of costs will occur on an annual basis once the project begins: the cost of monitoring the project and the cost associated with operating and maintaining the components of each alternative. Each of these categories is discussed in the next section.

E.11.3 THE IMPACT CATEGORIES

The five categories of impacts that will be considered are: (a) impacts due to construction activities; (b) impacts due to real estate purchases; (c) impacts due to

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[3] See Bureau of Economic and Business Research, 1996 and 1997 Florida Statistical Abstract, Table 24.74, in each annual volume for price levels for only two areas within Florida. The Consumer Price Index (CPI) of the Miami-Ft. Lauderdale area rose by 4% from an initial level of 148.9 in 1995 to 153.7 in 1996. This is compared to the CPI of the Tampa-St. Peterburg-Clearwater area, which rose by only 1.5% from an initial level of 129.7 in 1995 to 131.6 in 1996. Thus, the cost of living in the Tampa area in 1995 was 12.9% lower than the Miami area. By 1996, the gap in the cost of living between the two areas had risen to 14.4%. The appearance of higher household income in the study area may be due to higher prices in South Florida. Once these differences in prices are considered, the average household income in South Florida, which is 11.1% *higher* than the state average, might actually mean a *lower* standard of living.

changing land use; (d) impacts due to altered water deliveries; and (e) impacts due to monitoring costs.

E.11.3.1 Construction

Construction costs, the most significant of the five impact categories, were derived by summing up the costs of all the plan features for each alternative. These were estimated by summing the detailed line items of each feature.[4] Each line item was also allocated to one of 528 sectors of the IMPLAN[5] regional economic model, and these were aggregated to give total construction costs for all the features in each alternative in terms of economic sectors. Cost characteristics of six prototypical structures are given in Table 11.3.1-1.

Total costs for each of these structures are summarized in Table 11.3.1-2. Panel I of that table indicates the capacity, number, or volume of each design feature, for example, 61,152 to 92,538 cfs (cubic feet per second) of new pump capacity, 282,000 to 513,000 feet (that is, 53-97 miles) of new channels, and a total of 104,500 to 250,500 feet (that is, 20 to 47.5 miles) of seepage barriers and curtain walls.

The total costs of the first five types of structures account for about a third of the total cost of each alternative. The remaining costs are incurred by the Aquifer Storage and Recovery (ASR) facilities, seepage barriers, and, in Alternative D-13R, "other project elements."

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[4] To facilitate these computations, a profile of costs for each prototypical structure was made which classified all the items of that structure according to their economic sector. The total number of structures of each type was then calculated for each alternative. Total construction costs were thus recomputed in terms of the 528 economic sectors.

[5] Impact Analysis for Planning (IMPLAN), a static input-output regional economic model originally developed by the U.S. Forest Service. Current software and data is maintained by the Minnesota IMPLAN Group (MIG) in Stillwater, MN. See [www.IMPLAN.com].

Table 11.3.1-1
Cost Characteristics of Six Prototypical Structures

STRUCTURE	CHARACTERISTIC	ESTIMATED COST
A. Pumping Plant	74 different pumping stations designed, ranging from 50 to 4800 cubic feet per second (cfs). Costs assigned to 17 IMPLAN sectors & labor.	$12,102 per 1,000 cfs
B. Spillways	50 different spillways designed, varying by cfs and by number and size of gates. Costs assigned to 18 IMPLAN sectors & labor.	$3,303 per 2 gated spillway
C. Culverts	59 different projects, involving culverts ranging from 2-7 barrels, 70' to 300' long, & 48"-96" in diameter. Costs assigned to 9 IMPLAN sectors and labor Road costs assigned to 4 IMPLAN sectors & labor.	$149.90 per 70 ft. culvert
D. Channels and Canals	59 new canal structures, plus fills & enlargements, varying by length, width at top & bottom, and by depth. Costs assigned to 6 IMPLAN sectors & labor.	$174,000 per 500 ft.
E. Levees	45 projects plus rerouting, removing, and degrading of existing levees. Cost varies by length, height, surface area, and footprint area (acres). Costs assigned to 8 IMPLAN sectors & labor.	$30.0 million per 125,000 ft.
F. Aquifer Storage & Recovery (ASR)	11 projects, ranging from 315-355 wells per alternative. Costs assigned to 3 IMPLAN sectors.	$173 million per 5 MGD well

Table 11.3.1-2
Construction Costs

	ALTERNATIVE				
	A	**B**	**C**	**D**	**D13R**
I. Some Characteristics of the Construction Costs					
A. Pumping Plants (cfs)	61,152	63,852	72,652	75,352	92,538
B. Spillways (number of paired gates)	17	19	23	23	35
C. Culverts (length in feet)	3,480	4,208	4,618	4,548	5,914
D. Canals (length in feet)	282,238	428,990	512,970	512,970	512,970
E. Levees (length in 1,000 feet)	2,175	2,481	2,633	2,649	2,649
F. ASR (number of 5 MGD wells)	315	340	355	343	343
G. Seepage Barriers & Curtain Walls					
Linear feet: 1 foot wide, 10 feet deep	63,500	136,000	146,000	209,500	209,500
Linear feet: 1 foot wide, 28 feet deep	41,000	41,000	41,000	41,000	41,000
II. Principal Costs by Feature (Percentage Distribution)*					
A. Pumping Plant	21.4	19.5	19.2	18.0	19.0
B. Spillway	1.3	1.7	1.8	1.6	2.2
C. Culvert	0.3	0.3	0.3	0.3	0.3
D. Canals	3.1	4.2	4.3	3.9	3.7
E. Levees	11.0	11.3	10.5	9.6	9.0
Subtotal	37.6	37.0	36.0	33.4	34.2
F. ASR	60.0	56.5	51.1	44.7	42.1
G. Seepage Barriers	2.5	6.6	12.9	22.0	20.7
H. Other Project Elements	--	--	--	--	3.0
Total Percent	100.0	100.0	100.0	100.0	100.0
Total (million $)	$3,677.8	$4,377.8	$5,051.7	$5,625.9	$5,981.4

*Columns may not sum due to rounding.

E.11.3.2 Real Estate & Effects Of Other Land Acquisitions

The impacts of the sale of large tracts of real estate on the economy may be several types. The sale of land may be regarded as a simple change in which the owner held the value in real estate and now holds an equal value in cash. If the cash is spent locally or reinvested in regional enterprise, then new economic activity might be stimulated in the region and even more funds might be leveraged by the enterprise. For example, the sale of the Talisman sugar lands in the EAA by its owner, the St. Joe Corporation, is augmenting the company's investments in housing and other new developments throughout Florida.[6]

[6] See, for example, "A Land Giant is Stirring. Will Florida Ever Be the Same?" New York Times, Sunday, April 12, 1998, Business Section, p. 1.

When land sales also result in the transfer of fresh money into regional banks a general economic expansion in the region is supported through the banking multiplier if the local banks invest these new funds locally. If, however, landowners reside elsewhere or hold their funds in other regions, then the expansionary effects of large transfers of funds will not occur in the study area.

Due to the ambiguity of the ultimate use of real estate funds, the expenditures on land were treated as purchases in the real estate sector of the IMPLAN regional economic model and thus generates employment and income similar to other "productive" sectors. The effects of monetary expansion through the local banking system are not captured in the IMPLAN model.

Real estate purchases do, however, affect the use of land, for example, by changing agricultural land into water storage areas. Therefore, the impacts of the alternatives involve a reduction in agricultural production on the converted lands and an increase in agricultural production in other lands due to the additional supply of water and the improved regularity of water deliveries there.

The effects of converting 15,040 acres of pasture, 30,000 acres of citrus groves, 80,000-82,000 acres of sugarcane, and 1,660 acres of row corps into water storage areas may have yet other effects. If none of the converted land is replaced, the total agricultural output would decline in the future due to the land's withdrawal from cultivation. If, however, agricultural production shifts from the acquired lands to other lands within the study area that are not presently cultivated, then the purchase price of the land has served as a one-time payment for the relocation of agriculture, and there is no net decline in regional agricultural output.

The above alternative may be realistic for all the lands needed by the restoration project with the exception of the proposed purchase of 60,000 acres of prime sugar lands in the EAA. Here, the production of sugarcane is in close proximity to the processing mills, and the migration of sugar cultivation west of the EAA into Hendry County could result in serious loss of efficiency to existing mill capacity.

The region's six mills (excluding Talisman, which is concluding its operations in the coming few years) draw their cane from a total of 438,000 acres of planted sugarcane.[7] This means that, on the average, each mill draws on 73,000 acres of cane fields for its operation. In reality, the capacities of the existing mills range by a factor of almost three, the smallest being the Atlantic's mill in Belle Glade, which ground 1.2 million tons in the 1995/96 season, to U.S. Sugar's Clewiston's mill which ground 3.4 million tons.[8]

[7] Florida Sugar Cane League, "Forida Sugar Industry Production, 1976-1996."
[8] "Florida Factory Index," Gilmore Sugar Manual 1996/97, Fargo, ND: Sugar Publications, 1997, pp. 71-96.

The withdrawal of 60,000 acres from sugar production could imply a decline of 2.02 million tons of sugar for grinding or about 14% of the total sugar crop.[9] However, improvements in water deliveries to the remaining sugar lands, increased acreage and the expansion of mill capacity near the newly opened land, and the conversion to more productive strains of sugarcane could all offset the reduction of output due to land purchases.

The regional economic model will be used to compute the impacts due to agricultural land purchases according to two alternative assumptions. The first is to reduce the annual sales of the region by the total value of all the affected crops in each of the plans. The second alternative assumption and more likely scenario assumes that the sale of only the 60,000 acres of sugarcane will not be replaced by production elsewhere, and that the impact of this reduction does not extend forward into processing or milling. For all the alternative plans, the remainder of agriculture will enjoy higher yields due to improved deliveries of water as computed in the SWFFM model, and this is computed separately.

Total real estate purchases are estimated to range from $1.4 to $2.3 billion, which, spread over 20 years, would amount to $72.2 - $116.0 million per year. If production on the EAA sugarlands is not replaced elsewhere, then the reduction in agricultural output is estimated to be $84.7 million per year. The gains to the remaining agricultural lands from improved water deliveries are estimated to be around $2 million per year, for all the alternatives.

E.11.3.3 Operation And Maintenance (O & M)

O & M costs were estimated for each component of each alternative. These were aggregated into 6 IMPLAN sectors for all the components plus labor. These totals and their distribution are given in Table 11.3.3. The largest single item in the O & M budget will be the maintenance and operation of the Aquifer Storage and Recovery (ASR) facilities. This will range from 48% to 72 % of the total annual O & M budget across the alternatives.

E.11.3.4 Total Project Costs and Annual Project Costs

Total construction and real estate costs for the alternatives are summarized in Table 11.3.4, lines 1.A and B. These are annualized over 20 years in lines 2.A and B. The other categories of annual costs include the costs due to possible agricultural reductions (line C), costs (or benefits) due to improved water deliveries (line D), monitoring costs (line E), and O & M costs (line F).

[9] Calculated at 33.7 tons of cane per acre, the average of the past five harvests, 1992/93 to 1996/97.

Table 11.3.3
Operation and Maintenance Costs
By IMPLAN Sector
Percentage Distribution and Dollar Totals

SECTOR	ALTERNATIVE A	B	C	D	D-13R
Landscape Services	1.5	1.7	1.1	0.9	1.0
Maintain Structures	3.1	4.4	2.7	2.1	2.7
Maintain Wells & Pumps	10.8	10.6	10.6	8.3	8.4
Petroleum Purchases	1.9	1.7	1.0	0.8	0.8
Pump Parts	5.9	5.9	4.0	3.2	3.7
Electricity Purchases	19.5	17.8	10.5	8.3	8.2
Sanitation Services (chlorination, filters)	48.1	48.2	64.1	71.7	70.4
Direct Labor	9.3	9.7	6.0	4.7	4.7
Total Percent	100.0	100.0	100.0	100.0	100.0
Total ($1,000)	69,910	72,003	126,340	162,103	168,546

- Columns may not sum due to rounding.

Table 11.3.4
Summary of Total Project Costs and Annual Costs

COSTS	ALTERNATIVE A	B	C	D	D-13R
1. Total Project Costs ($1,000)					
A. Construction	3,784,863	4,377,808	5,051,689	5,625,887	6,014,276
B. Real Estate	1,444,064	1,645,331	1,673,049	1,709,180	2,320,840
C. Total	5,228,927	6,023,139	6,724,739	7,335,067	8,335,116
2. Annual Project Costs ($1,000/year)					
A. Construction	189,243	218,890	252,584	281,294	300,714
B. Real Estate	72,203	82,267	83,652	85,459	116,042
C. Reductions due to agric. Land reduction					
(1) EAA sugarland only	84,720	84,720	84,720	84,720	84,720
(2) All agricultural land	142,457	151,650	153,662	153,662	153,662
D. Gains due to water deliveries	(2,032)	(1,730)	(1,948)	(1,772)	(1,892)
E. Monitoring costs	10,000	10,000	10,000	10,000	10,000
F. Operation & Maintenance (O&M)	69,910	72,002	126,340	162,103	164,793
G. Total Annual Costs					
(1) EAA sugarland only	424,044	466,149	555,349	621,804	674,377
(2) all agric. land losses	481,781	533,079	624,291	690,746	743,319

E.11.4 THE METHOD OF REGIONAL IMPACT ANALYSIS

E.11.4.1 The Chain Of Inputs

The types of economic impacts that a new project can have on output, earnings, and jobs in a region are known as “direct,” “indirect,” and “induced.” “Direct” impacts are caused by first round of expenditure of the project. The “indirect” impacts count only the inputs which are purchased as a result of the first round expenditures. The importance of these “indirect” effects will vary with the complexity of production in the study area and the degree to which required materials are supplied by local producers.

The direct and indirect impacts are concerned primarily with the chains of production. For example, expenditure of $100 million for the construction of a new utility will require purchases of concrete, one of its key inputs. The production of concrete, in turn, requires inputs of sand and gravel, the mining of which requires purchases of petroleum fuel, and so on through many stages. A simple direct chain for six such stages is pictured in Figure 11.4.1-1, in which the percentage given below the label in each box represents the share of gross inputs accounted for by that sector. For example, in the case of stage 2.0, “concrete products” accounts for only 2.0% of all inputs that go into the making of “new utility structures.” In the preceding stage 3.0, “sand and gravel” accounts for only 3.1% of all inputs that are required by “concrete products.”

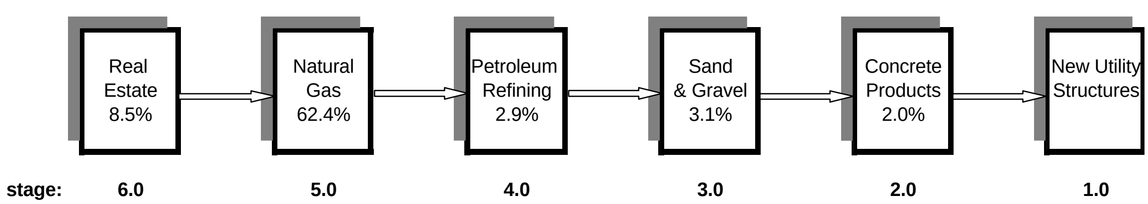

FIGURE 11.4.1-1
THE PRIMARY CHAIN OF INPUTS: SIX STAGES
SOUTH FLORIDA CONSTRUCTION

Clearly, many other inputs besides those pictured in Figure 11.4.1-1 are needed for each stage. In stage 2.0, for example, in addition to concrete products, other significant intermediate inputs include communication services, fabricated structures, non-ferrous wire drawing, architectural services, management consulting, and wholesale trade, and these are shown in stage 2.0 of Figure 11.4.1-2. Each of these seven stage 2.0 inputs in turn requires inputs. Some of the detailed "links behind the primary chain" are pictured as stages 3.0 and 4.0 in Figure 11.4.1-2. As in the previous figure, the percentage given below the label in each box represents the share of gross inputs accounted for by that particular sector.

Only a fraction of the indirect effects are shown in Figure 11.4.1-2, and these may be very complicated, depending on the technological needs of each sector and their location within the region. If intermediate suppliers have settled in the region, then the chain of production may be richly developed and intricate. If the suppliers are outside the region, the resulting chain could be very truncated and the indirect impacts sparse. Figure 11.4.1-2 depicts seven of the stage 2.0 intermediate suppliers for "new utility structures" but only two of the stage 3.0 and stage 4.0 suppliers for each of the stage 2.0 sectors. In reality, each stage consists of hundreds of different inputs, depending on the level of detail of the model and the "chains" that are located within the region.

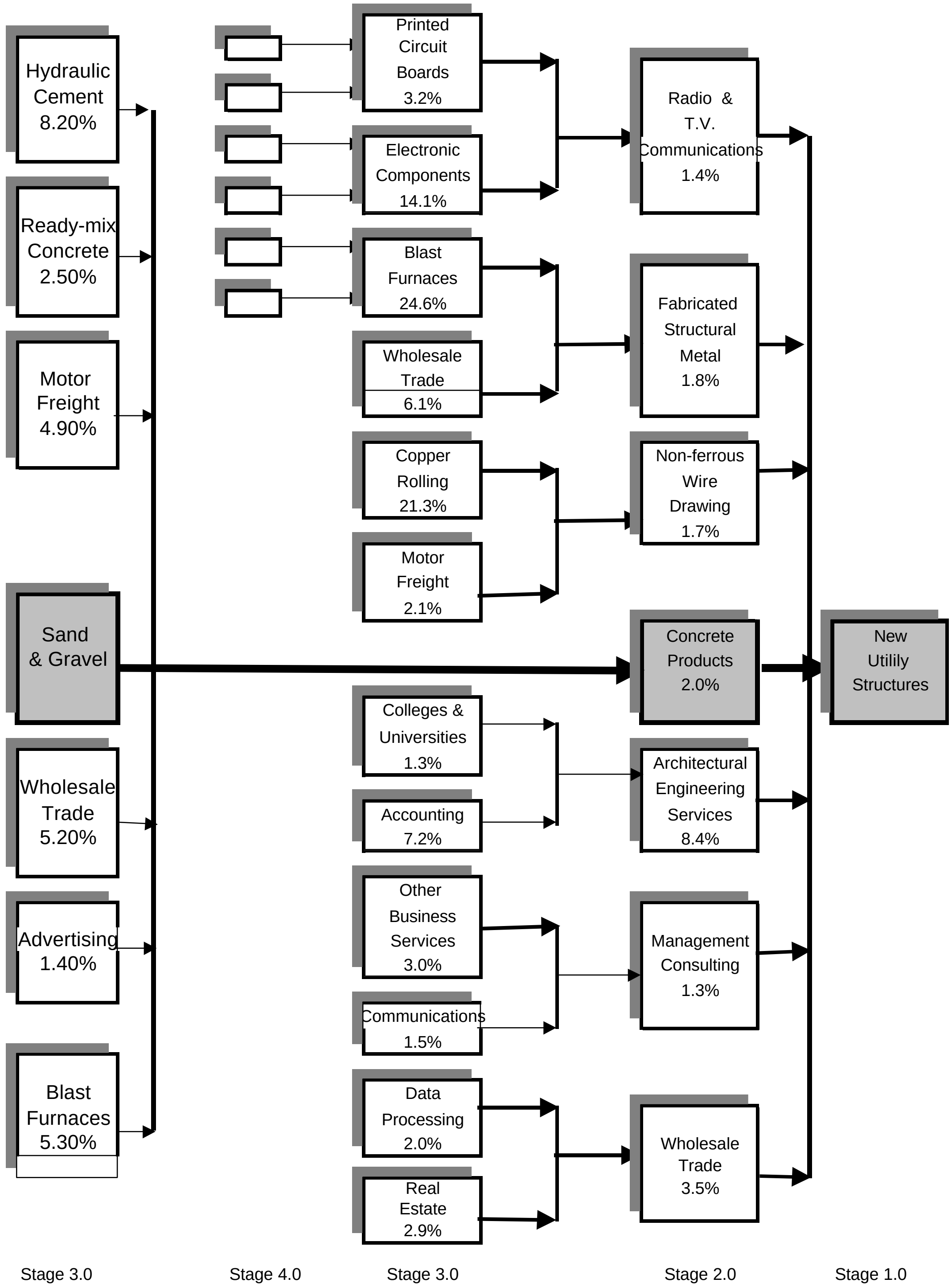

FIGURE 11.4.1-2
LINKS BEHIND THE PRIMARY CHAIN

Thus far, the analysis has dealt only with purchases that enterprises make of other enterprises. In addition to these "intermediate" inputs, each sector also employs workers directly, pays rent and taxes, and earns profits on the invested capital. These are the categories of "value added" (as opposed to "intermediate" or already-fabricated) inputs. Each of the rectangular-shaped sectors depicted in Figures 11.4.1-1 and 11.4.1-2, therefore, also requires these "value added" or primary inputs which are represented in Figure 11.4.1-3 as the parallelograms beneath the rectangles of the chain of direct or indirect inputs.

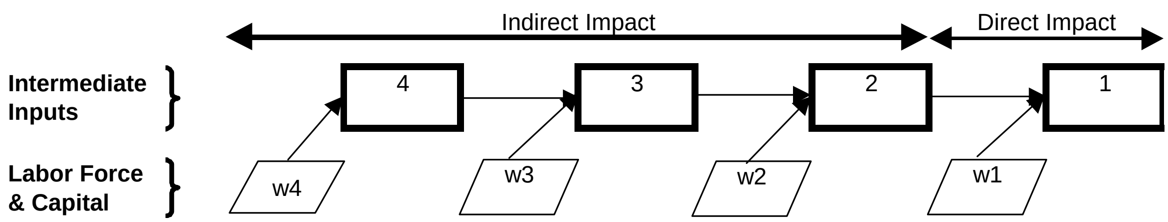

FIGURE 11.4.1-3
THE CHAIN WITH PRIMARY INPUTS INCLUDED

"Induced" impacts are the cumulative economic effects that result from the spending of the workers' earnings. This is illustrated in Figure 11.4.1-4 by the sales of bread from sector 5 to all the workers, W1 – W4, who are employed in sectors 1-4, plus the sale of flour, sector 6 together with its millers, W6, and the sale of grain, sector 7 with its farmers, W7. Bread may be sold to workers W5, W6, and W7, and this would also be counted in the induced impact. The regional model does not trace the feedbacks of the other categories of value-added, such as rent, taxes, and profits.

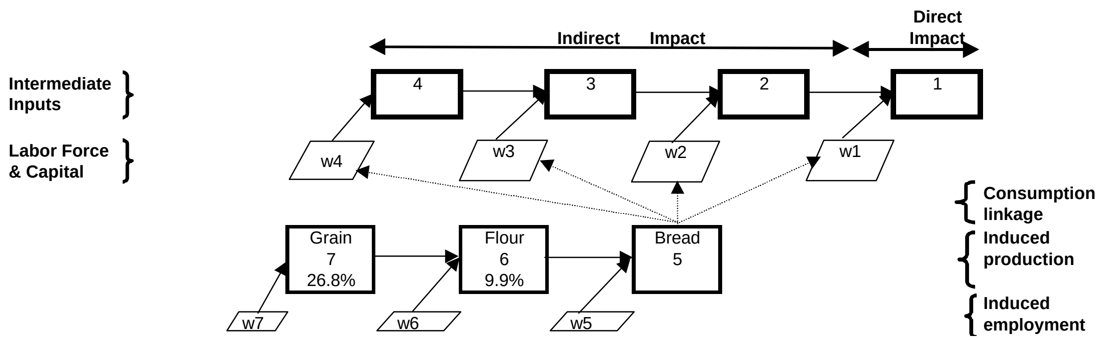

FIGURE 11.4.1-4
THE CHAIN WITH FAMILY EXPENDITURES

The chains of the induced impacts can be extremely important in regions where consumption activity is strong and services are well developed. In such areas, relatively weak direct and indirect impacts may lead to surprisingly high induced impacts. Therefore, it is the sum of all the impacts –direct, indirect, and induced— that is of interest in evaluating the regional effects of the restoration plans.

The actual computation of all the chains and impacts sketched above can be undertaken once the economic character of the region is cast into a statistical framework that specifies the inputs into each activity and the destination of the sales of each activity. The arrangement of data in this form is known as the "input-output table," and information for this table is gathered and reconciled by a number of statistical agencies.[10]

Once the regional accounts are established for the most recent year possible, then the statistical structure may be manipulated to answer the following question: what will be the effect of new major expenditures on the levels of output, earnings, and employment in the region, given the stability of the present economic structure and proportionate relationships between producing sectors? This means that the future economy is likely to look like the present one and that doubling the output of the construction sector, for example, will require a doubling of the current inputs, including the elements of value-added.

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[10] The Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce is responsible for publishing the US input-output tables. See Ann M. Lawson "Benchmark Input Output Accounts for the US Economy, 1992" in Survey of Current Business, November 1997, pp.36-86, and See Minnesota IMPLAN Group, Inc., IMPLAN Professional: User's Guide, Analysis Guide, Data Guide. Stillwater, MN: 1996, pp. 201-262.

The procedures for analyzing these impacts are now fairly well developed, but considerable care must be exercised in specifying, on as detailed a level as possible, the new activities and their magnitudes. Total construction costs of hundreds of millions of dollars must be disaggregated by the constituent line items and each of these assigned to a producing sector. The total economic impact of a project can then be computed as the sum of the chains triggered by all the intermediate purchases, for example, of concrete, steel rods, pumps, earthmoving, and engineering services, that are required, together with their inputs, the newly added value added, and the production triggered by the workers' spending.

E.11.4.2 The Regional Input-Output Structure

To get acquainted with input-output accounting as well as the characteristics of the South Florida region, the 528 economic sectors of the IMPLAN statistical framework have been aggregated into four major sectors.[11] The contents of each of the four major sectors is given in Table 11.4.2-1.

An aggregated input-output table for South Florida is presented in Table 11.4.2-2. Each vertical column in this table gives the recipe of inputs needed to produce that sector's final sales. Reading across the rows identifies the sector-destinations of those sales.

Inputs are of two types. The first five rows of Table 11.4.2-2 list the "intermediate inputs," the ingredients purchased from other sectors including purchases from other enterprises in the same sector. Thus, the agricultural-mining sector, column [1], purchases $628 million worth of products and services from enterprises within agriculture, row [1], plus $49 million from construction, row [2], $426 million from manufacturing, row [3], and $587 million from services, row [4]. The sum of intermediate inputs is $1.68 billion, given in row [5].

[11] For the reconciliation of the BEA categories with the 528 IMPLAN sectors, see Minnesota IMPLAN, <u>IMPLAN Professional</u>, Appendix A, pp. 269-79. The South Florida table is constructed by applying the sectoral totals for 1995 from the counties in the study area to the technologies given in the most recent national input-output table.

Table 11.4.2-1
The Four Major Sectors of South Florida

4-Sector Aggregation Scheme	528-Sector Aggregation Scheme
1. Agriculture and Mining (A)	47 sectors, including livestock, field crops, sugar crops, fruits and vegetables, greenhouses, landscape services, all mining, sand & phosphate rock quarrying
2. Construction (C)	10 sectors, including new homes, industrial & utility structures, maintenance & repair of structures & wells
3. Manufacturing (M)	375 sectors, including food processing, sugar mills, beverages, cigarettes, textiles, furniture, drugs, metals, motors, machinery, chemicals, vehicles, scientific equipment
4. Services (S)	96 sectors, including transportation, utilities, trade, finance, real estate, personal & business services, auto repair, entertainment & recreation, medical, legal, educational, social services, professional, all levels of government
Total	528 sectors

The second type of input consists of the categories of value-added, which are here grouped into two major portions: wages and salaries, row [6], valued at $1.10 billion, and “other,” row [7], which includes profits, rent, and taxes, valued at $1.27 billion. Total value added, row [8], is thus $2.37 billion. The grand sum of all costs, known as “gross inputs,” row [9], is $4.06 billion. Total employment in the agricultural or “A” sector is 93,100 workers, given in line [10] of column [1].

The sales or deliveries of the products of the agricultural-mining sector are read across the columns of the table. Thus, agriculture, row [1], sells $628 million to itself, $256 million to construction or “C,” column [2], $ 1.66 billion to manufacturing or “M,” column [3], and $ 1.72 billion to services or “S,” column [4]. The value of total sales from one sector (row) to other sectors for further processing is called “intermediate demand,” which, in the case of agriculture, amounts to $ 4.27 billion, shown in row [1] and column [5].

Table 11.4.2-2
South Florida Regional Input-Output Table
1995
(in millions of dollars)

Outputs / Industries → Inputs / Commodities ↓	[1] A	[2] C	[3] M	[4] S	[5] Total Intermediate Demand	[6] Household Expend.	[7] Other Final Demand	[8] Total Final Demand	[9] Total Output
	Intermediate Demand								
[1] Agriculture, Mining (A)	628	256	1,668	1,723	4,275	475	-684	-209	4,066
[2] Construction (C)	49	18	191	3,767	4,025	0	13,265	13,265	17,290
[3] Manufacturing (M)	426	6,059	9,094	9,956	25,534	15,768	-15,635	133	25,667
[4] Services (S)	587	4,066	5,189	42,750	52,592	62,995	64,068	127,063	179,655
[5] Total Intermediate Inputs	1,689	10,399	16,142	58,196	86,426	[79,238]			
[6] Wages & Salaries	1,102	5,008	6,572	66,196	[78,801]				
[7] Other Value Added (profits, rent, taxes)	1,275	1,884	2,953	55,264	61,453				
[8] Total Value Added	2,377	6,892	9,525	121,460				140,254	
[9] Gross Input	4,066	17,290	25,667	179,655					266,679
[10] Employment (1,000)	93.1	198.9	172.9	2,470.0				Sum	2,934.6

Sales to households, government, exports sent outside the region, imports received from outside the region, and sales regarded as investments are all classified as “final demand.” The regional table shown in Figure 11.4.2-2 divides final demand into two categories, “household expenditures,” shown in column [6], and “other final demand,” shown in column [7]. The latter includes all final sales other than to individual consumers. (The negative numbers in rows [1] and [3] of “other final demand” and in row [1] of “total final demand,” column [8], indicate the dominance of imports over all the other categories of final demand. The convention is to treat sales, including exports, as positive numbers which, in these three cases, have been outweighed by the value of imports, which is treated as a negative number.)

The sum of all the costs of “making” products, including profits, must equal the value of the sales of the products. Thus, the column sum of gross inputs purchased by agriculture, which is $4.06 billion, as shown in col. [1], row [9], must equal the value of total sales of A of $4.06 billion, shown in row [1], column [9]. Total intermediate inputs for the four sectors must equal total intermediate demands, that is, $ 86.4 billion, shown in row [5], column [5]. Total value added, which is the sum of all payments to the “factors” of production (labor, capital, land), plus taxes), must equal total final demand, that is, $ 140.2 billion, shown in row [8], column [8]. The value of gross inputs for the entire region equals the value of total output for the region, which is $ 226.67 billion, shown in row [9], column [9]. Total employment is 2.9 million workers, is shown in row [10], column [9].

The sectoral breakdowns –the vertical columns — summarize the fixed “recipes” for producing each sector’s outputs. Doubling final agricultural sales to households, shown in row [1], column [6], for example, requires doubling all the inputs into agriculture, including all the components of value-added and employment. But doubling final sales of agriculture also means doubling the $426 million that A buys from M, shown in column [1], row [3]. This, in turn, means that M must increase its output by a further $426 million, by purchasing more of the inputs according to the “recipe” found in column [3]. The final resolution of all these chains is computed by the mathematical process known as “inverting the input-output matrix,” and once accomplished, the statistical results provide shortcuts in the application to impact analysis.

It should be noted that the traditional definition of the input-output table is specified only by the rows and columns of Intermediate Demand, which is the lightly shaded area in Table 11.4.2-2. (from row [1]/column [1] to row [5]/column [5]). However, the inclusions of wages and salaries, row [6], and of household expenditures, column [6] (i.e., the more darkly shaded area in this table), makes it possible to compute the "induced" impacts of employees' spending within the region.[12]

The internal structure of the economy -who sells to whom and who buys from whom—is thus totally specified for all the sectors of the input-output table. It also gives a clear, analytic breakdown of the importance of each sector in the region in terms of value sold both to final and to intermediate demand. The largest of the four major sectors is services, column [4] and row [4], which purchases a total of $ 58 billion worth of intermediate inputs from other sectors, pays $ 66.2 billion in wages and salaries, and employs 2.47 million workers in the region, more than all the other sectors together! The service sector also dominates sales to households, which total $ 62.99 billion, and sales of $64.06 billion to the other categories of final demand.

E.11.4.3 Purchasing From Inside And Outside The Region

The regional economy is, by its nature, extremely "open" to products purchased from other areas. Regions tend to specialize in certain activities, buying what they need from other regions. Therefore, in evaluating the impacts of a given project on the region, it is helpful to have a measure of its economic "porousness" or "openness." Expenditures of $100 million could cause major ripples within an area or disappear without a trace, depending on the local economic "linkages" that exist between sectors in the region.

The input-output table shown above in Table 11.4.2-2 gives all the flows between sectors, regardless of whether the inputs are imported or locally produced. These "recipes," expressed as fractions of each column, and give the "direct requirements" for each sector, are called "gross absorption coefficients." However, only a portion of each of these ingredients is actually bought within the region, and this local portion is known as the regional purchase coefficient. The resulting share of each item in each column that is bought locally is called the "regional" (as opposed to "gross") absorption coefficient, and it is this fraction that traces the direct impact of new expenditure on the region. How these coefficients function and what can be learned from them will be examined in this section.

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[12] The first practical computation of this type which "closed" the input-output table by including income and expenditures within the basic matrix was done by R. Weisskoff, "Income Distribution and Export Promotion in Puerto Rico." In Advances in Input-Output Analysis, edited by K. Polenske and J. Skolka. Cambridge, MA: Ballinger Publishers, 1976. pp. 205-228. The computation of the induced impacts was extended to U.S. data by IMPLAN a decade later. On the importance of the inclusion of consumption linkages in improving the accuracy of forecasts, see R. Weisskoff, Factories and Food Stamps: The Puerto Rico Model of Development. Baltimore, MD: Johns Hopkins University Press, 1985, ch. 1-5, and Adam Rose, B. Stevens, and G. Davis, Natural Resource Policy and Income Distribution. Baltimore, MD: Johns Hopkins University Press, 1988, ch. 2 and 4.

The flows of annual expenditures laid out in ***Table 11.4.2-2*** above have been made into percentages, based on the total inputs needed by each of the major sectors, A (for agriculture), C (for construction), M (for manufacturing), and S (for services). These are shown in ***Table 11.4.3-1***.

Table 11.4.3-1
Direct Requirements
Gross Absorption Coefficients
(with no imports)

	A	**C**	**M**	**S**	**HH Exp.**
A	0.154	0.015	.0065	0.010	0.006
C	0.012	0.001	0.007	0.021	0.000
M	0.105	0.350	0.354	0.055	0.199
S	0.144	0.235	0.202	0.238	0.795
Sum Intermediate Demand	0.415	0.601	0.628	0.324	1.000
Value-added	0.585	0.399	0.372	0.676	
Total	1.000	1.000	1.000	1.000	

Where:

A = Agriculture & Mining
C = Construction
M = Manufacturing
S = Services
HH Exp = Household Expenditures

In the agricultural sector, for example, intermediate purchases and value-added are responsible for 41.5% and 58.5%, respectively, of total inputs. In the service sector, by contrast, intermediate purchases and value-added account for 32.4% and 67.6%, respectively, of total inputs. The right-most column in the table, household expenditure, gives the distribution of household expenditure among the sectors: 79.5% is spent on services, which includes rent, utilities, and retail markups, in contrast to 19.9% spent on manufactured goods and 0.6% spent on agriculture.

The high proportion of food, fuel, fertilizer, and manufactures imported by South Florida from other regions is reflected in the regional purchase coefficients shown in ***Table 11.4.3-2***. For example, only 22% of agricultural goods and 19% of manufactures are purchased locally, in contrast to 99% for construction and 84.2% for services.

Table 11.4.3-2
Regional Purchase Coefficients
(share of each sector's intermediate goods bought locally)

Sector	Percent
A	22.1%
C	99.4%
M	19.0%
S	84.2%

The combination of information from the two previous tables provides estimates of the regional absorption coefficients, shown in ***Table 11.4.3-3***. Here, the column fractions give the shares spent locally of each dollar's worth of inputs. In agriculture, for example, 18.8 cents of each total dollar are paid to local intermediate suppliers and 24.9 cents to local workers. This is relatively low compared to the fractions of spending of the service sector that remain in the area – 23.4 cents for local intermediate purchases and 36.8 cents for local compensation.

The distinction between the gross and regional absorption coefficients (***Tables 11.4.3-1*** and ***11.4.3-3***) highlights the difficulty encountered when a region tries to capture the economic linkages normally associated with major sectors. In the case of South Florida, the high degree of "openness" of the agriculture and manufacturing sectors reduces the degree of cohesiveness of the local economy and causes, in effect, a "leakage" or loss of funds to other regions. Florida's growth, in other words, contributes to the prosperity of other regions, and except for the service sector, the region must attract fresh sources of funds to sustain its own growth.

Table 11.4.3-3
Direct Requirements, Net of Imports
Regional Absorption Coefficients

	A	C	M	S	HH Exp.
A	0.034	0.003	0.014	0.002	0.001
C	0.012	0.001	0.007	0.021	0.000
M	0.020	0.067	0.067	0.011	0.038
S	0.122	0.199	0.170	0.200	0.669
Sum	0.188	0.270	0.258	0.234	1.000
Compensation	0.249	0.290	0.256	0.368	
Total Local	0.437	0.560	0.514	0.602	

A summary comparison of the sectoral structure of the region is shown in ***Table 11.4.3-4*** and is based on the rows of the input-output table. Services are shown to dominate the economy, accounting for 79.3% of output, 83.9% of compensation and 84% of regional employment. Manufacturing ranks second in its share of output and earnings but third, behind construction, in employment.

Table 11.4.3-4
Characteristics of the Four Primary Sectors in South Florida

Sector	Share Output	Share Compensation	Share Employment
A	1.8%	1.4%	3.2%
C	7.6%	6.4%	6.8%
M	11.3%	8.3%	5.9%
S	79.3%	83.9%	84.1%
Total	100.0%	100.0%	100.0%

The full regional input-output model for South Florida, with all 528 sectors, will now be utilized to evaluate the impacts of the restoration expenditures.[13]

[13]For other recent studies in the South Florida region, see R.L. Degner, S.D. Moss, and W.D. Mulkey, Economic Impact of Agriculture and Agribusiness in Dade County, Florida. Gainesville: Institute of Food and Agricultural Sciences, August 1997, and D.B.K. English, W. Kriesel, V. R. Leeworthy and P.C. Wilely, The Economic Contribution of Recreating Visitors to the Florida Keys/Key West. NOAA, November 1996.

E.11.5 REGIONAL ECONOMIC IMPACTS

E.11.5.1 Overall Impacts: Output, Jobs, and Earnings

The impact of all the categories of expenditure on gross output (sales), jobs, and earnings were computed for each alternative (***Tables 11.5.1-1***, ***2*** and ***3***). The expenditures responsible for each type of impact were then converted into uniform annual equivalents to account for the degree to which each impact would occur at different periods in the future and for differing lengths of time (***Tables 11.5.1-4, 5***, and ***6***).

For each alternative and for each indicator, three options are presented, depending on the assumptions applying to the output of the agricultural lands. In terms of output (***Table 11.5.1-1***), the impacts range from $ 278.5 million to $ 595.2 million when the foregone production of the EAA lands is subtracted (line G[1]). The impacts range from 0.12% to 0.26% of current total output in the study area. A similar range is found for the impacts on jobs and earnings.

When the impact-causing expenditures are converted into uniform annual equivalent values, then the effects are reduced (***Tables 11.5.1-4, 5,*** and ***6***). The total impacts on output for the medium option in which only EAA sugar output has been considered (line G [1] of ***Table 11.5.1-6***) range from 0.09% to 0.19% of regional output or less than 1/5th of one percent of total study area.

The impacts of the alternative restoration plans appear to be small compared to the total level of economic activity in the project area for a number of reasons. First, the highest level of new construction activity anticipated, for example, in alternative D-13r, is estimated to be $300.7 million per year (from ***Table 11.3.4*** above, line 2A). The normal level of all construction activity in the region, however, has been on the order of $9.0 *billion* per year.[14] The restoration project therefore represents a 3.34% or1/30th addition to the total level of regular construction in the region. In addition, the features of the plan which account for the greatest share of construction and maintenance costs rely heavily on imported materials and on technologies not yet acquired by local manufacturing and construction enterprises.

Despite the small quantitative effects, the restoration project may have significant effects on the region by securing the unique amenities of the area, the benefits of which fall outside the scope of traditional economic impact analysis.

[14] See 1997 Fla. Stat. Abstr., Tables 11.03, 11.15, and 11.20 to assess the share of S. Fl. in the statewide total.

TABLE 11.5.1-1
Grand Summary
Regional Economic Impacts on Output*
(millions of $1995)

EXPENDITURE TYPE	ANNUAL GROSS OUTPUT Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
A. Annual Construction Costs	221.6	242.8	291.5	370.5	376.9
B. Annual Real Estate Costs	69.4	79.0	80.3	82.1	111.5
C. Loss to agricultural land reduction:					
(1) EAA sugarcane only	-103.3	-103.3	-103.3	-103.3	-103.3
(2) All agricultural land	-192.0	-202.5	-336.4	-336.4	-336.4
D. Gains to modified water deliveries	3.1	2.7	3.0	2.7	2.9
E. Monitoring Costs	8.5	8.5	8.5	8.5	8.5
F. Operation and Maintenance	79.2	86.2	153.2	196.4	198.7
G. Total Impacts with:					
(1) EAA sugarcane only (as % of region)	278.5 (0.1229%)	315.9 (0.1394%)	433.2 (0.1911%)	556.9 (0.2457%)	595.2 (0.2626%)
(2) All agricultural land (as % of region)	189.8 (0.0837%)	216.7 (0.0956%)	200.1 (0.0883%)	323.8 (0.1428%)	362.1 (0.1597%)
(3) No agricultural land (as % of region)	381.8 (0.1684%)	419.2 (0.1849%)	536.5 (0.2367%)	660.2 (0.2912%)	698.5 (0.3081%)

* Note: Impacts from annual construction and real estate costs (lines A & B) represent the annual impact for a 20-year implementation period. Annual monitoring costs (line E) occur throughout the 50-year period. The other categories of costs (lines C, D, & F) represent the full effect of operations when implementation is finished.

TABLE 11.5.1-2
Grand Summary
Regional Economic Impacts on Jobs*
(number of jobs created)

EXPENDITURE TYPE	ANNUAL GROSS OUTPUT				
	Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
A. Annual Construction Costs	2,274	2,539	3,071	3,876	3,953
B. Annual Real Estate Costs	495	563	573	586	795
C. Loss to agricultural land reduction:					
(1) EAA sugarcane only	-1,194	-1,194	-1,194	-1,194	-1,194
(2) All agricultural land	-2,391	-2,537	-4,070	-4,070	-4,070
D. Gains to modified water deliveries	36	31	35	32	34
E. Monitoring Costs	155	155	155	155	155
F. Operation and Maintenance	1,369	1,464	2,601	2,995	3,062
G. Total Impacts with:					
(1) EAA sugarcane only (as % of region)	3,135 (0.1068%)	3,558 (0.1212%)	5,241 (0.1786%)	6,450 (0.2198%)	6,805 (0.2319%)
(2) All agricultural land (as % of region)	1,938 (0.0660%)	2,215 (0.0755%)	2,365 (0.0806%)	3,574 (0.1218%)	3,929 (0.1339%)
(3) No agricultural land (as % of region)	4,329 (0.1475%)	4,752 (0.1619%)	6,435 (0.2193%)	7,644 (0.2605%)	7,999 (0.2726%)

* Note: Impacts from annual construction and real estate costs (lines A & B) represent the annual impact for a 20-year implementation period. Annual monitoring costs (line E) occur throughout the 50-year period. The other categories of costs (lines C, D, & F) represent the full effect of operations when implementation is finished.

TABLE 11.5.1-3
Grand Summary
Regional Economic Impacts on Earnings*
(millions of $1995)

EXPENDITURE TYPE	ANNUAL GROSS OUTPUT				
	Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
A. Annual Construction Costs	65.9	72.6	87.0	109.5	111.6
B. Annual Real Estate Costs	9.8	11.1	11.3	11.6	15.7
C. Loss to agricultural land reduction:					
(1) EAA sugarcane only	-13.4	-13.4	-13.4	-13.4	-13.4
(2) All agricultural land	-30.0	-32.5	-49.0	-49.0	-49.0
D. Gains to modified water deliveries	0.4	0.3	0.3	0.4	0.4
E. Monitoring Costs	3.8	3.8	3.8	3.8	3.8
F. Operation and Maintenance	23.4	25.9	46.6	60.1	60.9
G. Total Impacts with:					
(1) EAA sugarcane only (as % of region)	89.9 (0.1142%)	100.3 (0.1274%)	135.6 (0.1723%)	172.0 (0.2185%)	179.0 (0.2274%)
(2) All agricultural land (as % of region)	73.3 (0.0931%)	81.2 (0.1032%)	100.0 (0.1270%)	136.4 (0.1733%)	143.4 (0.1822%)
(3) No agricultural land (as % of region)	103.3 (0.1312%)	113.7 (0.1445%)	149.0 (0.1893%)	185.4 (0.2355%)	192.4 (0.2444%)

* Note: Impacts from annual construction and real estate costs (lines A & B) represent the annual impact for a 20-year implementation period. Annual monitoring costs (line E) occur throughout the 50-year period. The other categories of costs (lines C, D, & F) represent the full effect of operations when implementation is finished.

TABLE 11.5.1-4
Grand Summary
Regional Economic Impacts on Output*
In Uniform Annual Equivalent Values (UAEV)*
(millions of $1995)

EXPENDITURE TYPE	ANNUAL GROSS OUTPUT				
	Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
A. Annual Construction Costs	174.7	191.5	229.9	292.2	297.3
B. Annual Real Estate Costs	54.7	62.3	63.3	64.8	87.9
C. Loss to agricultural land reduction:					
(1) EAA sugarcane only	-59.3	-59.3	-59.3	-59.3	-59.3
(2) All agricultural land	-110.3	-116.3	-193.2	-193.2	-193.2
D. Gains to modified water deliveries	1.5	1.3	1.5	1.3	1.4
E. Monitoring Costs	8.8	8.8	8.8	8.8	8.8
F. Operation and Maintenance	39.5	42.9	76.3	97.8	99.0
G. Total Impacts with:					
(1) EAA sugarcane only (as % of region)	219.9 (0.0970%)	247.5 (0.1092%)	320.5 (0.1414%)	405.6 (0.1790%)	435.1 (0.1919%)
(2) All agricultural land (as % of region)	168.9 (0.0745%)	190.5 (0.0840%)	186.6 (0.0823%)	271.7 (0.1224%)	301.2 (0.1329%)
(3) No agricultural land (as % of region)	279.2 (0.1232%)	306.8 (0.1353%)	379.8 (0.1675%)	464.9 (0.2051%)	494.4 (0.2182%)

* Note: UAEV represents the conversion of the impacts into an annual equivalent as they are estimated to occur over the 50-year period of analysis, using a discount rate of 6.875%. The factors for UAEV conversion for the various categories of costs are: 0.78872 for lines A & B; 0.57445 for line C; 0.49812 for line D; 1.03380 for line E; and 0.49812 for line F. Differences between the conversion factors for the different categories are due to the timing of the costs and the duration of their impacts.

TABLE 11.5.1-5
Grand Summary
Regional Economic Impacts on Jobs*
In Uniform Annual Equivalent Values (UAEV)*
(number of jobs created)

EXPENDITURE TYPE	ANNUAL GROSS OUTPUT Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
A. Annual Construction Costs	1,793.5	2,002.6	2,422.2	3,057.1	3,117.8
B. Annual Real Estate Costs	390.4	444.0	451.9	462.2	627.0
C. Loss to agricultural land reduction:					
(1) EAA sugarcane only	-685.9	-685.9	-685.9	-685.9	-685.9
(2) All agricultural land	-1,373.5	-1,457.4	-2,338.0	-2,338.0	-2,338.0
D. Gains to modified water deliveries	17.9	15.4	17.4	15.9	16.9
E. Monitoring Costs	160.2	160.2	160.2	160.2	160.2
F. Operation and Maintenance	681.9	729.2	1,295.6	1,491.9	1,525.2
G. Total Impacts with:					
(1) EAA sugarcane only (% of region)	2,358.0 (0.0804%)	2,665.5 (0.0908%)	3,661.4 (0.1247%)	4,501.4 (0.1534%)	4,761.2 (0.1623%)
(2) All agricultural land (% of region)	1,689.0 (0.0576%)	1,894.0 (0.0645%)	2,009.3 (0.0685%)	2,849.3 (0.0971%)	3,109.1 (0.1060%)
(3) No agricultural land (% of region)	3,043.9 (0.1037%)	3,351.4 (0.1142%)	4,347.3 (0.1481%)	5,187.3 (0.1768%)	5,447.1 (0.1856%)

*Note: UAEV represents the conversion of the impacts into an annual equivalent as they are estimated to occur over the 50-year period of analysis, using a discount rate of 6.875%. The factors for UAEV conversion for the various categories of costs are: 0.78872 for lines A & B; 0.57445 for line C; 0.49812 for line D; 1.03380 for line E; and 0.49812 for line F. Differences between the conversion factors for the different categories are due to the timing of the costs and the duration of their impacts.

TABLE 11.5.1-6
Grand Summary
Regional Economic Impacts on Earnings*
In Uniform Annual Equivalent Values (UAEV)*
(millions of $1995)

EXPENDITURE TYPE	ANNUAL GROSS OUTPUT				
	Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
A. Annual Construction Costs	52.0	57.3	68.6	86.4	88.0
B. Annual Real Estate Costs	7.7	8.8	8.9	9.1	12.4
C. Loss to agricultural land reduction:					
(1) EAA sugarcane only	-7.7	-7.7	-7.7	-7.7	-7.7
(2) All agricultural land	-17.2	-18.7	-28.1	-28.1	-28.1
D. Gains to modified water deliveries	0.2	0.1	0.1	0.2	0.2
E. Monitoring Costs	3.9	3.9	3.9	3.9	3.9
F. Operation and Maintenance	11.7	12.9	23.2	29.9	30.3
G. Total Impacts with:					
(1) EAA sugarcane only (as % of region)	67.8 (0.0861%)	75.3 (0.0957%)	97.0 (0.1232%)	121.8 (0.1547%)	127.1 (0.1615%)
(2) All agricultural land (as % of region)	58.3 (0.0741%)	64.3 (0.0816%)	76.6 (0.0973%)	101.4 (0.1288%)	106.7 (0.1356%)
(3) No agricultural land (as % of region)	75.5 (0.0959%)	83.0 (0.1054%)	104.7 (0.1330%)	129.5 (0.1645%)	134.8 (0.1713%)

*Note: UAEV represents the conversion of the impacts into an annual equivalent as they are estimated to occur over the 50-year period of analysis, using a discount rate of 6.875%. The factors for UAEV conversion for the various categories of costs are: 0.78872 for lines A & B; 0.57445 for line C; 0.49812 for line D; 1.03380 for line E; and 0.49812 for line F. Differences between the conversion factors for the different categories are due to the timing of the costs and the duration of their impacts.

E.11.5.2 Timing and Persistence of Impacts

Since the total effects of the six categories of impacts occur over different time horizons, the summary effects given in ***Tables 11.5.1-1*** through ***11.5.1-3*** represent the upper limit if all these effects were to occur simultaneously. In reality, the impacts of the construction and real estate purchases (lines A and B) last only as long as those activities are carried out, which is assumed to be 20 years. The impacts of the monitoring and operation-maintenance costs (lines E and F) begin at a relatively low level at the time the project is initiated, rise to a maximum, and then continue at a constant level once the project is completed. The impacts due to the transfer of agricultural land to water storage (line C) begin once the project is initiated and persist throughout the study period.[15] The agricultural gains due to modified water deliveries (line D), however, may be delayed until the project is near completion. The uniform annual equivalent values shown in ***Tables 11.5.1-4*** through ***11.5.1-6*** represent an estimation of the effect of the differences in timing of different impacts, and are generally slightly lower than the impact values in ***Tables 11.5.1-1*** through ***11.5.1-3***.

Moreover, the people who become unemployed will not necessarily be the same people who will be employed as a result of the project for a number of reasons. The skills and needs for new workers associated with construction do not necessarily coincide with those who are being displaced. Nor will the timing of the unemployment necessarily coincide with the timing of the newly employed.

Recent unemployment surveys from the U.S. Bureau of Labor Statistics have found from 87 to 90% of all the unemployed find new jobs within six months.[16]

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[15] This also represents an upper limit of this impact category, as it assumes that the effect of soil subsidence on crops grown on these lands is offset by the gains in productivity due to improved genetic strains. This may be unlikely, even in view of the reduced rates of subsidence found recently in a sample of five transects taken only in the upper belt of the EAA closest to Lake Okeechobee. See S.F. Shih, B. Glaz, and R.E. Barnes, Jr., Subsidence Lines Revisited in the Everglades Agricultural Area, 1997, IFAS University of Florida Agricultural Experiment Station Bulletin (Tech.) 902 (December 1997). In reviewing other studies and forecasts of subsidence in the EAA, Snyder and Davidson wrote that earlier research had found the historical rates of subsidence predicted in 1951 to be on target as recently as 1988, and that by the year 2000, it was expected that 45% of the soils would be less than one foot thick over the limestone bedrock. "Today," they wrote in 1994, "some farmers are in fact growing sugarcane on soil somewhat less than 1 ft. in thickness over the bedrock, but already areas have been abandoned, and only a few years of conventional production can be expected from such soil." They anticipated that wetland crops or new types of activity would have to be undertaken in the EAA in view of the reduced soil cover. They concluded by asking, "Will millions of dollars be spent creating a method for dealing with today's problem, without considering that agricultural activity in the EAA will likely diminish, or change dramatically, in the future?" See G. H. Snyder and J.M Davidson, "Everglades Agriculture: Past, Present, and Future," Chapter 5, in S. M. Davis and J.C. Ogden, Everglades: the Ecosystem and Its Restoration (Boca Raton, FL: St. Lucie Press, 1994), pp. 108-109. Independently, an economic study of the EAA had estimated that by the year 2013, nearly 81,000 acres of agricultural land would have to shift to other land uses due to an organic soil layer of six inches or less. See Hazen and Sawyer, Twenty Year Evaluation: Economic Impacts from Implementing the Marjory Stoneman Douglas Everglades Restoration Act and the United States versus SFWMD Settlement Agreement. Contract Completion Report. (Hollywood, FL: August 1993), p. 4-17.

[16] U.S. Department of Labor, Bureau of Labor Statistics, Monthly Unemployment Surveys (July 1998), Table A-6, which gives summary results of monthly surveys from July 1997 to July 1998. A study of the effect on the timber industry in Washington and Oregon by the U.S. Department of Interior applied three different reemployment scenarios. It assumed that 92% of the unemployed workers would be reemployed within the first six months and the remaining 8% would be reemployed within the second six months. Alternative assumptions were 80/20 and 70/30 for the fractions employed in the first and second six-month periods. See Depart of Interior, "The Report of the Secretary of the Interior to the Endangered Species Committee Related to the Application by the Bureau of Land Management for Exemption from the Requirements of Section 7(a)(2) of

However, the most recent survey of "displaced" workers, that is, those who lost their jobs due to plant closings, found that three quarters of the long-tenured workers were re-employed within two years, and that one half of these were in jobs earning as much or more than their former ones. One fourth suffered earnings losses of 20 percent or more.[17] The rates of reemployment and the degree of salary recovery vary according to the experience of the workers, occupation, industry, age, sex, and race. Displaced workers may be able to find new employment within the region or migrate to other areas, depending on their skills and the types of new opportunities created in the regional economy.

E.11.5.3 Fiscal Impacts

There are tax implications of the various impacts. These include the additional revenue that will accrue to the state due to new corporate profits from local construction companies (impact category A), the profits of the local companies engaged in monitoring (category E), and the increase in profits of the agricultural corporations due to the gains from modified water deliveries (category G). The spending of the increased earnings of newly employed workers will result in increased local and state sales taxes.

The biggest loss of county revenue may be from the transfer of land from agricultural use to water storage. The most significant block of this type of land is the 60,000-acre tract in the Everglades Agricultural Area in western Palm Beach County. If this block of land were located in the belt currently assessed at $500/acre that is furthest from the lake in the southern-most border of the county, then the county would lose $30 million in taxable land, which represents 4.05% of the total assessed value of agricultural land but only .06 of 1% of the county's total assessed property value.[18] The loss of revenue to the county would be $600,000 per year, calculated at the current ad valorum millage rate of 20, and this represents .04 of 1% of the total revenue of Palm Beach County in 1995.[19] Alternatively, some of this land may be abandoned as the organic soil subsides to a few inches of thickness covering the bedrock. The losses in rural property taxes may also be offset by increases in urban property taxes due to rising employment and increases in revenues from local sales taxes and impact fees.

[Data in this section of the appendix is based on current working estimates available at the time of the regional impact analysis, and hence may not be based on precisely the same cost data being used in the rest of the report; nonetheless, the

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the Endangered Species Act," April 29, 1992.

[17] See U.S. Bureau of Labor Statistics, "Worker Displacement, 1995-97." (August 19, 1998) [http://stats.bls.gov/newsrel.htm]. The most recent findings are consistent with the previous two surveys. See "Worker Displacement during the Mid-1990s," BLS Report, August 22, 1996, and Jennifer M Gardner, "Worker Displacement: A Decade of Change." Monthly Labor Review (April 1995), Table 5, p. 51.
[18] See Tables 23.95 and 23.91 from 1997 Fla. Stat. Abstr.
[19] See Table 23.83, 1997 Fla. Stat. Abstr.

results of the impact evaluation and analysis are not expected to differ significantly from analysis based on the latest cost data.]

E.12 OTHER SOCIAL EFFECTS

E.12.1 OVERVIEW

The Other Social Effects (OSE) account considers the effects of alternative plans in areas that are not already contained in the NED and RED accounts. The categories of effects contained within the OSE account include:

- Urban and community impacts,
- Life, health, and safety factors,
- Displacement,
- Long-term productivity, and
- Energy requirements and energy conservation.

The C&SF alternative restoration plans could result in beneficial and adverse OSE within the study area. As is evident throughout this appendix, a variety of positive and adverse NED impacts on water supply (agricultural and urban), recreation, commercial fishing, and commercial navigation are expected to result from Everglades restoration. Similarly, the alternative restoration plans could have positive or adverse OSE impacts on south Florida associated with (1) plan implementation, including land acquisition, project construction, and operations and maintenance (O&M) activities, and (2) operation of the modified C&SF system. As in the case of the NED effects, the OSE account is concerned with the net effects of the alternative plans (i.e., the differences between the with- and without-project future conditions).

Some of the potential OSE impacts would occur primarily at the regional scale, and others would have more localized effects. At both scales, there may be some individuals and communities that are positively affected by Everglades restoration, some that are adversely affected, and many that are not affected at all. Relative to the size of the regional or local economies, the OSE effects may be minimal. However, if these effects occur predominantly within a limited geographic area, or affect a relatively small or vulnerable population, then the impacts can be disproportionately large. Therefore, the purposes of OSE analysis include not only determining the total magnitude of potential impacts, but also identifying the population (and its characteristics) which would be affected by any proposed action.

Some of the categories of effects typically included in the OSE account do not pertain to the alternative restoration plans. For example, the alternative plans are not expected to affect energy use or energy conservation in the study area. As will be noted, other categories of potential OSE impacts have been addressed previously in this appendix.

E.12.2 POTENTIAL URBAN AND COMMUNITY IMPACTS

Urban and community impacts is the principal category of potential OSE impacts associated with the alternative restoration plans. This category of impacts includes effects on income distribution, employment distribution, population distribution and composition, and quality of community life. Some urban and community impacts have previously been addressed in this appendix. For example, regional income effects and fiscal impacts were discussed in the Regional Economic Development analysis (Chapter 11). In addition, the impacts of agricultural water supply and municipal and industrial water supply were discussed in detail in Chapters 4 and 5, respectively.

The OSE assessment of urban and community impacts considers both the potential for exposure to the effects of the alternative restoration plans and the degree of vulnerability to potential impacts. Exposure refers to whether an individual or community is subject to the other social effects of the alternative plans. Vulnerability refers to the ability of that individual or community to respond or adjust to those effects.

Potential urban and community impacts of the alternative restoration plans could result from: (1) land acquisition and potential relocation of populations for reservoir and other project construction features, (2) reduced agricultural activity associated with taking the reservoir lands out of cultivation, and (3) construction activity associated with plan implementation. In general, construction activity is considered to have positive impacts. At the local scale, construction and O&M activities associated with the alternative restoration plans can have positive effects to local residents and communities by providing jobs, increasing local wages, increasing local sales, increasing tax revenues and generally benefiting the local economy.

Among the largest construction activities and land purchases associated with the alternative restoration plans are new reservoirs that are intended to add storage to the C&SF system. The proposed locations of these multiple storage facilities have not yet been established, but potential locations include the Everglades Agricultural Area, the Caloosahatchee and St. Lucie basins, and the Kissimmee Basin. The availability of contiguous parcels of low intensity, agricultural land is one of the most important economic considerations in locating these reservoirs. A real estate analysis will be conducted during the next phase of study to determine the exact location of the storage facilities.

Lands associated with new reservoirs will be purchased from existing property owners who will be paid fair market value and will qualify for relocation assistance payments under the guidelines established by PL 91-646, The Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970. The OSE effects of population displacement cannot be estimated until the detailed design phase, when the magnitude of land purchases, and the number and characteristics of affected landowners are determined. During this phase, property owners will be contacted by real estate personnel to determine their willingness to sell. Negotiations will commence with willing sellers. If the property owner is unwilling to sell, or if a negotiated price cannot be reached, the government may choose to exercise its power to acquire lands by eminent domain. The results of these negotiations will also influence the extent and severity of OSE effects on displaced populations.

The effects of the land purchases may also not be confined solely to the land owners. Because the Federal government is not subject to local real estate taxes, transfer of land title from private to public ownership often results in tax revenue losses to local jurisdictions, unless payments in lieu of taxes are provided. Land values in surrounding areas may also be affected by speculation in anticipation of project implementation, and real estate taxes can be affected by changes in property values.

Regardless of the impacts on the land owners, when agricultural land is taken out of production, the associated farm labor (resident and migrant) may lose their jobs, and the local economy and community can be adversely affected by the decrease in agriculture-related spending. In many rural areas of south Florida, agriculture provides the economic foundation for local economies and community life. The economic resilience and social cohesion of affected families and communities determine the severity and duration of the effects of the conversion of farm land to reservoirs.

Job loss can cause lowered self image, depression, and anger. Subsequent adverse social effects can often follow. Agricultural communities are not immune to the economic fluctuations of farm economies arising from weather, pests, price fluctuations, and foreign competition. However, when adversity is attributed to government decisions, resentment often replaces resolve and communities can be further strained by a sense of abandonment.

The low population densities in the rural areas of south Florida suggest that it is unlikely that the conversion of farm land to reservoirs would create major population displacements. In addition, the low labor intensity of agriculture in the areas under consideration for reservoir siting (e.g., sugar cane and citrus) indicate that the employment effects may also be small. However, many of the communities in these rural areas are small and dependent on agriculture for their prosperity. If a significant percentage of local farm land is converted to a reservoir, the impacts on those communities could be very significant.

There are a variety of social and economic factors that are important determinants of an individual's or community's ability to cope with adversity. One of the most important economic factors in the ability of individuals and groups to respond is the number of employment alternatives available locally. The ability to find another job depends on the education and training of the work force as well as the needs of local economic concerns, such as other farms, agricultural-related services, or some other local business. The socio-economic makeup of the community is also an important consideration of the ability of individuals and the community at large to cope with the adverse effects of large-scale agricultural land conversion. Some groups in society are recognized as having less opportunity to respond to adversity. These groups include ethnic and racial minorities, the elderly, and the poor. Table 12.2-1 presents a socio-economic vulnerability profile for each of the study area counties. This profile contains information that indicates the ability of the county population to respond to social and economic adversity. It is important to recognize that the county scale may not accurately reflect the ability of any given community or groups within a community to accommodate potential changes associated with the alternative restoration plans. More detailed studies of individual communities is not warranted until the potential reservoirs have been sited.

Table 12.2-1 contains the racial/ethnic mix of each of the study area counties, as well as population over 65 years of age, 1990 unemployment, per capita income, and the expected changes in employment and income from 1990 to 2010. While this table contains all of the study area counties, those counties which are potential locations of new reservoirs include:

- Palm Beach County (Everglades Agricultural Area),
- Lee County (Caloosahatchee Basin),
- Martin County (St. Lucie Basin), and
- Highlands, Osceola, Orange, Polk, and Okeechobee counties (Kissimmee Basin).

The study area counties have a wide range of ethnic compositions, proportions of elderly population, unemployment rates, and per capita incomes. In general, the rural counties in the study area, such as Hendry and Okeechobee, have relatively high levels of unemployment, low per capita incomes, high levels of poverty, and slow growth in employment and income. These socio-economic characteristics suggest that the rural counties of the study area – those that are expected to provide locations for new storage reservoirs – are areas that are least able to accommodate the associated economic and social effects on local communities. However, in these rural areas the affected populations should be relatively small.

Although the restoration of the Everglades ecosystems is a unique undertaking, there have been other projects and programs with similar goals and socio-economic contexts. One study conducted by the U.S. Department of the Interior assessed the national and regional economic impacts of not allowing timber harvests in certain old-growth forests in Oregon in order to protect the Northern Spotted Owl. One aspect of this study investigated the re-employment of timber workers who had been displaced by the cessation of local logging activities. Surveys of displaced loggers suggested that they found that 57% of displaced workers reported post-displacement wages equal to or above their previous wages. According to the Bureau of Labor Statistics, 92% of displaced workers find new jobs within one year, and the remaining 8% find jobs within two years.

TABLE 12.2-1
SOCIO-ECONOMIC VULNERABILITY PROFILE

County	White	Black	American Indian	Hispanic*	Other	Population Over 65	Unemployment Rate (1990)	Anticipated Annual Change in Employment (1990-2010)	1990 Per Capita Income**	Anticipated Annual Change in Income (1990-2010)	Percent of Population Below Poverty Level
Broward	82%	15%	0.2%	8.6%	2.7%	20%	5.5%	1.6%	$ 23,987 (119%)	0.9%	7.1%
Charlotte	95%	4%	0.1%	2.5%	1.0%	36%	5.0%	2.6%	$ 18,647 (92%)	1.2%	5.2%
Collier	91%	5%	0.3%	13.6%	3.7%	24%	5.6%	3.1%	$ 29,313 (145%)	1.1%	6.4%
Dade	73%	21%	0.2%	49.2%	6.4%	14%	7.0%	1.1%	$ 18,977 (94%)	1.1%	14.2%
Glades	79%	12%	5.7%	8.0%	3.3%	22%	8.8%	1.9%	$ 13,160 (65%)	1.4%	9.7%
Hendry	72%	27%	2.1%	22.3%	9.0%	11%	11.2%	2.2%	$ 16,217 (80%)	1.1%	15.3%
Highlands	87%	10%	0.3%	5.1%	2.4%	35%	8.1%	1.7%	$ 16,628 (82%)	0.8%	11.3%
Lee	91%	7%	0.2%	4.5%	1.8%	25%	4.3%	0.4%	$ 20,920 (103%)	1.1%	6.1%
Martin	92%	6%	0.2%	4.7%	2.5%	28%	6.6%	1.8%	$ 30,695 (152%)	1.3%	5.0%
Monroe	92%	5%	0.3%	12.3%	2.2%	18%	3.3%	1.3%	$ 22,979 (114%)	1.7%	7.0%
Okeechobee	84%	6%	0.5%	11.8%	8.8%	17%	8.1%	1.8%	$ 13,847 (68%)	1.0%	14.8%
Orange	80%	15%	0.3%	9.6%	4.9%	11%	5.5%	2.3%	$ 19,096 (94%)	1.1%	7.8%
Osceola	89%	5%	0.3%	11.9%	4.8%	14%	4.9%	3.4%	$ 15,565 (77%)	0.7%	6.9%
Palm Beach	85%	12%	0.1%	7.7%	2.5%	24%	6.6%	2.0%	$ 31,354 (155%)	1.5%	6.2%
Polk	84%	13%	0.3%	4.1%	1.9%	20%	8.9%	1.5%	$ 16,443 (81%)	1.1%	9.4%
St. Lucie	81%	16%	0.2%	4.0%	2.0%	22%	11.5%	2.1%	$ 16,179 (80%)	1.0%	8.5%

*Hispanic can be any race.

**(% relative to state average)

E.12.3 ADDITIONAL CONSIDERATIONS

The OSE also includes potential impacts on life, health, and safety. Most of these concerns have been addressed previously in this appendix in Chapter 5 (municipal and industrial water supply) and in Chapter 6 (flooding). However, in particular, the OSE can include the potential risks to life, property, and public services associated with structural failure of project elements. Perhaps the most significant concerns regard structural failure of the Herbert Hoover levee system around Lake Okeechobee. It is anticipated that the alternative restoration plans represent significant improvements over the without-project future conditions. Although the regulation schedule for the lake is assumed to be the same under the with- and without-project future conditions, the alternative restoration plans are expected to result in fewer high water events on the lake, thereby reducing the potential for the levee to experience a catastrophic structural failure.

The OSE account also includes issues of long-term economic productivity. As discussed in Chapter 4 (agricultural water supply), the alternative restoration plans should result in significant increases in long-term agricultural productivity by increasing water supplies available to farmers in the Everglades Agricultural Area and the Lower East Coast. The reduction in the frequency of agricultural drought conditions in south Florida will promote long-term productivity by limiting adverse effects associated with soil desiccation, especially in the EAA. These effects include muck fires and soil subsidence.

E.13 SUMMARY OF SOCIO-ECONOMIC EFFECTS

Congress authorized the U.S. Army Corps of Engineers (Corps) and its local partner, the South Florida Water Management District (SFWMD) to conduct the C&SF Project Comprehensive Review Study (Restudy) to develop a comprehensive plan for the purpose of restoring, preserving, and protecting the south Florida ecosystem, as well as meeting other water resource planning objectives such as water supply, water quality, and flood control. This appendix has assessed the economic effects of the five alternative ecosystem restoration plans formulated in the feasibility phase of the Restudy (Alternatives A-D, and the Recommended Plan). The economic evaluation of the alternative restoration plans has included the following elements distributed over 12 chapters. Each of these elements are discussed below.

- Socio-economic profile of the study area,
- National Economic Development (NED) effects of alternative plans,
- NED costs of alternative plans,
- Regional economic development (RED) effects, and
- Other social effects (OSE).

E.13.1 SOCIO-ECONOMIC PROFILE OF THE STUDY AREA

The socio-economic profile of the study area is a compilation of current and projected socio-economic information on the study area, including race, income, employment, age, and poverty. As described in Chapter 2, this profile serves three important functions. First, it supports the description of the study area. Second, the demographic and economic forecasts for the study area are critical determinants of future water use in the region. The water demands of urban areas in south Florida are an important factor in formulating the alternative restoration plans. Third, the socio-economic profile supports the Other Social Effects (OSE) analysis which considers, among other factors, the resilience of local economies and the cohesion of local communities in determining the social and economic impacts of the alternative plans.

The socio-economic profile of the study area describes a diverse region that includes urban and rural areas, wealthy and poor communities, and commercial and agricultural economies. The diversity has particular relevance for the OSE analysis, since it suggests different abilities of local communities to respond to the potential adverse or beneficial effects associated with implementation of the alternative restoration plans.

As described in Chapter 3, population growth is expected to increase urban water demands in south Florida, particularly in the Lower East Coast (LEC). The expected population growth has relevance for the Restudy, because the projections of increased water demands form important without-project conditions that are incorporated in the South Florida Water Management Model (SFWMM), the principal analytical tool of the Restudy. The extent to which expected population growth translates into new urban water demands also depends on the adoption of water-saving devices and attitudes towards water conservation and water use. To account for the uncertainty underlying population growth and water consumption patterns, several scenarios were included in the forecasts of future study area water demands.

E.13.2 NED EFFECTS OF THE ALTERNATIVE PLANS

The alternative restoration plans have been designed with the goal of restoring the Everglades ecosystems and meeting other water resource planning goals and objectives. The physical and operational changes to the regional water management system proposed to accomplish this goal could potentially have positive or adverse effects on other water-dependent activities in south Florida, including: agricultural and urban water supply, flooding, commercial navigation, recreation, and commercial and recreational fishing. Each of these impact categories is the subject of a separate chapter in this appendix. The results of these analyses are encapsulated in Table 13.2-1, and the potential positive and adverse NED effects of the alternative plans are summarized below.

E.13.2.1 Agricultural Water Supply

As described in Chapter 4, the potential effects of the alternative restoration plans on agricultural water supply are based on the magnitude and frequency of irrigation water shortages. If crops do not receive sufficient moisture from precipitation or irrigation, crop transpiration is reduced, and growth rates can be affected. Reduced growth rates result in lower crop yields and, ultimately, lower farm income. The economic effects of the alternative plans are the differences between expected farm income under the with- and without-project conditions.

The NED account includes the net farm income effects associated with changes in revenues or production costs resulting from plan implementation. The SFWMD has developed an economic post-processor (EPP) to assess the economic effects of agricultural water supply shortages. The EPP, which is embedded in the SFWMM, was used to estimate the value of unmet agricultural water demand in the LEC and the Everglades Agricultural Area (EAA) for the with- and without-project future conditions. ***Table 13.2-1*** presents the values of unmet agricultural water demand for the 2050 without-project (base) condition, the four alternative plans, and the recommended plan.

TABLE 13.2-1
SUMMARY OF ECONOMIC EFFECTS OF ALTERNATIVE RESTORATION PLANS
(all dollar values in $ millions)

IMPACT CATEGORY	WITH- AND WITHOUT-PROJECT CONDITIONS					
	2050 Base Condition	Alternative A	Alternative B	Alternative C	Alternative D	Recommended Plan
NED EFFECTS						
Agricultural Water Supply: Avg. annual value of unmet demand*	$2.6	$0.6 (+$2.0)	$0.9 (+$1.7)	$0.7 (+$1.9)	$0.8 (+$1.8)	$0.7 (+$1.9)
M&I Water Supply: Avg. annual value of unmet demand*	$31.8	$10.2 (+$21.7)	$10.3 (+$21.5)	$6.4 (+$25.4)	$4.6 (+$27.2)	$4.6 (+$27.2)
Flood Control	• Limited evaluation of impacts, since SFWMM not designed for flood studies.					
Commercial Navigation	• No significant difference expected between with- and without-project conditions.					
Recreation	• Problematic to quantify effects of alternative plans. • Current Expenditures: $404 million (parks/preserves); $598 million (region). • Current Consumer Surplus: $290 million (parks/preserves); $764 million (region).					
Commercial/Recreational Fishing	• Annual revenues estimated for commercial and guided & recreational sportfishing in five areas: Lake Okeechobee, St. Lucie & Caloosahatchee estuaries, and Biscayne & Florida bays. • Significant positive economic impacts are expected to result from hydrologic modifications and consequent ecological impacts to all five areas with the exception of Biscayne Bay.					
NED COSTS						
Total Construction & Real Estate Costs		$5,229	$6,023	$6,725	$7,335	$7,820
Annual Operations & Maintenance Costs**		$70	$72	$126	$162	$173
Annual Monitoring Costs		$10	$10	$10	$10	$10
Annualized Costs (6.875% interest rate)		$251	$284	$338	$380	$404
REGIONAL EFFECTS						
Average annual effects (% of regional economy)						
Output		$169 (.07%)	$191 (.08%)	$187 (.08%)	$272 (.12%)	$301 (.13%)
Employment (jobs)		1,689 (.06%)	1,894 (.06%)	2,009 (.07%)	2,849 (.10%)	3,109 (.11%)
Earnings		$58 (.07%)	$64 (.08%)	$77 (.10%)	$101 (.13%)	$107 (.14%)
OTHER SOCIAL EFFECTS	• Potential community disruption from conversion of agricultural land to reservoirs.					

* A "+" indicates a reduction in unmet water demand; i.e., these are benefits.
** Fully constructed

The values in the table represent simulated income losses from agricultural water supply shortages during the SFWMM's 31-year simulation period. The numbers in the parentheses reflect the differences between the with- and without-project future conditions. For each of the alternative plans, the differences are positive, indicating that the alternative plans are expected to improve agricultural water supply in the EAA and LEC relative to the without-project condition. These improvements would be attributed to physical improvements to the C&SF system, such as adding storage capacity via new reservoirs and through more effective management of the regional water system. As indicated in the table, Alternative A is expected to have the greatest reduction in unmet agricultural water demand.

The Caloosahatchee River and the St. Lucie Canal serve as major outlets for Lake Okeechobee, connecting the lake to the Gulf of Mexico and the Atlantic Ocean, respectively. There is significant agricultural activity in the these basins. The EPP does not address agricultural water supply effects in these basins, since they are not included in the SFWMM's grid system. However, the SFWMM simulates the agricultural demands not met for these basins under the with- and without-project conditions. The comparison of these simulations suggests that all of the alternative restoration plans would significantly improve agricultural water supply in the Caloosahatchee and St. Lucie basins. Alternative D (and the Recommended Plan) are expected to have the best performance among the alternative with regard to agricultural water supply in both basins.

E.13.2.2 Municipal And Industrial Water Supply

As discussed in Chapter 5, the alternative restoration plans could also result in changes in the frequency, severity, duration, and location of municipal and industrial (M&I) water supply shortages. In the study area, most M&I water use is in the LEC. When water demands exceed supplies, shortages result, and cutbacks may be imposed by the SFWMD. The SFWMD's Water Shortage Plan curtails water use in south Florida using a four-phase program of progressively more severe restrictions.

The EPP estimates the value of unmet M&I water demand using the results of a survey of LEC water customers. This survey asked respondent's willingness to pay (WTP) for water not received during shortages. The economic impacts of the alternative plans are the differences between the with- and without-project costs associated with the alternative regulation schedules. ***Table 13.2-1*** presents the economic value of unmet demand for M&I water supply for the with- and without-project future conditions. As for agricultural water supply, the M&I numbers in this table that are in parentheses represent the differences between the with- and without-project conditions. Again, the positive numbers in parentheses suggest that the alternative plans would represent significant improvements in M&I water supply which could result from physical and operational improvements to the regional water system. Alternative D and the Recommended Plan are expected to result in the greatest reduction in unmet M&I water demand.

E.13.2.3 Flood Control

As described in Chapter 6, structural and operational changes to the regional water system resulting from the alternative plans could alter the frequency of flooding in some parts of south Florida. Studies to estimate the flooding implications of the alternative plans were limited by the spatial resolution of the SFWMM. This model was not designed for flood studies, and the relatively coarse spatial resolution of this regional model limits its utility in assessing the flood impacts of the alternative restoration plans. Recognizing these limitations, the flooding studies conducted for the Restudy employed a four-part methodology. First, using secondary information and professional judgement, flood problem areas in the region were identified. Second, the SFWMM was used to assess whether these areas would be expected to have higher or lower peak stages as a result of the implementation of the alternative plans. Third, other areas with potential adverse and beneficial effects from the alternative plans were identified. Finally, for those existing problem areas that are expected to be adversely affected, further studies were recommended.

E.13.2.4 Commercial Navigation

As discussed in Chapter 7, the alternative regulation schedules are expected to alter average lake stages on Lake Okeechobee, which is a critical link in the Lake Okeechobee Waterway connecting the Atlantic Ocean with the Gulf of Mexico via the Caloosahatchee River and the St. Lucie Canal. The waterway includes 154 miles of navigation channels and five lock structures. There are two navigation channels through Lake Okeechobee. Route 1, which cuts across the lake, has a deeper channel (8 feet). Route 2, which hugs the eastern shoreline, is known as the rim canal. The channel depths of 8 feet and 6 feet for the lake and rim channel, respectively, are measured relative to an average lake elevation of 12.56 feet NGVD. The channel depths vary with lake levels, and no dredging is performed on this waterway. If the alternative restoration plans affect the frequency of extremely low lake levels (i.e., less than 13 feet NGVD), commercial navigation could be impacted and result in delays, load reductions, or re-routing of commercial traffic.

There has been a small but relatively stable level of commercial navigation on this waterway over the past ten years. The Lake Okeechobee Waterway was used to transport 430,000 tons of freight in 1995. There are no commercial shipping lines which maintain regular service through the Lake Okeechobee waterway. As a result, there is no dedicated fleet of commercial waterway users, and there is no regularly scheduled routing of commodity shipments through the waterway. The commercial traffic consists of special barge shipments that take advantage of the shortcut across the peninsula, which can save 3 to 5 days of travel.

Based upon field research and database searches regarding commercial navigation on the Lake Okeechobee Waterway, it can be concluded that the effects of the alternative restoration plans on the NED account would be very small. All of the alternative restoration plans are expected to lead to significant reductions in the frequency of low lake stages. However, the economic effects of these improvements for commercial navigation are expected to be small.

E.13.2.5 Recreation

As described in Chapter 8, tourism is Florida's largest industry. Many visitors come to enjoy the state's recreation amenities, joining the thousands of Florida residents who are also taking advantage of the State's diverse recreation resources. Many Florida residents and visitors recreate in the Everglades-related recreation resources of south Florida, including Everglades National Park, Biscayne National Park, Big Cypress National Preserve, the Loxahatchee National Wildlife Refuge, and Lake Okeechobee.

The economic value of resource-based recreation is determined by the users' willingness to pay for a recreation occasion. The willingness of current and potential users to pay for resource-based recreation of specific quantity and quality constitutes the demand for that type of recreation. The interaction of demand with the quantity and quality of recreation resources available determines the recreation use or "participation" levels for that resource-based activity. When the quantity or quality of recreation resources is modified by a project, such as the alternative restoration plans, the change in value of resource-based recreation is based on the difference in the willingness of users to pay under the with- and without-project conditions.

The restoration of the Everglades ecosystems could potentially have significant impacts on the value of outdoor recreation in south Florida. The hydrologic changes associated with the Restudy's alternative restoration plans have been designed to improve the structure and function of the Everglades ecosystems. These improvements can be expected to result in increases in the quantity and quality of Everglades-related recreation resources. If the alternative restoration plans improve the ecology of the Everglades, the quality of the Everglades-related recreation and/or the number of people who participate in Everglades-related recreation could increase significantly. Consequently, the value of outdoor recreation in south Florida could increase as well.

As noted in Table 13.2-1, estimating the future value of Everglades-related recreation in south Florida is problematic, and anticipating the incremental changes in value associated with Everglades restoration is even more challenging. There are four principal uncertainties which limit the ability to anticipate the future quantity and quality of outdoor recreation under with- and without project conditions:

- Timing and character of the ecological changes from restoration: If the results of the restoration effort can not be predicted, secondary effects on recreation are even more uncertain.

- Marketing of tourism and Everglades-related recreation: Tourism is particularly sensitive to marketing efforts. Restoration may or may not be accompanied by promotion of the enhanced recreation opportunities.

- Development of recreational facilities and recreational access: Facilities and access are critical determinants of recreation participation. Restoration may or may not be accompanied by development of additional recreation facilities and access.

- Macroeconomic factors which influence tourism and recreation demand: National economic and social trends can greatly influence patterns of tourism and recreation. The uncertainty of these factors limits the ability to forecast tourism and recreation with confidence for more than a few years.

Given these uncertainties, it is beyond the scope of this analysis to quantify the value of Everglades-related recreation under the with- and without-project future conditions through the 50-year planning period. However, the alternative plan that is expected to be most effective in terms of restoration can be expected to also be most effective in terms of positive recreation effects. As indicated in ***Table 13.2-1***, current expenditures and consumer surplus were estimated for Everglades-related recreation in order to help frame the issues surrounding the recreation effects of the alternative restoration plans. There are approximately 6.3 million visitors annually to the principal Everglades parks and preserves. At the regional scale, there are approximately 16.6 million wildlife watching participants in south Florida. It is estimated that the current annual expenditures associated with visitation to the Everglades parks and preserves is approximately $404 million, and expenditures for wildlife watching in south Florida are approximately $598 million. In addition, it is estimated that the annual consumer surplus associated with visiting the parks and preserves is approximately $290 million, and the consumer surplus associated with wildlife watching in the region is $764 million. These estimates of expenditures and consumer surplus, which are based on secondary sources of information, provide insight to the value of the Everglades-related recreation resources, but they should not be interpreted as estimates of that value.

E.13.2.6 Commercial And Recreational Fishing

As explored in Chapter 9, the alternative plans have the potential to affect recreational and commercial fishing throughout south Florida by modifying the hydrologic regime in the region's waterways and estuaries. There are five principal fishing impact zones that would experience the majority of the potential economic effects on fishing in the region: Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, and Biscayne and Florida bays.

In this investigation, both recreational fishing and commercial fishing are discussed, including recreational sportfishing, guided sportfishing, and commercial fishing. The hydrologic changes that are expected to result from the alternative restoration plans may have economic implications for commercial and recreational fishing in the five impact zones. Economic effects on commercial fishing are estimated based on a net income approach. Increases or decreases in the net income of commercial fishermen can result from either changes in the size of the catch (i.e., revenues) or from changes in the cost of fishing operations (i.e., expenses). For recreational fishing, economic effects are measured based on changes in both the quality of the fishing experience, as well as changes in the frequency of fishing in a given area (e.g., number of fish caught per trip, number of trips, number of fishermen, or hours fished per trip).

Lake Okeechobee supports extensive commercial, guided sportfishing, and recreational sportfisheries. The annual revenues associated with the commercial fishery are estimated at $2.3 million, and spending associated with recreational sportfishing is approximately $700,000. The alternative restoration plans are expected to have positive effects on commercial and recreational fishing by moderating the extent and duration of extreme lake stage fluctuations. This could improve the habitat quality of the lake's littoral zone, which provides important habitat for the lake's commercial and recreational fish stocks. The commercial fishery is not expected to benefit significantly from this effect however, since neither the size of the catch nor the cost of the catch are expected to change. The recreational fishery might marginally benefit from the anticipated habitat improvements, but the sportfishery is already quite healthy and therefore relatively insensitive to the magnitude of the expected hydrologic and ecological changes.

Commercial fishing and guided sportfishing in the St. Lucie estuary have annual revenues of approximately $1.7 million and $800,000, respectively. In the Caloosahatchee estuary, commercial fishing and guided sportfishing have annual revenues of approximately $ 1.7 million and $4.8 million, respectively. Both estuaries receive water released from Lake Okeechobee. The lake is managed to keep lake levels low in the wet season to provide flood protection and high in the dry season for water supply purposes. The quantity, quality, and timing of the releases to the St. Lucie and Caloosahatchee estuaries are critical determinants of the diversity and productivity of those ecosystems. The ecological conditions have implications for commercial and recreational fishing in these estuaries.

There has been long-standing concern about the effects of regulatory releases on the St. Lucie and Caloosahatchee estuaries. Some aspects of the relationship between the regulatory releases and effects on fishing are relatively clear. In general, these estuarine ecosystems are stressed by the magnified oscillations in freshwater inputs to the estuary and other ecosystem perturbations. The stressors include the Lake Okeechobee releases and other influences from the estuary's contributing watershed. The variability in freshwater inputs to the Caloosahatchee Estuary creates an unstable salinity environment.

There is a great deal of uncertainty regarding the effects of the freshwater releases from Lake Okeechobee on these estuaries. These ecological uncertainties translate into uncertainties regarding the economic effects of the alternative restoration plans on commercial and recreational fishing. As indicated in Table 13.2-1, for both of these estuaries, the alternative restoration plans are expected to result in significant improvements over the without-project future condition. However, in the St. Lucie estuary, the alternative plans are not expected to meet the performance targets established for high water releases from Lake Okeechobee. For the St. Lucie and Caloosahatchee estuaries, the alternatives that are expected to have the best performance in terms of high water releases to the estuaries are Alternatives D and B, respectively.

For commercial and recreational fishing in Biscayne Bay and Florida Bay, the sequence of effects of the alternative restoration plans also depends on how the hydrologic changes affect the ecology of the bays and how the ecological changes translate into changes in commercial and recreational fishing. However, the bays have several important differences relative to the St. Lucie and Caloosahatchee estuaries. First, the bays lie at the downstream terminuses of the C&SF system where water flowing through the Everglades enters the sea. Second, the bays, which primarily lie within the Biscayne National Park and Everglades National Park, are recognized as estuaries of national and international significance. Third, the bays are much larger than the St. Lucie and Caloosahatchee estuaries. As a result, they play a much more significant role in south Florida's commercial and recreational fishing.

The quantity and timing of freshwater flows into Biscayne and Florida bays are critical determinants of the structure and function of the bay ecosystems. The bays differ from the two smaller estuaries, since they do not experience the magnified fluctuations of high and low freshwater inputs and resultant salinity levels. Instead, the bays in general receive less water throughout the year than they would under natural conditions.

The bays support significant commercial and recreational fisheries. Biscayne Bay is estimated to have the following annual revenues associated with its fisheries: commercial fishing ($1.5 million), guided sportfishing ($1.4 million), and recreational sportfishing ($8.5 million). Similarly, Florida Bay fisheries have the following estimated annual revenues: commercial fishing ($10.8 million), guided sportfishing ($1.0 million), and recreational sportfishing ($7.0 million).

In general, the with- and without-project future conditions in Biscayne Bay are expected to have freshwater inputs to the bay that fall short for the target discharges (wet and dry seasons). In addition, three of the alternative restoration plans are expected to have less desirable performance than the without-project conditions. The exception is Alternative D. The potential shortfall of the with- and without-project conditions relative to the targets for freshwater inputs to Biscayne Bay suggest a continued salinity stress on the bay ecosystem. This stress may have ecological effects that infer economic consequences for commercial and recreational fishing in the bay. The relatively stable abundance in recent years of economically valuable species suggests that the ecosystem has some resilience to the continued salinity stress from low freshwater inputs relative to historic levels. However, the sustainability of this abundance under continued stress is not known.

To analyze the effects of the with- and without-project conditions on the ecological health of Florida Bay, the SFWMM simulates freshwater inputs to the bay at four different discharge points. The benchmarks for these discharges are the flows that were simulated in the Natural System Model (NSM). As indicated in ***Table 13.2-1***, the alternative restoration plans are, in general, expected to exceed the without-project conditions, and in some cases meet or exceed NSM flows into the bay. While the hydrologic performance of the individual restoration plans are mixed, it appears that for most of the hydrologic measures, Alternative A is superior to the other restoration plans and to the future without-project conditions. The Recommended Plan is expected to produce effects equivalent to Alternative D.

E.13.3 NED COSTS

Chapter 10 describes the NED costs of the alternative restoration plans. As outlined in ***Table 13.2-1***, these costs include construction and real estate, operations and maintenance, and monitoring costs. The average annual costs for Alternatives A, B, C, and D range from $254 million to $383 million. The estimate of average annual costs for the Recommended Plan is $402 million. This estimate is not comparable to the estimates for Alternatives A-D, since it includes other plan elements, developed as part of the refinement of the Recommended Plan.

E.13.4 REGIONAL ECONOMIC EFFECTS

In Chapter 11, the effects of the alternative restoration plans on the regional economic development (RED) account were evaluated using a regional input-output model, IMPLAN. The analysis considered the primary and secondary consequences of the proposed structural and operational modifications of the regional water management system. Primary consequences include the economic activities stimulated by the purchases of materials and services required in the construction of the project, the purchases of real estate, operation and maintenance of the system and monitoring costs. Secondary consequences, such as the NED effects of the alternative plans were also evaluated, specifically the consequences of changing agricultural land use and of changing agricultural water supply.

The types of economic impacts that a new project can have on output, earnings, and jobs in a region are known as “direct,” “indirect,” and “induced.” Direct impacts are caused by first round of expenditures associated with the project. The indirect impacts count only the inputs which are purchased as a result of the first round expenditures. The importance of these “indirect” effects will vary with the complexity of production in the study area and the degree to which required materials are supplied by local producers. Induced effects are the multiplier effects of the project expenditures as that spending circulates in the regional economy.

Table 13.2-1 summarizes the regional economic development effects of the alternative plans. These effects are categorized as changes in output, employment, and earnings. They estimates for each of the alternative plans are presented in absolute terms for the 50-year period of analysis and as a percentage of the regional economy. As expected, the regional effects of the alternative plans generally increase from Alternative A to the Recommended Plan in accordance with the increasing expenditures associated with each plan.

E.13.5 OTHER SOCIAL EFFECTS

As discussed in Chapter 12, the C&SF alternative restoration plans could have socio-economic effects on the study area that are not identified in the national economic development (NED) account or in the regional economic development (RED) account. The Other Social Effects (OSE) account provides the opportunity to display and integrate into water resources planning information on plan effects from perspectives that are not reflected in the NED and RED accounts. The categories of effects in the OSE account include:

- Urban and community impacts,
- Life, health, and safety factors,
- Displacement,

- Long-term productivity, and

- Energy requirements and energy conservation.

As in the case of the NED effects, the OSE account is concerned only with the effects of the alternative plans (i.e., the differences between the with- and without-project future conditions). The most potentially significant OSE consideration for the alternative restoration plans concerns the development of new storage reservoirs in the rural areas surrounding Lake Okeechobee. These project features would convert farm land to reservoirs. Their development could eliminate the jobs of the individuals who depend on those lands for their employment and have adverse effects on local communities and economies. The potential locations of the new reservoirs are not known at this time. However, the resilience of local economies and the cohesion of local communities to agricultural land conversion depend on a variety of factors, including the age, ethnic, and racial composition of the community and income, unemployment, and poverty levels. A social vulnerability index was developed using county-scale socio-economic characteristics, and this type of analysis could be replicated in more detail when and if new reservoir sites are proposed.

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APPENDIX F

REAL ESTATE

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APPENDIX F
REAL ESTATE

F.1 PURPOSE

The purpose of the Comprehensive Review Study is to determine the feasibility of modifications to the Central and Southern Florida (C&SF) Project to restore the Everglades and Florida Bay ecosystems while providing for other water-related needs. The C&SF Project is a multi-purpose project. It provides flood control and water supply benefits to the people of south Florida, while allowing for water control, preventing salinity intrusion, providing navigation, preservation of fish and wildlife, and providing water to the Everglades National Park.

This Real Estate Appendix addresses the real estate requirements for the alternative plans and elements considered in the feasibility phase review study. This appendix is tentative in nature for planning purposes only and the real estate cost estimates provided are subject to change even after approval of the feasibility report.

F.2 AUTHORITY

This study is authorized by Section 309(l) of the Water Resources Development Act of 1992 (Public Law 102-580) which states:

> *(1) CENTRAL AND SOUTHERN FLORIDA. -- The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as House document 643; 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation.*

This study is also authorized by two resolutions of the Committee on Public Works and Transportation, United States House of Representatives, dated September 24, 1992. The first resolution states:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for*

Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes.

The second resolution states:

Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes for Florida Bay, including a comprehensive, coordinated ecosystem study with hydrodynamic modeling of Florida Bay and its connections to the Everglades, the Gulf of Mexico, and the Florida Keys Coral Reef ecosystem.

The WATER RESOURCES DEVELOPMENT ACT OF 1996, Public Law 104-303, Section 528, entitled “EVERGLADES AND SOUTH FLORIDA ECOSYSTEM RESTORATION” provided the Corps authority for the completion of a comprehensive restudy of the Central and Southern Florida Project. The pertinent portions of Section 528 provide as follows:

(a) DEFINITIONS.-In this section, the following definitions apply:

(1) CENTRAL AND SOUTHERN FLORIDA PROJECT.-The term "Central and Southern Florida Project" means the project for Central and Southern Florida authorized under the heading "CENTRAL AND SOUTHERN FLORIDA" in section 203 of the Flood Control Act of 1948 (62 Stat. 1176), and any modification to the project authorized by law.

(2) COMMISSION.-The term "Commission" means the Governor's Commission for a Sustainable South Florida, established by Executive Order of the Governor dated March 3, 1994.

(3) GOVERNOR.-The term "Governor" means the Governor of the State of Florida.

(4) SOUTH FLORIDA ECOSYSTEM.-The term "South Florida ecosystem" means the area consisting of the lands and waters within the boundary of the South Florida Water Management District, including the Everglades, the Florida Keys, and the contiguous near-shore coastal waters of South Florida.

(5) TASK FORCE.-The term "Task Force" means the South Florida Ecosystem Restoration Task Force established by subsection (f).

(b) RESTORATION ACTIVITIES.

(1) COMPREHENSIVE PLAN.

(A) DEVELOPMENT.--

(i) PURPOSE.-The Secretary shall develop, as expeditiously as practicable, a proposed comprehensive plan for the purpose of restoring, preserving, and protecting the South Florida ecosystem. The comprehensive plan shall provide for the protection of water quality in, and the reduction of the loss of fresh water from, the Everglades. The comprehensive plan shall include such features as are necessary to provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project.

(ii) CONSIDERATIONS.-The comprehensive plan shall

(I) be developed by the Secretary in cooperation with the non-Federal project sponsor and in consultation with the Task Force; and

(II) consider the conceptual framework specified in the report entitled "Conceptual Plan for the Central and Southern Florida Project Restudy", published by the Commission and approved by the Governor.

(B) SUBMISSION.-Not later than July 1, 1999, the Secretary shall

(i) complete the feasibility phase of the Central and Southern Florida Project comprehensive review study as authorized by section 309(1) of the Water Resources Development Act of 1992 (106 Stat. 4844), and by 2 resolutions of the Committee on Public Works and Transportation of the House of Representatives, dated September 24, 1992; and

(ii) submit to Congress the plan developed under subparagraph (A)(i) consisting of a feasibility report and a programmatic environmental impact statement covering the proposed Federal action set forth in the plan.

(C) ADDITIONAL STUDIES AND ANALYSES.-Notwithstanding the completion of the feasibility report under subparagraph (B), the Secretary shall continue to conduct such studies and analyses as are necessary, consistent with subparagraph (A)(i).

(2) USE OF EXISTING AUTHORITY FOR UNCONSTRUCTED PROJECT FEATURES.-The Secretary shall design and construct any features of the Central and Southern Florida Project that are authorized on the date of the enactment of this Act or that may be implemented in accordance with the Secretary's authority to modify an authorized project, including features authorized under sections 315 and 316, with funds that are otherwise available, if the Secretary determines that the design and construction

(A) will accelerate the restoration, preservation, and protection of the South Florida ecosystem;

(B) will be generally consistent with the conceptual framework described in paragraph (1)(A)(ii)(II); and

(C) will be compatible with the overall authorized purposes of the Central and Southern Florida Project.

(3) CRITICAL RESTORATION PROJECTS.

(A) IN GENERAL.-In addition to the activities described in paragraphs (1) and (2), if the Secretary, in cooperation with the non-Federal project sponsor and the Task Force, determines that a restoration project for the South Florida ecosystem will produce independent, immediate, and substantial restoration, preservation, and protection benefits, and will be generally consistent with the conceptual framework described in paragraph (1)(A)(ii)(II), the Secretary shall proceed expeditiously with the implementation of the restoration project.

(B) INITIATION OF PROJECTS.-After September 30, 1999, no new projects may be initiated under subparagraph (A).

(C) AUTHORIZATION OF APPROPRIATIONS.

(i) IN GENERAL.-There is authorized to be appropriated to the Department of the Army to pay the Federal share of the cost of carrying out projects under subparagraph (A) $75,000,000 for the period consisting of fiscal years 1997 through 1999.

(ii) FEDERAL SHARE.-The Federal share of the cost of carrying out any 1 project under subparagraph (A) shall be not more than $25,000,000.

(4) GENERAL PROVISIONS.

(A) WATER QUALITY.-In carrying out activities described in this subsection and sections 315 and 316, the Secretary

(i) shall take into account the protection of water quality by considering applicable State water quality standards; and

(ii) may include in projects such features as are necessary to provide water to restore, preserve, and protect the South Florida ecosystem.

(B) COMPLIANCE WITH APPLICABLE LAW.-In carrying out the activities described in this subsection and subsection (c), the Secretary shall comply with any applicable Federal law, including the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.).

(C) PUBLIC PARTICIPATION.-In developing the comprehensive plan under paragraph (1) and carrying out the activities described in this subsection and subsection (c), the Secretary shall provide for public review and comment on the activities in accordance with applicable Federal law.

(c) INTEGRATION OF OTHER ACTIVITIES.

(1) IN GENERAL.-In carrying out activities described in subsection (b), the Secretary shall integrate such activities with ongoing Federal and State projects and activities, including

(A) the project for the ecosystem restoration of the Kissimmee River, Florida, authorized by section 101 of the Water Resources Development Act of 1992 (106 Stat. 4802);

(B) the project for modifications to improve water deliveries into Everglades National Park authorized by section 104 of the Everglades National Park Protection and Expansion Act of 1989 (16 U.S.C. 410r-8);

(C) activities under the Florida Keys National Marine Sanctuary and Protection Act (16 U.S.C. 1433 note; 104 Stat. 3089); and

(D) the Everglades Construction Project of the State of Florida.

(2) STATUTORY CONSTRUCTION.

(A) EXISTING AUTHORITY.-Except as otherwise expressly provided in this section, nothing in this section affects any authority in effect on the date of the enactment of this Act, or any requirement of the authority, relating to participation in restoration activities in the South Florida ecosystem, including the projects and activities specified in paragraph (1), by

(i) the Department of the Interior;

(ii) the Department of Commerce;

(iii) the Department of the Army;

(iv) the Environmental Protection Agency;

(v) the Department of Agriculture;

(vi) the State of Florida; and

(vii) the South Florida Water Management District.

(B) NEW AUTHORITY.-Nothing in this section confers any new regulatory authority on any Federal or non-Federal entity that carries out any activity authorized by this section.

(d) JUSTIFICATION.

(1) IN GENERAL.-Notwithstanding section 209 of the Flood Control Act of 1970 (42 U.S.C. 1962-2) or any other provision of law, in carrying out the activities to restore, preserve, and protect the South Florida ecosystem described in subsection (b), the Secretary may determine that the activities

(A) are justified by the environmental benefits derived by the South Florida ecosystem in general and the Everglades and Florida Bay in particular; and

(B) shall not need further economic justification if the Secretary determines that the activities are cost-effective.

(2) APPLICABILITY.-Paragraph (1) shall not apply to any separable element intended to produce benefits that are predominantly unrelated to the restoration, preservation, and protection of the South Florida ecosystem.

(e) COST SHARING.

(1) IN GENERAL.-Except as provided in sections 315 and 316 and paragraph (2), the non-Federal share of the cost of activities described in subsection (b) shall be 50 percent.

(2) WATER QUALITY FEATURES.

(A) IN GENERAL.-Except as provided in subparagraph (B), the non-Federal share of the cost of project features to improve water quality described in subsection (b) shall be 100 percent.

(B) EXCEPTION.

(i) IN GENERAL.-Subject to clause (ii), if the Secretary determines that a project feature to improve water quality is essential to Everglades restoration, the non-Federal share of the cost of the feature shall be 50 percent.

(ii) APPLICABILITY.-Clause (i) shall not apply to any feature of the Everglades Construction Project of the State of Florida.

(3) OPERATION AND MAINTENANCE.-The operation and maintenance of projects carried out under this section shall be a non-Federal responsibility.

(4) CREDIT.-Regardless of the date of acquisition, the value of lands or interests in land acquired by non-Federal interests for any activity described in subsection (b) shall be included in the total cost of the activity and credited against the non-Federal share of the cost of the activity. Such value shall be determined by the Secretary.

(f) SOUTH FLORIDA ECOSYSTEM RESTORATION TASK FORCE.

(1) ESTABLISHMENT AND MEMBERSHIP.-There is established the South Florida Ecosystem Restoration Task Force, which shall consist of the

following members (or, in the case of a Federal agency, a designee at the level of assistant secretary or an equivalent level):

(A) The Secretary of the Interior, who shall serve as chairperson.

(B) The Secretary of Commerce.

(C) The Secretary.

(D) The Attorney General.

(E) The Administrator of the Environmental Protection Agency.

(F) The Secretary of Agriculture.

(G) The Secretary of Transportation.

(H) 1 representative of the Miccosukee Tribe of Indians of Florida, to be appointed by the Secretary of the Interior based on the recommendations of the tribal chairman.

(I) 1 representative of the Seminole Tribe of Florida, to be appointed by the Secretary of the Interior based on the recommendations of the tribal chairman.

(J) 2 representatives of the State of Florida, to be appointed by the Secretary of the Interior based on the recommendations of the Governor.

(K) 1 representative of the South Florida Water Management District, to be appointed by the Secretary of the Interior based on the recommendations of the Governor.

(L) 2 representatives of local government in the State of Florida, to be appointed by the Secretary of the Interior based on the recommendations of the Governor.

(2) DUTIES OF TASK FORCE.-The Task Force

(A) shall consult with, and provide recommendations to, the Secretary during development of the comprehensive plan under subsection (b)(1);

(B) shall coordinate the development of consistent policies, strategies, plans, programs, projects, activities, and priorities for addressing the restoration, preservation, and protection of the South Florida ecosystem;

(C) shall exchange information regarding programs, projects, and activities of the agencies and entities represented on the Task Force to promote ecosystem restoration and maintenance;

(D) shall establish a Florida-based working group which shall include representatives of the agencies and entities represented on the Task Force as well as other governmental entities as appropriate for the purpose of formulating, recommending, coordinating, and implementing the policies, strategies, plans, programs, projects, activities, and priorities of the Task Force;

(E) may, and the working group described in subparagraph (D), may

(i) establish such advisory bodies as are necessary to assist the Task Force in its duties, including public policy and scientific issues; and

(ii) select as an advisory body any entity, such as the Commission, that represents a broad variety of private and public interests;

(F) shall facilitate the resolution of interagency and intergovernmental conflicts associated with the restoration of the South Florida ecosystem among agencies and entities represented on the Task Force;

(G) shall coordinate scientific and other research associated with the restoration of the South Florida ecosystem;

(H) shall provide assistance and support to agencies and entities represented on the Task Force in their restoration activities;

(I) shall prepare an integrated financial plan and recommendations for coordinated budget requests for the funds proposed to be expended by agencies and entities represented on the Task Force for the restoration, preservation, and protection of the South Florida ecosystem; and

(J) shall submit a biennial report to Congress that summarizes

(i) the activities of the Task Force;

(ii) the policies, strategies, plans, programs, projects, activities, and priorities planned, developed, or implemented for the restoration of the South Florida ecosystem; and

(iii) progress made toward the restoration.

(3) PROCEDURES AND ADVICE.

(A) PUBLIC PARTICIPATION.

(i) IN GENERAL.-The Task Force shall implement procedures to facilitate public participation in the advisory process, including providing advance notice of meetings, providing adequate opportunity for public input and comment, maintaining appropriate records, and making a record of the proceedings of meetings available for public inspection.

(ii) OVERSIGHT.-The Secretary of the Interior shall ensure that the procedures described in clause (i) are adopted and implemented and that the records described in clause (i) are accurately maintained and available for public inspection.

(B) ADVISORS TO THE TASK FORCE AND WORKING GROUP.-The Task Force or the working group described in paragraph (2)(D) may seek advice and input from any interested, knowledgeable, or affected party as the Task Force or working group, respectively, determines necessary to perform the duties described in paragraph (2).

(C) APPLICATION OF THE FEDERAL ADVISORY COMMITTEE ACT.

(i) TASK FORCE AND WORKING GROUP.-The Task Force and the working group shall not be considered advisory committees under the Federal Advisory Committee Act (5 U.S.C.App.).

(ii) ADVISORS.-Seeking advice and input under subparagraph (B) shall not be subject to the Federal Advisory Committee Act (5 U.S.C.App.).

(4) COMPENSATION.-A member of the Task Force shall receive no compensation for the service of the member on the Task Force.

(5) TRAVEL EXPENSES.-Travel expenses incurred by a member of the Task Force in the performance of services for the Task Force shall be paid by the agency, tribe, or government that the member represents.

F.3 OTHER AUTHORITIES

FEDERAL AGRICULTURE IMPROVEMENT AND REFORM ACT OF 1996, Public Law 104-127, SECTION 390. “EVERGLADES ECOSYSTEM RESTORATION”, subsections (a), (b). (c), (d) and (e) [hereinafter referred to as the Farm Bill]:

(a) IN GENERAL.-On July 1, 1996, out of any funds in the Treasury not otherwise appropriated, the Secretary of the Treasury shall provide $200,000,000 to the Secretary of the Interior to carry out this section.

(b) ENTITLEMENT.-The Secretary of the Interior (referred to in this section as the "Secretary")

(1) shall be entitled to receive the funds made available under subsection (a);

(2) shall accept the funds; and

(3) shall use the funds to

(A) conduct restoration activities in the Everglades ecosystem in South Florida, which shall include the acquisition of real property and interests in real property located within the Everglades ecosystem; and

(B) fund resource protection and resource maintenance activities in the Everglades ecosystem.

(c) SAVINGS PROVISION.-Nothing in this subsection precludes the Secretary from transferring funds to the Army Corps of Engineers, the State of Florida, or the South Florida Water Management District to carry out subsection (b)(3).

(d) DEADLINE.-The Secretary shall use the funds made available under subsection (a) for restoration activities referred to in subsection (b)(3) not later than December 31, 1999.

(e) REPORT TO CONGRESS.-For each of calendar years 1996 through 1999, the Secretary shall submit an annual report to Congress describing all activities carried out under subsection (b)(3).

F.4 STUDY AREA

The study area, as shown in Figure 1-2 in the feasibility report, includes all of the area of the C&SF Project with the exception of the Upper St. Johns River Basin.

The study area stretches from Orlando to the southern tip of Florida and encompasses all or parts of 16 counties, an area of approximately 18,000 square miles. Major areas of the project include the Kissimmee River, Lake Okeechobee, Everglades Agricultural Area, Water Conservation Areas, Lower East Coast, Everglades National Park, Big Cypress National Preserve, and Florida Bay.

F.5 REAL ESTATE LEVEL OF DETAIL FOR THIS STUDY

The purpose of the feasibility phase of the Comprehensive Review Study is to review the entire C&SF Project, with the exception of the Upper St. Johns River Basin, to restore the Everglades and Florida Bay ecosystems while still providing for other water-related needs. Due to the magnitude of the study area, the level of detail provided by the other technical elements involved in this phase of the study is at a lower level than normally provided for a typical feasibility study. On December 5-6, 1996, a Special Review Conference was held in Jacksonville, Florida, to address various issues that would affect the development of the Comprehensive Plan. It also served to develop guidance to implement and complete the Comprehensive Plan for submittal to Congress. Enclosed, as Exhibit A, is the CECW-PE Memorandum Subject: C&SF Project Comprehensive Review Study Special Review Conference Project Guidance Memorandum that documents the issues, discussions and decisions that arose from this conference.

Some of the points of the Project Guidance Memorandum regard to the level of detail for this phase of the study are:

> *Due to the need to complete a Comprehensive Plan report in a timely manner and the geographic extent of the study area, the level of analysis and engineering detail will be less than traditionally provided to support plan selection and a base line cost estimate for projects recommended for Congressional authorization. Real estate cost estimates will be based on the analysis and assumptions made during the process of formulating and developing the components of the Comprehensive plan. A real estate baseline cost estimate will be between what is normally contained in a Reconnaissance Report and what is normally contained in a Feasibility Study, and will be provided as a range of values for each component. A gross appraisal will not be completed for the Comprehensive Plan, but appropriate documents will be prepared for each subsequent design document.*

F.6 COST ESTIMATE INFORMATION

Jacksonville District, Real Estate Division was tasked with developing real estate property cost estimates based on various categories of land, to be applied to each component, accordingly.

Land cost estimates were developed based on various categories of land within each county, which were applied to each component, accordingly. The land cost estimates were based on sales data obtained by the Jacksonville District, information from County Property Appraisers/Assessors, county tract appraisal information, the Jacksonville District staff appraiser's general county wide knowledge, input from the South Florida Water Management District, and actual land acquisition costs of lands already acquired by the South Florida Water Management District. For the purpose of this study, fee value was assumed in estimating all land costs to arrive at the per acre value. The actual required estates will be determined in each subsequent design document. Given the massive size of the study area, the broad conceptual nature and number of components, the level of detail for this phase of the study did not include: the determination of numbers, types and locations of structures or improvements; actual number of tracts; the associated relocations assistance costs (except for component VV, in which that information was available); or the possible severance damages associated with each plan component. The cost estimates for each of the components are preliminary, more detail will be presented for the appropriate design document for each component. According to the Study Team, the proposed acquisition lines for each of the components will primarily circumvent existing improvements, leaving only a minimum number of affected structures to be acquired. For this study, the contingency factor for each component was adjusted upward to cover unknown severance damages, number of tracts to be acquired, improvement costs, condemnations, and relocations assistance payments. A reliable determination of affected improvements and possible severance damages will be accomplished in each subsequent design document

F.6.1 ACQUISITION/ADMINISTRATIVE COST ESTIMATES

Acquisition/administrative estimates for the non-Federal sponsor include costs that will be incurred during real estate acquisition, such as the costs for acquisitions, appraisals, title insurance, surveys, closings, condemnations, relocation assistance, temporary permits, and damage claims. The Federal acquisition/administrative estimates include costs for project planning, obtaining temporary permits, review of acquisitions by the non-Federal sponsor, review of appraisals obtained by the non-Federal sponsor, review of Public Law 91-646 assistance costs, review of condemnations performed by the non-Federal sponsor, and monitoring of the acquisition process. Historical acquisition/administrative cost estimate data was relied upon in determining the proposed acquisition/administrative costs for each of the alternative plans addressed in this report. The approximate number of affected ownership tracts was estimated using Experian-computer ownership data from some Florida counties and plat books for the counties in which Experian data was not available.

In calculating the acquisition/administrative cost estimates for almost all of the components, an amount of $12,000 was applied to each affected tract for proposed non-Federal acquisition/administrative sponsor costs. An amount of $6,000 was estimated for each tract for proposed Federal acquisition/administrative costs. In certain components, both the Federal and non-Federal acquisition/administrative costs were reduced if there were an extremely large number of tracts in the component or increased because there was a lack of information regarding the estimated number of tracts.

Table F-1 entitled Federal and non-Federal Administrative/Acquisition Costs shows the probable administrative/acquisition costs for each component in the recommended Comprehensive Plan – Alternative D13R together with the Other Project Elements.

F.6.2 PUBLIC LAW 91-646 COST ESTIMATES

Due to the limited information available and the magnitude of the study area, it was assumed that the proposed acquisition lines for each component would affect only a minimum amount of structures. For each of the components (except Component VV, in which some improvement information was obtained), unknown improvement costs and relocations assistance estimates are covered in a higher than usual contingency cost added in for each component.

F.6.3 REAL ESTATE CONTINGENCY COST ESTIMATES

Typically, a real estate contingency factor of 25 percent is added in to the total real estate project cost, to cover uncertainties associated with elements such as valuation variance, negotiation latitude, condemnation awards and interest, and refinement of boundary lines during ownership verification. For this study, in most components, a contingency factor from 5 percent to 50 percent (depending on the reliability of the estimated cost information) has been applied to each of the components. ***Table F-2*** shows the contingency factor applied to each component in the Recommended Comprehensive Plan – Alternative D13R together with the Other Project Elements.

F.7 PRELIMINARY AND ALTERNATIVE PLANS

Five preliminary alternatives (Preliminary Alternatives 1 through 5), involving a combination of components, were originally studied. Preliminary cost estimates were generated for the purpose of comparing these preliminary alternative plans, and are based on conceptual designs. After the preliminary alternative screening, a total of four revised alternatives (Alternatives A through D) were determined for further study. Only the components in Alternatives A through D that include real estate requirements are addressed in this section of the Real Estate Appendix.

There were a total of 44 components requiring real estate cost estimates for Alternatives A through D. Following are descriptions and corresponding real estate costs for all of the components making up Alternatives A through D. The alternatives to which a particular component pertains are shown next to each heading. Many components remain constant throughout the Alternatives, as are shown below. Only the components that include real estate requirements are addressed in this appendix. ***Table F-3*** provides a comparison of Alternatives A through D as well as a comparison to the Initial Draft Plan - Alternative D13R, including the estimated low-end costs, the estimated high-end costs, and the estimated probable costs for Alternative D13R. For more detailed descriptions of the components in Alternatives A through D, refer to Appendix A.

Component A6 (Alternatives A, B, C &D)

The North of Lake Okeechobee Storage component consists of constructing a storage reservoir (20,000 acres at 10 feet maximum depth) north of Lake Okeechobee. The purpose would be to incorporate climate-based inflow forecasting to increase the utilization of the reservoir to provide additional flood protection, water supply and environmental enhancement. The reservoir could be located in any of five counties (Glades, Highlands, Okeechobee, Osceola, and Polk). The location of the reservoir would be on land currently agricultural in nature and as such, the appraiser valued land within the five counties that is currently of general agriculture use (pasture and citrus). The total estimated real estate cost of this component is $189,720,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component B2 (Alternatives A, B, C & D)

The Storage Reservoir St. Lucie/C-44 Basin component consists of establishing a storage reservoir (10,000 acres at 4 feet maximum depth) in the St. Lucie Basin. The purpose would be to capture local runoff from C-44 for flood attenuation, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The general area designated for this reservoir is north of the St. Lucie Waterway and in an easterly direction of Indiantown in Okeechobee County. This area appears to be primarily in citrus groves, with the total estimated real estate cost of this component being $90,675,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component D5 (Alternatives A, B, C & D)

Storage Reservoir with Aquifer Storage and Recovery (44, 5 million gallons per day wells) Caloosahatchee/C-43 Basin. This component's purpose would be to capture basin runoff and regulatory releases from Lake Okeechobee to provide water supply benefits (20,000 acres at 8 feet maximum depth), some flood attenuation and environmental water supply deliveries to the Caloosahatchee Estuary. This component would be operated in conjunction with the DDD5 component. The 20,000-acre storage site would be located in Glades County, on presumably agricultural land. The total estimated real estate cost of this component is $75,621,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component G3 (Alternatives A and B) and Component G5 (Alternatives C, & D)

Palm Beach Everglades Agricultural Area Storage Reservoir. For real estate purposes, both components G3 (Alternatives A and B) and G5 (Alternatives C and D) have identical real estate requirements of 60,000 acres, however, the components differ in the division of the 60,000 acres into compartments. Component G3 consists of one 20,000-acre compartment at 6 feet maximum depth for supplying Everglades Agricultural Area irrigation demands and one 40,000-acre compartment at 6 feet maximum depth for supplying environmental demands in the Everglades Agricultural Area with increased conveyance from Lake Okeechobee to the reservoir. Component G5 consists of three 20,000-acre compartments all at 6 feet maximum depth. The purpose, of both Components G3 and G5, are: (1) to improve timing of environmental deliveries to the Water Conservation Areas, including reducing damaging flood releases from the Everglades Agricultural Areas to the Water Conservation Areas; (2) to reduce Lake Okeechobee regulatory releases to estuaries; to meet supplemental agricultural irrigation demands; and (3) to increase flood protection within the Everglades Agricultural Area. The conveyance capacity of the Miami and North New River Canals between Lake Okeechobee and the storage reservoirs would be increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries. The proposed area for the 60,000-acre storage site is not clearly delineated, but lies south of Lake Okeechobee, between the North New River and the Miami Canals. This area is primarily sugar cane and was valued as such. The total estimated real estate cost of either of Components G3 and G5 is $285,852,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component K2 (Alternative A), Component K4 (Alternatives B & C) and Component K6 (Alternative D)

Water Preserve Areas / L-8 Project Phase II. For preliminary real estate cost estimating purposes, Components K2, K4 and K6 had identical real estate requirements. All three components consist of capturing water and improving stages in the West Palm Beach Water Catchment Area to reduce water supply restrictions in the Northern Palm Beach County Service Area. The intent is to increase water supply availability and provide pass through flow to enhance hydroperiods in Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River. The land required for this component is approximately 40 acres, and is valued as pasture/open land. The total estimated real estate cost of any of the three Components (K2, K4, or K6) is $2,576,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component M4 (Alternatives A, B & C)

Site 1 Impoundment- Palm Beach County component consists of a 1,660-acre impoundment site to include aquifer storage and recovery wells in Palm Beach County. The purpose of this component is to increase regional water resources and supplement water deliveries to the Hillsboro Canal during the dry-season. Existing land owned by South Florida Water Management District is proposed for the impoundment site. The total estimated real estate cost of this component is $8,734,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component M6 (Alternative D)

Site 1 Impoundment – Palm Beach County component consists of the same 1,660 acre impoundment site as in Component M4 owned by the South Florida Water Management District, plus an additional 800 acres (land-type unknown) located south of the 1,660-acre site, and also incorporates a portion of the Hillsboro Canal into the reservoir to increase the aquifer storage recovery capacity. The purpose is to increase regional water resources and supplement water deliveries to the Hillsboro Canal during the dry-season. The total estimated real estate cost of this component is $22,779,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component O1 (Alternative A), Component O4 (Alternatives A, B &C)

The Water Conservation Area 3A and 3B Levee Seepage Management in Broward County. For real estate purposes, both of these components (O1 and O4) have identical real estate requirements. The purpose is to reduce seepage from Water Conservation Areas 3A and 3B, to improve hydropatterns within the Water Conservation Areas by utilizing the marsh areas that are located east of the Water Conservation Areas and west of U.S. Highway 27, and to allow higher water levels and longer inundation durations within those marshes. Seepage from the marshes will be collected and returned to the Water Conservation Areas to maintain flood protection. Either of these components would also serve to separate Water Conservation Area 3A seepage water from urban runoff originating in the C-11 Basin. The real estate involved is land required for the location of a divide structure being added to the C-11 Canal just east of US 27, and a new levee west of US 27. The amount of acreage needed for either of these components is estimated at 6,542 acres of primarily vacant prairie land. The total estimated real estate cost for either of the components (O1 or O4) is $47,601,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component P2 (Alternative A)

The North New River Diversion Canal and Treatment Facility component consists of a diversion canal and treatment facility in Broward County with increased pump and structure capacities and seasonal S-141 operations. The purpose of this component is to capture excess North New River Canal and Water Conservation Area 2B water, store and treat it in western C-11, and backpump it to Water Conservation Area 3A. This will (1) restore a portion of water deliveries to Water Conservation Area 3A that are eliminated by segregating the C-11 runoff from levee seepage, (2) reduce stages above the Natural Systems Model in Water Conservation 2B, and (3) divert water through Water Conservation Areas 3A and 3B to Northeast Shark River Slough. Untreated, western C-11 runoff that is presently backpumped through the S-9 pump station into Water Conservation Area 3A will be redirected into the new canal and diverted to the Central Lake Belt Storage Area (refer to Component Q1). The water quality treatment area will consist of about 1,600 acres, in an area not specifically identified within Broward County. The diversion canal consists of about 400 acres, also type unknown. The total estimated real estate cost of this component is $68,167,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/ acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component Q1 (Alternative A)

Western C-11 Diversion Canal (to Central Lake Belt Storage) component is located in Broward County and its purpose is to divert untreated runoff from western C-11 (presently discharged into Water Conservation Area 3A) and excess flows from the North New River and C-9 Canals to the Central Lake Belt Reservoir. Approximately 535 acres of seemingly agricultural land will be needed for this component. The total estimated real estate cost is $5,156,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/ acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component Q4 (Alternative B) and Component Q5 (Alternatives C & D)

Western C-11 Diversion Impoundment and Canal (1,600 acres of stormwater treatment area/impoundment and 2,500 cfs diversion canal-935 acres). The purpose of both of these components (Q4 and Q5) is to divert untreated runoff from western C-11 that is presently discharged into Water Conservation Area 3A through the C-11 Stormwater Treatment Area/Impoundment and then into the North Lake Belt Storage Area. For real estate purposes, the real estate requirements of both of these components (Q4 and Q5) are identical and consist of a 1,600-acre impoundment area and 935 acres of canal, on what appears to be agricultural land. The total estimated cost of either of these components (Q4 or Q5) is $73,323,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component R3 (Alternative A) and Component R4 (Alternatives B, C & D)

C-9 Stormwater Treatment Area/Impoundment (2,500 acres at 4 feet maximum depth). The purpose of components R3 and R4 is to provide treatment of water supply deliveries from the North Lake Belt Storage Area prior to deliveries to the C-9, C-6/C-7 and C-2/C-4 Canals, and to provide groundwater recharge within the basin and seepage control of Water Conservation Area 3 and buffer areas to the west. For real estate purposes, the real estate requirements are identical for both components R3 and R4 and consist of the 2,500 impoundment area (land type unknown) within Broward County. The total estimated real estate cost for the components (R3 or R4) is $71,024,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component S3 (Alternative A)

Central Lake Belt In-ground Storage Area. The purpose of this component is to capture a portion of runoff from western North New River, C-11, C-9, C-6 and C-7 Basins in an in-ground reservoir, which will allow storage of untreated runoff without concerns of ground water contamination. The stored water will be used to maintain stages during the dry season in the C-9, C-6, Northwest Wellfield protection canal, C-4, C-2 and the South Miami-Dade Conveyance System Canals. The component will require approximately 6,070 acres of land identified as wetland prairie, melaleuca trees and rock quarry lands, located within Miami-Dade County. The total estimated real estate cost of this component is $188,007,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component S5 (Alternatives B and C) and Component S6 (Alternative D)

Central Lake Belt Storage Area (CLBSA) – The purpose of either of these components (S5 or S6) is to receive and store excess water from Water Conservation Area 2B, 3A and 3B without groundwater seepage losses in this highly transmissive region. The stored water will be provided based on priority to 1) Northeast Shark River Slough, 2) Water Conservation Area 3B, 3) to supply flows to Biscayne Bay and 4) when available to meet Snapper Creek demands and to maintain Dade-Broward levee borrow canal at elevation 5.0 feet NGVD. For real estate purposes, the land required for the components (S5 or S6) is identical and consists of approximately 5,770 acres of vacant and quarry lands within Miami-Dade County. The total estimated real estate cost of either of these components (S5 or S6) is $84,507,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component T6 (Alternatives A, B, C & D)

C-4 Structures (2). The purpose of this component is to maintain higher water levels in the C-4 Canal; to reduce seepage losses from the Pennsuco Wetlands and areas west of the Dade-Broward Levee; and to reduce deliveries from Lake Okeechobee and the Water Conservation Areas by diverting dry season stormwater flows into the C-2 Canal to increase recharge to several nearby coastal wellfields. Alternative D includes the second C-4 structure. Approximately 2 acres of commercial land in Miami-Dade County were valued for this component. The total estimated real estate cost of this component is $446,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/ acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component U3 (Alternative A), Component U4 (Alternatives B and C) and Component U6 (Alternative D)

Bird Drive Recharge Area (2,877 acres at 4 feet maximum depth). The purpose of each of these components U3, U4 and U6 is to provide flood peak attenuation by capturing runoff from western C-4 Basin and pumping it to the Bird Drive Recharge Area, and to enhance groundwater recharge and reduce seepage from the Everglades National Park buffer areas by increasing water table elevations east of Krome Avenue, with the introduction of inflows from the West Dade Wastewater Treatment Plant (treatment plant only in U6). The facility will also provide water supply deliveries to the South Dade Conveyance System and Northeast Shark River Slough. For real estate purposes, the land requirements are the same for all three of the components (U3, U4 or U6) and consist of 2,877 acres of mostly wetlands within Miami-Dade County. The total estimated real estate cost of either of the three components (U3, U4 or U6) is $71,625,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component V2 (Alternative A)

L-31N Levee Improvements for Seepage Management. The purpose of this component is to manage levee seepage along the eastern edge (L-31N) of Everglades National Park to eliminate losses to the East Coast. An additional feature was added to reduce all wet-season seepage/ground water flows to the east to help restore hydropatterns in Everglades National Park. The real estate requirements consist of 40 acres of land (type unknown) within Miami-Dade County. The total estimated cost of this component is $2,576,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component W2 (Alternatives A, B, C & D)

Taylor Creek/Nubbin Slough Storage and Treatment Area. The purpose of this component is to provide flood protection, water quality treatment, estuary protection and water supply benefits. Local runoff from the Taylor Creek/Nubbin Slough Basins would be pumped into a 5,000 acre reservoir and then into a 5,000-acre stormwater treatment area. The real estate requirements consist of two 5,000-acre sites of primarily pastureland within Okeechobee and/or St. Lucie Counties. The total estimated real estate cost of this component is $29,700,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component X6 (Alternatives A, B, C & D)

C-17 Backpumping. The purpose of this component is to reduce water supply restrictions in Northern Palm Beach County service area by providing additional flows from the C-17 Basin to the West Palm Beach Water Catchment Area and enhancing hydroperiods in the Loxahatchee Slough. A 550-acre site (land with mostly standing water) located within Palm Beach County is required for this component. The total estimated real estate cost of this component is $10,367,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component Y6 (Alternatives A, B, C & D)

C-51 Backpumping to Water Catchment Area. The purpose of this component is to increase regional water resources, to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-51 West Basin (which would otherwise be sent to tide) to the West Palm Beach Water Catchment Area, and to enhance hydroperiods in Loxahatchee Slough. Approximately 710 acres of land (primarily with standing water) located in Palm Beach County is required for this component. The total estimated real estate cost of this component is $13,475,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component BB4 (Alternatives A and B) and Component BB5 (Alternatives C & D)

Dade-Broward Levee/Pennsuco Wetlands. The purpose of this component is to reduce seepage to the east from the Pennsuco Wetlands and southern Water Conservation Area 3B, enhance hydroperiods in the Pennsuco Wetlands, and enhance recharge to Miami-Dade County's Northwest Wellfield. Approximately 70 acres of open pastureland in Miami-Dade County were valued for either component BB4 and BB5. The total real estate cost estimate of either component BB4 or BB5 is $4,361,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component FF3 (Alternative A)

Construction of S-356 A & B Structures (L-31N along east side of Northeast Shark River Slough). The purpose of this component is to improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3. Approximately 4.0 acres of pastureland located in

Miami-Dade County was valued for this component. The total estimated real estate cost of this component is $300,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component FF4 (Alternatives B, C & D)

Construction of S-356 A & B Structures and relocation of a portion of L-31N: The purpose of this component is to improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3. Approximately 3,947 acres of farmland with some quarry land located in Miami-Dade County is required for this component. The total estimated real estate cost of this component is $60,819,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component GG4 (Alternatives A, B, C & D)

Lake Okeechobee Aquifer Storage and Recovery. The purpose of this component is to utilize climate based operational rules for the aquifer storage and recovery wells, to provide additional regional storage while reducing both evapotranspiration losses and the amount of land removed from current land use (e.g. agriculture) that would normally be associated with construction and operation of above-ground storage facilities (reservoirs); to increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades; to manage a portion of regulatory releases from the Lake primarily to improve Everglades hydropatterns, to meet environmental targets within the Water Conservation Areas and to meet supplemental water supply demands of the Lower East Coast; to reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee Estuaries; and to maintain existing level of flood protection. This component would be located within Glades and/or Okeechobee Counties and would consist of the acquisition of approximately 300 acres of open pastureland. The total estimated real estate cost of this component is $7,065,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component KK4 (Alternatives A, B, C & D)

Loxahatchee National Wildlife Refuge Internal Canal Structures. The purpose of this component is to improve timing and location of water depths in the Refuge by keeping the borrow canal structures closed except to pass Stormwater Treatment Areas 1 East and 1 West outflow and water supply deliveries. The real estate requirements consist of the acquisition of approximately 5.0 acres of open pastureland within Palm Beach County. The total real estate cost of this component is $345,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component LL3 (Alternative A) and Component LL6 (Alternative D)

C-51 Regional Groundwater Aquifer Storage and Recovery (34 well clusters). Either of these components would be located in Palm Beach County. The purpose would be to capture and store excess water during wet periods, then recover the water for utilization during dry periods to increase regional water resources. For real estate purposes, both of these components (LL3 and LL6) have identical real estate requirements. Approximately 34 acres of open pastureland with some commercial land was valued for this component. The total estimated real estate cost of this component is $7,395,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component LL4 (Alternatives B & C)

C-51 Regional Groundwater Aquifer Storage and Recovery (54 well clusters). This component would be located in Palm Beach County. Its purpose would be to increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods. Approximately 54 acres of open pastureland with some commercial land was valued for this component. The total estimated real estate cost of this component is $11,745,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component MM4 (Alternatives A, B & C)

Hillsboro Canal Basin Regional Groundwater Aquifer Storage and Recovery (22 well clusters): The purpose of this component is to increase regional water resources by capturing and storing excess water during wet periods and recover the water for utilization during dry periods. This component would be located in Palm Beach and/or Broward Counties and would require approximately 22 acres of land. Commercial land was valued for this component, the total estimated real estate cost is $4,455,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component PP3 (Alternative A)

Backpumping of the C-7 Basin to the Central Lake Belt In-ground Storage Reservoir via the C-6 Canal: The purpose of this component is to backpump a portion of excess runoff from the C-7 Basin, previously lost to tide, to the Central Lake Belt Storage Reservoir to be used for water supply, and to decrease flooding problems in the C-7 Basin. Approximately 4.0 acres of commercial land in Miami-Dade County was valued for this component. The total estimated real estate cost of this component is $1,064,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component SS4 (Alternatives B, C & D)

Reroute Miami-Dade County Water Supply Deliveries. The purpose of this component is to reroute water supply deliveries made to Miami-Dade County from the Miami and Tamiami Canals and Water Conservation Area 3 to the North New River Canal due to the backfilling of the Miami Canal as part of the decompartmentalization of Water Conservation Area 3. Approximately 200 acres of land to be located within Palm Beach, Broward and Miami-Dade Counties would be required for this component (residential-type land was valued). The total estimated real estate cost of this component is $18,480,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component UU6 (Alternatives A, B, C & D)

Storage Reservoirs (20,200 acres at 8 feet maximum depth and 15,000 acres at 2 feet maximum depth). The purpose of this component is to capture local runoff from the C-23, C-24, and Northfork and Southfork Basins of the St. Lucie River Estuary for: flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. Approximately 35,200 acres of land within Martin and St. Lucie Counties were valued for this component. The total estimated real estate value of this component is $244,578,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component VV4 (Alternative B), Component VV5 (Alternative C), and Component VV6 (Alternative D)

Palm Beach County Agricultural Reserve Reservoir. For real estate purposes, the real estate requirements for the three components (VV4, VV5 and VV6) are identical. In general, the purpose of any of these components is to increase regional water resources in central and southern Palm Beach County by capturing and storing water currently discharged to tide to be used to maintain canal stages during the dry season. Approximately 1,660 acres of agricultural land in Palm Beach County is required for any of the three components (VV4, VV5 or VV6). The total estimated real estate cost of any of the three components (VV4, VV5 or VV6) is $57,657,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. An estimated 18 improvements would be acquired at a cost of $4,500,000 with relocation assistance costs of $414,000 included.

Component WW4 (Alternative B)

C-111N Spreader Canal. The purpose of this component is to reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Miami-Dade area. Approximately 9,225 acres of vacant land in Miami-Dade County will be required for this component. The total estimated real estate cost is $24,513,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component WW5 (Alternatives C & D)

C-111N Spreader Canal. The purpose of this component is to reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Miami-Dade area. C-111N was extended east of Card Sound Road. Approximately 12,415 acres of vacant land in Miami-Dade County was valued for this component. The total estimated real estate cost of this component is $45,741,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component XX4 (Alternative B)

North Lake Belt Storage Area. The purpose of this component is to increase regional water resources by capturing a portion of runoff from western C-6, western C-11 and C-9 Basins without seepage losses in this very transmissive groundwater region and without concerns of ground water contamination from untreated runoff. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals. Approximately 5,861 acres of vacant and quarry land in Miami-Dade County was valued for this component. The total estimated real estate cost of this component is $130,743,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component XX5 (Alternative C) and Component XX6 (Alternative D)

North Lake Belt Storage Area. The purpose of both of these components (XX5 and XX6) is to increase regional water resources by capturing a portion of runoff from western C-6, western C-11 and C-9 Basins without seepage losses in this very transmissive groundwater region and without concerns of ground water contamination from untreated runoff. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals. The real estate requirement for either Components XX5 or XX6 are the same. Approximately 5,861 acres of vacant and quarry land in Miami-Dade County was valued for this component. The total estimated real estate cost of both Component XX5 or XX6 is $121,302,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component YY4 (Alternatives B, C & D)

Divert Water Conservation Area 2 flows to Northeast Shark River Slough or Central Lake Belt Storage in Broward County. The purpose of this component is to capture excess water in Water Conservation Area 2B, to reduce stages above targets, and to divert water through improved L-37 and L-33 borrow canals to meet the following prioritized demands: (1) Northeast Shark River Slough; or (2) Central Lake Belt Area for future delivery to Northeast Shark River Slough; (3) to Snapper Creek; and (4) to maintain Miami-Dade-Broward levee borrow canal at elevation 5.0 feet NGVD. Approximately 835 acres of land (type unknown) in Miami-Dade County would be required for this component. The total estimated real estate cost of this component is $12,145,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component ZZ5 (Alternatives C & D)

Divert Water Conservation Area 3A and 3B flows to Central Lake Belt Storage Area. The purpose of this component is to capture excess water above target stages in Water Conservation Area 3A and 3B and divert it through modified structures at S-9 and S-31 to the Central Lake Belt Storage Area via the L-33 borrow canal. Approximately 2.0 acres of open pastureland in Miami-Dade County was valued for this component. The total estimated real estate cost of this component is $277,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component BBB6 (Alternatives C & D)

South Miami-Dade County Reuse (South District Reclaimed Water Treatment Plant). The purpose of this component is to augment water supply to the South Biscayne Bay and Coastal Wetlands Enhancement Project; to restore overland flow in the coastal area; to recharge groundwater; to enhance groundwater discharge to Biscayne Bay; and to provide saltwater intrusion benefits to the southern part of Miami-Dade County through the use of superiorly treated reclaimed water from the South District Wastewater Treatment Plant. Approximately 200 acres of land in Miami-Dade County would be required for this component. The total estimated real estate cost of this component is $3,324,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component CCC6 (Alternatives C & D)

Big Cypress/ L-28 Interceptor Modifications: The purpose of this component is to alleviate over-drainage in northeast Big Cypress, Kissimmee, Billy and Mullet Slough area, ensure applicable water quality treatment and restore sheetflow to wetland areas in northeast Big Cypress Addition. Approximately 1,900 acres of sugar cane land in Hendry, Collier and Broward Counties were valued for this component. The total estimated real estate cost of this component is $6,675,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component DDD5 (Alternatives A, B, C & D)

Caloosahatchee Backpumping with Stormwater Treatment Area. The purpose of this component is to increase the regional water resources by capturing excess C-43 Basin runoff and diverting it into Lake Okeechobee after treatment through a stormwater treatment area when storage is available in the Lake. Approximately 5,000 acres of pastureland in Hendry and Glades Counties were valued for this component. The total estimated real estate cost of this component is $13,179,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component FFF5 (Alternatives C & D)

Biscayne Bay Coastal Canals. The purpose of this component is to maintain higher stages in the C-102 and C-103 Canals for urban and environmental water supply. A proposed borrow canal will interconnect the downstream reaches of the C-102 and C-103 Canals. Approximately 350 acres of land located within Miami-Dade

County would be required for this component. The total estimated real estate cost of this component is $5,655,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component GGG6 (Alternative D)

C-51 and Southern L-8 Reservoir. The purpose of this component is to reduce the number, magnitude, and volume of discharges to the Lake Worth Lagoon; to provide water supply deliveries to the Northwest Fork of the Loxahatchee River, Lake Worth Drainage District and the West Palm Beach Water Catchment Area; and to provide flood peak attenuation to the C-51 and southern L-8 Basins. Approximately 1,800 acres in Palm Beach County would be acquired for this component. The total estimated real estate cost of this component is $27,351,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

Component HHH6 (Alternative D)

West Dade Reuse. The purpose of this component is to enhance groundwater recharge to the Bird Drive Recharge Area, and to provide water supplies to the South Dade Conveyance System and Northeast Shark River Slough. Approximately 100 acres of vacant land in Miami-Dade County was valued for this component. The total estimated real estate cost of this component is $3,540,000, which includes the estimated lands and damages costs, Federal and non-Federal administrative/acquisition costs, and a contingency. No improvements or relocation assistance costs were included.

F.8 RECOMMENDED PLAN-ALTERNATIVE D-13R

As Alternatives A through D were being formulated, more extensive real estate information was being obtained from the South Florida Water Management District, on lands that it had already acquired within components of the alternatives. Additionally, attempts were made to obtain information on the estates owned by South Florida Water Management District in lands within existing canal rights-of-way as well as the width of the rights-of-way. The teams from Real Estate Division and Planning Division also met to discuss the different components and the variables that would determine the contingencies for the components in Alternative D13R. Real Estate Division was requested to provide for each component a range of values (cost estimates). The range would present an estimated low-end cost, an estimated high-end cost, and the estimated probable cost for each component in the Initial Draft Plan. Estimated low-end, estimated probable, and estimated high-end costs are based on a number of different scenarios, which are discussed further in each of the components. After review of information obtained from the South Florida Water Management District, costs for the Initial Draft Plan were modified accordingly. Additional acreage was added to some of the components, because it was determined that South Florida Water Management District did not own some of the lands that were thought to be owned by it during the review of Alternatives A through D. Contingencies on each of the components could be reduced, if mineral interests outstanding in third parties were not acquired. A method of accomplishing this would be to secure a release of the right of entry to the surface from the owner of the third party mineral interest (see discussion in Paragraph 22 below). After completion of the Initial Draft Plan, South Florida Water Management District and other component proponents provided additional real estate information, including revised acreages and revised recommended land costs that have been incorporated into the recommended Comprehensive Plan.

Component A6

Component A6 is a storage reservoir and stormwater treatment area located north of Lake Okeechobee with a total storage capacity of 200,000 acre-feet. The purpose of the storage reservoir is to increase the capacity of the hydrologic system to better meet the water management objectives associated with flood protection, water supply and environmental enhancement and to reduce nutrient loads flowing to the lower Kissimmee River and Lake Okeechobee. The additional water storage capacity allows for greater detention of water during wet periods for subsequent use during dry periods. It is also anticipated that this increased storage capacity will shorten the duration and frequency of both high water levels in the Lake that are stressful to the Lake littoral ecosystems, and large discharges from the Lake that are disruptive to the downstream estuary ecosystems. Water from Lake Okeechobee is to be pumped into this storage reservoir when the climate-based inflow forecast projects that the Lake water level will rise significantly above those levels that are desirable for the Lake littoral zone. During the dry season, flows will be allowed back to the Lake from the reservoir when the Lake level is projected to fall to within three-quarters of a foot of the supply-side management line in the same dry season, or below 11.75 feet NGVD in the upcoming wet season. During the wet season, flow will be allowed from the reservoir to the Lake, when climate-based inflow forecast projects less than 1.5 million acre-feet of inflow during the next 6 months, and the Lake water level is either currently below 11.75 feet NGVD or projected to be in supply-side management during the upcoming dry season. There will be an inflow pump station with a capacity of 4,800 cfs and an outflow structure with a capacity of 4,800 cfs.

This component could lie in any of three counties north of Lake Okeechobee (Glades, Highlands, or Okeechobee). The counties appear to be primarily agricultural in nature and the approach to locating this component would be to stay in an area that was as rural as possible. The range of values estimated for this component are between $400 to $2,500 per acre for pasture land and other general agricultural uses; however, sales are dated due to slow growth and stabilized communities. Citrus is a large crop in some of the counties being analyzed. Older citrus grove sales in various counties reflect an estimate of value between $8,000 to $12,000 per acre. More recent citrus grove sales reflect an estimate between $4,000 and $6,000 per acre, generally. It is not anticipated that this component will have any impacts to commercial or residential properties, therefore, no commercial or residential sales are considered at this time. There are several large ownerships in these counties and sales are dated and sparse. Since this component covers such a large area, 20,000 acres, and the exact location has not been determined, and there are unknown land parameters; only very broad generalities can be surmised. There are no values being included for improvements at the present time.

Due to an indefinite location within the three counties being considered for this component, an estimated value of $6,000 per acre is being used for the estimated probable cost. As such, 20,000 acres at $6,000 per acre yields an estimate of $120,000,000 for the estimated probable land cost of Component A6. The number of affected ownership tracts is unknown, but is projected to be approximately 360 tracts. Based on this, the Federal administrative/acquisition cost is estimated at $2,160,000, and the non-Federal administrative/acquisition is estimated at $4,320,000. The number of residential and/or business relocations is unknown. A contingency of 50 percent is added to this component to cover these unknowns. The total estimated probable real estate cost of this component is $189,720,000.

The estimated low-end real estate cost of this component is $46,614,000. This estimate is based on the assumption that the site would be located in Okeechobee County on 18,720 acres identified as a potential site. This site is valued at $26,816,000. The same acquisition/administrative estimates apply, but the contingency factor is lowered to 40 percent due to identification of a potential site.

The estimated high-end real estate cost of this component is at $249,720,000. This is assuming that the site could be in any of the three counties and would include more citrus groves than pasture/crop land. The estimated land costs for the 20,000 acres is $160,000,000. The same acquisition/administrative estimates apply as well as a 50 percent contingency.

Component B2

Component B2 is a storage reservoir in the St. Lucie/C-44 Basin to be located in Martin County. The purpose of the storage reservoir to capture local runoff from C-44 Basin. The reservoir will be designed for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. It will have an inflow pump station with a 1,000 cfs capacity and an outflow structure with an 800 cfs capacity.

The general area designated for this 10,000-acre storage reservoir is north of the St. Lucie Waterway, and in an easterly direction of Indiantown. The specific site has not been selected and mapped. The general area identified appears to be primarily in citrus groves. Aerials available of this area show a preponderance of groves, which are assumed to be citrus.

Based on grove sales and sales listings in the area a value of $6,000 per acre or a total probable land value estimate of $60,000,000 for 10,000 acres of groves in the general area of this component. There are no values being placed on crops or improvements in this estimate. The number of affected ownership tracts is unknown, but is projected to be approximately 25 tracts. Based on this, the Federal administrative/acquisition cost is estimated at $150,000 and the non-Federal administrative/acquisition cost is estimated at $300,000. The number of residential and/or business relocations is unknown. A contingency of 50 percent is added to this component to cover these unknowns. The total estimated probable real estate cost of this component is $90,675,000.

The estimated low-end real estate cost of this component is $78,585,000, which reflects a 30 percent contingency on the estimated land costs of $60,000,000, and the assumption that the Federal and non-Federal administrative/acquisition costs would remain as set forth above. The 30 percent contingency is based on the assumptions that the site would include low cost or no improvements, there would be little or no severance damages, and minimal relocation costs.

The estimated high-end real estate cost of this component is $93,375,000. This is assuming that all the lands are groves at $6,000 per acre for a total estimated land cost of $60,000,000 and all 25 tracts contain improvements valued at $50,000 for each parcel ($1,250,000 total) and the owners will have to be relocated at an estimated cost of $550,000. The Federal and non-Federal administrative/acquisition costs would remain the same as set forth above and the contingency would be 50 percent.

Component D5

Component D5 is a storage reservoir with Aquifer Storage and Recovery in the Caloosahatchee/C-43 Basin to be located within Hendry, Glades or Lee Counties. The purpose of the storage reservoir(s) with aquifer storage and recovery is to capture basin runoff and releases from Lake Okeechobee. These facilities will be designed for water supply benefits, some flood attenuation, and to provide environmental water supply deliveries to the Caloosahatchee Estuary. Excess runoff from the C-43 Basin and Lake Okeechobee flood control discharges will be captured by the proposed C-43 reservoir(s). Water from the reservoir(s) will be used to provide environmental deliveries to the Caloosahatchee Estuary, to meet demands in the Caloosahatchee Basin and to inject water into the aquifer storage and recovery wellfield for long-term (multi-season) storage. Water from the aquifer storage and recovery facilities will be used to meet environmental demand of the estuary and meet basin demands. Any estuarine demands not met by basin runoff, the reservoir, and the aquifer storage and recovery system, will be met by Lake Okeechobee, as long as Lake Stage is above 11.5 feet NGVD. Lake water is also used to meet the remaining basin demands subject to supply-side management. The C-43 reservoir is operated in conjunction with Component DDD5, the Caloosahatchee Backpumping Facility, which includes a stormwater treatment area for water quality treatment. If the levels of water in the reservoir exceed 6.5 feet and Lake Okeechobee is below the pulse release zone, then water is released and sent to the backpumping/treatment facility at 2,000 cfs. The component will also have a total of 44, 5-million gallons per day (MGD) aquifer storage and recovery wells with inflow limited to 220 MGD and outflow structures limited to 220 MGD. The reservoir inflow pump will have a capacity of 3,800 cfs with an outflow structure capacity of 3,000 cfs.

This is a 20,000 acre storage site may be located in Glades, Lee or Hendry Counties. However, this no site has been finalized. Sales available on general agricultural land in these counties were from $400 to $2,500 per acre. Groves are estimated at $6,300 per acre. There can be no specific values included for structures as none are identified. More specific land uses can not be identified with the data currently available.

Based on the indefinite location, it is assumed that half of the required acreage (10,000 acres) would likely be sugar cane/pasture land at a value estimated at $2,500 per acre, and the other half of the required land (10,000 acres) would be groves at a value estimate of $6,300 per acre. This assumes that no significant amount of residential, or commercial property will be involved. Therefore 10,000 acres at $2,500 yields $25,000,000 and 10,000 acres at $6,300 yields $63,000,000 for a total of $88,000,000 in probable land costs for this component.

The number of affected ownership tracts is unknown, but is projected to be approximately 23 tracts. Based on this, the Federal administrative/acquisition cost is estimated at $138,000 and the non-Federal administrative/acquisition cost is estimated at $276,000. The number of residential and/or business relocations is unknown. A contingency of 50 percent is added to this component to cover these unknowns. Both the estimated probable and estimated high-end real estate cost estimates are the same for this component, $132,621,000.

The estimated low-end real estate cost of this component is $63,018,000, which reflects a probability that all 20,000 acres would be sugar cane/pasture land at $2,500 per acre for a total land value of $50,000,00 and that Federal and non-Federal administrative/acquisition costs would be the same as set forth above. A 25 percent contingency was applied. This contingency is based on the assumptions that the site would consist mostly of unimproved pastureland and that there would be only 23 affected tracts.

Component G6

Component G6 is a storage reservoir in the Everglades Agricultural Area conceptually located in Palm Beach County between the Miami & North New River Canals. The component will include Bolles and Cross Canal conveyance capacity improvements. The purpose of the storage reservoir is: (a) to improve the timing of environmental deliveries to the Water Conservation Areas, including reducing damaging flood releases from the Everglades Agricultural Area to the Water Conservation Areas; (b) to reduce Lake Okeechobee regulatory releases to estuaries; (c) to meet supplemental agricultural irrigation demands; and (d) to increase flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami and North New River Canals between Lake Okeechobee and the storage reservoir(s) is increased to convey additional Lake Okeechobee flood control releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries. Conveyance capacity of the Bolles and Cross Canals between the Miami and Hillsboro Canals is increased to facilitate interbasin transfers for storage and flood protection. The component will be operated so that inflows are from Lake Okeechobee regulatory discharges and runoff from Miami and North New River and canal basins. The reservoir will be divided into three compartments.

Compartment 1: 20,000 acres, meets Everglades Agricultural Area irrigation demands only. The source of water is excess Everglades Agricultural Area runoff. Inlet capacities for excess runoff are 2,700 and 2,300 cfs, for the Miami Canal and the North New River Canal Basins, respectively. Outlet capacities for Everglades Agricultural Area demands are 3,000 and 4,400 cfs, for the Miami Canal and the North New River Canal Basins. Overflow to compartment 2A occurs when the depth of water approaches 6 feet maximum and Lake Okeechobee regulatory discharges are not occurring or impending. Excess Everglades Agricultural Area runoff is diverted to compartment 2A only if Water Conservation Area 3A is too deep.

Compartment 2A: 20,000 acres, meets environmental demands as a priority, but can supply a portion of Everglades Agricultural Area irrigation demands if environmental demands equal zero. The sources of water are overflow from compartment 1 and Lake Okeechobee regulatory releases including the weather forecasting to initiate storage usage. Compartment 2A will be operated as a dry storage reservoir and discharges made down to 18 inches below ground level. This compartment will have inflow pumps with capacity of 4,500 cfs and 3,000 cfs for diversion of Lake Okeechobee regulatory releases from the Miami Canal and the North New River Canal, respectively, and an outflow structure with a capacity of 3,600 cfs at 6 feet head to Stormwater Treatment Area 3/4. The component also increases the conveyance capacity in the Miami, North New River and Bolles and

Cross Canal by 200 percent, with outflow structures to the Miami Canal of 4,500 cfs and to the North New River Canal of 3,000 cfs.

Compartment 2B: 20,000 acres, meets environmental demands as a priority. The sources of water are overflow from compartment 1 and 2A and Lake Okeechobee regulatory releases only during the extreme wet events. Compartment 2B will be operated as a dry storage reservoir and discharges made down to 18 inches below ground level. The conveyance of the northern reaches of the Miami and North New River Canals in the Everglades Agricultural Area are tripled (200 percent increase) for Lake Okeechobee regulatory releases. Structures with a capacity of 4,500 cfs for diversion of regulatory releases through the Miami Canal and 3,000 cfs for diversion of regulatory releases through the North New River Canal are added to compartments 2A and 2B. When the reservoir depth falls below 1.5 feet, Lake Okeechobee is used for meeting supplemental irrigation and environmental demands. The flows will be delivered to the Water Conservation Areas through Stormwater Treatment Area 3/4.

The Department of Interior and South Florida Water Management District are acquiring property in the Everglades Agricultural Area, known as the Talisman property, utilizing funds from the Farm Bill (Public Law 104-127, Section 390)-Interior funding and South Florida Water Management District funds. The purchase of the Talisman property will provide approximately 45,000 acres of the 60,000 acres required for this component. The purchase price for the Talisman property ($152,500,000) is being funded by the Department of Interior and South Florida Water Management District. The Department of Interior is contributing $108,000,000 and the South Florida Water Management District will contribute $44,500,000 ($25,500,000 for the lands to be utilized as stormwater treatment areas to be acquired pursuant to the State's Everglades Forever Act and $19,000,000 for the purchase of the retention rights of Talisman). The $19,000,000 will be applied to the Restudy cost share of the South Florida Water Management District; however, the $25,500,000 will not be credited. The lands ultimately acquired will eventually be transferred to the South Florida Water Management District and can be utilized for this component. The South Florida Water Management District and Interior are working on a series of exchange agreements with private parties that may provide up to 45,114 acres for this component. Additionally, Interior has funded through a Farm Bill grant, funding for the purchase of an additional 1,233 acres by South Florida Water Management District in the amount of $3,090,800. The South Florida Water Management District is also purchasing 5,280 acres in the same area for approximately $20,000,000 that could be utilized for this component. This land is a sod farm. Approximately $111,100,000 of Interior funds will be applied as part of the Federal cost share for this component. As this component requires a 60,000-acre storage site, for planning purposes, it is estimated that the remaining acreage required for this component will be approximately 8,400 acres. The remaining 8,400 acres are valued partly as sugar cane and partly as sod farms. Sales for lands in sugar cane are valued from $2,800 to $3,400 per acre in this area. However, there are other agricultural uses (sod farms) in this area that have a range in value between $3,700 and $4,000 per acre. This is an area of largely open agricultural lands. For planning purposes, it is assumed that of the remaining 8,400 acres; 4,000 acres would be in sugar cane valued at $3,400 per acre for a total of $13,600,000, and the remaining 4,400 acres would be sod farms at $4,000 per acre for a total of $17,600,000, therefore this 8,400 acres is valued at $31,200,000. The total estimated probable and estimated high-end real estate lands and damages valuation for this area would be $70,200,000 ($31,200,000-8,400 acres + $19,000,000 Talisman retention + $20,000,000 –5,280 acre sod farm).

The number of affected ownership tracts is unknown, but is projected to be approximately 18 tracts. The Federal administrative/acquisition cost is estimate at $9,000 per tract and non-Federal administrative/acquisition cost is estimate at $18,000 per tract. Based on this, the Federal administrative/acquisition cost is estimated to be $162,000 and the non-Federal administrative/acquisition cost is estimated to be $324,000. The number of residential and/or business relocations, mineral activity, and severance damages are unknown. A contingency of 50 percent is added to 8,400 acres land cost of $31,200,000 ($15,600,000 contingency) and the administrative/acquisition costs to cover these unknowns. Both the estimated probable and estimated high-end real estate cost estimates are the same for this component, $86,536,000 for the remaining acres required.

The estimated low-end real estate cost of this component is $63,006,000. This assumes the low-end range of value ($2,800) per acre for the remaining 8,400 acres ($23,520,000) added to the Talisman retention ($19,000,000) and the cost for the 5,280 acre sod farm ($20,000,000) for the lands and damages estimate. All the other cost estimates remain the same as the probable/high-end cost estimate, including a 50 percent contingency on the $23,520,000 and the Federal and non-Federal administrative/acquisition costs.

Component K6

Component K6 is a modification of the L-8 project, which includes a proposed reservoir as described in component GGG6 and an Aquifer Storage and Recovery capacity of 50 million gallons per day. It is located in the Water Preserve Area in Palm Beach County and comprises 380 acres (not including the proposed storage reservoir as described in component GGG6). The purpose of this component is to reduce water supply restrictions in the Northern Palm Beach County Service Area by capturing more of the annual discharges from portions of the southern L-8, C-51 and C-17 Basins and route this water to the West Palm Beach Water Catchment Area. Intent is to increase water supply availability and provide pass through flow to enhance hydroperiods in Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River. The component would be operated to capture excess L-8, C-51 and C-17 Basin water to meet urban water supply demands in the Northern Palm Beach County Service Area and enhance hydroperiods in the Loxahatchee Slough. Water would be diverted through the M-Canal to the Water Catchment Area. Stormwater treatment areas will be provided to meet all water quality standards required if necessary. The component will have aquifer storage and recovery well with a capacity of 50 million gallons per day to provide water during regionally triggered droughts and as a means of reducing withdrawals from the West Palm Beach Water Catchment Area when the water levels are substantially below the target hydrograph. The majority or all of the 50 million gallons per day aquifer storage and recovery well clusters will be located in the vicinity of the City of West Palm Beach Water Treatment Plant (Clear Lake). However, due to modeling limitations, the aquifer storage and recovery wells will be located in the West Palm Beach Water Catchment Area. During periods when the West Palm Beach Water Catchment Area is above 18.0 feet NGVD, an additional (above the flow rate required to supply the water treatment plant) 50 million gallons per day (78 cfs) will be sent to Lake Mangonia for subsequent storage through the aquifer storage and recovery clusters (surficial well discharging into a Floridan well). The aquifer storage and recovery wells will provide water directly to Lake Mangonia when water levels in the West Palm Beach Water Catchment Area are within 0.2 feet of the level that triggers regional supply to the West Palm Beach Water Catchment Area. Another part of the component will be to increase the pumping capacity from the L-8 Tieback into the M-Canal to 300 cfs to increase the volume of water captured from the southern L-8 Canal and deliver it to the Water Catchment Area. This pump has dual purposes, 1) to capture L-8 Basin runoff when available and 2) to deliver regional deliveries when needed. This component also assumes that the Indian Trail Improvement District will adopt an operation plan which promotes water conservation by prioritizing discharge so that excess storm water is first offered to the West Palm Beach Water Catchment Area through installation of 2 pumps (300 cfs and 200 cfs) and secondarily discharged through off peak releases to the C-51 Canal via the M-1 Canal. For this alternative, pumping from Indian Trail Improvement District into the M-Canal for subsequent discharge into the West Palm Beach Water Catchment Area will be assumed to occur under the following conditions: (a) when the City of West Palm Beach Water Catchment Area has sufficient need for imported water as defined by being below 18.2 feet NGVD; (b) when water levels in the lower M-1 Basin exceed 14.0 feet NGVD during the wet season (June 1 through October 31) or 16.0 feet NGVD during the dry season (November 1 through May 31) the lower M-1 Basin may discharge up to 200 cfs for subsequent storage; and (c) when water levels in the upper M-1 Basin exceed 15.0 feet NGVD during the wet season or 16.0 feet NGVD during the dry season) the upper M-1 Basin may discharge up to 300 cfs for subsequent storage. Other features will be to (a) increase the conveyance of the M-Canal between the pump and the West Palm Beach Water Catchment Area to accommodate the increased inflow from the L-8 Canal and the Indian Trail Improvement District; and (b) to install a new structure in the south leg of C-18 just south of the west leg to facilitate better management of water levels and discharges from the Loxahatchee Slough. The new gravity structure would consist of a variable discharge up to 400 cfs and emergency overflow weirs; install a 50 cfs pump for water supply deliveries to utilities. A recharge canal may be improved to convey deliveries to utilities. Additionally a Stormwater Treatment Area(s) may be needed upstream of the Water Catchment Area to attain acceptable water quality standards and to accommodate future degradation of water quality. The size and location of the Stormwater Treatment Area(s) will be determined if treatment is required. New culverts will be constructed under Bee-Line Highway for up to 100 cfs deliveries to Loxahatchee Slough.

This estimate is based on very general information and relies on county-wide general knowledge. This is not a site specific component estimate. The component requires 40 acres of pasture/open land, required for widening an existing canal, with an amount of $10,000 per acre applied for a total lands and damages estimate of $1,420,000 for this 40 acres. The 40 acres consists of land required in widening the existing M Canal right-of-way. An additional approximately 340 acres is within the existing right-of-way of the M Canal, currently owned by Palm Beach County, which will be required. If the local sponsor has to acquire an interest from Palm Beach County for the 340 acres, that cost will be approximately $1,020,000 based on a estimated value of $3,000 per acre.

The number of affected ownership tracts is unknown, but is projected to be approximately 80 tracts. Based on this, the Federal administrative/acquisition cost is estimated to be $480,000, and the non-Federal administrative/acquisition cost is estimated to be $960,000. The number of residential and/or business relocations, mineral activity, and severance damages are unknown. The total real estate cost estimate for the probable and high-end costs is $4,290,000. This includes a contingency of 50 percent for the unknowns, and also assumes that the non-Federal sponsor will have to acquire an interest in the existing 340-acre M Canal from the County of Palm Beach.

The low-end estimated real estate cost of this component is $2,576,000. This assumes that the only acquisition needed for this component is the additional 40 acres to expand the canal's existing right-of-way, plus a 40 percent contingency. An amount of $10,000 per acre is estimated, for a total lands and damages estimate of $1,420,000. The Federal and non-Federal administrative/acquisition costs and the contingency are the same as in the estimated probable costs.

Component M6

Component M6 is a reservoir in the Water Preserve Area in Palm Beach County with a portion of the existing Hillsboro Canal incorporated into the reservoir. There will also be aquifer storage and recovery capacity of 75 million gallons per day and increased backpumping capacity. The purpose is to provide a water supply storage reservoir to supplement water deliveries to the Hillsboro Canal during the dry-season. The reservoir will be filled during the wet-season from excess water backpumped from the Hillsboro Canal. Water will be released back to the Hillsboro Canal to help maintain canal stages during the dry-season. If water is not available in the reservoir, existing rules for water delivery to this region will be applied. Aquifer Storage and Recovery capacity is being increased to improve water supply during dry seasons and droughts. Fifteen (15) 5 million gallons per day capacity aquifer storage and recovery wells will be added for a total of thirty (30) aquifer storage and recovery clusters for this alternative (total injection and recovery capacity is 150 million gallons per day or about 230 cfs). Water from the Site 1 Impoundment will be injected into the aquifer storage and recovery wells when stages in the impoundment are greater than 12.0 feet NGVD (0.5 feet of depth). Water will be recovered from the aquifer storage and recovery wells when stages in the Hillsboro Canal are less than 7.0 feet NGVD. There will be an inflow pump with a capacity of 700 cfs, which will be relocated to the eastern end of the Hillsboro Canal; an outflow structure with a capacity of 200 cfs at 4 feet of head; an emergency outflow structure with a capacity of 700 cfs; and thirty (30) – 5 million gallons per day aquifer storage and recovery wells.

There is an existing site of approximately 1,658 acres owned by South Florida Water Management District. The purchase price for this approximately 1,658 acres was $8,300,000. An additional 800 acres is required contiguous and south of the above acreage. The estimated price of this additional land is $12,000 per acre for a total value of $9,600,000. Total estimated probable land and damages costs are $17,900,000.

The number of affected ownership tracts is unknown, but is projected to be approximately 31 tracts. Based on this, the Federal administrative/acquisition cost is estimated to be $186,000 and the non-Federal administrative/acquisition cost is estimated at $425,000. The number of residential and/or business relocations, mineral activity, and severance damages are unknown. For both the probable and high-end cost estimates, a contingency of five percent is placed on the acquisition/administrative costs of the site already owned by South Florida Water Management District (currently estimated at $65,000). A contingency of 50 percent is placed on the 800-acre site value and the balance of the acquisition/ administrative cost estimate ($546,000) for this component. These contingencies are added to cover unknowns such as number of landowners, possible severance damages, outstanding mineral interests and possible relocation costs. Both the probable and high-end real estate cost estimates are the same for this component, $23,587,000.

The low-end estimated real estate cost of this component is reduced only by lowering the contingency to 40 percent on the 800-acre value and associated acquisition/administrative costs. The low-end estimate for this component is $22,573,000.

Component O6

Component O6 is located in the Water Preserve Area in Broward County. The purpose of this component is to reduce seepage from Water Conservation Areas 3A and 3B to improve hydropatterns within the Water Conservation Areas by allowing higher water levels in the borrow canals and longer inundation durations within the marsh areas that are located east of the Water Conservation Areas and west of US Highway 27. Seepage from the Water Conservation Areas and marshes will be collected and directed south into the Central Lake Belt Storage Area. This will maintain flood protection and the separation of seepage water from urban runoff originating in the C-11 Basin and Lake Okeechobee water supply deliveries. The L-37 and L-33 borrow canals will be operated to be held at higher stages as part of the Water Conservation Area 2 seepage collection and conveyance system (Component YY). Seepage collected in the L-37 and L-33 borrow canals and from the marsh areas will be directed into the Water Conservation Area 2 seepage collection and conveyance system and directed south into the Central Lake Belt Storage Area or directly to Northeast Shark River Slough. New levees will be constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal to separate seepage water from the urban runoff in the C-11 diversion canal (Component Q). The L-37 and L-33 borrow canals will be controlled at higher stages as will the marshes located east of the Water Conservation Areas. A divide structure will be added to the C-11 Canal west of US Highway 27 to maintain the separation of seepage water from urban runoff. Water from C-11 west will be diverted to the North Lake Belt Storage Area.

This component is in Broward County. The real estate involved here is a divide structure being added to the C-11 Canal just east of US-27 and new levee west of Highway 27. The real estate needs for the divide structure have not been identified or quantified, but the acreage estimate given for this component is 6,542 acres. However, approximately 3,185 acres lie west of Levee 37 and east of Levee 68A. As this land was once contained in the adjacent Water Conservation Area 3A, it was acquired for the prior project and is therefore not valued.

For the remaining 3,352 acres, the South Florida Water Management District has acquired approximately 2,360 acres at a cost of $44,683,000. For the remaining 992 acres remaining to be acquired, 982 acres is valued at $19,000 per acre based solely on what South Florida Water Management District has previously paid per acre for a total of $18,658,000.

The remaining approximately 10 acres required are located to the east of US Highway 27. The land to the east of US-27 appears to have a range from $15,000 to $26,500 per acre. Any land with frontage on US-27 has the potential of higher value due to the road frontage. The estimate value for this 10 acres is $26,000 per acre for a total of $260,000. Total estimated probable land and damages cost is $63,601,000 ($44,683,000 + $18,658,000 + $260,000).

The number of affected ownership tracts is unknown, but is projected to be approximately 250 tracts. Based on this, the Federal administrative/acquisition cost is estimated to be $1,500,000 and the non-Federal administrative/acquisition cost is estimated at $3,000,000. The number of residential and/or business relocations, mineral activity, and severance damages are unknown. For both the probable and low-end end cost estimates, a contingency of 25 percent is added to the total real estate cost estimate. The lower contingency reflects more accurate information received from South Florida Water Management District, and the costs paid to date by them for the land already purchased. The total probable/low-end real estate cost estimate for this component is $85,126,000.

The high-end estimated real estate cost of this component reflects a value of $20,000 per acre for the additional 982 acres required, and a value of $30,000 per acre for the 10 acres east of U.S. Highway 27 required for this component. The Federal and non-Federal administrative/acquisition costs are the same as those in probable/low end cost estimate. The contingency is also increased to 30 percent on the overall cost to reflect unknowns. The total estimated high-end cost of this component is $89,859,000.

Component Q5

Component Q5 is the Western C-11 Diversion Impoundment and Canal located in the Water Preserve Area in Miami-Dade and Broward Counties. The purpose of this component is to divert untreated runoff from western C-11 that is presently discharged into Water Conservation Area 3A through the C-11 Stormwater Treatment Area /Impoundment to the North Lake Belt Storage Area. Runoff in the western C-11 Canal that was previously backpumped into Water Conservation Area 3A will be diverted to the C-11 Stormwater Treatment Area/Impoundment and then to North Lake Belt Storage Area. If storage capacity is not available in the impoundment or North Lake Belt Storage Area, then the S-9 pump will be used for flood protection for the Western C-11 Basin, which pumps to Water Conservation Area 3A. To improve groundwater elevations in the eastern C-11 Basin, the S-9 seepage divide structure will be operated to maintain the western C-11 Canal stage at elevation 3.0 feet NGVD. The component will have: (1) a 2,500 cfs diversion canal west of U.S. 27 between C-11 and C-9 and 2,500 cfs conveyance capacity improvements to the C-9 Canal between S-30 and the North Lake Belt Storage Area; (2) an intermediate 2,500 cfs pump station in the C-11 Canal to direct runoff to the C11 Stormwater Treatment Area/Impoundment; (3) a 1,600-acre, Stormwater Treatment Area/Impoundment with a maximum depth of 4 feet; (4) a Seepage Collection canal and Pump for C-11 Stormwater Treatment Area/impoundment; and (5) a 2,200 cfs structure to discharge from the impoundment to C-11 west of US 27 to diversion canal.

This component will require a new canal with a width of 500 feet and a length of 46,569 feet for a total of 535 acres. Land involving frontage on SR-27 could have higher zoning and/or commercial possibilities influencing the value. Generally, land west of, and in near proximity to, SR-27 is estimated at $5,000 per acre in Broward County and assumed to have some agricultural possibilities. Information indicates that South Florida Water Management District has paid $5,000 per acre for this type of land. Therefore, 535 acres at $5,000 per acre yields $2,675,000

A 1,600-acre Stormwater Treatment Area is also required for this component. The indicated estimate for this land is in the range of $15,000 to $20,000 per acre. South Florida Water Management District has purchased approximately 497 acres at a total cost of $11,366,000 or approximately $22,869 per acre. The land is being estimated at a value of $22,900 per acre for this area due to its dynamics, for the probable/high-end cost estimate. Having then approximately 1,103 acres at a value estimate of $22,900 per acre yields $25,258,700. When added to the amount already paid by South Florida Water Management District, the total probable/high-end cost estimate for this 1,600 acre area is $36,625,000.

In addition, 400 acres will be needed for an additional canal. Employing the $20,000 per acre value as discussed above, the estimated cost of the 400 acres for the canal is $8,000,000 for both the probable/high-end and low-end cost estimate.

The number of affected ownership tracts is unknown, but is projected to be approximately 639 tracts. Based on this, the Federal administrative/acquisition cost is estimated to be $3,834,000 and the non-Federal administrative/acquisition cost is estimated to be $7,668,000. The number of residential and/or business relocations, mineral activity, and severance damages are unknown. For both the probable and high-end cost estimates, a contingency of 50 percent is added to the total real estate cost estimate (less the 497 acres already purchased by South Florida Water Management District), to reflect costs for unknowns. The total probable/high-end real estate cost estimate for this component is $82,520,000.

The low-end estimated real estate cost of this component is based on appraisal information. For the low-end cost, a value of $20,000 per acre for the 1,600 acres totals $32,000,000. The 400-acre canal is valued at $8,000,000 and the 535 acres is valued at $2,675,000. A contingency of 40 percent on the 535-acre area and associated acquisition/administrative costs, and 35 percent on the 2,000 acre area to be acquired and associated acquisition/administrative costs to reflect a total low-end real estate cost estimate of $73,323,000.

Component R4

Component R4 is the C-9 Stormwater Treatment Area/Impoundment located in the Water Preserve Area in Broward County. The purpose of this component is the treatment of water supply deliveries from North Lake Belt Storage Area to C-9, C-6/C-7 and C-2/C-4 Canals. The North Lake Belt Storage Area is used to capture runoff from western C-9 Basin and C-11 west by backpumping into the curtain walled reservoir area. The C-9 impoundment will provide treatment of runoff stored in North Lake Belt Storage Area, groundwater recharge within the basin and seepage control of Water Conservation Area 3 and buffer areas to the west. Water supply deliveries from North Lake Belt Storage Area to C-9, C-6/C-7 and C-2/C-4 Canals will be pumped into the C-9 STA/impoundment for treatment of the stormwater runoff stored in the North Lake Belt Storage Area. Seepage from C-9 impoundment will be collected and returned to the impoundment. The component will have an inflow structure with a capacity of 1,500 cfs pump (North Lake Belt Storage Area); a gravity outflow structure with 1,500 cfs capacity at 4 foot head. Discharge will be made from the C-9 impoundment to C-9, C-6/C-7 and C-2/C-4 Canals for water supply deliveries.

This component will require 2,500 acres, of which 1,505 acres have already been purchased by the South Florida Water Management District for a price of $29,174,000 or approximately $19,385 per acre. The general area appears to be prairie and trees with heavy quarry influence from rock mining. There was one sale in this area that occurred in 1989 for approximately $15,000 per acre. However, land to the north has sales for $20,000 per acre and higher. Applying a 3 to 4 percent Consumer Price Index to this one sale and considering the sales to the north, indicate a value in the $20,000 per acre vicinity. Broward County has a positive and rapid growth policy and available land is being developed. This area is desirable for residential development and the pressure to develop is high.

Applying a value of $20,000 per acre to the approximately 995 acres remaining to be acquired yields a total of $19,900,000. This added to the amount paid by South Florida Water Management District ($29,174,000) totals $49,074,000 for the lands and damages cost estimate.

The number of affected ownership tracts is unknown, but is projected to be approximately 145. Based on this, the Federal administrative/acquisition cost is estimated to be $870,000 and the non-Federal administrative/acquisition cost is estimated to be $1,740,000. The number of residential and/or business relocations, mineral activity, and severance damages are unknown. For both the probable and high-end cost estimates, a contingency of 50 percent to cover unknowns is added to the 995-acre value of $19,900,000 and the associated acquisition/administrative cost estimates. The total estimated probable/high-end real estate cost estimate is $62,939,000.

The low-end estimated real estate cost of this component is $58,437,000. This includes a contingency of 30 percent on the 995-acre value of $19,900,000 and the associated acquisition/administrative cost estimates added to the costs of lands already acquired by South Florida Water Management District ($29,174,000).

Component S6

Component S6 is the Central Lake Belt Storage Area located in the Water Preserve Area in Miami-Dade County. The purpose of the in-ground reservoir is to receive excess water from Water Conservation Areas 2B, 3A and 3B. The in-ground reservoir, Central Lake Belt Storage Area, with perimeter seepage barrier will allow storage of large quantities of water without groundwater seepage losses in this highly transmissive region. The water stored in the Central Lake Belt Storage Area will be provided to 1) Northeast Shark River Slough, 2) Water Conservation Area 3B, and 3) to supply flows to Biscayne Bay when available. Inflows from L-33 (see Component ZZ) will be through a 1,500 cfs pump. Inflow ceases when stages reach ~21.0 feet NGVD (16 feet above adjacent land elevation). Inflows from L-33 will be diverted to the Central Lake Belt Storage Area. Outflows for water deliveries are pumped through a polishing marsh cell prior delivery to Northeast Shark River Slough via L-30 and a reconfigured L-31 N (see component U). Deliveries of water to Northeast Shark River Slough to maintain inundation will occur when Northeast Shark River Slough dries below trigger levels and target hydroperiods simulations call for Northeast Shark River Slough to be inundated. The Central Lake Belt Storage Area delivers water to Water Conservation Area 3B through a polishing marsh cells via L-30 to inundate the eastern area of Water Conservation Area 3B to a 6 inch depth when triggers call for deliveries. This delivery occurs when Water Conservation Area 3B dries below 6 inches above ground, and target hydroperiods simulations indicate inundation in Water Conservation Area 3B. When available, outflows will be directed to Biscayne Bay through discharges to Snapper Creek at the Turnpike. Supply from the reservoir can be withdrawn for stages down to –15 feet NGVD (up to 36 feet of working storage & maximum head on seepage barrier). The reservoir will also have a subterranean seepage barrier around the perimeter to enable drawdown during dry periods and to prevent seepage losses. Inflow structures will consist of: (a) a 1,500 cfs pump from the L-33 borrow canal; (b) a 500 cfs structure at S-9 pump station to gravity discharge from Water Conservation Area 3A to L-33; and (c) a 700 cfs structure (Existing S-31) for Water Conservation Area 3B to the Central Lake Belt Storage Area via C-6 Canal. Outflow structures will consist of: (a) a 800 cfs pump to polishing cell to make deliveries to Northeast Shark River Slough and Water Conservation Area 3B; (b) a 500 cfs pump off L-30 to deliver to Water Conservation Area 3B; (c) a 300 cfs pump to make deliveries for Snapper Creek Canal; and (d) a 1,100 cfs structure at 0.5 feet head to provide regional system deliveries to Snapper Creek Canal via C-6 if Central Lake Belt Storage Area is out of water.

This component will require 5,770 acres of what appears to be primarily wetland prairies, melaleuca trees, and quarries from rock mining. It is estimated that roughly 1,400 acres of this component appears to have quarry lakes left from rock mining. Ownership of these large lakes appears to be more a liability than an asset unless there is consideration for possible residential development, which would assume the physical land characteristics to allow this. Sales indications for the remaining lands show a low of about $2,500 per acre, which are presumed to be wetlands. Other sales have occurred at approximately $5,000 per acre and these seem to be more in the speculative realm. Then added to this mix are properties that are assumed to be quarry related by proximity to developed and developing quarry mining operations in the $10,000 to $25,000 per acre range. It should also be noted that South Florida Water Management District has paid $55,000 for an acre that was permitted for rock mining. In this case the mineral rights were included with the sale and were of significant value.

It follows that the closer land is to the ongoing rock mining operations or interest, the higher the land value with an indicated range of $10,000 to $25,000 per acre. For rock mining lands permitted and waiting on mining to commence the indication is for as much as $55,000 per acre for fee title.

The land being identified by this component, where full fee ownership is to be acquired, appears to be primarily owned by large rock companies. The 620 acres to be acquired in full fee with all mineral rights is being estimated at the highest price per acre indicated of $55,000 per acre for a total value of $34,100,000, which applies to both the probable/low-end cost estimate and the high-end cost estimate.

More distant properties from the current rock mining operations appear to be bought for speculation and have sales between $2,500 and $5,000 per acre as previously mentioned. The South Florida Water Management District has estimated the high end at $7,500 per acre for this type of land. There are many unanswered questions in this area; exact amount of land now in quarry lakes, how much land is currently under permit, how much has potential for permitting, and the remaining portion, which lies in the more speculative category. The price currently being paid for speculative land dealing appears to be $5,000 per acre; however, because of uncertainties, the South Florida Water Management District's estimate of $7,500 per acre was utilized to calculate the probable and high/end estimate. Most of the land identified in this component appears to be owned by large rock mining companies. When buying from these large rock companies, the net effect would be the same as buying quarry lakes. However, based on the market and ignoring ownership and questions of ultimate use $7,500 per acre can be justified. Of the total 5,770 acres, 620 acres is to be acquired in full fee and 5,150 will be acquired without mineral rights and allowing the excavation of limestone. So, subtracting out the 1,400 acres of quarry lakes from this 5,150-acre area leaves 3,750 acres. Therefore, the 3,750 acres is valued at approximately $7,500 per acre yielding $28,125,000, based on the South Florida Water Management District's information. This cost estimate is used for the probable/low-end estimate. For the low-end estimate, a value of $5,000 per acre for the 3,750 acres will be used, based on appraisal information.

Very large quarry lakes are left after land has been rock mined. This land is being mined so intensely that the leavings are a honeycomb effect of lakes with connecting land bridges separating them. Where a lake has been formed, by mining or borrowing in the past, residential subdivisions have been developed around them. This does not look possible with the intense method of mining that is on-going in the subject area. After mining the value is estimated to be very minimal and can only be compared with wetland sales. Therefore, an estimated $500 to $1,000 per acre is concluded for mined out properties. For purposes of this estimate, a value of $1,000 per acre is used for mined out properties, or quarry lake acreage. As such, the low-end cost estimate of this portion of the component is $1,400,000. A value of $3,500, based on South Florida Water Management District 's recommendation, is used for the probable/high-end estimate of this component ($4,900,000),

Adding the $34,100,000 value estimate for fee value with mineral rights for the 620 acres, the $28,125,000 for value excepting mineral rights and the right to excavate for limestone removal for the 3,750 acres, and the $4,900,000 value estimate for quarry lakes for the 1,400 acres, the total probable/high-end lands and damages estimate for this component is $67,125,000.

The low-end lands and damages estimate would amount to $54,250,000.

The number of affected ownership tracts is unknown, but is projected to be approximately 116 tracts. Based on this, the Federal administrative/acquisition cost is estimated to be $696,000 and the non-Federal administrative/acquisition cost is estimated to be $1,392,000. The number of residential and/or business relocations and severance damages are unknown. For the probable/high-end cost estimates, a contingency of 45 percent is added to cover unknowns. For the low-end estimate a contingency of 50 percent is added. The total estimated probable/high-end real estate cost for this component is $103,359,000. The total estimated low-end real estate cost for this component is $84,507,000.

Component T6

Component T6 is an additional C-4 Structure located in the Water Preserve Area in Miami-Dade County. The purpose of the proposed structure will provide benefits. This structure would reduce regional system deliveries by diverting dry season stormwater flows to the C-2 Canal to increase recharge nearby several coastal wellfields. The East structure would divert dry season stormwater flows from the western C-4 Basin to the C-2 Canal to recharge the wellfields in the eastern C-2 Basin. It would have an operable lift-gate with 6.5 feet NGVD overflow and approximately 400 cfs capacity (final design specifications will be determined in detailed design and hydrologic and hydraulic modeling in the future) and would be located just downstream of the Miami-Dade-Broward Levee in the C-4 Canal.

This estimate is based on very general information and relies on county-wide general knowledge. This is not a site specific component estimate. The component will require acquisition of 2.0 acres of commercial/open land. A value estimate of $75,000 per acre yields $150,000 for the estimated lands and damages cost.

The number of affected ownership tracts is unknown, but is estimated at 10 tracts. Based on this, the Federal administrative/acquisition cost is estimated to be $60,000 and the non-Federal administrative/acquisition cost is estimated to be $120,000. The number of residential and/or business relocations and severance damages are unknown. For the probable/high-end cost estimate at contingency of 50 percent is added for a total estimated real estate cost of $495,000. The total estimated low-end real estate cost for this component is $446,000, which includes only a 35 percent contingency.

Component U6

Component U6 is the Bird Drive Recharge Area located in the Water Preserve Area - Miami-Dade County. The purpose is to captures runoff from the western C-4 Basin and accepts inflows from the West Miami-Dade Wastewater Treatment Plant to recharge groundwater and reduce seepage from the Everglades National Park buffer areas by increasing water table elevations east of Krome Avenue. The facility will also provide C-4 flood peak attenuation and water supply deliveries to the South Dade Conveyance System and Northeast Shark River Slough. Inflows from western C-4 Basin and the West Miami-Dade Wastewater Treatment Plant will be pumped into the proposed Recharge Area. C-4 runoff in excess of 200 cfs will be discharged eastward. Inflows from the West Miami-Dade Wastewater Treatment Plant will be continuous when the Recharge Area depth is equal to or less than 3 feet above ground. West Miami-Dade Wastewater Treatment Plant discharges will be to deep injection wells if the depth is greater than 3 feet. A seepage management system will be operated around the east and southern perimeters of the Recharge Area. Recharge Area outflows will be prioritized to meet 1) groundwater recharge demands, 2) South Dade Conveyance System demands and 3) Northeast Shark River Slough demands, when supply is available. Regional system deliveries will also be routed through the seepage collection canal system of the Bird Drive Recharge Area to the South Dade Conveyance System, which should reduce seepage from areas west of Krome Avenue. The inflow structure will be a 200 cfs pump (to be resized as needed) from C-4 and the outflow structure will be a gravity structure with 200 cfs capacity at 2 feet of head. There will also be a Seepage Collection System up to 500 cfs pump to control a seepage collection canal at 5.0 feet NGVD. Seepage is returned to Bird Drive Recharge Area. An 800 cfs pump to provide regional system deliveries to South Dade Conveyance System. An 800 cfs canal capacity, in addition to the canal required for the Bird Drive seepage collection system, will be constructed to pass the regional system deliveries to the South Dade Conveyance System. Approximately 5 miles of canal with 800 cfs capacity between Bird Drive seepage collection system to C-1W just east of Krome Avenue. Plans are to relocate S-338 east of Krome Ave. and delivery canal.

This component will affect approximately 2,877 acres. Information from South Florida Water Management District and sales analyzed puts the value from $8,000 to $10,000 per acre in this area, though South Florida Water Management District recommends a higher value per acre of $14,000. This area has the potential of increasing pressure to develop similar to the way this is happening in Broward County currently

Using the top of the current value range, $10,000 per acre, for 2,877 acres, yields a total lands and damages probable/low-end estimate total of $28,770,000. The high-end lands and damages estimate would be $40,278,000 using the South Florida Water Management District's recommendation of $14,000 per acre.

The number of affected ownership tracts is unknown, but is estimated to be 1,460. Based on this, the Federal administrative/acquisition cost is estimated to be $5,840,000 and the non-Federal administrative/acquisition cost is estimated to be $13,140,000. Because of the number of estimated tracts, the Federal administrative/acquisition cost is estimated at $4,000 per tract and the non-Federal administrative/acquisition cost is estimated at $9,000 per tract. The number of residential and/or business relocations and severance damages are unknown. For both the probable/low-end and high-end cost estimates a contingency of 50 percent is added. The total estimated real estate cost for the probable/low-end component cost is $71,625,000. The high-end total estimated real estate cost is $88,887,000 based on a per acre value of $14,000 per acre with the administrative/acquisition costs remaining the same as in the probable cost estimate and a 50 percent contingency.

Component W2

Component W2 is the Taylor Creek/Nubbin Slough Storage and Treatment Area located is either Okeechobee or St. Lucie Counties and is comprised of a total of 10,000 acres, with a Storage Reservoir of 5,000 acres at 10 feet maximum depth having an inflow pump with a capacity of 2,500 cfs and an outflow pump with a capacity of 1000 cfs, and a Stormwater Treatment Area of 5,000-acres at 4 feet maximum depth having an inflow pump with a capacity of 1,000 cfs (same structure as reservoir outflow) and an outflow pump with a capacity of 1,000 cfs. The purpose of the storage reservoir and stormwater treatment area is to provide flood protection, water quality treatment, estuary protection and water supply benefits. The component will be operated so that local runoff from the Taylor Creek/Nubbin Slough Basins is pumped into the 5,000-acre reservoir and then into the 5,000-acre stormwater treatment area. The stormwater treatment area will reduce phosphorus concentrations in the runoff from approximately 0.528 mg/l to 0.107 mg/l. Treated water will then be pumped into Lake Okeechobee when the lake stage is falling and is at least 0.5 feet below the bottom pulse release zone.

This component requires a storage reservoir and stormwater treatment area in the vicinity of Taylor Creek/Nubbin Slough, a small part of which appears to be in Okeechobee County and the larger part in Martin County. The mapping provided for this component was general in nature and did not give a detailed location for this 10,000-acre tract. The Martin County Property Assessor's Office states that this area is primarily cleared pasture and sales reflect a range of $1,500 to $1,800 per acre.

This 10,000-acre site is being estimated at $1,800 per acre for a value of $18,000,000 for the probable/low-end lands and damages cost estimate. South Florida Water Management District's recommendation of $3,000 per acre for a total of $30,000,000 is estimated for the lands and damages high-end cost estimate.

The number of affected ownership tracts is unknown, but is projected to be approximately 100. Based on this, the Federal administrative/acquisition cost is estimated to be $600,000 and the non-Federal administrative/acquisition cost is estimated to be $1,200,000, for both the probable/low-end and high-end costs. The number of residential and/or business relocations, mineral activity, and severance damages are unknown. For both the probable/low-end and high-end cost estimates, a contingency of 50 percent to cover unknowns is added. The total estimated real estate cost for the probable/low-end estimate is $29,700,000. The total estimated cost for the high-end estimate is $47,700,000.

Component X6

Component X6 is the C-17 Backpumping with the land required being located in Palm Beach County. The purpose is to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-17 Basin to the West Palm Beach Water Catchment Area and enhance hydroperiods in the Loxahatchee Slough. The component will be operated to capture excess C-17 Canal water to meet urban water supply demands in North Palm Beach Service Area. Water would be diverted through existing canals to a stormwater treatment area and ultimately to the West Palm Beach Water Catchment Area. The component will be designed to have a 200 cfs pump in the existing Northern Palm Beach County Improvement District Canal at its intersection with the Turnpike Canal to pull flows west and direct them south into the east Turnpike Canal. A culvert will be constructed under 45th Street (N/S) to connect the east Turnpike Canal. A 150 cfs capacity culvert and pump from the Turnpike Canal will direct flows into the proposed stormwater treatment area. There will be a 550-acre stormwater treatment area at 4 feet maximum depth with a 200 cfs culvert to connect the stormwater treatment area under Florida's Turnpike to allow nonrestrictive flows and a 100 cfs gravity discharge structure into West Palm Beach Water Catchment Area.

This site is a 550-acre Stormwater Treatment Area to be located west of the West Palm Beach Water Catchment Area. The property in this general area is reported to be underwater year round. Property records show sales from approximately $5,000 per acre to $21,000 per acre in this vicinity. Palm Beach County owns land in this area and appears to have paid an estimated $16,000 per acre for some of it.

However, land that is underwater year round or even most of the year should logically be valued in the lower range. However, as land delineation is not being accurately detailed at this stage of planning, the property is being valued at $12,500 (or mid-range) for the probable cost lands and damages estimate to total $6,875,000. The low-end estimate includes valuing the property at $5,000 per acre for a total of $2,750,000. The high-end estimate includes valuing the property at $21,000 per acre for a total of $11,550,000.

The number of affected ownership tracts is unknown, but is estimated to be two. Based on this, the Federal administrative/acquisition cost is estimated to be $12,000 and the non-Federal administrative/acquisition cost is estimated to be $24,000. The number of residential and/or business relocations and severance damages are unknown. For all three component costs, a contingency of 50 percent is added. The probable total estimated real estate cost is $10,367,000, the low-end is $4,179,000 and the high-end estimate is $17,325,000.

Component Y6

Component Y6 is the C-51 Backpumping to Water Catchment Area located in the Water Catchment Area in Palm Beach County. The purpose is to reduce water supply restrictions in Northern Palm Beach County Service Area by providing additional flows from the C-51 West Basin to the West Palm Beach Water Catchment Area and enhance hydroperiods in Loxahatchee Slough. The component will be operated to capture excess C-51 Canal water to meet urban water supply demands in the North Palm Beach County Service Area. Water would be diverted from C-51 to a water treatment area and then into the Water Catchment Area. A 600 acres at 4 feet maximum depth to be used for stormwater treatment. The S-155A structure will be relocated east of the intersection of Lake Worth.

This component also requires relocation of the S-155A structure east of the intersection of the Lake Worth Drainage District' s E-1 Canal and the C-51 Canal and increase the capacity of S-155A as necessary to pass the additional inflows, and improvement of conveyance between C-51 and the stormwater treatment area as necessary. A 450 cfs inflow pump will be constructed to the stormwater treatment area with a 100 cfs gravity discharge structure into West Palm Beach Water Catchment Area.

This site consists of 710 acres, located southeast of the West Palm Beach Water Catchment Area. As in component W6 above, properties in this area have sold in the broad range of $5,000 to $20,000 per acre. Palm Beach County owns large parcels of land in this area and appears to have paid approximately $16,000 per acre for some of it.

Depending on the boundary structure for this area, residential lands and developments could be impacted. Moving south toward Okeechobee Blvd. increases both the development potential and existing developed areas. Moving boundaries westward also puts the proposed component into existing and potential residential area, but this appears to not be affecting those areas.

The same value ranges as used above in component W6 are used here. The probable lands and damages estimate is at $8,875,000 using the mid-range value estimate of $12,500. The high-end lands and damages estimate totals $14,910,000 based on $21,000 per acre. The low-end lands and damages estimate values each acre at $5,000 for a total of $3,550,000.

The number of affected ownership tracts is unknown, but is estimated to be six. Based on this, the Federal administrative/acquisition cost is estimated to be $36,000and the non-Federal administrative/acquisition cost is estimated to be $72,000. The number of residential and/or business relocations and severance damages are unknown. For all three component costs, a contingency of 50 percent is added. The probable total estimated real estate cost is $13,475,000, the low-end is $5,487,000 and the high-end estimate is $22,527,000.

Component BB5

Component BB5 is the improvements to the Miami-Dade Broward County Levee/Pennsuco Wetlands located in the Water Preserve Area in Miami-Dade County. The purpose is to reduce seepage to the east from the Pennsuco Wetlands and southern Water Conservation Area 3B and enhance hydroperiods in the Pennsuco Wetlands. Also an improved Dade Broward Levee will enhance recharge to Miami-Dade County's Northwest Wellfield. Recharging the conveyance features of the Miami-Dade-Broward levee from the regional system deliveries provides recharge to Miami-Dade County's Northwest Wellfield. Treatment areas will be provided to meet all water quality standards required, if necessary. The existing Miami-Dade-Broward Levee will be constructed or improved to five-foot height with 2-foot top width while creating or improving existing conveyance to a capacity of up to 300 cfs. An 150 cfs bypass structure and canal from C-6 Canal to the Miami-Dade-Broward Levee will provide recharge from the regional system via the improved US Highway #27 borrow canal. A 150 cfs gravity structure in the Miami-

Dade-Broward Levee Borrow Channels will be constructed due west of the southern end of the Northwest Wellfield.

This component requires the acquisition of approximately 384 acres of open pastureland. There is a wide range of values indicated by the sales in this area. The sales form a range from approximately $2,300 per acre to $8,475 per acre. For the low-end cost estimate, the bottom of the range ($2,300) per acre is used to provide a total lands and damages estimate of $883,200. The high range (or $8,500) per acre provides the probable cost lands and damages estimate, which totals $3,264,000. South Florida Water Management District recommends a figure of $10,000 per acre. Using this per acre value yields the high-end lands and damages estimate of $3,840,000.

The number of affected ownership tracts is unknown, but is estimated to be 140. Based on this, the Federal administrative/acquisition cost is estimated to be $840,000 and the non-Federal administrative/acquisition cost is estimated to be $1,680,000. The number of residential and/or business relocations and severance damages are unknown. For all three cost estimates (high-end, probable and low-end) a contingency of 50 percent is added. The estimated probable total real estate cost is $8,676,000, the low-end estimate is $5,105,000 and the high-end estimate is $9,540,000.

Component CC6

Component CC6 is the Broward County Secondary Canal System improvements located in Broward County. The purpose is to increase pump capacity of existing facilities (from the 2050 Base Case), and construct additional canal and pump facilities for the Broward Secondary Canal System to provide recharge to wellfields located in central and southern coastal Broward County, to stabilize the salt water interface, and reduce storm water discharges to tide. The component will be operated so that when excess water is available in the basin, the water is pumped into the coastal canal systems to maintain canal stages. When local water is not sufficient to maintain canal stages, canals are maintained first from local sources and then from Lake Okeechobee and the Water Conservation Areas. Local sources include the Site 1 Impoundment (Component M) and the North Lake Belt Storage Area (Component XX). Secondary canals maintained are: 1) Broward County's C-2 from the Hillsboro Canal, 2) north secondary canal from C-13, 3) south secondary canal from C-13, 4) Turnpike canal south from C-12 Canal north from C-9 at levels as follows: (a) improve canal conveyance of secondary canal located east of the Florida Turnpike from the C-12 Canal south to the Fort Lauderdale Golf and Country Club and includes routing of water eastward to recharge the aquifer and help stabilize the saltwater interface at Ft. Lauderdale. Canal conveyance improvements may also be necessary for the Old Plantation Water Control District's eastern canal and in southeastern Broward County. Pump capacities and maintenance levels are as follows: (a) a 100 cfs pump from Hillsboro to Broward

County Secondary Canal (pump #1); (b) a 100 cfs pump from C-13 north to Broward County Secondary Canal; (c) a 100 cfs pump from C-13 south to Broward County Secondary Canal (pumps #2 and #3 described in the 2050 Base Case increased from 33 cfs to 100 cfs); (d) a 100 cfs pump on the east Turnpike canal withdrawing water from the C-12 Canal; and (e) a 150 cfs pump on the C-9 Canal for maintaining water in southeastern Broward County. Canal improvements and control elevations will be to improve east and west Turnpike canals and golf course lake system between C-12 and the North New River to achieve an average top width of 200 feet. The Turnpike canals shall be maintained at a minimum elevation of 4.0 feet NGVD. Also improvements for the canal/ lake systems in southeastern Broward County and the Orangebrook Golf Course to have an average canal top width of 30 feet. The southeastern Broward Canal system shall be maintained at a minimum elevation of 2.5 feet NGVD.

All three estimates are constant for this component. Approximately 245 acres will be required. The lands and damages estimate totals $740,000 (55 acres at $10,000 per acre plus 190 acres at $1,000 per acre).

The number of affected ownership tracts is unknown, but is estimated to be 30. Based on this, the Federal administrative/acquisition cost is estimated to be $180,000 and the non-Federal administrative/acquisition cost is estimated to be $360,000. The number of residential and/or business relocations and severance damages are unknown. For all three component costs a contingency of 50 percent is added. The probable, high-end and low-end total estimated real estate cost is $1,920,000.

Component FF4

Component FF4 is the construction of S-356 A & B Structures in Miami-Dade County. The purpose of these structures is to improve deliveries to Northeast Shark River Slough in Everglades National Park and reduce seepage to Lower East Coast Service Area 3. The structures will be operated to redirect S-357 outfall from L-31N to the mid-point of the Modified Water Deliveries mitigation canal northwest of the 8.5 Square Mile Area. The new 356 pumps will be operated to direct seepage collection from the Water Conservation Areas and water deliveries from Central Lake Belt Storage Area to Northeast Shark River Slough. The design of this component will require removal of the Modified Water Deliveries S-356 structure; relocation of the Modified Water Deliveries S-357 structure; adding S-356 A & B Structures (900 cfs each) at locations along modified L-31N between G-211 and Tamiami Trail; rerouting the L-31N borrow canal to east side of buffer cell; relocating L-31N to east side of buffer cell; backfilling a portion of L-31N where the levee is moved; and constructing a 5 foot levee along west side of existing lakes.

This area is located east of Levee 30 to Highway 997, extending from just south of the Tamiami Canal to just south of Kendall Drive. There appears to be no canal to inhibit access from the highway as has been the case on many of the previous components along this north south corridor. This highway could make this land more valuable if development were to push this far westward. A total of approximately 3,947 acres will be required.

In the absence of sales, the assessed value of land in the central segment of this component was $3,500 per acre. This area has 1,237 acres that is to be valued allowing the excavation of limestone, as the owners would retain the right to mine the property as is being done currently in this segment. Approximately 155 acres of the 1,237 acres is already mined and left in a quarry lake that appears under active mining operation currently. Using a value of $1,000 per acre for this 155 acres and valuing the remaining 1,082 acres at $3,500 per acre yields $3,942,000 for this central segment containing 1,237 acres. This $3,942,000 estimate is applied to the probable/high-end cost estimate and the low-end cost estimate.

Of the remaining 2,710 acres which would be acquired in full fee, 1370 acres lies to the north of the quarry lake and 1,340 acres lies to the south. Land in the northern segment showed sales ranging from $8,000 to $10,000 per acre, while land in the southern segment, sales ranged around $10,000 per acre. South Florida Water Management District estimated the per acre value of both the northern and southern segments at $20,000 per acre. For planning purposes, the low-end cost estimate for this 2,710 acres was valued at $10,000 per acre for a total of $27,100,000. The probable and high-end cost estimate was valued at $20,000 per acre for a total lands and damage estimate of $54,200,000.

For the probable and high-end cost estimate, the total lands and damages estimate is $58,142,000. The low-end cost estimate for lands and damages is $31,042,000.

The number of affected ownership tracts is unknown, but is estimated to be 528. Based on this, the Federal administrative/acquisition cost is estimated to be $3,168,000and the non-Federal administrative/acquisition cost is estimated to be $6,336,000. The number of residential and/or business relocations and severance damages are unknown. For the low-end cost estimate, a contingency of 50 percent is added. For the probable/high-end cost estimate, contingency of 40 percent is added. The low-end total estimated real estate cost estimate is $60,819,000. The probable/high-end real estate cost estimate is $94,704,000.

Component GG4

Component GG4 is the Lake Okeechobee Aquifer Storage and Recovery to be located in Glades and Okeechobee Counties. The purpose is to provide additional regional storage while reducing both evapotranspiration losses and the amount of land removed from current land use (e.g. agriculture) that would normally be associated with construction and operation of above-ground storage facilities (reservoirs); to increase the Lake's water storage capability to better meet regional water supply demands for agriculture, Lower East Coast urban areas, and the Everglades; to manage a portion of regulatory releases from the Lake primarily to improve Everglades hydropatterns, to meet environmental targets within the Water Conservation Areas, and to meet supplemental water supply demands of the Lower East Coast; to reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee Estuaries; to maintain existing level of flood protection. The system will be operated so that water from Lake Okeechobee is pumped into the Lake Aquifer Storage and Recovery wells when the climate-based inflow forecast projects that the Lake water level will rise significantly above those levels that are desirable for the Lake littoral zone (15.25 - 14.85 feet NGVD). During the dry season, flow may be made back to the Lake from the aquifer storage and recovery wells either when the Lake water level is projected to fall to within three-quarters of a foot of the supply-side management line the same dry season, or below 11.75 feet NGVD the upcoming wet season. During the wet season, flow is allowed from the aquifer storage and recovery wells to the Lake when climate-based inflow forecast projects less than 1.5 million acre-feet of inflow during the next 6 months, and the Lake water level is either below 11.75 feet (NGVD) during the current wet season, or is projected to be in supply-side management during the upcoming dry season. There will be a total of 200, 5-million gallons per day aquifer storage and recovery wells and associated infrastructure.

This estimate is based on very general information and relies on county-wide general knowledge. This is not a site specific component estimate. The component is to be based on 300 acres of pasture/open land. A value estimate of $2,500 per acre yields $750,000 for the low-end lands and damages estimate. A value of $3,500 is provided for a probable/high-end lands and damages estimate totaling $1,050,000.

The number of affected ownership tracts is unknown, but is estimated to be 220. Based on this, the Federal administrative/acquisition cost is estimated to be $1,320,000and the non-Federal administrative/acquisition cost is estimated to be $2,640,000. The number of residential and/or business relocations and severance damages are unknown. For all the cost estimates, a contingency of 50 percent is added. The probable/high-end total estimated real estate cost is $7,515,000. The low-end real estate cost is $7,065,000.

Component KK6

Component KK6 is for additional structures in the Loxahatchee National Wildlife Refuge Internal Canal in Water Conservation Area 1 located in Palm Beach County which are to improve the timing and location of water depths in the Refuge. The two structures, one a L-7 borrow canal structure (consisting of a 1,500 cfs gravity structure at 0.5 foot head) and the other a L-40 borrow canal structure (consisting of a 1,500 cfs gravity structure at 0.5 foot head), would remain closed except to pass Stormwater Treatment Area 1 East and Stormwater Treatment Area 1 West outflow and water supply deliveries.

This estimate is based on very general information and relies on county wide general knowledge. This is not a site specific component estimate. The component will require 5.0 acres of pasture/open land. A value estimate of $10,000 per acre totals $50,000 for the probable, high-end and low-end lands and damages estimate.

The number of affected ownership tracts is unknown, but is estimated to be 10. Based on this, the Federal administrative/acquisition cost is estimated to be $60,000and the non-Federal administrative/acquisition cost is estimated to be $120,000. The number of residential and/or business relocations and severance damages are unknown. For all cost estimates, a contingency of 50 percent is added. The probable, high-end and low-end total estimated real estate cost is $345,000.

Component LL6

Component LL6 is the C-51 Regional Groundwater Aquifer Storage and Recovery to be located in Palm Beach County. This is a regional groundwater aquifer storage and recovery system, which will capture and store excess water during wet periods and recover the water for utilization during dry periods. The ability to use the recovered water during dry periods will increase regional water resources. Water will be captured and stored when water is being discharged out of S-155 to tide. Water will be recovered during dry periods based on canal elevations. Recoverable water is limited to 70 percent of injected water. This component consists of 34 well clusters located along the West Palm Beach Canal (C-51 Canal), each being composed of two (2) surficial aquifer wells and one Upper Floridan aquifer, aquifer storage and recovery well. The surficial aquifer wells will each have a 2.5 million gallons per day withdrawal capacity and be located in proximity to the canal so that the water withdrawn would result in the interception of water that would otherwise go to tide in wet periods. Each upper Floridan aquifer storage and recovery well will have a capacity of 5 million gallons per day (the total injection and recovery capacity of the aquifer storage and recovery system is 170 million gallons per day or about 264 cfs.). Water will be injected when stages in the C-51 Canal are above 8.0 feet NGVD. Water will be retrieved from the aquifer storage and recovery wells when canal stages are below 7.8 feet NGVD. Recovered water will be discharged to the C-51 Canal.

This estimate is based on very general information and relies on county wide general knowledge. This is not a site specific component estimate. The component will require acquisition of approximately 34 acres of commercial/open land. A value estimate of $100,000 per acre yields $3,400,000 for the low-end cost estimate. South Florida Water Management District recommends using a value of $150,000 per acre. Based on this, the high-end/probable cost lands and damages estimate is $5,100,000.

The number of affected ownership tracts is unknown, but is estimated to be 85. Based on this, the Federal administrative/acquisition cost is estimated to be $510,000 and the non-Federal administrative/acquisition cost is estimated to be $1,020,000. The number of residential and/or business relocations and severance damages are unknown. For all cost estimates, a contingency of 50 percent is added. The probable/high-end total estimated real estate cost is $9,945,000. The low-end total estimated real estate cost is $7,395,000.

Component QQ6

Component QQ6 is the decompartmentalization of Water Conservation Area 3 in Broward and Miami-Dade. The purpose is to remove most flow obstructions to achieve unconstrained or passive flow between Water Conservation Areas 3A and 3B and Northeast Shark River Slough and reestablish the ecological and hydrologic connection between these areas. Structural Changes will be to backfill the Miami Canal in Water Conservation Area 3 from the east coast protective levee to one to two miles south of the S-8 pump station to maintain flood discharge capability. Water supply deliveries previously made through the Miami Canal will be delivered through the North New River, and improved US 27 borrow canal (see Component SS); to remove the L-68A levees; to degrade the L-67C levee and backfill the adjacent borrow canal; to backfill the L-67A Canal from Tamiami Trail approximately 7.5 miles north; to relocate a single S-349 structure at the downstream end of L-67A Canal (downstream of the S-345 structures); to remove the L-29 levee and canal (south of Water Conservation Areas -3A and 3B) to restore sheetflow into Everglades National Park; to remove the L-28 and L-28 Tieback levees and borrow canals from L-28 Tieback south to L-29; to elevate Tamiami Trail (U.S. 41) through the installation of a series of bridges between L-31N and L-28 consist with conveyance capacities determined at I-75 and any increases required due to inflows downstream of I-75 and upstream of Tamiami Trail; to remove the S-344, S-343A and B and S-12 structures; to construct 8 passive weir structures along the entire length of L-67A to promote sheetflow during high flow conditions and locate the S-345s (component AA3) just downstream of the new termination of L-67A Canal. Operational Changes include 1) Operate Water Conservation Areas 2A import trigger using only 2A-N gage as the trigger rather than using average of 2A-N and 2A-17 gages; 2) The time series target at 2A-N was truncated at 1.25 ft above and 0.5 ft below land surface elevation; 3) The time series target at 3A-NE was truncated at 1.0 ft above and 0.5 ft below land surface elevation; 4) S-345 operations are now based on triggers at R33C26 and the NESRS-1 and NESRS-2 gages (the 3A-4 gage is no longer used); 5) S-349 structure operations are the same as the S-345's operations.

Approximately 18 acres of fee and 37 acres of temporary easements are required for this component. A total of 20 bridges will be constructed in a twenty-mile strip of Tamiami Trail (each one mile apart). Each bridge will be 1,000 feet in length and 40 feet in width (.9 of an acre is required in fee for each bridge for a total of 18 acres). It is unknown what title Florida Department of Transportation holds to the underlying lands currently comprising the Tamiami Trail, and the width of the existing right-of-way varies.

Additional temporary easements for construction of the bridges will be required. These easements will be either within the existing right-of-way of Tamiami Trail, within lands owned by the National Park Service or within lands owned by South Florida Water Management District. Lands owned by South Florida Water Management District may require a different estate then what the Water Management District currently owns.

The 18 acres required in fee is valued at $4,000 per acre for a total of $73,600. The 37 acres required as temporary easements are valued at $2,000 per acre for a total of $73,600. Total lands and damages cost estimate is $147,200.

The number of affected ownership tracts is estimated to be two, for a Federal acquisition/administrative cost estimate of $64,000 and a non-Federal acquisition/ administrative cost estimate of $108,000. These higher acquisition/administrative cost estimates include additional expenses for negotiating relocation contracts with the Florida Department of Transportation. The total estimated real estate cost for this component for the probable, high-end and low-end estimates is $479,000.

Component SS4

Component SS4 is designed to reroute Miami-Dade County Water Supply Deliveries in the Everglades Agricultural Area and Miami-Dade County from the Miami and Tamiami Canals and Water Conservation Area 3 to the North New River Canal due to the backfilling of the Miami Canal as part of the decompartmentalization of Water Conservation Area 3. The operation will send water supply deliveries from Lake Okeechobee to Miami-Dade County southeast through the North New River Canal in the Everglades Agricultural Area (L-20, L-19, L-18) to S-150. From S-150 send deliveries into L-38W and at the southern terminus of L-38W south through a 1,500 cfs pump to the borrow canal along the west side of US 27. The component will double the capacity of the North New River Canal south of the proposed Everglades Agricultural Area Storage Reservoir (see Component G3) to convey additional water supply deliveries to Miami-Dade County as necessary; will double the capacity of S-351 and S-150 to pass additional water supply deliveries to Miami-Dade County as necessary; will improve conveyance in the borrow canal on the west side of US 27 between L-38W and the Miami Canal as necessary to pass the additional flows.

This estimate is based on very general information and relies on county-wide general knowledge. This is not a site specific component estimate. The component requires 200 acres of residential land. A value estimate of $30,000 per acre yields

$6,000,000 for the low-end lands and damages cost estimate. A probable/high-end value of $50,000 is applied to total $10,000,000 for the lands and damages cost estimate.

The number of affected ownership tracts is unknown, but is estimated to be 400. Based on this, the Federal administrative/acquisition cost is estimated to be $2,400,000 and the non-Federal administrative/acquisition cost is estimated to be $4,800,000. The number of residential and/or business relocations and severance damages are unknown. For all the cost estimates, a contingency of 50 percent is added. The probable/ high-end total estimated real estate cost is $25,800,000. The low-end cost estimate is $19,800,000.

Component UU6

Component UU6 is for storage reservoirs in the St. Lucie River Estuary/C-23, C-24, C-25 Northfork and Southfork Basins. The storage reservoirs are to capture local runoff from the C-23, C-24, C-25 and Northfork and Southfork Basins of the St. Lucie River Estuary. The reservoirs will be designed for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. There will be one reservoir in each basin. A total of 39,000 acres at 8 feet maximum depth distributed as follows among these basins: C-23 – 8,400 acres, C-24 – 6,000 acres, C-25 - 12,800 acres; and Northfork – 11,800 acres. In the Southfork Basin storage requirements were met using 9,350 acres inundated to a depth of 4 feet.

This component includes the acquisition of approximately 48,350 acres of land in Martin (17,750 acres) and St. Lucie (30,600 acres) Counties. From a general evaluation of the areas, including land uses, it was determined that for the probable/low-end lands and damages cost estimate, a value of $5,800 per acre for the 30,600 acres located within St. Lucie County is reasonable (for a total of $177,480,000). The high-end cost estimate assumes that 30,000 acres in St Lucie County is prime citrus land valued at $7,500 per acre (total value estimate of $225,000,000) and the remaining 600 acres are residential land valued at $25,000 per acre (total value estimate of $15,000,000). The 17,750 acres in Martin County are valued at $6,000 per acre for the probable and high-end estimates ($106,500,000) and at $4,000 per acres for the low-end estimate ($71,000,000).

The number of affected ownership tracts is unknown, but is estimated to be 114. Based on this, the Federal administrative/acquisition cost is estimated to be $684,000 and the non-Federal administrative/acquisition cost is estimated to be $1,368,000. The number of residential and/or business relocations and severance damages are unknown. For all the cost estimates, a contingency of 50 percent is added. The total estimated real estate probable cost is $429,048,000, the low-end is $375,798,000 and the high-end estimate is $522,828,000.

Component VV6

Component VV6 is the Palm Beach County Agricultural Reserve Reservoir located in Palm Beach County. The purpose of the reservoir is to increase water supply for central and southern Palm Beach County by capturing and storing water currently discharge to tide. The reservoir will be filled during the wet-season from excess water pumped out of the western portions of the Lake Worth Drainage District (backpumped). Water will be released back to Lake Worth Drainage District to maintain canal stages during the dry-season. Regional water will be supplied to the Lake Worth Drainage District when water levels fall below 15.8' NGVD. Water will be back pumped into the reservoir when water levels are above 16.0 feet NGVD. Aquifer Storage and Recovery capacity is included to improve supply during dry seasons and droughts. Fifteen (15) 5-million gallons per day capacity aquifer storage and recovery wells (total injection and recovery capacity 75 million gallons per day or about 116 cfs) are included. Water from the reservoir will be injected when depths in the impoundment are above 1 foot. Water will be supplied from the reservoir before tapping water from aquifer storage and recovery systems. Specifically, the water supplied from the reservoir will be maximized (up to the outflow capacity) before water is supplied from aquifer storage and recovery storage. The reserve reservoir will consist of 1,660 acres, with a maximum depth of 12 feet (volume of 19,920 acre-feet), with an inflow pump capacity of 500 cfs (provided by two 250 cfs pumps), an outflow structure with a capacity of 500 cfs @ 4 feet head, and an emergency outflow structure with a capacity of 300 cfs.

The land required for this component (1,660 acres) lies west of Highway 441 in Palm Beach County. The aerials indicate that this land is used primarily for farming. Its location on Highway 441 could indicate a higher value due to its frontage. At the northern end of this area a sale indicates approximately $35,000 per acre. Other sales nearby have indicated $20,000+ per acre. However, the agricultural branch of the tax assessor's office feels a value of $12,000 per acre is indicated based on agricultural activity. This property is in the Agricultural Reserve Area of West Palm Beach, which dictates that property in this area will remain agricultural. This policy is very controversial and has been receiving a large amount of attention and it is not known if this usage is going to hold. South Florida Water Management District estimates a value of $25,000 per acre. For the probable/low-end lands estimate, a per acre value of $20,000 is applied to the 1,660 acres for a total of $33,200,000. The high-end estimate uses the $25,000 per acre recommended by South Florida Water Management District for a total of $41,500,000. Some improvement information was gathered for this component. There are an estimated 29 improvements in the area to be acquired which are valued at a total of $4,500,000.

It is estimated that 18 tracts will be affected for this component. As such, the Federal acquisition/administrative cost estimate is $108,000 and the non-Federal acquisition/administrative cost estimate is $216,000. Applying a cost of $23,000 per improved tract (18) for relocation expenses totals $414,000.

A contingency of 50 percent is applied to all costs estimates. The total estimated probable/low-end real estate cost is $57,657,000. The total estimated high-end cost is $70,107,000.

Component WW5

Component WW5 is the C-111N Spreader Canal located in South Miami-Dade County. The purpose of the spreader canal is to reduce wet season flows in C-111, improve deliveries to Model Lands and Southern Glades and decrease potential flood risk in the lower south Dade area. Water is pumped from C-111 and C-111E into a Stormwater Treatment Area prior to pumping through S-332E into C-111N to Southern Glades and Model Lands. S-197 and S-18C are removed and C-111 is backfilled. The component will increase S-332E to 500 cfs from 50 cfs (pump when available); relocate C-111N to southwest theoretical 440th street (approximately 1 section north); construct a culvert under US 1 and a culvert under Card Sound Road; build a Canal through triangle area of Model Lands, east of Card Sound Road; fill in C-111 south of confluence with C-111N to S-197; remove levees and access roads; completely backfill C-110; create a Stormwater Treatment Area in triangle land between C-111 and C-111E to clean water prior to putting in Model Lands.

The land required for this component lies south of Homestead and extends to the Manatee Bay and Middle Key area along the coast. The total land required is estimated at 12,415 acres. Using a sampling of sales in and around the delineated area, the northerly one-fifth of the area reflects sales as high as $5,000 per acre. Much of the land appears to be wetlands. The low-end of the wetland sales that were found are generally around $500 per acre. Other wetland sales have indicated $1,000 to $1,500 per acre. No structures appear to be in this area.

Approximately 3,000 acres of the site are being estimated at the upper end of the indicated range ($5,000 per acre) for a total of $15,000,000 for all three estimate levels (probable, high and low-ends). The remaining 9,415 acres are being estimated at $1,000 per acre (($9,415,000) for the low-end estimate, $1,250 per acre ($11,773,000) for the probable cost and $1,500 per acre ($14,123,000) for the high-end estimate.

Total probable land and damages cost estimate for the entire 12,415 acres is $26,773,000. For the low-end, land and damages costs are estimated at $24,415,000 and for the high-end at $29,123,000.

It is estimated that 396 tracts will be affected for this component. As such, the Federal administrative/acquisition cost estimate is $2,376,000 and the non-Federal administrative/acquisition cost estimate is $4,752,000.

A contingency of 35 percent is added to the probable cost estimate, which brings the total estimated probable real estate cost estimate to $45,766,000. A contingency of 40 percent is added to the low-end cost estimate, which brings the total estimated low/end real estate cost estimate to $44,160,000. A contingency of 50 percent is added to the high-end cost estimate, which brings the total estimated high/end real estate cost estimate to $54,376,000.

Component XX6

Component XX6 is the North Lake Belt Storage Area located in the Water Preserve Area in Miami-Dade County. This in-ground reservoir is to capture a portion of runoff from C-6, western C-11 and C-9 Basins. The in-ground reservoir with perimeter seepage barrier will allow storage of untreated runoff without concerns of ground water contamination. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals and to provide deliveries to Biscayne Bay to aid in meeting salinity targets. The component will be operated so that inflows from C-6 (west of the turnpike), western C-11, and C-9 Basin runoff are pumped and gravity fed into the in-ground reservoir. The inflow ceases when stages reach ~5.0 feet NGVD (0 feet above adjacent land elevation). Outflows for water supply are pumped to the C-9 Storm Water Treatment Area /Impoundment prior to delivery to the C-9, C-6, C-7, C-4 and C-2 Canals. Water from the reservoir can be withdrawn down to a stage of -15 feet NGVD (up to 20 feet of working storage & maximum head on seepage barrier). The following will be the prioritization of outflows: (1) if water levels in North Lake Belt Storage Area are from between +5.0 feet NGVD and 0.0 feet NGVD flows will be discharged to Biscayne Bay via the C-2 Canal; (2) if water levels in North Lake Belt Storage Area are from between –10 feet NGVD and 0.0 feet NGVD flows will be discharged to C-9, C-6, C-7, C-4 and C-2 Canals only to prevent salt water intrusion; (3) if water levels in North Lake Belt Storage Area drop to levels between –15 feet NGVD and -10.0 feet NGVD flows will be limited to discharge to the C-9 Canals only to avoid water shortage restrictions. The storage area is 4,500 acres with subterranean seepage barrier around perimeter to enable drawdown during dry periods, prevent seepage and to prevent water quality impacts. The inflow structures will be a 2,500 cfs gravity structure at 0.5 feet head from C-11W; a 600 cfs pump from C-9; a 300 cfs pump from C-6 west of divide structure. The outflow structures will be a 1,000 cfs pump to C-9 STA/Impoundment for treatment prior to deliveries to C-6, C-7, C-2, C-4 and C-9 to prevent saltwater intrusion in coastal canals. (Stormwater Treatment Area detention time requirements need to be addressed. Pretreatment in reservoir may reduce size requirements of treatment area). In the Canal: an 800 cfs canal capacity. Water supply discharges are routed to C-4/C-2 via a canal to be located east of the Snapper Creek Canal (Northwest wellfield protection canal system). Two 1,400 cfs delivery structures, one each at the new canal's confluence with C-6 and C-4. A total of 5,861 acres will be required for this component.

This component requires approximately 5,861 acres and has an irregular shape and therefore affects a wider diversity of lands. Approximately 1,200 acres are in existing quarry lakes. These quarry lakes were valued at $1,000 per acre for the probable, high-end and low-end cost estimates. The cost estimate for this 1,200 acres at $1,000 per acre yields $1,200,000.

The remaining 4,661 acres, includes a 350 acre canal that was subsequently added to this component during review of alternative D13R. Based strictly on sales information, for the probable/high-end cost estimate, it is assumed that acquisition of the full fee for this 4,661 acres would be required. South Florida Water Management District recommends $20,000 per acre value for this area. The fee is estimated at $20,000 per acre for a total of $93,220,000. The estimated probable and high-end real estate cost is $94,420,000 ($93,220,000 + $1,200,000).

For the low end cost estimate, this component was valued with approximately 3,344 acres of the remaining 4,661 acres of land (does not include 1,200 acres in quarry lakes) that would be acquired with mineral rights and limestone excepted and the landowner retaining the right to excavate the limestone and minerals and 1,317 acres that would be acquired with full fee title which includes the 350 acre canal. The 3,344 acres (not including the 350 acre canal) is valued at $12,000 per acre for the low-end cost estimate for a total of $40,128,000. The 350 acre canal is being estimated at $20,000 per acre for a low-end estimate of $7,000,000. .

The other land totaling 967 acres would be acquired with full fee title. Depending on where the mining permit stage is for property within these tracts, the values could be dramatically different. South Florida Water Management District has paid as much as $55,000 for one acre of permitted land. Based strictly on limited sales information for the area, a value of $20,000 per acre is being estimated for 567 acres for a total of $11,340,000) for and $12,500 per acre is applied to the remaining 400 acres for the low-end cost estimate for a total of $5,000,000. The total lands and damages for the low-end cost estimate is $64,668,000.

The number of affected ownership tracts is unknown, but is estimated to be 900. Based on this, the Federal administrative/acquisition cost is estimated to be $5,400,000 and the non-Federal administrative/acquisition cost is estimated to be $10,800,000. The number of residential and/or business relocations and severance damages are unknown. For the probable/high-end cost estimate, a contingency of 40 percent is added. For the low-end cost estimate, a contingency of 50 percent is added. The probable/high-end total estimated real estate cost is $154,868,000. The low-end real estate cost estimate is $121,302,000.

Component YY4

Component YY4 is designed to divert Water Conservation Area 2 flows to the Central Lake Belt Storage Area and is located in Broward County. The purpose is to capture excess in Water Conservation Area 2B; to reduce stages above desired target levels in Water Conservation Area 2B; and to divert water through improved L-37 and L-33 Borrow Canals to 1) Northeast Shark River Slough to meet targets or 2) Central Lake Belt Storage Area. Surface water in Water Conservation Area 2B above NSM will overflow through 3 structures along L-35 and L-35A to North New River Canal along with seepage from Water Conservation Area 2B and pumped to L-37. North New River Canal, L-37 and L-33 Borrow Canals will be improved to accept this additional flow along with the seepage collected from Water Conservation Area 3. This water will be pumped to Northeast Shark River Slough if the Slough is below target levels or into a lined reservoir south of the confluence of L-33 and the C-6 Canal referred to as the Central Lake Belt Storage Area. Construction will consist of the following: (1) 3-diversion structures with 120 cfs capacity @0.5 feet of head and 350 cfs capacity at 4.0 feet of head along the southern perimeter of Water Conservation Area 2B; (2) an intermediate 1,500 cfs pump station to divert overflow and seepage from NNR to L-37; (3) an inverted siphon with 1,500 cfs capacity to pass water supply deliveries from L-38 borrow canal to US 27 West borrow canal; (4) improved conveyance of L-37 and L-33 to 3,000 cfs to handle Water Conservation Area 2B flows plus seepage from Water Conservation Area 3; and (5) removal of S-9XN and S-9XS or improve structures to accommodate increased flows.

This estimate is based on very general information and relies on county wide general knowledge. This component requires the acquisition of approximately 835 acres which has not been delineated. A per acre value of $5,000 is applied which totals $4,175,000 for the probable, high-end and low-end lands and damages estimate.

The number of affected ownership tracts is unknown, but is estimated to be 250. Based on this, the Federal administrative/acquisition cost is estimated to be $1,500,000 and the non-Federal administrative/acquisition cost is estimated to be $3,000,000. The number of residential and/or business relocations and severance damages are unknown. For the probable/high-end cost a contingency of 50 percent is added to yield a total estimated real estate cost of $13,013,000. A contingency of 40 percent is added to the low-end estimate to total an estimated real estate cost of $12,145,000.

Component ZZ5

Component ZZ5 is designed to divert Water Conservation Area 3 flows to Central Lake Belt Storage Area. The structures will be located in the eastern levees of Water Conservation Area 3 in Broward and Miami-Dade Counties. The purpose is to capture excess in Water Conservation Area 3A and Water Conservation Area 3B to reduce stages above target stages in Water Conservation Area 3 and to divert water through modified structures at S-9 and S-31 to Central Lake Belt Storage Area via the L-33 borrow canal. The component will be operated so that when surface water in Water Conservation Area 3B exceeds target depths by 0.10 feet it will be diverted to the Central Lake Belt Storage Area via L-33. When surface water in Water Conservation Area 3A near S-9 exceeds target depths by 1.0 foot, water will be diverted to the Central Lake Belt Storage Area via L-33. Two outflow structures will be constructed (1) a 500 cfs structure at 2.0 feet of head (new structure) at S-9 (Water Conservation Area 3A) and (2) a 700 cfs structure (modify existing S-31 if necessary) (Water Conservation Area 3B).

This estimate is based on very general information and relies on county wide general knowledge and is not based on the delineation of a specific site. The component requires 2.0 acres of pasture/open land. A value of $12,500 is applied to the acreage to total $25,000 for the lands and damages estimate for all levels of cost.

The number of affected ownership tracts is unknown, but is estimated to be 10. Based on this, the Federal administrative/acquisition cost is estimated to be $60,000 and the non-Federal administrative/acquisition cost is estimated to be $120,000. The number of residential and/or business relocations and severance damages are unknown. For the probable/high-end cost a contingency of 50 percent is added to yield a total estimated real estate cost of $308,000. A contingency of 40 percent is added to the low-end estimate to total an estimated real estate cost of $277,000.

Component BBB6

Component BBB6 is the South Miami-Dade County Reuse (South District Reclaimed Water Treatment Plant) located in Southern Miami-Dade County. The existing South District Wastewater Treatment Plant located north of the C-1 Canal will provide wastewater treatment coupled with superior treatment technology to supply reclaimed water to the South Biscayne Bay and Coastal Wetlands Enhancement Project. The water will be provided throughout the year to augment water supply to the South Biscayne Bay and Coastal Wetlands Enhancement Project upon demand. This supplemental water will restore overland flow in the coastal area and recharge groundwater to enhance groundwater discharge to Biscayne Bay. Saltwater intrusion benefits to the southern part of Miami-Dade County are anticipated. The South District Wastewater Treatment Plant with superior treatment technology will be operated when the additional water is needed to supply the South Biscayne Bay and Coastal Wetlands Enhancement Project. When water is not needed, the South District Wastewater Treatment Plant will stop treatment beyond secondary treatment standards and will dispose of the secondary treated effluent into the existing deep injection wells. The South District Wastewater Treatment Plant will be designed to add on pretreatment and membrane treatment system to the existing secondary treatment facility. The plant will have a capacity of 131 million gallons per day. It is anticipated that phosphorus will be the constituent of concern in the reclaimed water. Therefore, the treatment will be designed to remove total phosphorous to acceptable levels. The South District Wastewater Treatment Plant will be located at, or in the vicinity of, the existing South District Wastewater Treatment Plant. The reclaimed water will be discharged to the C-1 Canal (Black Creek), upstream of S-21A, and then delivered southward towards the C-102 and C-103 Canals, and northward towards the C-100 Canal. The wastewater treatment facility will provide advanced treated water to L-31E. Flow southward in L-31E towards C-102 and C-103 shall be 202 acre-feet per day. Flow northward in L-31E towards C-100 shall be 200 acre-feet per day (through a canal extension). The combined inflow into L-31E shall be 402 acre-feet per day for every day of the simulation. Flows will reach C-102 and C-100 via modifications to L-31E. Operation of C-102 and C-103 shall be contingent upon Component FFF5.

This component consists of 200 acres in Miami-Dade County. It lies north of the Goulds Canal, east of the Florida Turnpike, south of Black Canal, and west of SW 9th Ave. This acreage is being estimated at $10,000 per acre. The total lands and damages estimate is constant for all levels of cost for this component is $2,000,000.

The number of affected ownership tracts is unknown, but is estimated to be 12. Based on this, the Federal administrative/acquisition cost is estimated to be $72,000 and the non-Federal administrative/acquisition cost is estimated to be $144,000. The number of residential and/or business relocations and severance damages are unknown. The probable/high-end and low-end cost estimates are all the same with a contingency of 50 percent and the total estimated real estate cost of $3,324,000.

Component CCC6

Component CCC6 is the Big Cypress/L-28 Interceptor Modifications with a purpose to alleviate over drainage in Northeast Big Cypress, Kissimmee Billy and Mullet Slough area and ensure that inflows meet applicable water quality standards. The system will be operated to reroute water from West and North Feeder Canals to wetlands in Northeast Big Cypress. It will allow flow along the south side of the West Feeder at designated locations and through a new S-190 Pump Station, while maintaining flood protection on Tribal lands and consistency with the Seminole Tribe's Conceptual Water Conservation System master plan. It will establish sheetflow south of the West Feeder Canal across the Native Area of the Big Cypress Reservation. It will establish sheetflow off the reservation in the Big Cypress National Preserve Addition. Pumps will be operated for approximate equalization of flows. Construction will consist of: degrading the levee, on the southwest side of the L-28 Interceptor Canal below the S-190 structure; backfilling the L-28 Interceptor Canal at a point, south of the Big Cypress Reservation boundary with Big Cypress National Preserve Addition; constructing a retaining levee on northeast side of L-28 Interceptor through the Big Cypress Seminole Reservation; construction of three pump stations and spreader canals to develop sheetflow along the south side of the West Feeder Canal. The pump station locations shall be adjacent to the discharge points from Water Resource Areas 1, 2 and 3 of the Seminole Conceptual Water Conservation System. The component also is designed to replace S-190 gated structure (existing capacity of 2,960 cfs) with a 1,460 cfs pump station. Construction of a North Feeder stormwater treatment area (1,100 acres at 4-foot maximum depth with an inflow pump station of 270 cfs and an outflow structure of 100 cfs). Construction of a West Feeder stormwater treatment area (800 acres at 4-foot maximum depth with an inflow pump station of 430 cfs and an outflow structure of 150 cfs. This component will be located in the Western Basin, Big Cypress Seminole Reservation, Big Cypress National Preserve Addition in Hendry and Collier Counties.

This component consists of two areas of land located in Hendry County, Florida. One of the areas has 800 acres and the other 1,100 acres for a total of 1,900 acres. From a discussion of agricultural values and uses in these general areas with the Hendry County Property Appraiser's Office, the most probable use is sugar cane. The estimate for this type of land is $2,500 per acre for a total lands and damages estimate of $4,750,000 for all three cost ranges.

The number of affected ownership tracts is unknown, but is estimated to be two. Based on this, the Federal administrative/acquisition cost is estimated to be $12,000 and the non-Federal administrative/acquisition cost is estimated to be $24,000. The number of residential and/or business relocations and severance damages are unknown. For the probable/low-end cost a contingency of 40 percent is added to yield a total estimated real estate cost of $6,700,000. A contingency of 50 percent is added to the high-end estimate to total an estimated real estate cost of $7,179,000.

Component DDD6

Component DDD5 is the Caloosahatchee Backpumping with Stormwater Treatment Area and is located in Hendry and Glades. The purpose is to capture excess C-43 Basin runoff to augment the regional system. These facilities will be designed to backpump excess water from C-43 to Lake Okeechobee after treatment through a Stormwater Treatment Area. This component operates after estuary and agricultural/urban demands have been met in the C-43 Basin and when water levels in the C-43 storage reservoir (Component D5) exceed 6.5 feet. When this situation occurs, water will be released from the reservoir and delivered to the Stormwater Treatment Area at the capacity of the backpumping/treatment system

(2,000 cfs). The Stormwater Treatment Area water is then backpumped to Lake Okeechobee. An additional requirement for the backpumping to take place is that Lake Okeechobee must be considered to have available storage, i.e. when its levels are below the pulse release zone line. The key components in the design are pumps and a stormwater treatment area. For the design it has been assumed that the Stormwater Treatment Area is located adjacent to Lake Okeechobee. Because it is not known where the reservoir will be located relative to the Stormwater Treatment Area, it has been assumed that water to be delivered to the Stormwater Treatment Area will be released from the reservoir to the Caloosahatchee River and then pumped from the River into the Stormwater Treatment Area. Since no pump to bring water from the lower basin (below S-78) to the upper basin has been included in the reservoir design and since most of the basin runoff is generated in the lower basin, a pump to bring the water from the lower Caloosahatchee Basin to the upper basin has also been included. The Stormwater Treatment Area has been included to meet the anticipated need to improve the quality of the water before it enters Lake Okeechobee. Finally, a pump station will be used to lift the water from the Stormwater Treatment Area to Lake Okeechobee. The following pumps will be required: (a) 1 pump of 2,000 cfs capacity to take water from the lower Caloosahatchee Basin to the upper Caloosahatchee Basin; (b) 1 pump of 2,000 cfs capacity to take water from the Caloosahatchee River into the Stormwater Treatment Area; and (c) 1 pump of 2,000 cfs capacity to discharge water from the Stormwater Treatment Area to Lake Okeechobee. The Stormwater Treatment Area will be comprised of approximately 5,000 acres and is proposed to achieve water quality improvements.

This component lies in Glades County and requires the acquisition of approximately 5,000 acres. The site is located west of Lake Okeechobee and consists mostly of sugar cane and pasture. For the probable cost lands and damages estimate, a value of $1,000 per acre ($2,500,000) is applied to half of the required 5,000 acres, assuming open pastureland. The balance of the acreage (2,500) is assumed to be sugar cane with a value per acre of $2,500, for a total of $6,250,000. The estimated probable land and damages costs are $8,750,000. The low-end estimate assumes the entire acreage to be pasture at a per acre value of $1,000 per acre for the entire 5,000 acre for a total estimated land and damages costs of $5,000,000. The high-end estimate values the entire acreage (5,000 acres) as sugar cane with a $2,500 per acre value, for a total estimated land and damages costs of $12,500,000.

The number of affected ownership tracts is unknown, but is estimated to be two. Based on this, the Federal administrative/acquisition cost is estimated to be $12,000 and the non-Federal administrative/acquisition cost is estimated to be $24,000. The number of residential and/or business relocations and severance damages are unknown. For all three levels of cost estimates a contingency of 50 percent is applied. The total estimated real estate probable cost is $13,179,000. The total estimated real estate low-end cost is $7,554,000, and the estimated total high-end cost is $18,804,000.

Component FFF5

Component FFF5 is the Biscayne Bay Coastal Canals located in Miami-Dade County. The purpose is to maintain higher stages in C-102 and C-103 for urban and environmental water supply with water provided from local sources. Wet season operation for C-102 between S-21A and S-195 (open at 2.2 feet NGVD, close at 2.0 feet NGVD) and for C-103 between S-20F and S-179 (open at 2.2 feet NGVD, close at 2.0 feet NGVD) will remain unchanged. Dry season operation of C-102, between S-21A and S-195, and C-103 between S-20F and S-179, will both change from opening at 1.4 feet NGVD and closing at 1.2 feet NGVD to opening at 1.6 feet NGVD and closing at 1.5 feet NGVD. A borrow canal (3.5 miles) will be constructed west of L-31E which directly connects the downstream reach of C-102 with C-103 to maintain levels in the lower reaches of C-103.

This component lies in Miami-Dade County and would require acquisition of approximately 350 acres, in three separate segments. The northerly delineated lands contain two of the segments and totals 200 acres. The southerly segment has 150 acres.

The land sales in these areas indicate a value of $10,000 per acre. The total value of the 350 acres is therefore estimated at $3,500,000, for all three levels of cost estimates.

The number of affected ownership tracts is unknown, but is estimated to be 15. Based on this, the Federal administrative/acquisition cost is estimated to be $90,000 and the non-Federal administrative/acquisition cost is estimated to be $180,000. The number of residential and/or business relocations and severance damages are unknown. For all three levels of component estimates a contingency of 50 percent is applied, yielding a total real estate cost estimate of $5,655,000 for this component

Component GGG6

Component GGG6 is the C-51 and Southern L-8 Reservoir located in the Water Preserve Area in Palm Beach County. The storage reservoir managed for the following environmental and water supply goals: (a) to reduce the number of events when discharges to the Lake Worth Lagoon exceed the desired daily average flow rate of 500 cfs; (b) to reduce the magnitude of events exceeding the desired flow rate of 500 cfs; (c) to reduce the average annual volume discharged to tide (over the S-155 structure) by detaining storm water runoff for subsequent environmental (routing from the West Palm Beach Water Catchment Area to the Northwest Fork of the Loxahatchee River) and water supply needs (providing water to the Lake

Worth Drainage District and the West Palm Beach Water Catchment Area); and to provide increased drainage to the C-51 Basin and the Southern L-8 Basin by lowering the average stages in the C-51 Canal. The reservoir will be filled, with excess water from the Southern L-8 Basin and the C-51 Basin, when flows over the S155 structure exceed 300 cfs during the wet-season from excess water in C-51 Canal and Southern L-8 (backpumped). Water will be released back to C-51 to help maintain canal stages during the dry-season. The reservoir will consist of 1,200 acres of usable area with a 100-foot deep, 2-foot thick slurry wall for seepage control along the approximate perimeter length of 6 miles (this depth assumes a surficial aquifer thickness of 170 feet, 20 feet of embankment and 10 feet of embedment of the slurry was into the confining layer). The reservoir will use have a total storage depth of 40 feet (30 below grade and 10 above grade). An inflow pump with a capacity of 1,500 cfs will be located at the reservoir, together with an emergency outflow structure with a capacity of 1,500 cfs to be operated when the water level exceeds the maximum operation depth of 40 feet by 2 feet. This component includes a 1,000 cfs pump at S-155A, which will be operated when flows through S-155 exceed 300 cfs, and there is capacity in the reservoir.

This component is in Palm Beach County, and lies north of the West Palm Beach Canal in the vicinity of Twenty Mile Bend. The component will require acquisition of 1,800 acres of land. The estimated land value is $10,000 per acre for a total probable/low-end lands and damages estimate of $18,000,000. South Florida Water Management District recommends a value of $15,000 per acre. Using this value, a total of $27,000,000 is estimated for the high-end lands and damages estimate.

The number of affected ownership tracts is unknown, but is estimated to be 13. Based on this, the Federal administrative/acquisition cost is estimated to be $78,000 and the non-Federal administrative/acquisition cost is estimated to be $156,000. The number of residential and/or business relocations and severance damages are unknown. For all levels of cost estimates a contingency of 50 percent is applied. The total estimated real estate cost for the probable/low-end is $27,351,000. The total estimated high-end cost is $40,851,000.

Component HHH6

Component HHH6 is the West Miami-Dade Reuse located in the Water Preserve Area in Miami-Dade County. The future West Miami-Dade Wastewater Treatment Plant, will be located immediately south of the Bird Drive Recharge Area and east of the relocated L-31 North Protective Levee, will provide wastewater treatment coupled with superior treatment technology to supply reclaimed water to the Bird Drive Recharge Area. The water will be supplied year round as needed to enhance groundwater recharge. Excess water, when available, will be sent as a second priority to the South Dade Conveyance System, to Northeast Shark River Slough as a third priority and to deep injection wells when there are no demands from the three designated priorities. The proposed reclaimed water production facility will be operated by Miami-Dade County and has the potential to discharge 100 million gallons per day. When all demands have been met, the West Miami-Dade Wastewater Treatment Plant will stop treatment beyond secondary treatment standards and will dispose of the secondary treated effluent into deep injection wells. Treatment will be biological nutrient-removal advanced wastewater treatment (AWT) followed by a superior treatment technology using iron salts to lower phosphorus to levels required for Everglades discharges. The iron salt coagulation system would be designed for a constant flow rate of 100 million gallons per day. The West Miami-Dade Wastewater Treatment Plant will pump superior, advanced treated water to the Bird Drive Recharge Area when the elevation of the Recharge Area is equal to or below 3 feet above natural ground at a rate of 155 cfs (100 million gallons per day).

This component will require 100 acres in Miami-Dade County, located at the southeast corner of State Road 997, Krome Ave., and Bird Drive. The estimated land value is $20,000 per acre for a total lands and damages estimate of $2,000,000, for all three cost estimate levels.

The number of affected ownership tracts is unknown, but is estimated to be 20. Based on this, the Federal administrative/acquisition cost is estimated to be $120,000 and the non-Federal administrative/acquisition cost is estimated to be $240,000. The number of residential and/or business relocations and severance damages are unknown. For this cost estimate a contingency of 50 percent is applied. The total estimated real estate cost for the probable, high-end and low-end is the same, $3,540,000

F.9 OTHER PROJECT ELEMENTS

After selection of the Initial Draft Plan, as set forth above, the Restudy Team developed a list of potential Other Project Elements that could not be evaluated during the iterative alternative plan formulation process. The list of Other Project Elements was developed by the Restudy Team from the Critical Projects list; the Governor's Commission Conceptual Plan, and nominations from Restudy Team members. After initial screening of a comprehensive list, the remaining Other Project Elements to be included in the Comprehensive Plan was developed. The Comprehensive Plan is comprised of the components of Alternative D13R and a select group of these Other Project Elements. For a more detailed discussion see Appendix A-5 entitled "Critical Projects" and Appendix A-6 entitled “Description of Other Project Elements. In the draft report there were eleven Other Project Element, eight of which included real estate with estimated real estate costs provided. Since the draft report, one (North New River Restoration) Other Project Element was deleted from inclusion in the final Comprehensive Plan. The North

New River Restoration Project was approved and will be funded as a Critical Project (see Appendix A-5). There were nineteen Other Project Elements recommended for inclusion into the final Comprehensive Plan. Of these nineteen Other Project Elements, sixteen were Critical Projects (see Appendix A-5). The nineteen Other Project Elements to be included in the Comprehensive Plan are: (1) Seminole Tribe Big Cypress Water Conservation Plan; (2) the Biscayne Bay Coastal Wetlands; (3) Melaleuca Eradication Project and other Exotic Plants; (4) the Protection and Enhancement of Existing Wetland Systems along the Loxahatchee National Wildlife Refuge, including the Strazulla Tract; (5) Pal Mar and Corbett Hydropattern Restoration; (6) Acme B Basin Discharge; (7) Lake Okeechobee Watershed Water Quality Treatment Facilities; (8) Miccosukee Water Management Plan; (9) Lake Okeechobee Tributary Sediment Dredging; (10) Lake Worth Lagoon Restoration; (11) Restoration of Pineland and Hardwood Hammocks in C-111 Basin; (12) Winsburg Farms Wetland Restoration; (13) Lake Istokpoga Regulation Schedule; (13) Southern Golden Gates Estate Restoration; (14) Southern Crew Project Addition; (15) Lake Trafford Restoration; (16) Henderson Creek/Belle Meade Restoration; (17) Lakes Park Restoration; (18) Florida Keys Tidal Restoration; and (19) Palm Beach County Wetlands-Based Water Reclamation. . Sixteen of these Other Project Elements require real estate that will be acquired for the particular Project Element, however, the full extent of the real estate required and the estimate costs have not been fully determined. The real estate cost estimates provided below are based solely on the estimated costs provided by the proponent of the Other Project Element. A description of the Other Project Elements that have been determined to include real estate and the project cost of the real estate are discussed below.

Lake Okeechobee Watershed Water Quality Treatment Facilities (Lake Okeechobee Water Retention/Phosphorous Removal)

Many of the wetlands in the Lake Okeechobee watershed have been ditched and drained for agriculture and flood control. The purpose of this project is to restore the hydrology of selected isolated and riverine wetlands in the region. A two-pronged approach will be taken in this project: (1) restoring hydrology of isolated wetlands by plugging the connection to drainage ditches; and (2) diversion of canal flows through constructed stormwater treatment areas to attenuate peak flows and retain phosphorus.

This feature includes two reservoir-assisted stormwater treatment areas and plugging of select local drainage ditches. The initial design of these reservoir-assisted stormwater treatment areas assume a 1,775 acre facility in the S-154 Basin in Okeechobee County and a 2,600 acre facility in the S-65D sub-basin of the Kissimmee River Basin in Highlands and Okeechobee Counties. The plugged drainage ditches will result in restoration of approximately 3,500 acres of wetlands throughout the Lake Okeechobee watershed basin. A total of 4,515 acres will be required which includes the reservoirs and interest in lands in the drainage ditches.

Participation by landowners will be voluntary. Non-standard perpetual flowage/conservation easement estates will be developed and discussed in subsequent design documents. It is estimated that the cost of lands for this OPE will be no greater than $14,448,000, which would include all land costs and administrative/acquisition costs (both Federal and non-Federal).

Lake Okeechobee Tributary Sediment Dredging

This project involves dredging sediments from 10 miles of primary canals within an 8-basin area that encompasses the most intense agriculture in the northern watershed of Lake Okeechobee. The sediment in these tributaries is an undesirable source of phosphorous that contributes to the excessive loading to Lake Okeechobee. Dredging would remove the sediment as a potential source of phosphorous loading to the lake. Dredge material disposal areas would have to been identified and real estate interest would have to be obtained. The amount of acreage required for dredge disposal sites has not been determined, but is estimated at 320 acres. No real estate cost estimate was provided by the proponent of this OPE. However for planning purposes it is estimated that the real estate costs would be $900,000, which would include all land costs and administrative/acquisition costs (both Federal and non-Federal).

Pal Mar and Corbett Hydropattern Restoration

This component involves the acquisition of 3,000 acres between the South Florida Water Management District's Pal-Mar Save Our Rivers Project (approximately 35,435 acres) and the State of Florida's J.W. Corbett Wildlife Management Area (approximately 60,000 acres) to extend the spatial extent of protected natural areas. The project will also provide hydrologic connections between the J.W. Corbett Wildlife Management Area and; (1) the Moss Property, (2) the C-18 Canal, (3) the Indian Trails Improvement District, and (4) the L-8 Canal. These connections would relieve the detrimental effects on native vegetation frequently experienced during the wet season. Pal-Mar is a large pine flatwood/wet prairie/depression marsh complex located in Palm Beach and Martin Counties, northeast of the J.W. Corbett Wildlife Management Area. Acquisition of this approximately 3,000 acres of privately owned parcel of land between Pal-Mar and J.W. Corbett Wildlife Management Area would form an unbroken 126,000-acre greenbelt, extending from the Dupuis Reserve (approximately 21,800 acres) near Lake Okeechobee across the J.W. Corbett Wildlife Management Area, and connecting with Jonathan Dickinson State Park (approximately 8,000 acres). The estimated real estate cost of this 3,000 acres is $8,000,000, which would include all land costs and administrative/acquisition costs (both Federal and non-Federal).

Acme Basin B Discharge

This project involves the construction of a wetland treatment area to treat Acme Basin "B" runoff discharged to the Loxahatchee National Wildlife Refuge. The remainder of the discharge will be sent to a temporary storage reservoir to attenuate peak flows until such time as the water can be discharged to one of two alternative locations: Palm Beach County Agricultural Reserve reservoir or the in-ground reservoir area located adjacent to the L-8 Canal. Depending upon which storage facility is most feasible for long term storage, improvements to existing canals and new or modified pump stations will be necessary. The wetland treatment area will be comprised of 310 acres and the temporary storage area will be comprised of 620 acres. Estimated real estate cost of this 930 acres is $8,500,000, which would include all land costs and administrative/acquisition costs (both Federal and non-Federal).

Lake Worth Lagoon Restoration

This Project involves three phases, which will lead to improved water quality and the restoration of Lake Worth Lagoon located in Palm Beach County. Phase I will examine both quantity and quality of bottom sediment accumulations within the C-51 Canal and downstream discharge area within the lagoon. Phase II will develop a plan and project plan to provide for sediment removal or capping that could include creating a series of sediment traps along the C-51 where sediment accumulations increase. Phase III will involve the removal of bottom sediments with the C-51 Canal as well as implementing a prototype project to either remove or cap the organic bottom layer within the lagoon. The elimination of these sediments form the C-51 discharge will provide for long-term improvements to the lagoon and ensure success of additional habitat restoration projects. Dredge material disposal areas would have to been identified and real estate interests obtained. The amount of acreage required for dredge disposal sites has not been determined. No real estate cost estimate was provided by the proponent of this OPE. However for planning purposes, it is estimated that the real estate costs would be $300,000 which would includes all land costs and administrative/acquisition costs (both Federal and non-Federal).

Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including the Strazulla Tract

This component involves the acquisition of 3,335 acres to expand the spatial extent of protected natural areas. This project will make a hydrological and ecological connection to the Loxahatchee National Wildlife Refuge. This land will act as a buffer between higher water stages to the west and agriculture lands to the east that must be drained. This increase in spatial extent will provide vital habitat connectivity for species that require large unfragmented tracts of land for survival. It also contains the only remaining cypress habitat in the eastern Everglades and one of the few remaining sawgrass marshes adjacent to the coastal ridge. This is a unique and endangered habitat that must be protected. This area provides an essential Everglades landscape heterogeneity function. The total real estate cost, including contingency, of this OPE is estimated to be $48,972,000, which would includes all land costs and administrative/acquisition costs (both Federal and non-Federal).

Biscayne Bay Coastal Wetlands

The ability of the Initial Draft Plan to provide hydrologic benefits to the southern Everglades is supported in large part by the Biscayne Bay Coastal Wetlands Component FFF. This component replaces freshwater inputs to the Biscayne Bay estuary that are reduced by the Initial Draft Plan (i.e., seepage control components along the protective levee and the capture of other discharges to tide). This OPE compliments Component BBB and is necessary to properly distribute the additional flows to the estuary. This project has five sub-components located in southeast Miami-Dade County, covering the southwest shoreline of Biscayne Bay from the Deering Estate at C-100C south to the Florida Power and Light Turkey Point Power Plant, generally along L-31E.

- **Sub-component 1 - Deering Estate Flowway** - Operation of this sub-component involves pumping water from the SW 160th Street ditch (a tributary to C- 100C) through property adjacent to the Deering Estate and ultimately into Cutler Drain which runs through the Deering Estate. The design involves; adding a 50 cfs pump station at end of SW 160th Street Canal, filling in mosquito ditches in coastal mangroves, and constructing weirs to delay water passage in old Cutler Drain.

- **Sub-component 2 - Cutler Wetlands** - Operation of this sub-component involves: (1) routing water south from C-100A to the Cutler Wetlands Proposal Area via a shallow distribution swale on the surface of the marl to C-100B, (2) pumping water from C-100B to a spreader swale, and (3) pumping water from C-100A south into a spreader swale to allow sheetflow to Biscayne Bay. Depending on water quality, flows may need to be routed through Stormwater Treatment Areas (STA). Design involves constructing; (1) a spreader swale from C-100A south to C-100B, (2) a levee west of the spreader swale, (3) a 200 cfs pump along the north end of the spreader swale at C-100A. If water quality dictates, the design may also involve construction of: (4) an STA adjacent to C-100B, (5) a 200 cfs pump adjacent to the STA and C-100B, and (6) a levee seepage canal along the north and southern end of the STA.

- **Sub-component 3 - L-31E Flowway** – The purposes of this sub-component are (1) to reestablish conditions for living oyster bars along shoreline of the bay and (2) to hydrologically isolate the Miami-Dade County landfill. A flow redistribution system will be created west of L-31E and existing wetlands will be restored in the area between L-31E and the western boundary of the redistribution system. A distribution swale with a western levee will be constructed along this boundary. The wetland area west of L-31E should be used for short-term, shallow ponding of water to maintain wetlands and help drive freshwater flow to the nearshore Bay out of the east bank of L-31E. Depending on water quality, flows may need to be routed through an STA. Design involves; (1) installation of culverts and risers under L-31E, (2) construction of a spreader swale east of L-31E, (3) backfilling Military Canal, (4) construction of a plug in C-100B, (5) construction of a canal west of the landfill to intersect with L-31E borrow canal, and (6) filling in mosquito ditches. If water quality dictates, the design may also involve construction of: (7) an STA from C-102 to C-103 and east of Homestead Air Force Base, (8) a seepage collection ditch on the western side of the STA, (9) construction of a 200-cfs pump at C-102 to the STA, and (10) construction of a 200-cfs pump at C-103 to the STA.

- **Sub-component 4 - North Canal Flowway** – The operation of this sub-component involves; (1) pumping available water from C-103 and the Florida City Canal to re-establish sheetflow across freshwater and coastal wetlands to Biscayne Bay. Depending on water quality, flows may need to be routed through an STA. Design involves: (1) construction of a 200-cfs pump on C-103, (2) construction of a 200 cfs pump on Florida City Canal, (3) installation of culverts and risers under L-31E, (4) construction of a delivery canal from C-103 south to North Canal, (5) construction of a spreader swale east of L-31E, (6) backfilling the North Canal east of SW 112 Avenue and (7) construction of a flowway south from the Florida City Canal from SW 127th Avenue to SW 107th Avenue. If water quality dictates, the design may also involve construction of: (8) an STA on the western edge of the coastal wetlands in between the C-103 and the Florida City Canal, (9) an STA associated with the flowway south of the Florida City Canal, and (10) construction of seepage management facilities around the STAs.

- **Sub-component 5 - Barnes Sound Wetlands** – Operation of this sub-component involves pumping available water from the Florida City Canal to a shallow east-west spreader canal. Depending on water quality, flows may need to be routed through an STA. Design involves construction of: (1) a 50-cfs pump at the Florida City Canal, (2) a new canal south from Florida City Canal to a shallow spreader swale along the edge of the coastal wetlands. If water quality dictates, the design may also involve construction of an STA and seepage management facility.

There are some general problems or considerations that apply to the entire area. These include existing ditches, which are extensive, the presence of exotic plants and animals, potential water quality problems, and land ownership constraints. The areas under review for restored sheet flow were extensively ditched early in the twentieth century. This cross ditching interferes with providing restored historic flow patterns. For these reasons, the ditches may need to be filled. In addition, the area would require an extensive and possibly ongoing invasive exotic plant removal program. Most of the lands to be acquired are under current acquisition efforts by the State of Florida, the South Florida Water Management District, and Miami-Dade County.

The total acreage required for this component is estimated to be 13,600 acres with an estimated real estate cost for this component of $200,000,000, which would include all land costs and all Federal and non-Federal administrative/acquisition costs.

Seminole Tribe Big Cypress Water Conservation Plan

This feature includes construction of water control, management, and treatment facilities in the central, western and eastern portion of the Big Cypress Reservation. The construction elements include conveyance systems, including major canal bypass structures, irrigation storage cells, and water resource areas. The features proposed are part of a larger project known as the Seminole Tribe Comprehensive Water Conservation Project. This project has been divided into two separate elements, with the western portion being an approved Critical Project.

The purpose of this feature is to improve the quality of water and runoff from phosphorus generating agricultural sources within the Reservation. The area is traversed by the L-28 and L-28I Canals and the North and West Feeder Canals, all of which were constructed as part of the C&SF Project. This comprehensive watershed management system is designed to achieve environmental restoration on the Reservation, the Big Cypress Preserve, and the Everglades Protection Area (EPA). In addition, the project will reduce flood damage and promote water conservation.

The removal of pollutants will be achieved using natural treatment processes in pretreatment cells and water storage areas. A phosphorus level of 50 ppb is the goal, which is the current level to be achieved by the stormwater treatment areas of the ECP. Should design performance levels for phosphorus become more stringent, this project has sufficient flexibility is designed to be able to incorporate additional alternative technology to meet stricter levels.

It is estimated that 3,800 acres will be required at a total estimated real estate cost of $5,735,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Miccosukee Water Management Plan

This feature includes construction of a 900-acre wetland retention/detention area on the Miccosukee Tribe's Alligator Alley Reservation. The feature includes a pump station, levees, trenches and culverts to create the inflow and outflow facilities for the retention/detention area..

The purpose of this feature is to provide water storage capacity and water quality enhancement for waters which discharge into the Everglades Protection Area.

It is estimated that 900 acres will be required at a total estimated real estate cost of $1,718,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Winsburg Farms Wetland Restoration

This feature includes the construction of a 175-acre wetland east of Loxahatchee Wildlife Preserve in Palm Beach County. The feature will reduce the amount of treated water from the Southern Region Water Reclamation Facility wasted in deep injection wells by further treating and recycling the water.

The purpose of this facility is to create a wetland from water, which would be normally lost to deep well injection and lost for any future beneficial use. The wetland will reuse a valuable resource, recharge the local aquifer system and create a new and ecologically significant wildlife habitat and extend the function of the nearby Wakodahatchee Wetland.

It is estimated that 175 acres will be required at a total estimated real estate cost of $4,140,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Southern Golden Gate Estates Restoration

This feature includes a combination of spreader channels, canal plugs, road removal and pump stations in the Western Basin and Big Cypress, Collier County, south of I-75 and north of U.S. 41 between the Belle Meade Area and the Fakahatchee Strand State Preserve.

The purpose of this feature is to restore and enhance the wetlands in Golden Gate Estates and in adjacent public lands by reducing overdrainage. Implementation of the restoration plan would also improve the water quality of coastal estuaries by moderating the large salinity fluctuations caused by freshwater point discharge of the Fahka Union Canal. The plan would also aid in protecting the City of Naples' eastern Golden Gate wellfield by improving groundwater recharge.

A Federal Farm Bill grant has allocated $25,000,000 in funds to aid in acquisition of lands required for this project, therefore, no real estate funds are required in the implementation of this project.

Southern Crew Project Addition

This feature includes the acquisition and restoration of 4,670 acres of land, and replacement of the Kehl Canal Weir in southern Lee County, adjacent to Corkscrew Sanctuary.

The purpose of this feature is to: 1) re-establish historic flow patterns and hydroperiods on the project lands, as well as CREW and Corkscrew Sanctuary wetlands to the east; 2) restore historical storage potential of the Southern CREW lands; 3) reduce excessive freshwater discharges to Estero Bay during the rainy season; 4) decrease saltwater intrusion during the dry season; 5) reduce loading of nutrients and other pollutants to the Imperial River and Estero Bay; 6) increase aquifer recharge and water supply for an area frequently facing water restrictions during dry years; and 7) reduce flooding of homes and private lands west of the project area.

Hydrologic restoration of this land will include the following modifications: removal of existing road beds, removal of single family homes, removal of junk debris, filling of ditches, and removal of agricultural canals and berms. Other components within the plan include: replacement of the Kehl Canal weir, clearing and snagging on Imperial River, Estero River and Halfway Creek, and reconnection of Spring Creek and Halfway Creek under U.S. Interstate 75.

The total estimated real estate cost is $30,104,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Lake Trafford Restoration

This feature includes a lakewide organic sediment removal to Lake Trafford near Ft. Myers, Florida. Lake Trafford has poor water quality, extensive muck accumulations, loss of native submergent plant communities, periodic aquatic weed infestations, and numerous moderate fish kills. Poor water quality is attributed to internal nutrient cycling from extensive organic much deposits throughout the lake basin.

The purpose of this feature is to preserve the headwaters of the Corkscrew Swamp and Camp Keais Strand. The water quality of the lake affects these wetland resources that have been targeted for protection. These wetlands drain into important estuarine systems such as Estero bay and Cape Ramono. Lake Trafford is an integral contributor to the sheet flow that traverses such areas as the CREW and the Southern Golden Gates Estates area. As the only major lake in southwest Florida, Lake Trafford provides a sanctuary during the dry season. The quality of the lake and the associated watershed affects important wildlife species and offers a sanctuary for migrating birds.

This OPE will require acquisition of a 449 acre temporary disposal area and pipeline with a total estimated real estate cost of $744,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Henderson Creek/Belle Meade Restoration

This feature combines multiple individual elements to complement each other to form a larger-scale combined effect. This feature includes a 10-acre stormwater lake/marsh filtering system, four culverts under State Road 951; hydrologic restoration around Manatee Basin including culverts, ditching, removal of some roadbed; invasive, exotic plant removal, and a public access point and interpretive boardwalk; construction of a swale and spreader system; and removal of the Road-to-Nowhere. This southwest Florida feature is located in Collier County. The area known locally as Belle Meade is the primary drainage basin for the Henderson Creek estuary, which drains into Rookery Bay.

The purpose of this feature is to restore historic sheetflow to the estuary, treatment of stormwater, improve water quality and increase habitat value and wetland functions.

It is estimated that 125 acres will be required at a total estimated real estate cost of $1,029,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Lakes Park Restoration

This feature includes the construction of a 40-acre marsh/flowway in an abandoned rock mine, removal of exotic vegetation, and planting native vegetation on 11 acres of uplands and 9 acres of littoral zone. This feature is located in the Lee County Lakes Regional Park, upstream of Estero Bay.

The purpose of this feature is to enhance surface water runoff quality by creating a meandering flowway with shallow littoral zones to enhance pollution removal and oxygen content, removing aquatic and upland exotic infestation while allowing public access into upland areas of improved native habitat. The restoration will provide immediate habitat and water quality benefits at Lakes Park and improve downstream conditions in Hendry County and the Estero Bay Aquatic Preserve.

It is estimated that 40 acres will be required at a total estimated real estate cost of $166,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Florida Keys Tidal Restoration (OPE)

This feature includes the use of bridges or culverts to restore the tidal connection between Florida Bay and the Atlantic Ocean in Monroe County. The four locations are as follows: 1) Tarpon Creek, just south of Mile Marker 54 on Fat Deer Key (width 150 feet); 2) unnamed creek between Fat Deer Key and Long Point Key, south of Mile Marker 56 (width 450 feet); 3) tidal connection adjacent to Little Crawl Key (width 300 feet); and 4) tidal connection between Florida Bay and Atlantic Ocean at Mile Marker 57 (width 2,400 feet).

The purpose of this feature is to restore the tidal connection that was eliminated in the early 1900's during the construction of Flagler's railroad. Restoring the circulation to areas of surface water that have been impeded and stagnant for decades will significantly improve water quality, benthic floral and faunal communities, larval distribution of both recreational and commercial species (i.e. spiny lobster) and the overall hydrology of Florida Bay.

It is estimated that 5 acres will be required at a total estimated real estate cost of $51,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

Palm Beach County Wetlands Based Water Reclamation project

The Wetlands-Based Water Reclamation feature proposes to treat wastewater from the East Central Regional Wastewater Treatment Facility using Advanced Wastewater Treatment processes to remove nitrogen and phosphorus. This will then be followed up with superior treatment technology to remove phosphorus to approximately 50 parts per billion or less. This feature will consist of a 10 million gallons per day operation with 6 million gallons per day of the water discharged into approximately 1,500 acres of bermed marsh where it will be used to rehydrate the marsh as well as manage the hydroperiod and water quality of the wetland environment. The water will then be pumped to another marsh of approximately 300 acres surrounding the City of West Palm Beach wellfield. Infiltration of the water into the wellfield will occur as the wellfield pumps groundwater into the adjacent M Canal where it becomes surface water. The surface water in M Canal will flow towards Clear Lake, which is the surface water source of drinking water for the City of West Palm Beach. At the City's water treatment plant, the surface water will be treated to drinking water standards prior to entering the water supply distribution system for the City as well as the Town of Palm Beach and South Palm Beach. The remaining 4 million gallons per day of the

10 million gallons per day of reclaimed water will be routed from the Advanced Wastewater Treatment/superior treatment technology facility to residential lake systems surrounding both the City's wellfield and Palm Beach County's 8W Water Treatment Plant wellfield.

The purpose of the wetlands based water reclamation is to reduce the City's dependence on surface water from Lake Okeechobee during dry or drought events. In addition, approximately 2,000 acres of wetlands would be created or restored. Other benefits include aquifer recharge and replenishment, reduction of water disposed in deep injection wells and a reduction of stormwater discharge to tide.

It is estimated that 2,000 acres will be required at a total estimated real estate cost of $2,800,000, which includes all land costs and all Federal and non-Federal administrative/acquisition costs.

F.10 NON-FEDERAL SPONSOR-OWNED PROJECT LANDS

The South Florida Water Management District, the non-Federal sponsor for the Central & Southern Florida Project, owns a variety of interests in lands within different components of the Restudy Area. Some of the lands were acquired for the existing Central & Southern Florida Project, while other lands were acquired by the South Florida Water Management District utilizing Federal funds, State funds or Water Management District funds. Following is a discussion of lands owned by the South Florida Water Management District within the Initial Draft Plan's components. More detailed discussions and identification of lands and interests owned by the South Florida Water Management District will be provided in more detail in subsequent design documents as more detailed site information is determined.

In Component G5-Palm Beach Everglades Agricultural Area Storage Reservoir, the United States Department of Interior, U.S. Fish and Wildlife Service has contracted to purchase fee title to 45,000 acres, more or less, within the Everglades Agricultural Area. The funding for the purchase of this land will be provided by Interior from the Farm Bill account (Public Law 104-127, Section 390(a). The land will be conveyed to the South Florida Water Management District and could be utilized as part of this Component.

In Component M6-Site 1 Impoundment Water Preserve Area Palm Beach County, of the approximately 2,458 acres in this component, the South Florida Water Management District has acquired approximately 1,658 acres at a cost, (including most incidental costs) of $8,359,706.12. South Florida Water Management District has received Farm Bill funding for this purchase (50 percent Federal and 50 percent non-Federal). South Florida Water Management District also owns lands within the right-of-way of the Hillsboro Canal, which were acquired and certified for the existing Central and Southern Florida Project. The estate owned by South Florida Water Management District and the width of the existing right-of-way have not been determined and therefore may not be sufficient for construction of a pump station.

Component O4, the Water Conservation Area 3A and 3B Levee Seepage Management Water Preserve Area-Broward County. Of the approximately 6,542 acres required for this Component, South Florida Water Management District owns fee title to approximately 5,550 acres, 3,190 of which were acquired and certified for the existing Central and Southern Florida Project. The remaining 2,360 acres owned by South Florida Water Management District were purchased between 1991 and 1997. The Department of Interior, U.S. Fish and Wildlife Service, South Florida Water Management District, and Broward County participated in the purchase of approximately 1,051 acres with the Department of the Interior contributing $4,134,000 toward the purchase of these lands by means of a Grant. The South Florida Water Management District also owns the existing right-of-way of the C-11 Canal. The estate own by South Florida Water Management District in the C-11 Canal and the width of the existing right-of-way may not be sufficient for construction of a pump station.

In Component Q5 Western C-11 Diversion Impoundment and Canal Water Preserve Area Broward County, the South Florida Water Management District has purchased and owns fee title to approximately 497 acres of the C-11 Impoundment Area. The land was purchased for $11,366,000, which includes most incidental costs associated with acquisition. The South Florida Water Management District also owns the right-of-way of the L-33 and L-37 levees and borrow canals.

In Component R C-9 Stormwater Treatment Area/Impoundment Water Preserve Area, Broward County, the South Florida Water Management District owns fee title to approximately 1,505 acres within the impoundment area. The land was purchased for $29,174,000, which includes most incidental costs associated with the acquisition.

In other components, which are described below, the South Florida Water Management District owns some interest in canals, levees, borrow canals, and the Water Conservation Areas, which were certified for the existing Central and Southern Florida Project. Many structures (pump stations, levee, canal improvements) may be constructed within these existing right-of-way; however, the interest owned by South Florida Water Management District and the width of the existing right-of-way have not been reviewed and therefore may not be sufficient to allow the construction proposed in the Plan. For that reason, and because most structures and improvements have not been clearly defined, or specifically and precisely located, for planning purposes, Real Estate Division has assumed that the existing estates of the South Florida Water Management District and the width of the existing right-of-way are not sufficient for the planned improvements. The following provides a review of components where South Florida Water Management District owns an interest and a right-of-way, which were certified for the existing Central and Southern Florida Project:

In Component B2, South Florida Water Management District owns lands within the existing right-of-way of C-44.

In Component D5, South Florida Water Management District owns lands within the existing right-of-way of C-43.

In Component G6, South Florida Water Management District owns lands within the right-of-way of the Bolles and Cross Canals, Miami Canal; and North New River Canal

In Component K6, South Florida Water Management District owns the L-8 Canal right-of-way in this area; the right-of-way of the L-8 Tieback Levee and borrow canal; and the south leg of the C-18 Canal.

In Component M6, South Florida Water Management District owns the right-of-way for the Hillsboro Canal.

In Component O4, South Florida Water Management District owns the right-of-way for the C-11 Canal.

In Component Q5, South Florida Water Management District owns right-of-way in C-11 Canal.

In Component R4, South Florida Water Management District owns right-of-way in C-9 Canal.

In Component S 6, South Florida Water Management District owns the rights-of-way or an interest in land the L-33 borrow canal, L-30 levee and borrow canal, C-6 Canal, Snapper Creek Canal, and C-4 Canal.

In Component T6, South Florida Water Management District owns the right-of-way for the C-4 Canal.

In Component Y6, South Florida Water Management District own lands within the right-of-way of the C-51 Canal and the Existing E-1 Canal.

In Component BB4, South Florida Water Management District owns the right-of way for the Dade Broward Levee and the right-of-way for the C-4 Canal;

In Component FF4, South Florida Water Management District owns the right-of-way to the existing L-7 borrow canal structure and the L-40 borrow canal.

In Component KK4, South Florida Water Management District owns the right-of-way to the existing L-31N Levee and borrow canal.

In Component LL6, South Florida Water Management District owns the right-of-way to the existing C-51 Canal.

In Component QQ6, South Florida Water Management District owns the right-of-way to Miami Canal, L-68A levee, L-67A Canal, L67C levee, L-29 levee and canal.

In Component SS4, South Florida Water Management District owns the right-of-way for the North New River Canal and lands underlying the existing S-351 and S-150 structures.

In Component UU6, South Florida Water Management District owns rights-of-way for C-23 Canal, C-24 Canal and the St Lucie Canal.

In Component WW5, South Florida Water Management District owns the lands where the Stormwater Treatment Area and C-111N spreader canal will be located and owns the fee to lands underlying C-111, S-197, C-110 and S-18C. The lands underlying the Stormwater Treatment Area and the Southern Glades lands affected by this Component will be provided as an item of the C-111 Project Modifications.

In Component XX6, South Florida Water Management District owns the right-of-way for the C-11 Canal.

In Component YY4, South Florida Water Management District owns the right-of-way for the North New River Canal, L-37 and L-33.levees and borrow canals; and the lands underlying the S-9XN and S-9XS structures.

In Component ZZ5, South Florida Water Management District owns the lands underlying the S-9 structure and S-32 structure.

In Component CCC6, South Florida Water Management District owns right-of-way for L-28 levee and borrow canal and lands underlying S-190.

F.11 FEDERAL GOVERNMENT OWNED LAND

The only known Federal Government owned land within the study area is located along the south side of Tamiami Trail in Component QQ, which lands are owned or are being purchased by the Department of Interior, National Park Service for the Everglades National Park Expansion.

F.12 FARM BILL FUNDING OF LAND ACQUISITION

Pursuant to Section 390, Federal Agriculture Improvement and Reform Act of 1996, Public Law 104-127, the Department of Interior entered into a Grant to provide South Florida Water Management District with land acquisition funds. The Grant provides that South Florida Water Management District must provide matching funds. To date (end of May 1998), the Department of Interior has provided $29,367,066 to the South Florida Water Management District for land acquisition. South Florida Water Management District has matched the Department of Interior funding for land acquisition by providing $32,602,675 to date (May 1998). Of the figure of $61,969,741, approximately $51,611,723 has been applied toward the acquisition costs of 3853 acres lands within various components of the restudy. In Component M, 7.5 acres at a cost of $40,019, in Component VV6, 1658 acres at a cost of $8,359,706. In Component XX, 26 acres at a cost of $203,379. In Component S, 178 acres at a cost of $3,348,476. In Component R, 1036 acres at a cost of $20,122,669. In Component Q, 947 acres at a cost of $19,537,471.

Additionally, the Department of Interior has contracted to purchase fee title to 45,000 acres, more or less, within the Everglades Agricultural Area (Talisman Property). See discussion in Section F.8, Component G6.

F.13 NON-FEDERAL SPONSOR'S AUTHORITY TO PARTICIPATE IN PROJECT

The South Florida Water Management District was created by virtue of Florida Statutes, Chapter 373, Section 373.069. The South Florida Water Management District was created to further the State policy of flood damage prevention, preserve natural resources of the State including fish and wildlife and to assist in maintaining the navigability of rivers and harbors. (There are other enumerated purposes but they are not directly applicable to this project.) The South Florida Water Management District is specifically empowered to

> *Cooperate with the United States in the manner provided by Congress for flood control, reclamation, conservation, and allied purposes in protecting the inhabitants, the land, and other property within the district from the effects of a surplus or a deficiency of water when the same may be beneficial to the public health, welfare, safety, and utility. (Section 373.103)*

To carry out the above purposes, the South Florida Water Management District is empowered to:

...hold, control, and acquire by donation, lease, or purchase, or to condemn any land, public or private, needed for rights-of-way or other purposes, and may remove any building or other obstruction necessary for the construction, maintenance, and operation of the works; and to hold and have full control over the works and rights-of-way of the district.

The term *works of the district* is defined by Section 373.019 to be

...those projects and works, including, but not limited to, structures, impoundments, wells, and other water courses, together with the appurtenant facilities and accompanying lands, which have been officially adopted by the governing board of the district as works of the district.

Section 373.139 specifically empowers the Water Management District:

...to acquire fee title to real property and easements therein by purchase, gift, devise, lease, eminent domain, or otherwise for flood control, water storage, water management, and preservation of wetlands, streams and lakes, except that eminent domain powers which may be used only for acquiring real property for flood control and water storage.

F.14 EXISTING FEDERAL PROJECTS WITHIN STUDY AREA

Below is a listing of all the existing Federal Projects within the Study Area, for a more complete description of the Projects see Appendix K.

Rivers and Harbor Act of 1930-Miami River channel; improvements to Caloosahatchee River and Canal from Lake Okeechobee to Gulf of Mexico; improvements to Taylor Creek from Okeechobee City to Lake Okeechobee; Lake Okeechobee Levee and a channel from the south shore of the lake from Fisheating Creek to the St. Lucie Canal; improvements to the St. Lucie River channel; and protection works in the St. Lucie Canal for erosion control. Table K-1 lists the CR&LODA Project features incorporated into the C&SF Project.

Flood Control Act of 1948-created the Central and Southern Florida Project for Flood Control and Other Purposes. Table K-2 lists the project features authorized or authorized to be modified by the 1948 authorization.

Flood Control Act of 1954-act authorized the remainder of the Comprehensive Plan for the C&SF Project. Table K-3 lists project works authorized by the 1954 act.

Flood Control Act of 1958-authorized cost sharing and changes to the Comprehensive Plan. TableK-4 lists the project works authorized by the 1958 act.

Flood Control Act of 1960-authorized flood protection for the Nicodemus Slough area, Glades County, Florida. Table K-5 lists the project works authorized by the 1960 act

Flood Control Act of 1962-authorized modification and extension of the C&SF Project for flood control and major drainage. The 1962 authorization affected the following areas: a. West Palm Beach Canal; Boggy Creek; South Dade County; Shingle Creek; Cutler Drain Area of Dade County. Table K-6 lists the project works authorized by the 1962 act

Flood Control Act of 1965-authorized a new plan for Hendry County west of Levees L-1, 2, and 3 and flood protection for Southwest Dade County. Table K-7 lists the project works authorized by the 1965 act

Flood Control Act of 1968-authorized modification to the existing project for improved conservation and distribution of available water and extended flood protection. Table K-8 lists the project works authorized by the 1968 act.

River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970-provided funding for accelerated construction of borrow canal L-70, Canal C-308, Canal C-119W and pumping station S-326 to meet increased water requirements of Everglades National Park.

Kissimmee River Restoration Project-was authorized by the U.S. Congress in the Water Resources Development Act of 1992. The major components of the project include: 1) reestablishment of inflows from Lake Kissimmee that will be similar to historical discharge characteristics (headwaters component), 2) acquisition of approximately 85,000 acres of land in the lower Kissimmee Chain of Lakes and river valley and approximately 20,000 acres in the chain of Lakes (Lake Cypress, Lake Tiger, Lake Hatchineha; and Lake Kissimmee); 3) continuous backfilling of 22 miles of canal, 4) removal of 2 water control structures; and 5) recarving of 9 miles of former river channel.

Herbert Hoover Dike Study-study to determine whether strengthening of the Herbert Hoover Dike should be accomplished.

Lake Okeechobee Regulation Schedule-the Lake is regulated to provide flood control, navigation, and water supply for agricultural irrigation, municipalities and industry, Everglades National Park, regional groundwater control, and salinity control; enhancement of fish and wildlife; and recreation. Lake water levels are regulated by a complex system of pumps and locks managed by the Corps and the

South Florida Water Management District. Lake Okeechobee is currently operated under a regulation schedule known as the "Run 25", which utilizes a 15.65 - 16.75 foot range with four levels above this range. The zones of operation control discharge to outlets ranging from non-harmful to maximum rate of discharge. The Run 25 schedule was adopted in May 1992. An Environmental Assessment along with a Finding of No Significant Impact have been completed.

New Water Conservation Area 1 Regulation Schedule -Water Conservation Area 1 is located within the Arthur R. Marshall Loxahatchee National Wildlife Refuge in southeast Palm Beach County. The Water Conservation Area covers 143,085 acres. Lands within Water Conservation Area 1 are leased to the U.S. Fish and Wildlife Service by the South Florida Water Management District. The Water Conservation Areas perform a wide variety of functions including flood control, agricultural water supply, municipal water supply, fish and wildlife habitat enhancement, groundwater recharge, recreation, Everglades National Park water supply, and prevention of saltwater intrusion. Water Conservation Area 1 receives inflow via two pumping stations, a spillway (S-5A-S), and rainfall. The U.S. Fish and Wildlife Service has asked that a new regulation schedule be adopted to improve conditions within the Refuge. The improved schedule incorporates a flood stage that ranges between 15.75 feet and 17.5 feet. The water supply zone is between the range of 14.0 feet and 15.75 feet. The drought zone is 14.0 feet and no releases occur. Any Releases are also a function of Lake Okeechobee levels. This new schedule was designed to accomplish the following:

(1) allow higher water levels during wet years in the northern portion of the refuge.

(2) increase the hydroperiod of interior marshes of the refuge such that dryout does not occur on an annual basis.

(3) increase the proportion of the interior marsh of the refuge that serves as nursery areas for aquatic organisms.

(4) improve the timing of winter stage drawdown in the refuge to benefit wading birds.

(5) restore conditions in the refuge similar to those found when the area was used by snail kites for nesting.

(6) allow for storage of a greater quantity of water within the C&SF system during wet and normal rainfall years.

Everglades National Park Hole-in the Donut Restoration.

The Hole-in the Donut is a tract of land (approximately 10,000 acres) within Everglades National Park that was previously farmed and has now become overgrown with Brazilian Pepper trees. Research has shown that the only effective method for the elimination of the invasive Brazilian Pepper and the re-establishment of native wetland conditions is complete removal of the disturbed soil. Up to 4.8 million cubic yards of material is expected to be removed from this area (restoration area approximately 6,000 acres) over the next 15 – 20 years.

Modified Water Deliveries to Everglades National Park.

The Modified Water Deliveries to Everglades National Park Project was authorized by the Everglades National Park Protection and Expansion Act (Public Law 101-229). The purpose of the project is to provide for structural modifications to the C&SF Project to enable the restoration of more natural water flows to Shark River Slough in Everglades National Park. The project is being implemented by the Corps in conjunction with the acquisition of about 107,600 acres of land by the Department of Interior. Land acquisition for the levee, canal, and pump station for the flood mitigation system in the 8.5-square-mile area is underway.

This project is presently in the design and construction phase. The addition of water control structures and culverts will reestablish the natural distribution of water from Water Conservation Area 3A into Water Conservation Area 3B. Outlets from Water Conservation Area 3B (S-355A & B) will be constructed to discharge into Northeast Shark River Slough. An existing levee and canal (L-67 Extension) along the eastern edge of the existing Everglades National Park boundary will also be removed. A Miccosukee Indian camp will be floodproofed to avoid periodic flooding that would otherwise be caused by the project.

In order to prevent adverse flood impacts to the 8.5-square-mile residential area, the project includes the construction of a seepage levee and canal around the western and northern edges of the area and a pump station (S-357) to remove excess seepage water. These project features are designed to maintain the existing level of flood protection in the residential area after the Modified Water Deliveries to the Everglades National Park project returns water levels in Northeast Shark Slough to natural (slightly higher) levels. A second pump station (S-356) will be constructed to pump excess seepage water from the L-31N borrow canal and residential area into the L-29 borrow canal. This water will then flow through culverts under US Highway 41 into Northeast Shark River Slough.

The structural modifications were designed to provide for maximum operational flexibility so that as more is learned through the continued iterative testing program, the operation of the project can be adjusted accordingly.

C-111 Project.

Plan 6a, recommended in the Corps' General Reevaluation Report dated May 1994, will create the operational capability and flexibility to provide restoration of the ecological integrity of Taylor Slough and the eastern panhandle areas of the Everglades National Park and flood protection to the agricultural interests adjacent to C-111.

The C-111 Plan 6a will protect the natural values for a portion of the Everglades National Park, and will maintain flood damage prevention within the C-111 Basin, east of L-31N and C-111. The project, which consists of both structural and non-structural modifications to the existing project works within the C-111 Basin, will restore the hydrology in 128 square miles of Taylor Slough and its headwaters in the Rocky Glades. In addition, the hydroperiod and depths in 1,027 square miles of Shark River Slough are beneficially impacted by the higher stages in the Rocky Glades, resulting in a net increase in water volume within Shark River Slough.

Experimental Program of Water Deliveries to Everglades National Park

Authority for conducting the Experimental Program for Modified Water Deliveries to Everglades National Park expires upon completion of construction of the Modified Water Deliveries to Everglades National Park Project.

Everglades National Park and Everglades National Park Expansion- The Everglades National Park and Everglades National Park Expansion, owned or being acquired by the United States Department of Interior, National Park Service comprises 1,506,539 acres in Miami-Dade, Monroe and Collier Counties.

Big Cypress National Preserve and Addition-The Big Cypress National Preserve owned or being acquired by the United States Department of Interior, National Park Service, comprises 728,000 acres in Collier County.

Biscayne National Park is owned by the United States Department of Interior, National Park Service and lies in Miami-Dade and Monroe counties.

F.15 NAVIGATIONAL SERVITUDE

The navigational servitude will likely not be applicable to any components within the Restudy.

F.16 INDUCED FLOODING

At present, all components were valued as if fee title would be required. Whether there will be flooding induced by the construction or the operation and maintenance of the various components of the project has not been analyzed. No written analysis has been completed for any component, except for lands within Components O, and YY. These lands were acquired by the South Florida Water Management District as a result of adverse rulings in inverse condemnation actions.

F.17 ESTATES TO BE ACQUIRED

STANDARD ESTATES

Land values for all Components have valued as if fee title would be acquired. As additional data is obtained and provided, and as more definite plans and specifications are developed, lesser estates (in accordance with Chapter 12, ER 405-1-12) may be determined to be appropriate. The determination of the required estates will be addressed in future documents applicable to the different components. For the purposes of this document the following estates may be acquired:

1. FEE. The fee simple title to (the land described in Schedule A) /(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

2. FEE EXCEPTING AND SUBORDINATING SUBSURFACE MINERALS. The fee simple title to (the land-described in Schedule A) (Tracts Nos. ____, ____ and ____), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding from the taking all (coal) (oil and gas) in and under said land and all appurtenant rights used in connection with the exploration, development, production and removal of said (coal), (oil and gas), including any existing structures and improvements; provided, however, that the said (coal) (oil and gas) and appurtenant rights so excepted and excluded are hereby subordinated to the prior right of the (United States and non-federal project sponsor) to flood and submerge the land as may be necessary in the construction, operation and maintenance of the project; provided further that any exploration or development of said (coal) (oil and gas) in and under said land shall be subject to Federal and State laws with respect to pollution of waters of the reservoir, and provided that the type and location of any structure, improvement and appurtenance thereto now existing or to be erected or constructed on said land in connection with the exploration and/or

development of said (coal) (oil and gas) shall be subject to the prior written approval of the representative of the non-federal project sponsor), or his duly authorized representative.

3. FEE EXCLUDING MINERALS (With Restriction on Use of the Surface). The fee simple title to (the land described in Schedule A) (Tracts Nos. ____, ____ and ____), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding from the taking all (coal) (oil and gas), in and under said land and all appurtenant rights for the exploration, development, production and removal of said (coal) (oil and gas), but without the right to enter upon or over the surface of said land for the purpose of drilling and extracting therefrom said (coal) (oil and gas).

4. FEE EXCLUDING MINERALS (With Restriction on Use of the Surface and Subordination to the Right to Flood). The fee simple title to (the land described in Schedule A) (Tracts Nos.____, ____ and ____), subject, however, to existing easements for public roads highways, public utilities, railroads and pipelines; excepting and excluding from the taking all (coal) (oil and gas) in and under said land and all appurtenant rights for the exploration, development, production and removal of said (coal) (oil and gas), but without the right to enter upon or over the surface of said land for the purpose of drilling and extracting therefrom said (coal) (oil and gas); provided, however, that the said (coal) (oil and gas) and appurtenant rights so excepted and excluded are subordinated to the prior right of the United States and the non-federal project sponsor to flood and submerge the land in connection with the operation and maintenance of the ____________ project.

5. FLOWAGE EASEMENT (Permanent Flooding). The perpetual right, power, privilege and easement permanently to overflow, flood and submerge (the land described in Schedule A) (Tracts NOS. ____, ____ and ____), (and to maintain mosquito control) in connection with the operation maintenance of the ________________ project as authorized by the Act of Congress approved _______________, and the continuing right to clear and remove any brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project, may be detrimental to the project, together with all right, title and interest in and to the timber, structures and improvements situate on the land (excepting _____________, (here identify those structures not designed for human habitation which the representative of the non-federal project sponsor determines may remain on the land)); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as writing by the representative of the non-federal project sponsor in charge of the project, and that no excavation shall

be conducted placed on the land without such approval as to the may be approved in charge of the and no landfill location and method

6. FLOWAGE EASEMENT (Occasional Flooding). The perpetual right, power, privilege and easement occasionally to overflow, flood and submerge (the land described in Schedule A) (Tracts Nos.____, ____ and ____). (and to maintain mosquito control) in connection with the operation and maintenance of the __________ project as authorized by-the Act of Congress approved _____________, together with all right, title and interest in and to the structure; and improvements now situate on the land, except fencing (and also excepting _____________________ (here identify those structures not designed for human habitation which the non-federal project sponsor determines may remain on the land)) ; provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the non-federal project sponsor in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of land-fill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

7. FLOWAGE EASEMENT (Portions of Land to be Subjected to Permanent Inundation and Portions to be Subjected to Occasional Flooding). The perpetual right, power, privilege and easement in, upon, over and across (the land described in Schedule “A”) (Tracts Nos. ____, ____ and ____) for the purposes set forth below:

a. Permanently to overflow, flood and submerge the land lying below elevation __________ (and to maintain mosquito control,) in connection with the operation and maintenance of the ___________ project for the purposes as authorized by the Act of Congress approved _______________, together with all right, title and interest in and to the timber and the continuing right to clear and remove any brush, debris and natural obstructions which, in the opinion of the representative of the non-federal project sponsor in charge of the project may be detrimental to the project.

b. Occasionally to overflow, flood and submerge the land lying above elevation _________ (and to maintain mosquito control,) in connection with the operation and maintenance of said project.

Together with all right, title and interest in and to the structures and improvements now situate on the land, except fencing above elevation ________ (and also excepting _______ (here identify those structures not designed for human habitation which the representative of the non-federal project sponsor determines may remain on the land)) provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the non-Federal Project sponsor in charge of the project, and

8. CHANNEL IMPROVEMENT EASEMENT. A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos.____, ____ and ____) for the purposes as authorized by the Act of Congress approved _____________, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

9. FLOOD PROTECTION LEVEE EASEMENT. A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos.____, ____ and ____) to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

10 ROAD EASEMENT. A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and ____) for the location, construction, operation, maintenance, alteration replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in Schedule B); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

11. BORROW EASEMENT. A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. ____, ____ and ____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the land-owners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights. and easement hereby acquired.

12. TEMPORARY WORK AREA EASEMENT. A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and ____), for a period not to exceed ______________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary

NON-STANDARD ESTATES

13. FEE EXCEPTING THE RIGHT TO EXCAVATE THE LAND FOR THE PURPOSE OF QUARRYING LIMESTONE, AND SAND. The fee simple title to (the land described in Schedule A) (Tracts Nos.____, ____ and ____), subject, however, to existing easements for public roads highways, public utilities, railroads and pipelines; excepting that excavation for the purpose of quarrying (limestone) (sand) shall be permitted, subject only to such approval as to the placement and disposal of overburden, if any, in connection with such excavation.

14. RELEASE OF SURFACE EXPLORATION RIGHTS

WHEREAS ________________ is the owner of certain (oil, gas, phosphate, etc.) and other mineral rights or reservations, together with the right of access to explore, prospect, exploit, develop and otherwise seek (oil, gas, phosphate, etc.) and other mineral deposits on the lands hereinafter described on Exhibit “A”; and

WHEREAS, a release and waiver of such rights of surface exploration has been requested of __________________ by the SOUTH FLORIDA WATER MANAGEMENT DISTRICT, and a valuable consideration for so doing has been paid by the SOUTH FLORIDA WATER MANAGEMENT DISTRICT.

NOW, THEREFORE, for and in consideration of the sum of ____________ Dollars and other good and valuable considerations paid by said SOUTH FLORIDA WATER MANAGEMENT DISTRICT,

________________________________ does for itself, its successors, heirs, and assigns, subject to existing mineral leases, if any, hereby waive and release to said SOUTH FLORIDA WATER MANAGEMENT DISTRICT, its successors and assigns, its rights of access to explore for (oil, gas, phosphate, etc.) and mineral deposits on the land described on Exhibit "A" situated in ____________ County, Florida.

EXPRESSLY RETAINING AND RESERVING, HOWEVER, all (oil, gas, phosphate, etc.) and mineral right reservations otherwise owned by _____________ in the land described on Exhibit "A", as to which the right of access for surface exploration is hereby released, and

EXPRESSLY RETAINING AND RESERVING SPECIFICALLY, the right to receive bonuses, rentals, royalties, and other payments to which it may be otherwise entitled by reason of the leasing, sale, or exploration of said (oil, gas, phosphate, etc.) and mineral rights.

F.18 ATTITUDE OF LANDOWNERS

The attitude of landowners within the project study area varies. Some are totally in favor of the project, while others are totally against the project or components of the project.

F.19 MINERALS

There are no known minerals in the project area, however, limestone is mined and quarried in portions of Components S and FF. The landowners will be allowed to continue to extract and excavate limestone in portions of these Components. The Non-Standard Fee estate will be utilized to acquire interests in these lands. Limestone, pursuant to Florida case law (<u>Florida Audubon Society v. Ratner</u>, 497 So.2d 672, (3rd D.C. App, Fla.) 1986, is not considered a mineral subject to a normal reservation of mineral rights or interests.

For other components within the recommended Comprehensive Plan, during subsequent design documents, the outstanding third party mineral interests will be more fully discussed. Conceptually, land costs could be reduced if the owners of the outstanding third party mineral interests were allow to retain the royalties, bonus, rentals and other payments that they may be entitled to by reason of the exploration of the minerals. This could be accomplished by the non-Federal sponsor securing from the owner of the outstanding third party mineral interest, a release of their surface exploration rights. The standard Release of Surface Exploration Rights is as set forth in the Non-Standard Estates, paragraph 21 above.

F.20 STANDING TIMBER AND VEGETATIVE COVER

Standing timber or other vegetative cover that has significant recreation or scenic value has not been identified at this time. It will be identified is subsequent design documents.

F.21 MITIGATION

Mitigation lands, if any, will be identified in subsequent design documents.

F.22 OUTSTANDING RIGHTS

Outstanding rights will be identified in subsequent design documents.

F.23 HAZARDOUS, TOXIC AND RADIOACTIVE WASTES (HTRW)

Phase I Hazardous, Toxic and Radioactive Waste (HTRW) Site Assessments were conducted in all subregions in conformance with the scope and limitations of ASTM Practice E 1527 and Engineer Regulation ER-1165-2-132. The findings and conclusions provided below reflect existing HTRW conditions based on database searches, aerial photography, review of available records, site inspections and interviews. These findings and conclusions are of existing conditions at this time. The project conditions assume that any HTRW found during any phase of the project would be remediated in accordance with local, state and federal laws. Therefore, it can be assumed that conditions at future construction sites will be contamination free or of low levels which would include de minimis conditions that generally do not present a material risk of harm to public health or the environment.

The assessment covered all Restudy sub-regions, within the general vicinity of proposed project features or existing features proposed for significant modification. Several site visits were conducted over the past few years, with the most recent survey having been performed during the week of 12 August 1998. The HTRW database search was performed on the entire area and it indicated that overall, the majority of the proposed new construction areas are free of hazardous and toxic waste. Most of these general features are proposed for remote and rural areas, and were farms, vacant land, or wildlife management areas. The most common type of HTRW, hydrocarbons, was found along state highways in which the majority of the gasoline stations had leaking underground storage tanks. The leaking underground storage tanks are found on roads crossing potential project lands at the Kissimmee River, Lake Okeechobee perimeter road, Upper East Coast roads, and Lower East Coast Roads.

Databases also revealed that several locations are National Priority Listed (NPL). Most of these NPL sites are due to past landfill operations. These sites are located in Palm Beach County, the Lower East Coast Lakebelt area in the vicinity of S-9 Structures and in Broward County south of Alligator Alley. Contaminated sites located on the perimeter of any proposed water storage area may be migrating or expanding into the project area. Any such sites would require further survey and specific evaluation prior to detailed design for Restudy features. Another feature of concern is the numerous landfills and waste handling facilities existing in the Lower East Coast sub-region. To the extent feasible, water storage areas should not be sited immediately adjacent to these known sites.

There are, in addition to identified sites, numerous undocumented tanks and landfills that may be present in future project areas which were not included in the database. These HTRW locations may be due to undocumented dumping or other HTRW operations. Within the agricultural areas there are numerous temporary pump sites and fuel storage areas. These makeshift portable tanks are not reported, and therefore are not presented in the HTRW database. In addition, pesticide/chemical mixing areas may also exist. Project implementation requires that any HTRW problems revealed during the real estate acquisition or actual project construction require full remediation

The database and Phase-1 assessment results are maintained at the US Army Corps of Engineers, Planning Division, as a series of maps and GIS overlays. It is not appropriate to include detailed information in this Programmatic Report and EIS. However, the data will be available to planners for consultation during development of specific project features, and is expected to aid in avoiding sites with major remediation needs.

F.24 RECREATION RESOURCES

There are no separable recreation lands required for this project.

F.25 RELOCATIONS OF ROADS, BRIDGES, UTILITIES/FACILITIES, TOWNS AND CEMETERIES

Based on available information, required relocations of roads, bridges, utilities, towns or cemeteries could not be identified. These will be accomplished in subsequent design documents.

F.26 CHART OF ACCOUNTS - RECOMMENDED COMPREHENSIVE PLAN

Alternative D-13R

O1	LAND AND DAMAGES	
01B	ACQUISITIONS	
01B20	BY LOCAL SPONSOR (LS)	$77,525,000
01B40	REVIEW OF LS	$38,055,000
01R	REAL ESTATE PAYMENTS	
01R10	LAND PAYMENTS	
01R1B	BY LS	$1,499,796,000
01R2	PL 91-646 ASSISTANCE PAYMENTS	
01R2B	BY LS	$414,000
TOTAL REAL ESTATE COST EXCLUDING CONTINGENCY		$1,615,790,000
CONTINGENCY (see note 2)		$605,645,000
	TOTAL FOR COMPREHENSIVE PLAN	$2,221,435,000

Note 1- These costs are not broke-out. Federal acquisition/admin costs are estimated at $6,000 per tract which are included in account 01B40 includes accounts 01A00, 01C40, 01E50, 01F40, 01G40, and 01M00. Non-federal acquisition admin costs included in account 01B20 includes accounts 01C20, 01E30, 01F20, 01G20, and 01G60.

Note 2 –Contingency on the components are shown on Table F-2. .

Real Estate costs for “Other Project Elements” were based solely on information provided from the proponents of the “Other Project Element” and have not been verified by Real Estate Division, Jacksonville District.

TABLE F-1
FEDERAL AND NON-FEDERAL ADMINISTRATIVE/ACQUISITION COSTS

Includes Funds For Project Planning Purposes, Appraisals, Acquisitions, Temporary Permits, Condemnations,									
Also Includes Funds For Project Planning Purposes, And Review Of The Following: Appraisals, Acquisitions, Temporary Permits, Condemnations,									
	Component	**County Or Counties**	**Acres**	**Number of Owners**	**Federal Acquisition Cost**	**Non-Federal Acquisition Costs**	**Contingency Percentage**	**Contingency Amount**	**TOTAL**
A	Storage Reservoir North Of Lake Okeechobee	Glades, Highlands, Or Okeechobee,	20000	360	$2,160,000	$4,320,000	50 %	$3,240,000	$9,720,000
B	Storage Reservoir Stlucie/C-44 Basin	Martin	10000	25	$150,000	$300,000	50 %	$225,000	$675,000
D	Storage Reservoir Caloosahatchee C-43 Basin	Hendry Glades And Lee	20000	23	$138,000	$276,000	50 %	$207,000	$621,000
G	Storage Reservoir Everglades Agricultural Area	Palm Beach	`17500	10	$60,000	$120,000	45%	$81,000	$ 261,000
K	Water Preserve Area Palm Beach County-Additional L-8 Improvements	Palm Beach	380	80	$480,000	$960,000	50 %	$720,000	$2,160,000
M	Water Preserve Area Palm Beach County -Site 1 Impoundment Reservoir	Palm Beach	2458	31	$186,000	$425,000	5 % ON $65,000 50 % ON $546,000	$3250 $273000	$887,300
O	Water Preserve Area-Broward County-Water Conservation 3A and 3B Levee Seepage Management	Broward	3352	250	$1,500,000	$3,000,000	25%	$1,125,000	$5,625,000
Q	Water Preserve Area-Broward County-Western C-11 Diversion Impoundment And Canal To North Lake Belt Storage Area	Broward, Miami-Dade	2535	639	$3,824,000	$7,668,000	50 %	$5,746,000	$17,238,000
R	Water Preserve Area-Broward County-C-9 Stormwater Treatment Area /Impoundment	Broward	2500	145	$870,000	$1,740,000	50 %	$1,305,000	$3,915,000
S	Water Preserve Area-Miami-Dade County-Central Lake Belt Storage Area	Miami-Dade	5770	116	$696,000	$1,392,000	45%	$939,600	$3,027,600

TABLE F-1
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Also Includes Funds For Project Planning Purposes, And Review Of The Following: Appraisals, Acquisitions, Temporary Permits, Condemnations,									
	Component	County Or Counties	Acres	Number of Owners	Federal Acquisition Cost	Non-Federal Acquisition Costs	Contingency Percentage	Contingency Amount	TOTAL
T	Water Preserve Area-Miami-Dade County-C-4 Structures	Miami-Dade	2	10	$60,000	$120,000	50 %	$90,000	$270,000
U	Water Preserve Area-Miami-Dade County-Bird Drive Recharge Area	Miami-Dade	2877	1460	$5,840,000	$13,140,000	50 %	$9,490,000	$28,470,000
W	Taylor Creek/Nubbin Slough Storage And Treatment Area	Okeechobee, St Lucie	10000	100	$600,000	$1,200,000	50 %	$900,000	$2,700,000
X	Water Preserve Area -Palm Beach County-C-17 Backpumping	Palm Beach	550	2	$12,000	$24,000	50 %	$18,000	$54,000
Y	Water Catchment Area-C-51 Backpumping To Water Catchment Area	Palm Beach	710	6	$36,000	$72,000	50 %	$54,000	$162,000
BB	Water Preserve Area-Palm Beach County Dade Broward Levee Pensuco Wetlands	Miami-Dade	384	140	$840,000	$1,680,000	50 %	$1,260,000	$3,780,000
CC	Improve Broward County Secondary Canals	Broward	245	30	$180,000	$360,000	50 %	$270,000	$810,000
FF	Water Preserve Area-Miami-Dade County-Construction Of S356A & B Structures	Miami-Dade	3947	528	$3,168,000	$6,336,000	50 %	$4,752,000	$14,256,000
GG	Lake Okeechobee Aquifer Storage And Recovery	Glades And Okeechobee	300	220	$1,320,000	$2,640,000	50 %	$1,980,000	$5,940,000
KK	Water Conservation Area 1- Loxahatchee National Wildlife Refuge Internal Canal Structures	Palm Beach	5	10	$60,000	$120,000	50 %	$90,000	$270,000
LL	Lower East Coast Service Area 1 C-51 Regional Groundwater Aquifer Storage And Recovery	Palm Beach Broward	34	85	$510,000	$1,020,000	50 %	$765,000	$2,295,000
QQ	Decompartmentalize Water Conservation 3	Miami-Dade	55	2	$64,000	$108,000	50 %	$86,000	$258,000

TABLE F-1
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Also Includes Funds For Project Planning Purposes, And Review Of The Following: Appraisals, Acquisitions, Temporary Permits, Condemnations,									
	Component	**County Or Counties**	**Acres**	**Number of Owners**	**Federal Acquisition Cost**	**Non-Federal Acquisition Costs**	**Contingency Percentage**	**Contingency Amount**	**TOTAL**
SS	Everglades Agricultural Area And Miami-Dade County Reroute Miami-Dade County Water Supply Deliveries	Palm Beach, Broward And Miami-Dade	200	400	$2,400,000	$4,800,000	50 %	$3,600,000	$10,800,000
UU	St Lucie Estuary C-23,C-24,C-25, Northfork And Southfork Basins Storage Reservoirs	Martin And St Lucie	48350	114	$684,000	$1,368,000	50 %	$1,026,000	$3,078,000
VV	Palm Beach County Agriculture Reserve Reservoir	Palm Beach	1660	18	$108,000	$216,000	50 %	$162,000	$486,000
WW	South Dade County C-111N Spreader Canal	Miami-Dade	12415	396	$2,376,000	$4,752,000	35 %	$2,494,800	$9,622,800
XX	Water Preserve Area-Miami-Dade County North Lake Belt Storage Area	Miami-Dade	5861	900	$5,400,000	$10,800,000	40%	$6,480,000	$22,680,000
YY	Water Conservation Area – Water Preserve Area-Lake Belt Divert Water Conservation Area 2 Flows To Central Lake Belt Storage	Broward Miami-Dade	835	250	$1,500,000	$3,000,000	50 %	$2,250,000	$6,750,000
ZZ	Water Conservation Area – Water Preserve Area-Lake Belt-Divert Water Conservation Area 3 Flows To Central Lake Belt Storage Area	Miami-Dade And Broward	2	10	$60,000	$120,000	50%	$90,000	$270,000
BBB	Southern Miami-Dade County Reuse	Miami-Dade	200	12	$72,000	$144,000	50 %	$108,000	$324,000
CCC	Big Cypress L-28 Interceptor Modifications	Hendry, And Collier	1900	2	$12,000	$24,000	40 %	$14,400	$50,400
DDD	Caloosahatchee Backpumping With stormwater Treatment Area C-43 Basin	Glades	5000	2	$12,000	$24,000	50 %	$18,000	$54,000
FFF	Biscayne Bay Coastal Canals	Miami-Dade	350	15	$90,000	$180,000	50 %	$135,000	$405,000

TABLE F-1
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Also Includes Funds For Project Planning Purposes, And Review Of The Following: Appraisals, Acquisitions, Temporary Permits, Condemnations,									
	Component	**County Or Counties**	**Acres**	**Number of Owners**	**Federal Acquisition Cost**	**Non-Federal Acquisition Costs**	**Contingency Percentage**	**Contingency Amount**	**TOTAL**
GGG	Water Preserve Area –Palm Beach County- C-51 And Southern L-8 Reservoir	Palm Beach	1800	13	$78,000	$156,000	50 %	$117,000	$351,000
HHH	Water Preserve Area- Miami-Dade County West Miami Dade Reuse	Miami-Dade	100	20	$120,000	$240,000	50 %	$180,000	$540,000
OPE	Lake Okeechobee Watershed Water Quality Treatment Facilities (Lake Okeechobee Water Retention/ Phosphorous Removal	Glades, Highlands and Okeechobee	4515	Unknown	$248,000	$496,000	none	$0	$744,000
OPE	Lake Okeechobee Tributary Sediment Dredging	Glades, Highlands and Okeechobee	320	Unknown	$48,000	$96,000	15%	$22,000	$166,000
OPE	Seminole Tribe Big Cypress Water Conservation Plan	Hendry and Broward	3800	Unknown	$16,000	$12,000	25%	$7,000	$35,000
OPE	Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration	Palm Beach and Martin	3000	Unknown	$120,000	$240,000	26%	$94,000	$454,000
OPE	Protect and Enhance Wetland Systems along Loxahatchee National Wildlife Refuge including Strazzulla Tract	Palm Beach	3335	Unknown	$30,000	$61,000	45%	$41,000	$132,000
OPE	Southern Crew Project Addition	Collier	4670	Unknown	$1,200,000	$2,400,000	5%	$180,000	$3,780,000
OPE	Lake Trafford Restoration	Collier	449	Unknown	$15,000	$15,000	None	$0	$30,300
OPE	Miccosukee Water Management Plan	Broward	900	Unknown	$15,000	$15,000	25%	$7,500	$37,500
OPE	Palm Beach County Wetlands Based Water Reclamation	Palm Beach	2000	Unknown	$60,000	$120,000	28%	$50,500	$230,500
OPE	Florida Keys Tidal Restoration	Monroe	5	Unknown	$16,000	$12,000	18%	$5,000	$33,000

TABLE F-1
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Also Includes Funds For Project Planning Purposes, And Review Of The Following: Appraisals, Acquisitions, Temporary Permits, Condemnations,									
	Component	**County Or Counties**	**Acres**	**Number of Owners**	**Federal Acquisition Cost**	**Non-Federal Acquisition Costs**	**Contingency Percentage**	**Contingency Amount**	**TOTAL**
OPE	Lake Worth Lagoon Restoration	Palm Beach		Unknown	$12,000	$24,000	None	$0	$36,000
OPE	Acme Basin B Discharge	Palm Beach	930	Unknown	$90,000	$180,000	10%	$27,000	$297,000
OPE	Biscayne Bay Coastal Wetlands	Miami-Dade	13600	Unknown	$240,000	$480,000	None	$0	$720,000
OPE	Henderson Creek/ Belle Meade Restoration Project	Collier	125	Unknown	$60,000	$120,000	5%	$9,000	$189,000
OPE	Winsburg Farms Wetlands	Palm Beach	175	Unknown	$200,000	$400,000	15%	$90,000	$690,000
OPE	Lake Park Restoration Project	Lee	40	Unknown	$12,000	$12,000	15%	$3,600	$27,600
		TOTALS	**220141**	**6424**	**$38,048,000**	**$77,528,000**		**$50,831,700**	**$166,407,700**

Table F-2
Summary Of Estimated Project Real Estate Costs Probable Costs

Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
Storage Reservoir North Of Lake Okeechobee	Glades, Highlands, Or Okeechobee	20000	$6,000	$120,000	Unknown	Unknown	Unknown	$2,160	$4,320	$126,4800	$63,240	$189,720	50
Storage Reservoir St Lucie/C-44 Basin	Martin	10000	$6,000	$60,000	Unknown	Unknown	Unknown	$150	$300	$60,450	$30,225	$90,675	50
Storage Reservoir Caloosahatchee/ C-43 Basin	Hendry, Glades And Lee	20000	10000 @ $2,500 10000 @ $6300	$88,000	Unknown	Unknown	Unknown	$138	$276	$88,414	$44,207	$132,621	50
Storage Reservoir Everglades Agricultural Area	Palm Beach	17500	$3,400	$59,500	Unknown	Unknown	Unknown	$60	$120	$59,680	$26,856	$86,536	45
Water Preserve Area Palm Beach County-Additional L-8 Improvements	Palm Beach	380	40 @ $10,000 340 @ $3,000	$1,420	Unknown	Unknown	Unknown	$480	$960	$2,860	$1,430	$4,290	50
Water Preserve Area Palm Beach County-Site 1 Impoundment Reservoir	Palm Beach	2458	800 @ $12,000 1658 @ $5006	$17,900	Unknown	Unknown	Unknown	$186	$425	$18,511	$5,076	$23,587	5 ON $65000 50 ON $10,146,000

Table F-2
Summary Of Estimated Project Real Estate Costs Probable Costs

Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
Water Preserve Area-Broward County-Water Conservation 3A And 3B Levee Seepage Management	Broward	3352	2350 owned by SFWMD-$19014 7982 @ $19,000 10@ $26,000	$63,601	Unknown	Unknown	Unknown	$1,500	$3,000	$68,101	$17,025	$85,126	25
Water Preserve Area-Broward County-Western C-11 Diversion Impoundment And Canal To North Lake Belt Storage Area	Broward, Miami-Dade	2535	497 owned by SFWMD @ 22870 535 @ $5,000 1103 @ $22,900 400 @ $20,000	$47,300	Unknown	Unknown	Unknown	$3,834	$7,668	$58,802	$23,718	$82,520	50% ON $47,435,000 ALL BUT $11,366,000
Water Preserve Area-Broward County- C-9 Stormwater Treatment Area/Impoundment	Broward	2500	1505 owned by SFWMD @ $19390 995 @ $20,000	$49,074	Unknown	Unknown	Unknown	$870	$1,740	$51,684	$11,255	$62,939	50% ON $22,510,000 ALL BUT $29,174,000
Water Preserve Area-Miami-Dade County-Central Lake Belt Storage Area	Miami-Dade	5770	620 @ $55,000 3750 @ $7,500 1400 @ $3,500	$67,125	Unknown	Unknown	Unknown	$696	$1,392	$69,213	$31,146	$100,359	45
Water Preserve Area-Miami-Dade County- C-4 Structures	Miami-Dade	2	$75,000	$150	Unknown	Unknown	Unknown	$60	$120	$330	$165	$495	50

Table F-2
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Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
Water Preserve Area-Miami-Dade County-Bird Drive Recharge Area	Miami-Dade	2877	$10,000	$28,770	Unknown	Unknown	Unknown	$5,840	$13,140	$47,750	$23,875	$71,625	50
Taylor Creek/Nubbin Slough Storage And Treatment Area	Okeechobee, St Lucie	10000	$1,800	$18,000	Unknown	Unknown	Unknown	$600	$1,200	$19,800	$9,900	$29,700	50
Water Preserve Area –Palm Beach County- C-17 Backpumping	Palm Beach	550	$12,500	$6,875	Unknown	Unknown	Unknown	$12	$24	$6,911	$3,456	$10,367	50
Water Catchment Area-C-51 Backpumping To Water Catchment Area	Palm Beach	710	$12,500	$8,875	Unknown	Unknown	Unknown	$36	$72	$8,983	$4,492	$13,475	50
Water Preserve Area-Palm Beach County Dade Broward Levee Pensuco Wetlands	Miami-Dade	384	$8,500	$3,264	Unknown	Unknown	Unknown	$840	$1,680	$5,784	$2,892	$8,676	50
Improve Broward County Secondary Canals	Broward	245	55 @ $10,000 190 @ $1,000	$740	Unknown	Unknown	Unknown	$180	$360	$1,280	$640	$1,920	50
Water Preserve Area-Miami-Dade County- Construction Of S356a &B Structures	Miami-Dade	3947	155 @ $1,000 1082 @ $3,500 2710 @ $20,000	$58,142	Unknown	Unknown	Unknown	$3,168	$6,336	$67,646	$27,058	$94,704	40

Table F-2
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Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
Lake Okeechobee Aquifer Storage And Recovery	Glades Okeechobee	300	$3,500	$1,050	Unknown	Unknown	Unknown	$1,320	$2,640	$5,010	$2,505	$7,515	50
Water Conservation Area 1- Loxahatchee National Wildlife Refuge Internal Canal Structures	Palm Beach	5	$10,000	$50	Unknown	Unknown	Unknown	$60	$120	$230	$115	$345	50
LEC Service Area 1 C-51 Regional Groundwater Aquifer Storage And Recovery	Palm Beach Broward	34	$150,000	$5,100	Unknown	Unknown	Unknown	$510	$1,020	$6,630	$3,315	$9,945	50
Decompartmentalize Water Conservation 3	Miami-Dade	55	18.4 @ $4,000 36.8 @ $2,000	$147	Unknown	Unknown	Unknown	$64	$108	$319	$160	$479	50
Everglades Agricultural Area And Miami-Dade County Reroute Miami-Dade County Water Supply Deliveries	Palm Beach, Broward And Miami-Dade	200	$50,000	$10,000	Unknown	Unknown	Unknown	$2,400	$4,800	$17,200	$8,600	$25,800	50
St Lucie Estuary C-23,C-24, Northfork And Southfork Basins Storage Reservoirs	Martin And St Lucie	48350	30600 @ $5,800 17750 @ $6,000	$283,980	Unknown	Unknown	Unknown	$684	$1,368	$286,032	$143,016	$429,048	50
Palm Beach County Agriculture Reserve Reservoir	Palm Beach	1660	$20,000	$33,200	$4,500	Unknown	$414	$108	$216	$38,438	$19,219	$57,657	50

Table F-2
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Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
South Dade County C-111N Spreader Canal	Miami-Dade	12415	3000 @ $5,000 9375@ $1,250	$26,773	Unknown	Unknown	Unknown	$2,376	$4,752	$33,901	$11,865	$45,766	35
Water Preserve Area-Miami-Dade County North Lake Belt Storage Area	Miami-Dade	5861	1200 @ $1,000 4661 @ $20,000	$94,420	Unknown	Unknown	Unknown	$5,400	$10,800	$110,620	$44,248	$154,868	40
Water Conservation Area-Water Preserve Area-Lake Belt Divert Water Conservation Area 2 Flows To Central Lake Belt Storage	Broward Miami-Dade	835	$5,000	$4,175	Unknown	Unknown	Unknown	$1,500	$3,000	$8,675	$4,338	$13,013	50
Water Conservation Area -Water Preserve Area-Lake Belt-Divert Water Conservation Area 3 Flows To Central Lake Belt Storage Area	Miami-Dade And Broward	2	$12,500	$25	Unknown	Unknown	Unknown	$60	$120	$205	$103	$308	50
Southern Miami-Dade County Reuse	Miami-Dade	200	$10,000	$2,000	Unknown	Unknown	Unknown	$72	$144	$2,216	$1,108	$3,324	50
Big Cypress L-28 Interceptor Modifications	Hendry, And Collier	1900	$2,500	$4,750	Unknown	Unknown	Unknown	$12	$24	$4,786	$1,914	$6,700	40

Table F-2
Summary Of Estimated Project Real Estate Costs Probable Costs

Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
Caloosahatchee Backpumping With stormwater Treatment Area C-43 Basin	Glades	5000	2500 @ $1,000 2500 @ $2,500	$8,750	Unknown	Unknown	Unknown	$12	$24	$8,786	$4,393	$13,179	50
Biscayne Bay Coastal Canals	Miami-Dade	350	$10,000	$3,500	Unknown	Unknown	Unknown	$90	$180	$3,770	$1,885	$5,655	50
Water Preserve Area –Palm Beach County- C-51 And Southern L-8 Reservoir	Palm Beach	1800	$10,000	$18,000	Unknown	Unknown	Unknown	$78	$156	$18,234	$9,117	$27,351	50
Water Preserve Area-Miami-Dade County West Miami Dade Reuse	Miami-Dade	100	$20,000	$2,000	Unknown	Unknown	Unknown	$120	$240	$2,360	$1,180	$3,540	50
Lake Okeechobee Watershed Water Quality Treatment Area	Glades, Highlands and Okeechobee	4515	Various	$13,704	Unknown	Unknown	Unknown	$248	$496	$14,448	none	$14,448	0
Lake Okeechobee Tributary Sediment Dredging	Glades, Highlands and Okeechobee	320	$2,000	$640	Unknown	Unknown	Unknown	$48	$96	$784	$116	$900	15%
Seminole Tribe Big Cypress Water Conservation Plan	Hendry and Broward	3800	$1,200	$4,560	Unknown	Unknown	Unknown	$16	$12	$4,588	$1,147	$5,735	25%

Table F-2
Summary Of Estimated Project Real Estate Costs Probable Costs

Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration	Palm Beach, Martin	3000	$2,000	$6,000	Unknown	Unknown	Unknown	$120	$240	$6,360	$1,640	$8,000,	26%
Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including Strazulla Tract	Palm Beach	3335	$10,100	$33,683	Unknown	Unknown	Unknown	$30	$61	$33,774	$15,198	$48,972	45%
Southern Crew Project Addition	Collier	4670	Various	$25,070	Unknown	Unknown	Unknown	$1,200	$2,400	$28,670	$1,434	$30,104	5
Lake Trafford Restoration	Collier	449	$1,590	$714	Unknown	Unknown	Unknown	$15	$15	$744	none	$744	0
Miccosukee Water Management Plan	Broward	900	$1,500	$1,350	Unknown	Unknown	Unknown	$12	$12	$1,374	$344	$1,718	25%
Palm Beach County Wetlands Based Water Reclamation	Palm Beach	2000	$1,500	$2,000	Unknown	Unknown	Unknown	$60	$120	$2,180,	$620	$2,800	28%
Florida Keys Tidal Restoration	Monroe	5	$3,000	$15	Unknown	Unknown	Unknown	$16	$12	$43	$8	$51	19%
Lake Worth Lagoon Restoration	Palm Beach			$264	Unknown	Unknown	Unknown	$12	$24	$300	none	$300	0

Table F-2
Summary Of Estimated Project Real Estate Costs Probable Costs

Component	County Or Counties	Acres	Per Acre Value	Total Value of Lands in Thousands	Improvement in Thousands	Severance in Thousands	P.L 91-646	Federal Acquisition Costs in Thousands	non-Federal Acquisition Costs in Thousands	Total w/o Contingency in Thousands	Contingency in Thousands	Probable Costs in Thousands	Contingency Percentage
Acme B Basin Discharge	Palm Beach	930	$8,000	$7,440	Unknown	Unknown	Unknown	$90	$180	$7,710	$790	$8,500	10%
Biscayne Bay Coastal Wetlands	Miami-Dade	13600	Various	$199,280	Unknown	Unknown	Unknown	$240	$480	$200,000	none	$200,000	0
Henderson Creek/ Belle Meade Restoration Project	Collier	125		$800	Unknown	Unknown	Unknown	$60	$120	$980	$49	$1,029	5%
Winsburg Farms Wetlands	Palm Beach	175		$3,000	Unknown	Unknown	Unknown	$200	$400	$3,600	$540	$4,140	15%
Lake Park Restoration Project	Lee	40		$120	Unknown	Unknown	Unknown	$12	$12	$144	$22	$166	15%
		220141		**$1,495,296**	**$4,500**	**Unknown**	**$414**	**$38,055**	**$77,525**	**$1,615,790**	**$605,645**	**$2,221,435**	

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
A	Storage Reservoir North Of Lake Okeechobee A6,A6,A6,A6	Glades, Highlands, Or Okeechobee	$189,720	20000	$189,720	20000	$189,720	20000	$189,720	20000	$46,614	$249,720	$189,720	20000	General Agricultur e- Pasture And Citrus	50%-Unknowns: Location, Total Acres, Type Of Land, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
B	Storage Reservoir St Lucie/C-44 Basin B6,B6,B6,B6	Martin	$90,675	10000	$90,675	10000	$90,675	10000	$90,675	10000	$78,585	$93,375	$90,675	10000	Citrus Groves	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
C	Environmental Water Supplies To St Lucie Estuary C6, C6, C6, C6	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	NO RE	NO RE	NO RE	no RE	No RE	No RE
D	Storage Reservoir Caloosahatchee/ C-43 Basin D5,D5,D5,D5	Hendry, Glades And Lee	$75,621	20000	$75,621	20000	$75,621	20000	$75,621	20000	$63,018	$132,621	$132,621	20000	Sugar Cane and Groves	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
E	Environmental Water Supplies To Caloosahatchee Estuary E5, E5, E5, E5	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	no RE	no RE	No RE	No RE
F	Lake Okeechobee Regulation Schedule F3, F3, F3, F3	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
G	Storage Reservoir Everglades Agricultural Area G3,G3,G5,G5	Palm Beach	$285,852	60000	$285,852	60000	$285,852	60000	$285,852	60000	$71,311	$86,536	$86,536	17500	Sugar Cane	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
H	Everglades Rain Driven Operations H3,H4,H6,H6	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
I	Improve Conveyance Between Water Conservation 3B And Everglades National Park, 13, No, No, No	No RE	no Re	no Re	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
J	No,No,No,No		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
K	Water Preserve Area Palm Beach County-Additional L-8 Improvements K2,K4,K4,K4	Palm Beach	$2,576	40	$2,576	40	$2,576	40	$2,576	40	$2,576	$4,290	$4,290	380	Open Pasture	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations **Note: Total Acres Could Be As Low As 40**
L	Relocate Wellfield Operations L3,L3,L3,L3	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
M	Water Preserve Area Palm Beach County-Site 1 Impoundment Reservoir M4,M4,M4,M6	Palm Beach	$8,734	1658.16	$8,734	1658.16	$8,734	1658.16	$22,779	2458	$22,573	$23,587	$23,587	2458.	Agriculture, Upland Forests, Vacant	Sfwmd Owns 1658.19 Acres Purchased For $8,300,000 Remaining 800 Acres Is To Be Acquired Contingency Of 40% On This Acreage Unknowns Are: Improvements, Relocations; No. Owners; Condemnations.
N	Water Conservation Area 2b Levee Seepage Management N2, No, No, No	No RE	no RE	no RE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
O	Water Preserve Area-Broward County-Water Conservation 3a And 3b Levee Seepage Management O1,O4,O4,O6	Broward	$47,601	6542	$47,601	6542	$47,601	6542	$47,601	6542	$85,126	$89,859	$85,126	3352	Prairie With Trees	25% Because Sfwmd Owns 2360 Acres Purchased For $44,682,637 However Not All Administrative Costs Have Been Calculated Per Acre Cost Of $19,000
P	North New River Diversion And Treatment P2, No, No, NO		$68,167	2000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
Q	Water Preserve Area-Broward County-Western C-11 Diversion Impoundment And Canal To North Lake Belt Storage Area Q1,Q4,Q5,Q5	Broward, Miami-Dade	$5,156	535	$73,323	2535	$73,323	2535	$73,323	2535	$73,323	$82, 520	$82, 520	2535	Appears To Be Agricultural	50% Contingency On $47,435,000 . Sfwmd Already Owns 497 Acres Purchased For $11,366,000.

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
R	Water Preserve Area-Broward County- C-9 Stormwater Treatment Area/Impoundment R3,R4,R4,R4	Broward	$71,024	2500	$71,024	2500	$71,024	2500	$71,024	2500	$58,437	$62,939	$62,939	2500	Agriculture, Prairie, Commerc-ial	50% Contingency On $22,510,000. Sfwmd Owns 1505 Acres Purchased For $29,174,040
S	Water Preserve Area-Miami-Dade County-Central Lake Belt Storage Area S3,S5,S5,S6	Miami-Dade	$188,007	6070	$84,507	5770	$84,507	5770	$84,507	5770	$84,507	$103,359	$103,359	5770	Vacant And Quarry	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
T	Water Preserve Area-Miami-Dade County – C-4 Structures T6,T6,T6,T6	Miami-Dade	$446	2	$446	2	$446	2	$446	2	$446	$495	$495	2	Commercial	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
U	Water Preserve Area-Miami-Dade County-Bird Drive Recharge Area U3,U4,U4,U6	Miami-Dade	$71,625	2877	$71,625	2877	$71,625	2877	$71,625	2877	$71,625	$88,887	$71,625	2877	Vacant	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
V	Water Preserve Area-Miami-Dade County-L31N Levee Improvements for Seepage Management V2,V4,V4,V4	Miami-Dade	$2,576	40	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
W	Taylor Creek/Nubbin Slough Storage And Treatment Area W2,W2,W2,W2	Okeechobee, St Lucie	$29,700	10000	$29,700	10000	$29,700	10000	$29,700	10000	$29,700	$47,700	$29,700	10000	Pasture	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
X	Water Preserve Area –Palm Beach County- C-17 Backpumping X6,X6,X6,X6	Palm Beach	$10,367	550	$10,367	550	$10,367	550	$10,367	550	$4,179	$17,325	$10,367	550	Upland Forests, Some Agricultur e, Wetlands With Standing Water	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
Y	Water Catchment Area-C-51 Backpumping To Water Catchment Area Y6,Y6,Y6,Y6	Palm Beach	$13,475	710	$13,475	710	$13,475	710	$13,475	710	$5,487	$22,527	$13,475	710	Upland Forest, Wetlands With Standing Water	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
Z	Z	No	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
AA	Additional S-345 Structures AA3,No,AA3,AA3	No RE	no RE	no RE	NO	NO	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
BB	Water Preserve Area-Palm Beach County Dade Broward Levee Pensuco Wetlands BB4,BB4,BB4,BB4	Miami-Dade	$4,361	70	$4,361	70	$4,361	70	$4,361	70	$5,105	$9,540	$8,676	384	Open Pasturela nd	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
CC	Improve Broward County Secondary Canals CC6,CC6,CC6,CC6	Broward	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	$1,920	$1,920	$1,920	$245	Various	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
DD	New Regulation Schedule For Holeyland DD5,DD5,DD5,DD5	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
EE	Modify Regulation Schedule For Rotenberger EE5,EE5,EE5,EE5	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
FF	Water Preserve Area-Miami-Dade County-Construction Of S356a &B Structures FF3,FF4,FF4,FF4	Miami-Dade	$300	4	$60,819	3947	$60,819	3947	$60,819	3947	$60,819	$94,704	$94,704	3947	Quarry And Farming	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
GG	Lake Okeechobee Aquifer Storage And Recovery GG4,GG4,GG4,GG 4	Glades And Okeechobee	$7,065	300	$7,065	300	$7,065	300	$7,065	300	$7,065	$7,515	$7,515	300	Open Pasture	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
HH	Modify S-343 A&B Operations HH3,No,HH3,HH3	No RE	no RE	no RE	NO	NO	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
II	Modify G-404 Structure II3,II3,II3,II3	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
JJ	No,No,No,No	No	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
KK	Water Conservation Area 1-Loxahatchee National Wildlife Refuge Internal Canal Structures KK4,KK4,KK4,KK4	Palm Beach	$345	5	$345	5	$345	5	$345	5	$345	$345	$345	5	Open Pasture	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
LL	Lower East Coast Service Area 1 C-51 Regional Groundwater Aquifer Storage And Recovery LL3,LL4,LL4,LL6	Palm Beach and Broward	$7,395	34	$11,745	54	$11,745	54	$7,395	34	$7,395	$9,945	$9,945	34	Open/Commercial	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
MM	Lower East Coast Service Area Hillsboro Canal Basin Regional Groundwater Aquifer Storage And Recovery, MM4, MM4, MM4, No	Palm Beach, Broward	$4,455	22	$4,455	22	$4,455	22	NO	NO	NO	NO	NO	NO	No	No
NN	No,No,No,No	No	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
OO	Modifications To South Dade In Southern Portion Of L-31N And C-111 OO4, OO4, OO4,OO4	No RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
PP	Backpumping Of The C-7 Basin To Central Lake Belt Storage System Via The C-6 , PP3, No, No, No	Miami-Dade	$1,064	4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
QQ	Decompartme Intalize Water Conservation 3 No, QQ4, QQ5, QQ6	Miami-Dade	NO	NO	no RE	no RE	no RE	no RE	no RE	no RE	$479	$479	$479	55.2	Unknown	50%-Unknowns: Location, Total Acres,
RR	Improve Flow To Central Water Conservation Area 3A, No, RR4, RR4, RR4	No	NO	NO	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
SS	Everglades Agricultural Area And Miami-Dade County Reroute – Miami-Dade County Water Supply Deliveries No, SS4, SS4, SS4	Palm Beach, Broward And Miami-Dade	NO	NO	$18,480	200	$18,480	200	$18,480	200	$19,800	$25,800	$25,800	200	Commerc-ial Residenti al	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
TT	No,No,No,No	No	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	No	No
UU	St Lucie Estuary C-23,C-24, Northfork And Southfork Basins Storage Reservoirs UU6,UU6,UU6,UU6	Martin and St Lucie	$244,578	35200	$244,578	35200	244,578	35200	244,578	35200	$375,798	$522,828	$429,048	48350	Citrus, Pasture	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
VV	Palm Beach County Agriculture Reserve Reservoir No, VV4, VV5, VV6	Palm Beach	NO	NO	$57,657	1660	$57,657	1660	$57,657	1660	$57,657	$70,107	$57,657	1660	Agricultur al	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
WW	South Dade County, C-111n Spreader Canal No, WW4, WW5, WW5	Miami-Dade	NO	NO	$24,513	9225	$45,741	12415	$45,741	12415	$44,160	$54,375	$45,766	12415	Wetlands	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
XX	Water Preserve Area-Miami-Dade County North Lake Belt Storage Area No,XX4,XX5,XX5	Miami-Dade	NO	NO	$130,743	5861	121,302	5861	121,302	5861	$121,302	$154,868	$154,868	5861	Vacant, Quarry, Agricultur e,	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
YY	Water Conservation Area – Water Preserve Area – Lake Belt Divert Water Conservation Area 2 Flows To Central Lake Belt Storage, No, YY4, YY4, YY4	Broward And Miami-Dade	NO	NO	$12,145	835	$12,145	835	$12,145	835	$12,145	$13,013	$13,013	835	Unknown	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
ZZ	Water Conservation Area – Water Preserve Area – Lake Belt Divert Water Conservation Area 2 Flows To Central Lake Belt Storage, No, No, ZZ5, ZZ5	Miami-Dade And Broward	NO	NO	NO	NO	$277	2	$277	2	$277	$308	$308	2	Pasture And Commerc -ial	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
AAA	Lower East Coast Service Area Lower East Coast Water Conservation, No, No, Aaa6, AAA6		NO	NO	NO	NO	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
BBB	Southern Miami-Dade County Reuse No, No, BBB6, BBB6	Miami-Dade	NO	NO	NO	NO	$3,324	200	$3,324	200	$3,324	$3,324	$3,324	200	Agricultur e	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
CCC	Big Cypress L-28 Interceptor Modifications No,No,CCC6,CCC6	Hendry, And Collier	NO	NO	NO	NO	$6,675	1900	$6,675	1900	$6,700	$7,179	$6,700	1900	Sugar Cane	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations

TABLE F-3
COMPARISON OF ALTERNATIVE-REAL ESTATE
Cost In Thousands of Dollars

	Component	County Or Counties	A	Acres A	B	Acres B	C	Acres C	D	Acres D	D-13R Low End Costs	D-13R High End Costs	D-13R Probable Costs	Acres D-13R	Land Type	Contingency And Unknown Factors
DDD	Caloosahatchee Backpumping With stormwater Treatment Area C-43 Basin DDD5,DDD5,DDD5, Ddd5	Glades	$13,179	5000	$13,179	5000	$13,179	5000	$13,179	5000	$7,554	$18,804	$13,179	5000	Sugar Cane	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
EEE	Water Conservation Area-Water Preserve Area-Lake Belt Flows To Eastern Water Conservation Area 3B From Central Lake Belt Storage Area No, No, EEE5, EEE5	No	NO	NO	NO	NO	no RE	no RE	no RE	no RE	no RE	no RE	no RE	no RE	No RE	No RE
FFF	Biscayne Bay Coastal Canals No, No, Fff5, Fff5	Miami-Dade	NO	NO	NO	NO	$5,655	350	$5,655	350	$5,655	$5,655	$5,655	350	Agricultur e, Commerc -ial	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
GGG	Water Preserve Area –Palm Beach County- C-51 And Southern L-8 Reservoir No, No, No, GGG6	Palm Beach	NO	NO	NO	NO	NO	NO	$27,351	1800	$27,351	$40,851	$27,351	1800	Agricultur e, Commerc -ial, Vacant	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
HHH	Water Preserve Area-Miami-Dade County West Miami Dade Reuse No, No, No, HHH6	Miami-Dade	NO	NO	NO	NO	NO	NO	$3,540	100	$3,540	$3,540	$3,540	100	Wetlands	50%-Unknowns: Location, Total Acres, No. Of Owners, Improvements, No. Of Tracts, Severance, Minerals, Relocations
TOTAL ALTERNATIVE			**$1,444,064**	**184163**	**$1,645,331**	**205563**	**$1,673,049**	**211205**	**$1,709,180**	**213863**	**$1,465,898**	**$2,150,840**	**$1,896,828**	**182277**		

APPENDIX G

LOCAL COOPERATION
AND
FINANCIAL ANALYSIS

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SPONSOR'S LETTER OF INTENT

South Florida Water Management District

3301 Gun Club Road, West Palm Beach, Florida 33406 • (561) 686-8800 • FL WATS 1-800-432-2045
TDD (561) 697-2574

GOV 02-04-02

February 10, 1999

Colonel Joe R. Miller
District Engineer, Jacksonville District
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Miller:

Subject: Local Sponsorship of the Central and Southern Florida Project Comprehensive Review Study

Restoration of the Everglades ecosystem, including Lake Okeechobee, the St. Lucie and Caloosahatchee estuaries and the provision of adequate water supplies for South Florida has been a priority of the South Florida Water Management District (SFWMD) for many years. While the Central and Southern Florida (C&SF) Project, first authorized in 1948, has provided tremendous benefits to the region, it has also contributed to a precipitous decline in the health of the Everglades and Florida Bay, Lake Okeechobee, Lake Worth Lagoon, as well as the St. Lucie and Caloosahatchee estuaries. In addition, the continuing and projected growth of the region increasingly will strain the ability of the existing project to provide water for agricultural and urban purposes. Clearly, a comprehensive and balanced approach for solving these problems is needed.

The Central and Southern Florida Project Comprehensive Review Study (the Restudy) provides the best opportunity for solving the region's environmental and water resource problems on a regional scale. Thus, we strongly support the Restudy, which we believe will provide the basis for a healthy, sustainable Everglades ecosystem and adequate future water supply for the region.

SFWMD supports approval of the Comprehensive Plan by Congress as a guideline, and as a basis for establishing federal support for the Plan. We encourage congressional authorization for a series of pilot projects that are necessary prior to construction of select components at the full scale. Authorization of pilot projects and a series of initial components will enable the Corps and SFWMD to continue to work together to meet the future water needs for all users in a timely manner.

Implementation of the Comprehensive Plan must not result in delay of the important projects that Congress has already approved. The Kissimmee River Restoration, Modified Water Deliveries, C-111, STA-1 East, and Critical Restoration Projects are already underway and are essential to Everglades Restoration. Any necessary delays to these projects should be minimized to the maximum extent possible.

Mailing Address: P.O. Box 24680, West Palm Beach, FL 33416-4680

Colonel Joe R. Miller
February 10, 1999
Page 2

Implementation of the Restudy will take many years. The recommended plan outlines the additional studies, pilot projects, and engineering, economic, and environmental analyses that must occur before construction. As these detailed analyses are completed for each project, a Project Cooperation Agreement will be prepared that specifies the scope of the project and the financial obligations of the federal government and the local sponsor.

As the implementation plan crystallizes, several outstanding issues of great importance to the SFWMD and the State of Florida must be adequately addressed. These issues are 1) capital projects cost share, 2) operation, maintenance and monitoring cost share, 3) permitting of Restudy Comprehensive Plan components and projects, 4) assurances to existing legal users, 5) provision of flood protection, 6) impacts to on-going projects, 7) water quality, and 8) scientific peer review. The attachment to this letter describes the issues and concerns of the SFWMD in more detail.

Ensuring strong support from the Governor and the State Legislature continues to remain a key goal. The 1998 session of the Florida Legislature documented the State's significant interest in the Restudy. The Florida Legislature must approve any projects that require state appropriations. In addition, the State of Florida Joint Legislative Committee on Everglades Oversight, which is charged with overseeing this agency's action relative to Everglades restoration projects, can provide oversight and review of the Restudy.

The SFWMD is a public corporation of the State of Florida and as such is legally capable of fulfilling the requirements of local sponsor for this project in accordance with Section 221 of the Flood Control Act of 1970 as amended (Public Law 91-611). This letter, while not legally binding on the SFWMD in any way, is intended to demonstrate our support for the Restudy.

The SFWMD looks forward to continuing our partnership with the Corps of Engineers in this important endeavor.

Sincerely,

Frank Williamson, Jr.
Chairman, Governing Board
South Florida Water Management District

FW/pv

Colonel Joe R. Miller
February 10, 1999
Page 3

C Governor Jeb Bush
Senator Bob Graham
Senator Connie Mack
J. Allison DeFoor II
David B. Struhs
Joint Legislative Committee on Everglades Oversight
Florida Congressional Delegation
SFWMD Governing Board Members

Attachment to South Florida Water Management District Local Sponsor Letter

Issues Associated with Implementation of the Restudy Comprehensive Plan

Capital Projects Cost Share

Specifying a 50/50 cost share for the initial capital project costs is appropriate at this conceptual stage in the implementation process. Numerous funding decisions will be necessary over the next 25 years as we progress into the detailed design and planning phase of implementation for the individual projects. Until project implementation is at hand, we should not rule out other cost share formulas that may be appropriate. As individual Project Implementation Reports are considered by Congress, it may be appropriate to seek a larger federal share of the capital costs. Flexibility to accomplish, under certain circumstances, a larger federal share must be preserved. It is also imperative that flexibility be preserved in determining the credits that can be received for lands already purchased. This flexibility is needed to assure that the amount credited equitably reflects the time value of the funds invested in land purchased in advance of the construction of components and the value of the land given its allowable uses at the time of purchase.

Operation, Maintenance and Monitoring Cost Share

The operations and maintenance costs present a similar dilemma. Estimates are at $175 million per year for operation, maintenance and monitoring of the projects contemplated in the draft Comprehensive Plan. This cost is over and above current operation, maintenance and monitoring costs. These projected costs are a significant issue for this agency and the State of Florida. The Plan contains a large number of components that together accomplish restoration of the South Florida ecosystem. In addition, a monitoring program will be a necessary component for providing information and data regarding the effects of changes to the South Florida ecosystem and for providing a basis for adjustments to the Comprehensive Plan in the future. While we are committed to working with the State Legislature and local interests to find solutions to this issue, increased federal funding of the operation, maintenance and monitoring of the Comprehensive Plan will be required. South Florida Water Management District pledges to work with the Corps, the United States Congress and the State Legislature to develop a fair and realistic mechanism and cost share allocation to fund the Comprehensive Plan’s OMM&R.

Permitting of Restudy Comprehensive Plan Components and Projects

Unprecedented projects, in terms of scope and purpose, are contained within the Comprehensive Plan. To put it simply, these projects do not fall within the traditional mold of projects that are subject to Federal and State agency permitting requirements.

Recent experiences with the Everglades Stormwater Treatment Areas and the C-111 Project (S-332D) demonstrate that there is serious uncertainty associated with the permitting of such projects. While maintaining agency permitting jurisdiction, there is a critical need to develop a formal process that requires each regulatory agency to provide reliable assurances concerning project permittability during its “up-front” plan review. Otherwise, substantial costs, delays and uncertainty in the outcome of permitting Restudy projects could result.

Assurances to Existing Legal Users

The SFWMD and the Corps should work with all stakeholders to develop appropriate water user assurances to be incorporated as part of the Comprehensive Plan authorizations. These water user assurances should be based on the following principles:

A. Physical or operational modifications to the C&SF Project by the Federal government or the SFWMD will not interfere with existing legal uses and will not adversely impact existing levels of service for flood management or water use, consistent with State and Federal law.

B. Environmental and other water supply initiatives contained in the Restudy shall be implemented through appropriate State (Chapter 373, F.S.) processes.

C. In its role as local sponsor for the Restudy, the SFWMD will comply with its responsibilities under State water law (Chapter 373, F.S.).

D. Existing Chapter 373, F.S. authority for the SFWMD to manage and protect the water resources shall be preserved.

Provision of Flood Protection

As a general principle, the Comprehensive Plan should not compromise or adversely affect levels of service for flood protection now provided by the C&SF Project. Furthermore, it is the South Florida Water Management District's intent to utilize the Project Implementation Report process to address any flood protection issues in the areas potentially affected by the Comprehensive Plan. This will not compromise the environmental goals of the plan, but instead will be an effective way to add economic benefit and public support.

Impacts to On-Going Projects

Implementation of the Comprehensive Plan must not result in delay of the important projects that Congress has already approved. The Kissimmee River Restoration, Modified Water Deliveries, C-111, STA-1 East, and Critical Restoration Projects are already underway and are essential to Everglades Restoration. Any necessary delays to these projects should be minimized to the maximum extent possible.

Water Quality

Water Quality remains a complex and in some cases unresolved issue in the Comprehensive Plan. The Comprehensive Plan effort must develop and propose specific solutions for dealing with the water quality implications resulting from increased water deliveries to the Everglades Protection Area, as well as inflows to Lake Okeechobee and the coastal estuaries.

A number of components in the Comprehensive Plan provide either direct or indirect water quality benefits. As the Comprehensive Plan progresses into more detailed planning and design for individual projects, improving water quality will need to remain a high priority in project design. It is critical that the SFWMD and the Corps work closely with other agencies with water quality regulatory responsibilities to design projects that will optimize water quality benefits.

The priority given to water quality components of the Comprehensive Plan, as well as how such components will be funded, regulated and operated, are issues that must be squarely addressed as soon as possible.

Scientific Peer Review

The South Florida Water Management District supports the establishment of an ongoing outside scientific review process as being developed by the South Florida Ecosystem Restoration Task Force as an essential component to ensure an effective adaptive management process for South Florida Ecosystem Restoration. Such peer review should in no way delay the Restudy process.

FINANCIAL CAPABILITY STATEMENT AND FUNDING PLAN

G.1 INTRODUCTION

This is the financial capability statement and funding plan submitted by the South Florida Water Management District (SFWMD) in support of its role as local sponsor for the Central and Southern Florida Project Comprehensive Review Study and the projects proposed for authorization in the Water Resources Development Act of 2000. The Comprehensive Plan is a general document that will be implemented over a long period of time. More detailed evaluations called Project Implementation Reports will be completed on individual components or groups of components to settle design, cost and timing issues. For these reasons the SFWMD's financial capabilities with respect to the Comprehensive Plan are discussed in general terms. At the same time, authorization is proposed for pilot projects and an initial set of the components of the Comprehensive Plan, and a continuing financial need for the adaptive assessment and monitoring efforts has been identified. Thus, more detailed financial capability statement and funding plan are provided for these pilot projects, components proposed for initial authorization and the adaptive assessment and monitoring efforts (monitoring program).

G.1.1 Participation of the South Florida Water Management District as Local Sponsor

The Central and Southern Florida Flood Control District (FCD) was created by the Florida Legislature in 1949 to serve the functions of local sponsor for the Central and Southern Florida (C&SF) Flood Control Project authorized by the U.S. Congress in 1948 to be constructed by the U.S. Army Corps of Engineers (USCOE). Upon completion of components, the FCD assumed operation and maintenance responsibility for project works.

The Florida Water Resources Act of 1972 modified the boundaries of the FCD and greatly expanded its responsibilities creating the South Florida Water Management District (SFWMD). The SFWMD is the local sponsor of the C&SF Project and the partner to USCOE in the development of the Central and Southern Florida Project Comprehensive Review Study (Restudy). The SFWMD's state mandated responsibilities include environmental protection and enhancement, water supply, flood protection and water quality protection. Thus, the mission of the South Florida Water Management District corresponds with the goals of the Restudy and the SFWMD is an appropriate partner to the USCOE for the implementation of the Restudy recommendations.

G.1.2 Statutory Authority for the South Florida Water Management District to Act as Local Sponsor

The SFWMD is authorized to enter into contracts with public agencies pursuant to section 373.083, Florida Statutes (F.S.). Furthermore, the SFWMD is authorized, under Section 373.103, F.S., to cooperate with United States in the manner provided by Congress for flood control, reclamation, conservation and allied purposes. In recent years the SFWMD has utilized its capabilities in this regard to be an effective local partner in several ongoing restoration efforts including the Kissimmee River Restoration, the C-111 South Dade Project and the C-51 West/STA-1 East project.

G.1.3 SFWMD Taxing and Fundraising Authority

The SFWMD is an independent special district under the Florida Constitution and the special district classification scheme established by general law. The SFWMD's powers and authority are established in provisions of Chapter 373, FS. The SFWMD's authority to impose fees and special assessments and to incur debt is based on the construction of the expressed powers provided in Chapter 373, F.S. In order for the SFWMD to tax or levy fees and assessments, it must first have statutory authority to do so. Because the SFWMD has no home rule power, it can only impose those fees and special assessments which have been expressly provided by law or which can reasonably be implied from an express grant of authority. Likewise, the SFWMD is limited by any specific legislative restrictions or conditions placed on its authority to impose fees or special assessments.

G.1.3.1 Expressly Granted Taxing Authority

The major taxing authority granted the SFWMD is the levying of ad valorem taxes. This taxing authority is subject to two caps on the total rates, a 1 mill cap contained in Florida's constitution and a legislatively mandated .8 mill cap. Within the total, the SFWMD levies three millage rates. The first is the SFWMD at large millage rate, which is levied against the value of all real and personal property within SFWMD boundaries. The second is the Okeechobee Basin millage rate, which is levied on property in fifteen of the sixteen counties (excludes the Big Cypress Basin, which consists of Collier County and a small portion of Monroe County). The third applies to the Big Cypress Basin. Lands within the SFWMD are, then, subject to the District at large millage levy and one of the two basin levies. There is also a statutory limit that no more than 40% of the levy can be for District purposes and 60% for basin purposes. This means that the maximum rate allowed by law for the District millage is 0.32 mills and 0.48 mills for either basin millage.

As a result of the Everglades Forever Act the SFWMD is also now levying an Agricultural Privilege Tax on agricultural properties within the Everglades Agricultural Area and the C-139 Basin. The schedule of rates for this tax is established in the Legislation. The funds from this tax are dedicated toward the completion of the Everglades Construction Project.

G.1.3.2 Expressly Granted Authority To Levy Fees And Assessments

The only fees that the SFWMD can impose are those prescribed by statute and administrative rule. In general the fees the SFWMD may impose relate to permits issued by the SFWMD or grants of rights for utilization of SFWMD rights of way. All permit fees must be based on and are limited to the costs incurred by the SFWMD in their issuance.

Two requirements for the imposition of special assessments in Florida are: 1) the property assessed must derive a special benefit from the improvement or service provided; and 2) the assessment must be fairly and reasonably apportioned among the properties that receive the special benefit. There must exist a “logical relationship” between the service provided and the benefit to property. The District has specific authorization to impose special assessments within stormwater system benefit areas for water quality benefit except on property subject to an Agricultural Privilege Tax. There are many informational requirements regarding the extent to which parcels contribute to the need for water quality management programs that must be met in order to develop and implement the fair apportionment required for the implementation of special assessments.

G.1.3.3 Expressly Granted Authority to Issue Bonds and Incur Debt

The SFWMD can issue bonds and incur debt to finance its operations under specified circumstances. Bonds payable from its ad valorem revenues can be issued with the approval of the electorate. The SFWMD can also issue bonds, but without the requirement for approval of the electorate, when the Legislature authorizes the SFWMD a new taxing source or transfers a portion of existing state tax revenues to the SFWMD for its use for SFWMD purposes. For example, funds appropriated in the Water Management Lands Trust Fund created in section 373.59, F.S., are distributed to the SFWMD and have been pledged for the payment of SFWMD bonds issued for land acquisition.

G.2 OVERALL SFWMD FINANCIAL CAPABILITY STATEMENT AND FUNDING PLAN FOR THE RESTUDY

This section discusses in general terms the strategy that the SFWMD intends to implement to complete its obligation as local sponsor for the Restudy. To understand the reasons for the proposed strategy, it is important to understand both the recent and the anticipated future growth in the SFWMD’s responsibilities and consequent funding needs.

G.2.1 Recent SFWMD Experience with Funding Responsibilities

In recent years the SFWMD has been charged with or undertaken the implementation of many significant projects that have greatly increased its spending and consequently its funding responsibilities. These tasks have included the restoration of the Kissimmee River and the completion of the Everglades Construction Project. The Everglades Construction Project is required under the Everglades Forever Act (EFA), passed by the Florida Legislature in 1994. The EFA required the SFWMD to construct six stormwater treatment areas to clean stormwater runoff from farms in the Everglades Agricultural Area (EAA). The total cost of the ECP was estimated at $796 million over 20 years in the 1998 Everglades Annual Report and it is one of the largest environmental restoration activities ever undertaken in the United States. As the agency responsible for implementing this statute, much of the actual expense of the project has fallen on the SFWMD. The increased funding required to meet these and other expanding obligations has increased the burden on the existing fund raising capabilities of the SFWMD granted by the state. The district's principal taxing authority is to levy ad valorem taxes. To some extent the ad valorem taxes have been raised to meet the expanding responsibilities. For instance, a special .1 mill levy within the Okeechobee Basin is dedicated to the ECP. Other major sources of additional funds for meeting these responsibilities have been inter-governmental transfers and new dedicated taxes. The intergovernmental transfers have included significant transfers by the state of Florida to the SFWMD for land acquisition, as well as transfers of federal money, including “Farm Bill” money, which have also been used for land purchases. A special tax on agricultural land users in the EAA, which is called an Agricultural Privilege tax, has been an additional source of funds dedicated to the completion of the ECP. Agricultural Privilege taxes are also collected from lands in the C-139 Basin.

G.2.2 Expected Future Increases in Funding Responsibility

Funding the local sponsor’s share of the cost of the Restudy, will be an increase in SFWMD funding responsibility of an unparalleled magnitude. However, this is not the only expanded or additional responsibility that the SFWMD will have to assume in the upcoming decades. A second major task and funding responsibility will be for the completion of phase two of the ECP. This additional effort to improve the quality of water going into the EPA is necessary because the facilities completed under the first phase of the ECP may not be able to meet the water quality standards that will be promulgated by the Florida Department of Environment Protection (FDEP). Recent changes to the state constitution have clearly established that polluters will be primarily responsible for the payment of efforts to clean up the pollution entering the EPA. However, SFWMD funds, in addition to payments by the polluters, may be required to achieve the desired water quality standards. Because the standard, the means to achieve the standard and the sources of funding are all yet to be identified, the amount of funding by the SFWMD can not be determined at this time. The SFWMD is also expecting that the additional feasibility studies recommended as part of the Restudy Comprehensive Plan will result in additional recommended expenditures. In addition, as the local sponsor for the C&SF Project, the SFWMD has responsibility for the rehabilitation, repair and replacement of major project facilities as they reach the ends of their useful lives. Because the SFWMD does not have established funds set aside for these purposes, the upcoming expenses in this area also represent significant future funding obligations. Finally, there are expected to be significant increases in O&M costs associated with the expanded facilities and operations. The cumulative impact of all of these funding needs calls for the development of an overall funding strategy. The strategy for funding the local sponsor's financial obligations for the Restudy will be an important component of the overall implementation strategy.

G.2.3 SFWMD Overall Funding Strategy to Meet Existing and Future Responsibilities

In anticipation of these greatly expanded funding needs, the SFWMD is currently developing a funding strategy. The strategy will include but not be limited to the following:

1) Operate efficiently to obtain maximum value from funds received,
2) Make full use of existing tax authority,
3) Use fees and assessments when the projects or programs confer special benefits or assist in alleviating water quality problems for which contributors to the problem may have responsibility for the solution,
4) Implement cost sharing agreements with other Florida public entities when there is a mutuality and commonality of interest or responsibility,
5) Seek an expansion of direct financial assistance from the State of Florida in the land acquisition area,
6) Seek legislative authorization for additional taxing authority or the dedication of a portion of state revenues and
7) Make appropriate use of bonding to enhance the capabilities of funding authority to meet the temporarily higher spending needs associated with the Restudy and other Capital Improvement Projects.

Each of these components of the proposed strategy is now discussed in turn in a way that highlights its applicability to the funding of the Restudy.

G.2.3.1 Operate Efficiently To Obtain Maximum Value From Funds Received

The SFWMD recognizes that the more cost effectively it can discharge its normal and continuing responsibilities the larger the amount from its funding capabilities that can be made available to fund capital improvement responsibilities such as the Restudy. To this end the SFWMD has and will continue to streamline processes and reprioritize programs.

G.2.3.2 Make Full Use Of Existing Tax Authority

The principal source of funds and the major taxing authority of the SFWMD is to levy ad valorem taxes. As was discussed above, there are several important limitations placed upon the millage that the SFWMD can levy. In fiscal year 1998 the total millage levied by the SFWMD was 0.697 mills for the Okeechobee Basin and 0.662 mills to the Big Cypress Basin. The SFWMD's governing board can, under its existing authority, raise the total millage up to legislative limits of 0.8 mils. In addition, with legislative authorization, the millage rates could be raised up to the full 1 mill limit contained in Florida's constitution. Any increases beyond that level would require modifications to Florida's constitution.

The SFWMD may, as part of its efforts to fund the Restudy and its other emerging obligations, request legislative authorization to raise the millage to the 1 mill constitutional cap and to remove the limitations on the basin and district-wide proportions. Most of the future additional obligations are district-wide in nature. For instance, the ecosystem restoration being provided by the Restudy is of district-wide benefit, even when the particular ecosystem restoration components are located in the Okeechobee or Big Cypress Basin. Thus, the SFWMD expects to use a district-wide assessment for the funding of Restudy components not covered by other elements of its funding strategy. The SFWMD recently estimated the additional revenue that would have been available for its Fiscal Year 1999 budget if the full 1 mill of taxing authority were used as $89.1 million dollars. The comparable additional revenue that would have been available if taxes were raised to the .8 mill legislative cap was estimated as $29.8 million dollars.

An important consideration in looking at funding sources, is whether the sources are likely to grow over time due to the effects of inflation and economic growth. The SFWMD's experience with the value of taxable property is that it has continued to grow significantly over time. In the period from 1989 to 1999 the average annual growth rate in assessed values was 5.5%. This was due both to the addition of new structures and higher valued land uses and to the increase in values of existing properties. The expected growth of the South Florida population and economy indicate that the capability of ad valorem taxes at any given millage rate to help support projects such as the Restudy will be increasing over time.

G.2.3.3 Make Appropriate Use Of Fees And Assessments

In looking at alternative funding sources, one of the important considerations is the extent to which the benefits of the project component accrue to specific entities or property. This would occur, for instance, when a project includes facilities to bring water from regional system canals to secondary canals that serve to recharge specific well fields. It would also occur when projects or specific facilities included in those projects serve to increase flood protection within specific sub-basins. A second rationale for the use of alternative funding sources is the extent to which there are contributors to a specific water quality problem that the project is designed to solve. The use of alternative funding sources for financing the components that serve to solve pre-existing problems could be directly implemented when they are consistent with the Constitution and existing law. The SFWMD would seek additional authorization from the Florida legislature if this source is deemed appropriate for certain project components and additional authorization is needed.

G.2.3.4 Seek And Implement Cost Sharing Opportunities

Cost sharing opportunities arise when there is a mutuality or commonality of interest or responsibility between the activities of the SFWMD and those of local governments. For instance, many counties within the SFWMD have in the past pursued the purchase of environmentally sensitive lands and have joined with the SFWMD and the state of Florida in such efforts. In the past counties have also participated with the SFWMD in the construction of secondary drainage/recharge facilities, one example being the secondary canal system improvements in coastal Broward County being completed as part of the SFWMD's Interim Plan for Water Supply for the Lower East Coast. Local governments have also partnered with the SFWMD in the retrofit of stormwater management systems, an example of this being stormwater management projects in Miami-Dade County implemented as part of SWIM plans for Biscayne Bay.

Recently, as a result of evaluations undertaken for the SFWMD by the Government Services Group, twenty (20) Restudy components were identified as having the potential for cost sharing. In many cases only some of the facilities and not the whole component may be applicable for cost sharing. Most of the components potentially suitable for cost sharing fall into one of several categories: 1) they enhance environmental resources that are of great local interest, 2) they directly enhance flood protection, 3) they recharge areas that protect wellfields from salt water intrusion or 4) they improve water quality in an area in which an existing entity such as a drainage district can be a conduit for the recovery of costs.

G.2.3.5 Seek An Expansion Of Direct Financial Assistance From The State Of Florida In The Land Acquisition Area

The financial assistance provided in the land acquisition area through the Preservation 2000 Trust Fund, the Conservation and Recreation Lands Trust Fund (CARL) and the Water Management Lands Trust Fund has played a major role in the successful participation of the SFWMD in restoration programs. In recent years the total additions to the Preservation 2000 and Water Management Lands Trust Funds allocated to the SFWMD has provided a base level of funding of about $41 to $46 million per year. In individual years $26 to $27 million in allocations to the SFWMD were made to the Preservation 2000 Trust Fund while $14 to $19 million were allocated to the SFWMD in the Water Management Lands Trust Fund. In several recent years there have been special allocations that have significantly increased this amount. In 1996 the SFWMD received a special allocation from the Preservation 2000 Trust of $24 million to assist with land purchases for the Everglades East Coast Buffer. In 1998 about $14 million from the Conservation and Recreation Lands Trust Fund was used, principally to purchase lands as part of the Indian River Lagoon and Atlantic Ridge ecosystem projects.

The legislative authorization for the sale of bonds to support the Preservation 2000 programs will expire in 2000. It is expected that legislation authorizing a similar program to continue this effort will be enacted. The SFWMD will support the continuation of these programs and will point out the importance of increasing the dollar participation to assist in meeting the expanded obligations for land purchases under the Restudy and other ecosystem restoration and enhancement efforts. Flexibility in the use of the funds, such as allowing them to be used to support the construction of reservoirs and not just the purchase of lands, will also be important in the implementation of the Restudy.

G.2.3.6 Seek And Utilize Additional Taxing Authority Or Dedicated State Funding

It is expected that to meet all of its future obligations, the SFWMD will have to receive additional taxing authority or dedication of state funding. In this case there are many options from which the legislature can choose. One option would be for the state to authorize the SFWMD to levy parcel property taxes to fund certain facilities that provide services for specific areas. The Agricultural Privilege Tax, which is levied on a per acre basis for agricultural land uses within specific basins, is an example of this type of levy. Another option would be to dedicate a portion of state revenue from selected sources for funding specific projects that are of statewide benefit. State Documentary Stamp Taxes are a source, portions of which have been dedicated to land acquisition programs, but some of which could be dedicated to the funding of capital projects which serve statewide purposes. Alternatively a portion of state sales tax revenues could be dedicated to fund specific project components. Providing the water management districts authority to levy fees for consumptive use permits or water withdrawals is another alternative source of funding for water management related activities throughout Florida. There also may be some potential for State Department of Transportation funds to be used when implementation of the component requires highway improvements for which the state has responsibility.

G.2.3.7 Make Appropriate Use Of Bonding Capabilities

Bonding is not an original revenue source, but it is an important tool when spending needs temporarily exceed revenue generation capabilities and there is a willingness to utilize future revenues to meet the present spending needs. Because the spending needs generated by the Restudy will be spread out over more than 20 years, the potential benefits of bonding as a means of balancing the timing of spending and income will be limited unless the bonds issued are repaid beyond that period.

G.3 SFWMD FINANCIAL CAPABILITY STATEMENT AND FUNDING PLAN FOR PILOT PROJECTS, THE COMPONENTS FOR WHICH AUTHORIZATION IS REQUESTED AND MONITORING

This section discusses the financial capabilities of the SFWMD to fund the pilot projects, the components proposed for authorization in the Water Resources Development Act of 2000 and the monitoring program.

G.3.1 Funding Needs of the Pilot Projects, the Components for Which Authorization is Requested and the Monitoring Program

The funding needs of the pilot projects, the components for which authorization is requested and the monitoring program have been developed based on the timing and cost of those components as presented in the implementation plan. These total first costs and the timeframes for the expenditures are presented in ***Table G-1***. Additional details on the costs and the timing of expenditures for each individual component are provided in the Implementation Plan which is part of this plan. ***Table G-1*** shows that the total estimated first cost (planning, design, land purchase and construction) of the pilot projects and components for which authorization is being requested as well as the monitoring program is $1.2 billion in 1998 dollars and has a proposed expenditure schedule extending through 2012.

G.3.2 SFWMD Plan for Funding the Pilot Projects, the Components for Which Authorization is Requested and the Monitoring Program

At this time the SFWMD plan for funding for the pilot projects, the components proposed for initial authorization and the monitoring program is presented in terms of several scenarios. This will help demonstrate the SFWMD's capabilities under a variety of approaches that may be selected. All scenarios will require legislative action. This may include a continuation or expansion of SFWMD allocations from state programs such as Preservation 2000. Adjustments to the programs, so that funds can be spent on surface facilities associated with lands (such as reservoirs) and not just the lands themselves, may also be necessary. The granting of authority for the SFWMD to increase its ad valorem tax rates beyond

TABLE G-1
EXPENDITURE SCHEDULE FOR PILOT PROJECTS, COMPONENTS RECOMMENDED FOR AUTHORIZATION AND MONITORING PROGRAM

Year	PROPOSED EXPENDITURE ($1999)
1999	$4,792,334
2000	$15,257,469
2001	$60,317,389
2002	$214,669,882
2003	$206,260,050
2004	$106,004,085
2005	$89,074,279
2006	$148,069,171
2007	$145,017,440
2008	$124,659,933
2009	$76,569,505
2010	$7,025,194
2011	$167,308
2012	$33,974
Total	$1,197,918,013

present legislative limits and the relaxation of present restrictions of basin and district-wide caps on assessments may also be necessary. It appears that none of the scenarios will require voter approval of bond issues. The designs of the components and the functionality built into the designs, which will be determined in the Project Implementation Reports, will clarify the potential for cost sharing of the local sponsor share with other South Florida government agencies and the state of Florida. Furthermore, many options, in addition to those presented in these scenarios, are available to legislature when they consider how best to support the funding of the Restudy. Thus, it is too early to specify a single direction and the scenario approach has been taken. In developing the scenarios certain baseline assumptions regarding borrowing costs, interest rates and inflation were developed. In addition, for each scenario specific assumptions were developed regarding the proposed funding sources. These include initial amounts, starting and ending years and expected escalation over time.

G.3.2.1 Baseline Assumptions for the Development of Funding Scenarios

In order to develop the alternative future funding scenarios, it was necessary to make baseline projections of price level escalation, growth in tax bases, and real and nominal interest rates.

Recently the historical inflation rates for most broad indices of prices and costs have been at about 3%. A reasonable baseline assumption is that this rate will continue into the future. It is significant that this rate was selected as the cost escalation factor for the legislation dealing with mitigation costs for the Lake Belt mining. The 3% estimate is a good base assumption to use for price level inflation including costs of the components, inflationary effects on taxable sales and property values and the inflationary component of the nominal interest rate.

Interest rates that might either be paid or earned are frequently analyzed in terms of a real rate of return and an inflationary component. Real rates of return for fairly low risk investments such as treasury bonds have historically approximated 2%.

Together the proposed projection of inflation of 3% and the real rate of return of 2% give a nominal interest rate of 5%. This rate is proposed for use as the rate at which SFWMD surplus funds will earn interest and as the rate that the SFWMD will have to pay on funds that it borrows. Using the same interest rate for earnings and payments will make the analysis neutral with regard to the SFWMD's borrowing capabilities. The SFWMD will not attempt to show that it has the financial resources to meet its obligations by borrowing funds on which it could earn more interest than it paid.

A related general assumption is the cost of borrowing. When the funding balances in any evaluation become significantly negative and persist for several years, this indicates that the funding problem can not be addressed by means of short-term adjustments to spending schedules. However, the problem can be addressed by long-term financing, bonding. There are costs associated with the bonding including underwriting, bond insurance and the creation of a debt service reserve account. The latter, by far the largest component, is unique in that interest is earned on the account and the funds in the account are eventually returned to the borrower and can in fact be used to make the final payment on the bonds. Because these costs net out in the long-run and the remaining borrowing costs are relatively small, in the scenario evaluations these costs are assumed to be zero. The spreadsheet model developed and used to evaluate the funding scenarios can evaluate scenarios including borrowing costs when they are specified as a percent of the funding deficit in each year.

With one exception the local sponsor share is the 50% established in WRDA-96. The exception results from previous land acquisition agreements that affect the

EAA Storage and Conveyance component, Phase 1 of which is a component proposed for initial authorization. This is discussed in 10.6.5 of the main report. The net result is that the SFWMD cost share for this component is $36,000,000 ($1998) greater than its normal 50% share. This is handled by proportionally increasing the SFWMD funding obligations for this component to make the new total $36,000,000 more than half of the cost cited for this component in the Implementation Plan.

Escalations in tax yields over time are assumptions associated with the scenarios. However, it is useful here to discuss assumptions that can be used, especially for the property tax base. A reasonable baseline escalation in the property tax base is 5%. In the long run, it is likely that the price inflation in housing and property costs will approximate the overall inflation rate, the baseline assumption for which is 3%. Added to this would be an escalation to cover structural improvements and changes of lands to higher value uses that are due both to the increased population/economic growth and to the accumulation of wealth by the population. Projecting additions to the property tax base due to growth is appropriate considering that the Restudy also projects significant population growth. Historically the SFWMD's ad valorem property tax base has grown at 5.5% per annum. This rate has held over both the past 5 and the past 10 years (1994-1999 and 1989-1999 respectively). The proposed 5% rate is, thus, somewhat conservative compared to the historical rate.

G.3.2.2 Formulation And Evaluation Of Funding Scenarios

The revenue sources the SFWMD anticipates using to fund the local sponsor portion of costs for the programs under discussion are:

1) credits for lands already purchased,
2) funds from the existing Preservation 2000 programs and its successor program which is now being considered by the Florida Legislature
3) ad valorem tax proceeds,
4) cost shares obtained from local governments and private interests, and
5) special fees and assessments.

Three funding scenarios are presented below. Key assumptions are presented in ***Table G-2*** while results are presented in ***Table G-3*** and ***Figures G-1 – G-3***. The spreadsheets that contain the analyses are presented as Attachments 1 through 3.

The SFWMD recognizes that, during the timeframe of the implementation of the pilot projects and components proposed for authorization, additional spending is anticipated on Restudy components covered by programmatic authority and additional authorizations. In the implementation plan, total Restudy costs for land, construction and monitoring through 2010 are about $4 billion, much more than the $1.2 billion included in the schedule being evaluated here which includes only the pilot projects, initial authorization components and monitoring. Furthermore operations and maintenance costs will have to be met and will gradually increase as components are completed. O&M costs for the initial authorization components are approximately $20 million ($1998). Other water management and restoration programs are also likely to expand. For these reasons, all of the scenarios were constructed using conservative assumptions to assure that some leeway was provided for these other expenditures.

The major conservative elements incorporated into the development of the scenarios are:

1) All scenarios are developed so that SFWMD debt financing will not be required. Scenarios that would have required SFWMD debt financing would limit the ability to fund Restudy components in the period after 2010.
2) Funds from state land acquisition programs and ad valorem taxes are raised only through 2010 even though some construction takes place through 2012.
3) The funds from state land acquisition programs consider only revenues from the Preservation 2000 fund and its successor program. The SFWMD also receives funds from the Water Management Lands Trust Fund and the CARL program. Much of the additions to the Water Management Lands Trust Fund over the next 10 years will be devoted to servicing of debt and the maintenance of properties already purchased. However, some funds will be available for land purchases (for example $8.6 million in 1997 and $1.7 million in 1998 were so spent) and the fund had a balance of $23 million at the end of fiscal 1998. CARL funds used by the SFWMD for the purchase of lands totaled $55.8 million in the last four fiscal years (1995–1998). Also SFWMD's balance in the Preservation 2000 Trust Fund at the end of fiscal 1998 was $53 million and the proposed funding does not include the use of any of these funds.
4) In the scenarios, the assumed share of Preservation 2000 funds devoted to the pilot projects and initial authorization components varies from 50% to 85%. Room is always left for some of the funds to be applied to other Restudy and non-Restudy efforts.
5) In developing the successor program to the Preservation 2000 program the legislature will consider a wide range of options for increasing the overall program amount and changing the rules and procedures for the allocation of the funds. At present the SFWMD typically receives less than 10% of the program allocations. Two of the scenarios limit future funding to recent historical levels while the third uses the historical high allocation as the average for the future.
6) With legislative authorization, the maximum increase in District ad valorem funding from fiscal 1999 levels would be slightly over .3 mills. The scenarios assume increases of .075 to .15 mills, which will leave

significant room for the funding of other Restudy and non-Restudy construction or operation and maintenance costs from ad valorem taxes.

G.3.2.2.1 Scenario 1

G.3.2.2.1.1 Formulation of Scenario 1

Scenario 1 represents a balanced reliance on state assistance, ad valorem taxes and cost sharing/fees and assessments. First of all, scenario 1 includes credits for lands already purchased which will be utilized for these components ($67,655,000). Scenario 1 is somewhat conservative regarding the availability of funds from Preservation 2000 and its successor program. It assumes that from 1999 to 2010 the funds available are $27,000,000 which is close to levels received by the SFWMD in past years when significant special allocations were not made to the SFWMD to assist with land purchases. On the other hand it assumes that the SFWMD uses 85% of the funds to support the pilot projects and components for which authorization is requested. It is conservative regarding the funding available from ad valorem sources in that only slightly more than .1 mill is dedicated to implementation of this part of the Restudy. If other SFWMD future funding needs can be met within the 1999 millage rates, the SFWMD would not require legislative authorization raising its maximum millage rate in order to provide these funds. This represents about a third of the potential revenues available from the actual 1999 millage rate to the 1 mill constitutional cap. Since legislative action would not necessarily be required, the funds from this source begin in 2000. Scenario 1 also includes the “middle” preliminary assessment of revenues that will be available from cost sharing/fees and assessments. SFWMD staff recently completed this assessment. Overall, the estimated $28 million ($1998) for cost sharing/fees and assessments represents about 13% of the local sponsor’s cost for the components to which the alternative funding sources apply.

G.3.2.2.1.2 Evaluation of Scenario 1

Revenues from the major funding sources for Scenario 1, which are estimated only through 2010, are adequate to provide the full local share. Funding balances remain positive throughout the period except for 2008 when a funding deficit of $1.35 million occurs. This is indicated by the statistics summarized in ***Table G-3*** and by the fact that the current funding balance, plotted in ***Figure G-1***, remains positive throughout the period except for 2008. Since the funding balance becomes significantly positive by 2010, slight modifications to the spending schedule would permit the funding balance to remain positive throughout the implementation. This demonstrates that Scenario 1 is one approach by which the SFWMD could meet its obligations for the funding of the pilot projects, the components for which authorization is being requested and the monitoring program.

G.3.2.2.2 Scenario 2

G.3.2.2.2.1 Formulation of Scenario 2

Scenario 2 places a relatively heavy reliance on state assistance and on cost shares/fees and assessments and decreased reliance on ad valorem taxes. First of all, Scenario 2 includes credits for lands already purchased which will be utilized for these components ($67,655,000). Regarding state assistance, it focuses on funds from the current Preservation 2000 program and the expected successor program. The present program will provide funds for 1999 and 2000. For these years it is assumed that the allocations are $27,000,000, the same as in Scenario 1. For years 2001 to 2010 Scenario 2 assumes that the successor program makes $51,000,000 per year available to the SFWMD. This is the level of funding received in 1996 when a special allocation was made for the purchases of land in the East Coast Buffer. In all years, it is assumed that 75% of the funds are used to support the pilot projects and components in the initial authorization package. Scenario 2 is conservative regarding the funding needed from ad valorem sources. Only .075 mills are dedicated to the implementation of this portion of the Restudy. Since legislative action would not necessarily be required, the funds from this source begin in 2000. This represents about a quarter of the potential revenues available from the actual 1999 millage rate to the 1 mill constitutional cap. Scenario 2 also includes the “optimistic” preliminary assessment of revenues that will be available from cost sharing/fees and assessments. SFWMD staff recently completed this preliminary assessment. Overall, the estimated $44.8 million ($1998) from these sources represents 21% of the local sponsor’s cost for the components to which the alternative funding sources apply.

G.3.2.2.2.2 Evaluation of Scenario 2

Revenues from the major funding sources for Scenario 2 through 2010 are adequate to provide the full local share. Funding balances remain positive throughout the period. This is indicated by the statistics summarized in ***Table G-3*** and by the fact that the current funding balance, plotted in ***Figure G-2***, remains positive throughout the period. This demonstrates that Scenario 2 is a second approach by which the SFWMD could meet its obligations for the funding of the pilot projects, the components for which authorization is being requested and the monitoring program.

G.3.2.2.3 Scenario 3

G.3.2.2.3.1 Formulation of Scenario 3

Compared to Scenarios 1 and 2, Scenario 3 relies more heavily on ad valorem revenues. First of all, Scenario 3 includes credits for lands already purchased which will be utilized for these components ($67,655,000). Scenario 3 is very conservative regarding funds from the Preservation 2000 program and its successor. It assumes that allocations to the SFWMD in both programs is at $27,000,000 per year and that only 50% of the available funds are utilized to support the implementation of this portion of the Restudy. The scenario plans for significant revenue from ad valorem sources. Specifically it is assumed that .15 mills of ad valorem taxing authority are dedicated to Restudy implementation. This is about one-half of the ad valorem funds that could be generated if rates were increased from their 1999 historical levels to the constitutional maximum. Since legislative action would be required to raise the rates this full amount, the ad valorem contributions begin in 2001. Scenario 3 also includes the “middle” preliminary assessment of revenues that will be available from cost sharing/fees and assessments. SFWMD staff recently completed this preliminary assessment. Overall, the estimated $28 million ($1998) for cost sharing/fees and assessments represents 13% of the local sponsor’s cost for the components to which the alternative funding sources apply.

G.3.2.2.3.2 Evaluation of Scenario 3

Revenues from the major funding sources for Scenario 3 through 2010 are adequate to provide the full local share. Funding balances remain positive throughout the period. This is indicated by the statistics summarized in ***Table G-3*** and by the fact that the current funding balance, plotted in ***Figure G-3***, remains positive throughout the period. This demonstrates that Scenario 3 is a third approach by which the SFWMD could meet its obligations for the funding of the pilot projects, the components for which authorization is being requested and the monitoring program.

TABLE G-2
SUMMARY OF ASSUMPTIONS FOR FUNDING SCENARIOS

Funding Component	Scenario 1	Scenario 2	Scenario 3
Credits for Lands Already Purchased	$67,655,000, this is the best available estimate of the cost of lands that the SFWMD owns and for which it can receive credit toward the funding of the Restudy initial authorization components and pilot projects. Credits for each component for which lands have been purchased are credited as cost reductions in the years during which real estate acquisition is scheduled for these components in the Implementation Plan.	$67,655,000, this is the best available estimate of the cost of lands that the SFWMD owns and for which it can receive credit toward the funding of the Restudy initial authorization components and pilot projects. Credits for each component for which lands have been purchased are credited as cost reductions in the years during which real estate acquisition is scheduled for these components in the Implementation Plan.	$67,655,000, this is the best available estimate of the cost of lands that the SFWMD owns and for which it can receive credit toward the funding of the Restudy initial authorization components and pilot projects. Credits for each component for which lands have been purchased are credited as cost reductions in the years during which real estate acquisition is scheduled for these components in the Implementation Plan.
Funds from State Land Acquisition Programs	$22,950,000 for 1999 through 2010. The underlying assumption is that the SFWMD receives $27,000,000 per year from the present Preservation 2000 program and its successor program each year and uses 85% for the Restudy Initial Authorization Components and Pilot Projects	$20,250,000 for 1999 and 2000 and $38,250,000 for 2001 through 2010. The underlying assumption is that the SFWMD receives $27,000,000 per year from the present Preservation 2000 program in 1999 and 2000 and $51,000,000 per year from the Preservation 2000 successor program from 2001 through 2010. In each case it uses 75% for the Restudy Initial Authorization Components and Pilot Projects.	$13,500,000 for 1999 through 2010. The underlying assumption is that the SFWMD receives $27,000,000 per year from the present Preservation 2000 program and its successor program and uses 50% for the Restudy Initial Authorization Components and Pilot Projects.
Ad valorem Tax Proceeds	$31,290,000 starting in 2000 continuing to 2010, escalating at 5% per annum. Assumes full yield of ad valorem taxing authority from 1999 millage up to the .8	$22,758,750 starting in 2000 continuing to 2010, escalating at 5% per annum. Assumes .075 mills of ad valorem taxing authority is dedicated to Restudy Initial	$45,517,500 starting in 2001 and continuing to 2010, escalating at 5% per annum. Assumes full yield from .15 mills of ad valorem taxing authority is dedicated

Funding Component	Scenario 1	Scenario 2	Scenario 3
	mill legislative cap is dedicated to Restudy Initial Authorization Components, Pilot Projects and Monitoring. This is slightly more than .1 mills.	Authorization Components, Pilot Projects and Monitoring.	to Restudy Initial Authorization Components, Pilot Projects and Monitoring.
Cost Sharing/ Special Fees and Assessments	$2,973,833 starting in 2000 and continuing till 2009, escalating at 3% per annum to match the expected cost inflation. This is a "middle" preliminary estimate developed by District staff by individually evaluating each of the components identified in the report "Funding the Central and Southern Florida Restudy" as having the potential for cost sharing/fees and assessments. Under this estimate, cost sharing, fees and assessment would cover about 13% of the local sponsor cost for these components.	$4,758,132 starting in 2000 and continuing till 2009, escalating at 3% per annum to match the expected cost inflation. This is an "optimistic" preliminary estimate developed by District staff by individually evaluating each of the components identified in the report "Funding the Central and Southern Florida Restudy" as having the potential for cost sharing/fees and assessments. Under this estimate, cost sharing, fees and assessment would cover about 21% of the local sponsor cost for these components.	$2,973,833 starting in 2000 and continuing till 2009, escalating at 3% per annum to match the expected cost inflation. This is an "middle" preliminary estimate developed by District staff by individually evaluating each of the components identified in the report "Funding the Central and Southern Florida Restudy" as having the potential for cost sharing/fees and assessments. Under this estimate, cost sharing, fees and assessment would cover about 13% of the local sponsor cost for these components.
New State Taxing Authority or Distributions of State Revenues	None	None	None

TABLE G-3
SUMMARY STATISTICS SHOWING
FUNDING CAPABILITIES RELATIVE TO NEEDS[A]

Funding Result	Scenario 1	Scenario 2	Scenario 3
Projected 2012 Current Dollar Funding Balance	$85 million	$147 million	$119 million
Years with Cumulative Funding Deficits and Maximum Deficit	One year, maximum deficit of $1.35 million	No deficits	No deficits
1999 Present Value of Available Funds Less Required Expenditures	$47 million	$77 million	$65 million

[a] Three performance statistics are summarized in Table G-3. A positive value for the "Projected 2012 Current Dollar Funding Balance" implies that the funding in the scenario is capable of meeting the projected funding needs by the year of completion of the components for which authorization is being requested (in this case 2012). "Years with Cumulative Funding Deficits and Maximum Deficit" give some indication of the extent to which debt financing is needed to meet the funding obligations. Not having deficits indicates that the revenue sources are adequate to "pay-as-you-go" to meet the funding needs. Having a positive "1999 Present Value of Available Funds Less Required Expenditures" is simply another way of indicating the extent to which the funding scenario is capable of meeting the projected funding needs by the year of completion of the components as a group.

FIGURE G-1

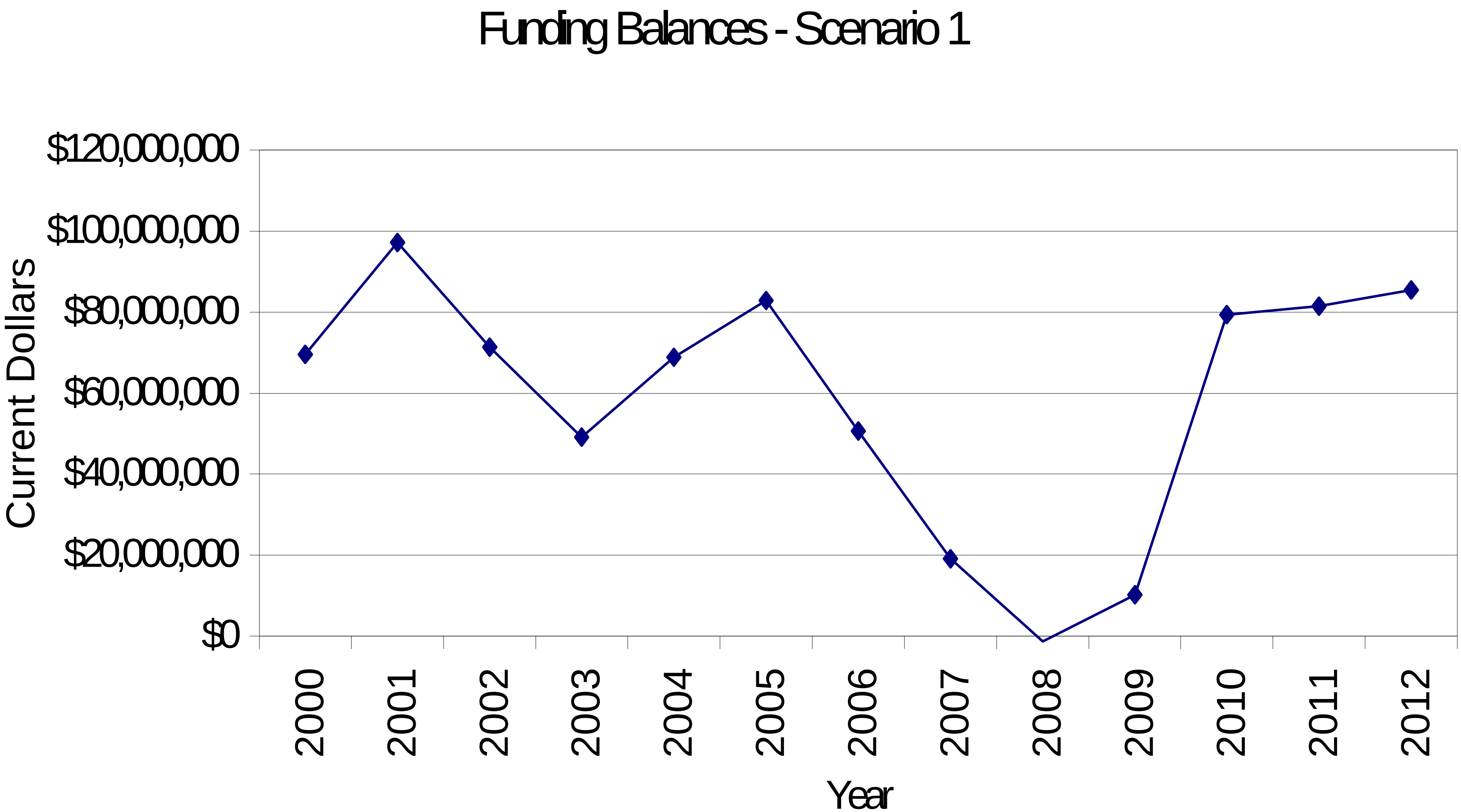

Funding Balances - Scenario 1
Current Dollars
$120,000,000
$100,000,000
$80,000,000
$60,000,000
$40,000,000
$20,000,000
$0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year

FIGURE G-2

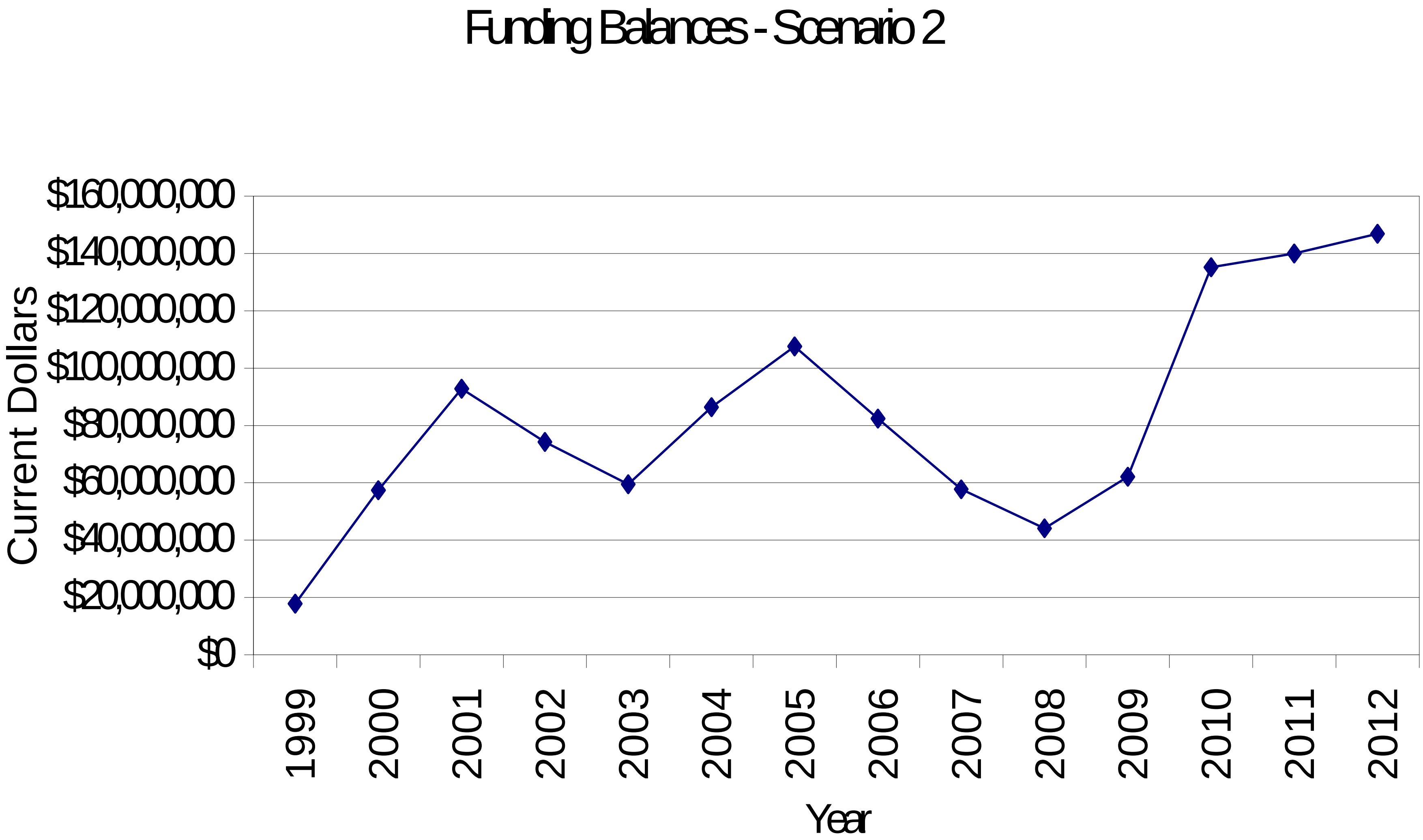
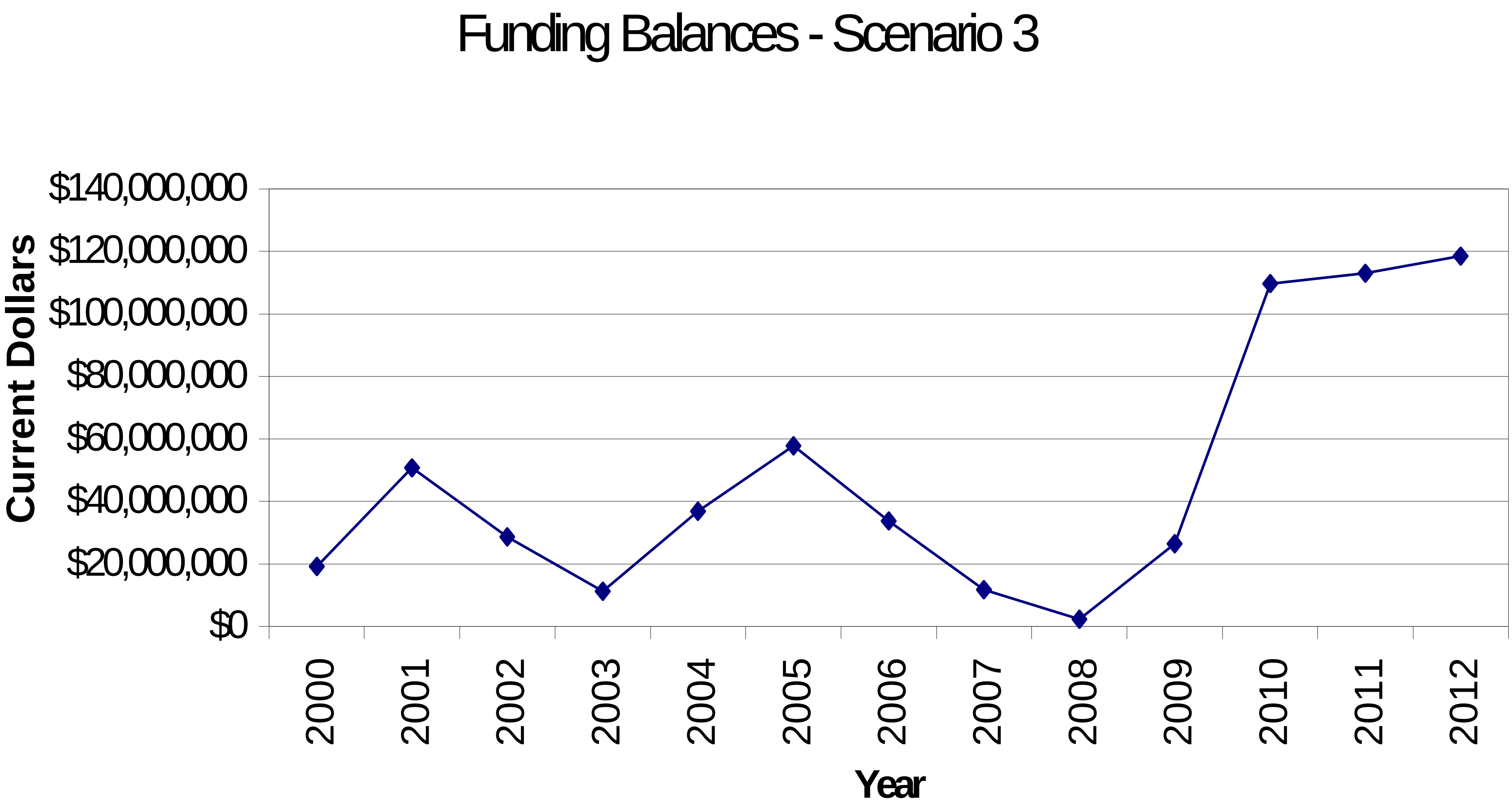

Funding Balances - Scenario 2
Current Dollars
$160,000,000
$140,000,000
$120,000,000
$100,000,000
$80,000,000
$60,000,000
$40,000,000
$20,000,000
$0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year

FIGURE G-3


Funding Balances - Scenario 3
Current Dollars
$140,000,000
$120,000,000
$100,000,000
$80,000,000
$60,000,000
$40,000,000
$20,000,000
$0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year

APPENDIX H

WATER QUALITY

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ATTACHMENTS

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C – Regulations and Standards
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E – Overview of Historic Condition
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APPENDIX H

WATER QUALITY

Appendix H is the water quality appendix for the Draft Feasibility Report and Programmatic Environmental Impact Statement (PEIS). As such, it includes both existing conditions and environmental effects water quality information. Specifically, Appendix H is a detailed expansion of water quality aspects of Section 2 (*Historic Condition*), Section 3 (*Existing Conditions*), and Section 8 (*Environmental Effects*) of the report. Appendix H also includes Attachments A-F.

H.1 REGIONAL SYSTEM

H.1.1 INTRODUCTION

As previously indicated in this PEIS, the study area of the C&SF Restudy Project is divided into ten designated study regions. These regions are as follows: the Kissimmee River Region, Lake Okeechobee, Upper East Coast (UEC) and Indian River Lagoon (IRL) (which for this water quality review includes the St. Lucie River subregion and the Indian River Lagoon subregion), Everglades Agricultural Area (EAA), Water Conservation Areas (WCAs) (which here include the Loxahatchee National Wildlife Refuge subregion, WCA-2A/2B subregion, and WCA-3A/3B subregion), Lower East Coast (LEC) and Biscayne Bay (which here includes the Loxahatchee River Aquatic Preserve (LRAP=Preserve) subregion, Lake Worth subregion, and Biscayne Bay subregion), Everglades National Park (ENP=Park) and Florida Bay (which here includes the Shark River Slough/Taylor Slough subregion, Florida Bay subregion, Whitewater Bay subregion, and Ten Thousand Islands subregion), Florida Keys, Big Cypress Region, and Caloosahatchee River Region. These regions are depicted in ***Figure H.1.1-1***. Subregions were reviewed for some regions due to their importance to the region, size, and/or unique or different water quality characteristics within the region.

The suite of water quality parameters of concern in the study area consisted of metals, pesticides, nutrients, biologicals, physical parameters, and other parameters. These are listed in ***Table H.1.1-1***. These parameters are subsequently described in detail in Section H.1.4 and Attachment A. From this list of parameters, several "key" parameters of concern were selected for each region and considered subregions (see Section H.1.6). Baseline water quality data were compiled for key parameters for individual regions (see Section H.1.7) and for additional "other" parameters for those regions (see Section H.1.7 and Attachment B).

TABLE H.1.1-1

Suite of Water Quality Parameters of Concern in the Study Area of the C&SF Restudy Project	
Metals	Mercury, Copper, Cadmium, Lead, Zinc, Arsenic, and Tributyltin (TBT)
Pesticides	DDT and Derivatives, Atrazine, Simazine, Ametryn, Endosulfan Compounds, Ethion, Bromacil, 2,4-D, Aldecarb, and Fenamiphos
Nutrients	Phosphorus, Nitrite/Nitrate, and Ammonia/Unionized Ammonia
Biologicals	Fecal Coliforms and Pathogens, and Chlorophyll-*a*
Physical	pH, Dissolved Oxygen, Conductivity, Turbidity, Oil & Grease, Temperature, and Salinity
Other Parameters	Polycyclic Aromatic Hydrocarbons (PAHs), Dioxins and Furans, Sulfate, Chloride, Polychlorinated Biphenyls (PCBs), and Volatile Organic Carbons (VOCs)

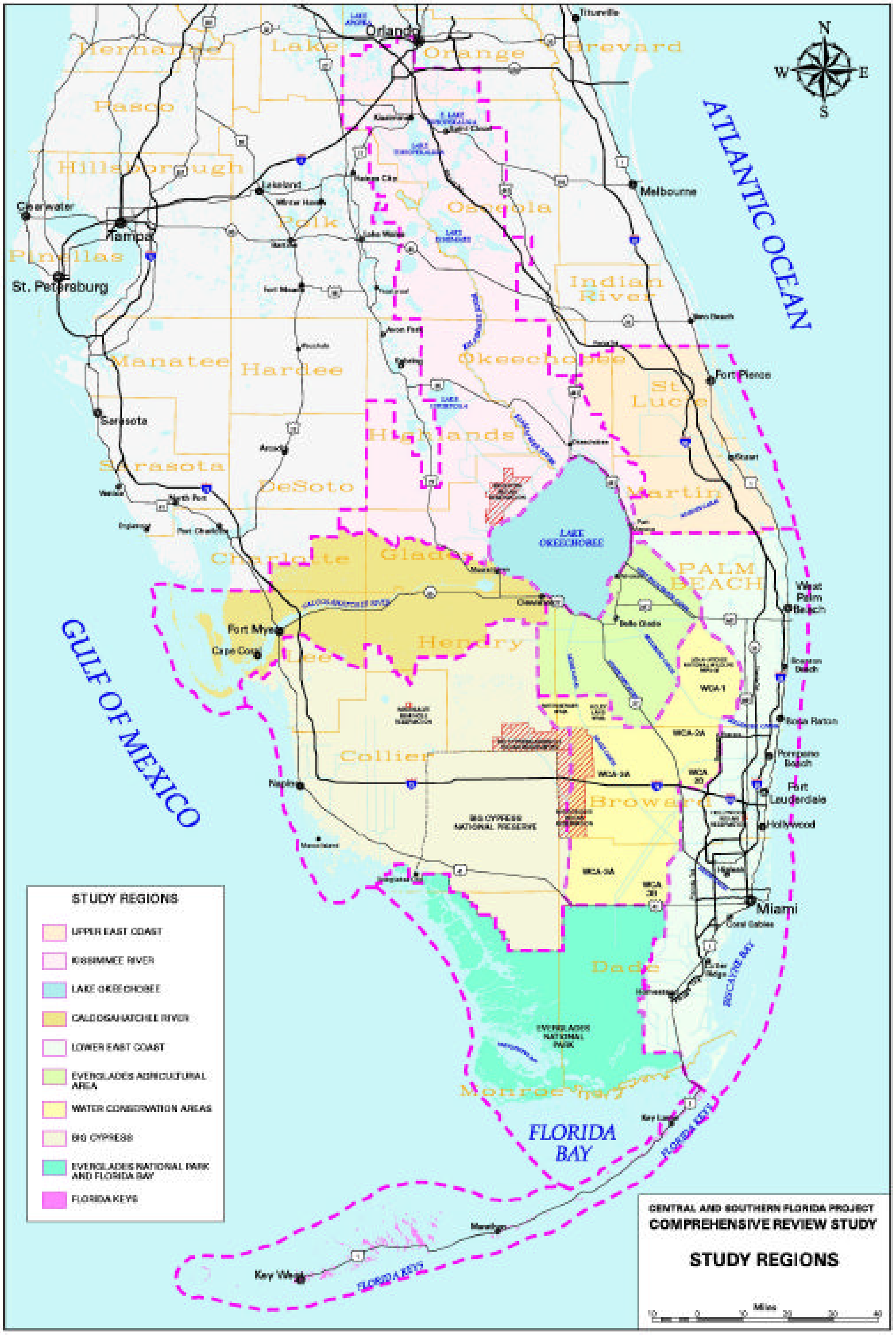


Figure H.1.1-1. Base map of the study area of the C&SF Restudy Project showing the ten regions of the Restudy as designated in this PEIS.

Water quality concerns have been identified for several of these parameters. Accordingly, both water quantity and water quality actions will be fully considered in the hydrologic restoration of South Florida via the Restudy PEIS.

Significant published references important to the description and/or data compilation of the ten regions and considered subregions include Boyer and Jones (1998), SFWMD (1998a, 1998b, 1992a, 1992b, 1982), USEPA (1996a;1998: draft), FDEP (1996), USGS (1996a), Limno-Tech (1995), Woodward-Clyde Consultants (1994), and USACE (1991). In addition, several reference citations were obtained via the EXTONET website (EXTONET, 1998: internet) searched in 1998. Also, unpublished data (1991-1997) were obtained from a SFWMD database (1998: unpublished) through 1998 personal communication with the SFWMD (M. Slayton) and were reduced to means and medians by a USEPA contractor. Unpublished pesticides data (1992-1997) were also obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Published data, as opposed to more recent but raw sampling data, were chiefly used for data compilation. Reliance on published data, resulted in the typical period of record for the data being from the late 1980's to the early 1990's. However, the specific period of record ranged from 1973 to 1997 and included some recent (1996-1998) published references such as those listed above. The established baseline year for the PEIS is 1995.

In addition to the narrative presented in Section 3, the current baseline water quality conditions of the ten regions of the study area are further discussed in the following narrative. An overview of historic water quality conditions is presented for comparison in Attachment E, which also supplements historic information presented in Section 2 (*Historic Condition*).

Kissimmee River Region

In general, the 305(b) report (FDEP, 1996) states the water quality trends for the basin are stable at forty sites, declining in Arbuckle Creek and Lake Underhill, and improving in Lake Tohopekaliga, Lake Kissimmee, and the Kissimmee River. The worst reported water quality conditions occurred in Reedy Creek and Bonnet Creek, while the best water quality conditions were observed in Lake Conway, Crooked Lake, and the Butler Chain of Lakes. Health advisories recommending the limited consumption of largemouth bass because of mercury have been issued for Lakes Kissimmee, Toho, East Toho, and Istokpoga.

Water quality in the channeled part of the river between Lake Kissimmee and Lake Okeechobee varies from north to south. From Lake Kissimmee to near Lake Okeechobee, where the channel flows mostly through unimproved rangeland, water quality was characterized as fairly good. As the river nears Lake

Okeechobee, however, cattle and dairies grow more numerous. Along the channel, water rich in nutrients and Biochemical Oxygen Demand (BOD) flows quickly to Lake Okeechobee, exacerbating eutrophication.

Lake Okeechobee

According to the 1996 305(b) report (FDEP, 1996) for Lake Okeechobee, the major pollution sources for the lake include runoff from ranch and dairy operations in the north where pollution has elevated phosphorus and coliform bacteria concentrations and created a continuous algal bloom. In the south, historic back-pumping of runoff from row crops and sugar cane has elevated nutrient and pesticide levels. The back-pumping has mostly ceased but still occurs when water in the primary canal of the Everglades Agricultural Area (EAA) reaches 13 feet (flood-control levels). As a result, depending on location and seasonal rainfall or drought, the lake receives varying amounts of nutrients, substances creating BOD, bacteria, and toxic materials. Other pollutants include high levels of total dissolved solids, unionized ammonia, chloride, color, and dissolved organic chemicals. The lake's Total Phosphorus (TP) levels have doubled in the last decade.

Biological sampling indicated variability but generally indicated eutrophic conditions. In recent years, several widespread algal blooms (one covering about 100 square miles) and at least one major fish kill (all of which were widely publicized) launched the environmental community and governmental agencies into intense investigation and analysis of the lake's problems. The Lake Okeechobee Technical Advisory Committee, formed to assess the situation and recommend solutions, determined that phosphorus from dairies and agriculture was a major cause of the noxious algal blooms and that levels should be reduced by 40 percent. A secondary cause of increased phosphorus may be the flooding of hundreds of acres of perimeter wetlands after the SFWMD decided in the late 1970's to raise the lake's water level. The higher level also reduced valuable fish-spawning grounds and waterfowl feeding and nesting habitat.

The Florida Steel Superfund site exists two miles northwest of Indiantown in Martin County. It consists of a 150-acre former steel mill that operated from 1970 to 1982. The USEPA has identified heavy metals, including arsenic, cadmium, and lead in the dust and ground water. PCBs have also been found at various locations. Adjacent wetlands are threatened by migrating contamination.

In general, the water quality trends for the lake are stable at six sites, improved at two sites, and degraded at two sites. The best water quality observations were noted for the flow entering Fisheating Creek and along the west near wetlands. The worst water quality conditions occurred in the south by agricultural areas, and to the northeast by Taylor Creek, Nubbin Slough and the St. Lucie Canal. The reported major pollution sources in this basin were dairies and agriculture. A generalized assessment of the lake shows the lake as having fair water quality conditions, except for Myrtle Slough which was shown to have poor water quality, and the extreme south-southwest section of the lake where good water quality conditions are described by the 305(b) report (FDEP, 1996).

Upper East Coast and Indian River Lagoon

Most pollutants found in surface waters along the Upper East Coast come from storm water (FDEP, 1996). Any water quality problems in these areas can be exacerbated by the extensive network of canals, which tend to diminish water quality and lower dissolved oxygen levels which in turn may lead to fish kills. In general, the 1996 305(b) report states that water quality in the northeastern basin is relatively good. The major problems in the basin are found near Port St. Lucie. Five-Mile and Ten-Mile creeks, which receive citrus grove runoff, have poor water quality with high pesticide levels that may be harming the North Fork of the St. Lucie River and Estuary. Water quality in the North Fork improves downstream of the confluence of Five-Mile and Ten-Mile creeks but, along with the main stem, is still affected by runoff from construction sites and urban development along the river in Port St. Lucie.

In general, the worst water quality conditions in the Upper East Coast Basin are reported in the St. Lucie River and the canals leading from the Everglades Agricultural Area. In general, the water quality indices for the areas west of the Indian River Lagoon and approximately centered on Port St. Lucie are reported as poor. The major sources of pollution in this basin are urban runoff, agriculture, boat discharge, and sewage overflows. Although the Savannas State Preserve, a 15-mile-long freshwater marsh between Ft. Pierce and Stuart, has fairly good water quality, mercury concentrations in fish tissue were high enough to warrant a no-consumption advisory for largemouth bass.

Water quality in the south section of the Indian River Lagoon was rated as fair by a National Estuary Program technical report (Woodward-Clyde Consultants, 1994). The best water quality conditions were identified in the areas south of Ft. Pierce; the worst in Belcher Canal. The main water quality issues in this segment of the basin were urban runoff, sewage discharge, freshwater discharge, rangeland runoff, and citrus runoff.

Everglades Agricultural Area

The 1996 305(b) report (FDEP, 1996) for the EAA states that the L-8, West Palm Beach, Hillsboro, North New River, and Miami canals from Lake Okeechobee to the L4-L7 canals; which roughly define the EAA; have poor water quality with extremely high nutrient and low dissolved oxygen levels. Other problems include pesticides, BOD, bacteria, and suspended solids. Agricultural runoff and overflow or seepage from sugar mill retention ponds also contribute pollutants. In addition, between the L-8 and West Palm Beach canals, biosolids-spreading operations may cause pollution. Fish kills occur periodically in the West Palm Beach Canal after heavy rains due to drainage from the Chemair Spray hazardous waste site. Canals bordering the Water Conservation Areas generally have very low dissolved oxygen levels typical of marsh waters. Nutrient levels at the marsh perimeter are elevated, probably from the breakdown of organic debris as well as agricultural drainage. To date, the FDEP has identified four major violations of Class III criteria caused by nutrients including imbalances of aquatic flora and fauna, dominance by nuisance species, diminished biological integrity, and low levels of dissolved oxygen. Controversy has been considerable over agriculture's effect on water quality in Lake Okeechobee, the canals, the Water Conservation Areas (WCAs), and Everglades National Park (ENP=Park). In the WCAs as well as the Park, cattails have been replacing the predominant native sawgrass community.

In general, the 1996 305(b) report rates water quality in the EAA as fair in the areas southeast of the lake, and poor in the areas south of the lake. The worst water quality conditions are reported for the canals from the EAA.

Water Conservation Areas

The 1996 305(b) report (FDEP, 1996) generalizes the water quality conditions in the WCAs as ranging from poor to good. The conditions for WCA-1 are rated as fair throughout the basin, with the exception of the northern area, which is shown to have poor water quality. The ten-year trend for WCA-1 shows no change for the areas currently described as having fair water quality. Interestingly, the ten-year trend shows water quality conditions have improved in the areas currently described as having poor water quality.

The 1996 305(b) report classifies water quality conditions as good in the northernmost areas of WCA-2 transitioning to a fair condition throughout most of the remainder of the basin. Poor water quality conditions are shown to exist along the L-38E canal. The ten-year trend analysis indicates that conditions have improved in the easternmost section of WCA-2A, and generally have not changed throughout the remainder of the basin.

The 1996 305(b) report classifies water quality conditions in WCA-3B as poor. The conditions in WCA-3A are rated as fair north of the county line, and are rated as good on the south side of the line. The ten-year trend does not show significant changes have occurred in the basin.

A health advisory recommending no consumption of largemouth bass because of mercury content has been issued for WCA-2A and -3A, and portions of ENP. An advisory has also been issued for limited consumption in WCA-1 and portions of the Park.

Lower East Coast and Biscayne Bay

The 1996 305(b) report for the Lower East Coast states that good-to-fair water quality was found throughout the Loxahatchee Basin. A small section of the North Fork of the Loxahatchee River has low dissolved oxygen levels. Waters in Jonathan Dickinson State Park have high coliform bacteria counts. In the last decade, seagrass beds in the estuarine portion of the Loxahatchee River have declined dramatically. Jupiter Sound has good water quality and a healthy biological community.

Lake Worth has good water quality near the inlet and mostly good water quality north of the inlet; however, water quality degrades to the south, especially where the West Palm Beach Canal enters the lake. Water quality improves again at the South Lake Worth Inlet and near Boca Raton Inlet.

Ft. Lauderdale is particularly plagued with water quality problems from urban runoff and wastewater treatment discharges. The westernmost stations on the canals often have the worst water quality from agricultural runoff. Canals are often choked with weeds that must be mechanically removed or treated with herbicides. An FDEP study of major Miami-Dade County canals in 1985 showed poor water quality, low biological diversity, and many exotic plants and animals.

The most serious problems confronting the Miami River are chronic and acute coliform bacteria contamination and heavy metal and organic pollution in sediments. The metal pollution in the sediments ranks among the highest in Florida. Chronic contamination results from illegal sewer connections to storm water pipes, leaking pipes and joints, and broken pipes. Acute contamination occurs when raw sewage flows from either emergency overflows or manholes.

In Miami-Dade, Broward, and Palm Beach counties, ten major public drinking-water wellfields have shown petroleum contamination, including the cities of:

- Riviera Beach
- Delray Beach
- Hallandale
- Dania
- Deerfield Beach
- North Miami Beach
- Miami Springs' Preston Wellfields
- Ft. Lauderdale's Peele-Dixie Wellfield

- Fort Lauderdale's Executive Airport Wellfield

Major petroleum assessments and cleanups are also in progress at Port Everglades, Miami International Airport, and Homestead Air Force Base, among others.

Biscayne Bay, although polluted by canal discharges and port activities, has fairly good water quality because of flushing from the Atlantic Ocean, especially south of Key Biscayne. Much of the bay is blanketed with seagrasses, which are associated with high levels of biological diversity. A potential threat is increased turbidity from resuspended spoil from the bay's bottom. Boat traffic, shoreline development, and pollutants from the Miami River also threaten the bay. High nitrogen concentrations have been measured in some of the canals that flow into Biscayne Bay from the agricultural area of southeastern Miami-Dade County. Another threat is from agricultural pesticides. A system that calculated pounds applied per acre of drainage area per year ranked Biscayne Bay as the second worst estuary in the U. S. for intensity of per-unit application of the more hazardous pesticides (Pait et al. 1992)

Everglades National Park and Florida Bay

As reported in the 1996 305(b) report (FDEP, 1996), the water quality conditions in the ENP were fair throughout the inland areas, and good along the coastal areas. The ten-year trend analysis presented in the report shows that water quality conditions in the ENP have been stable during the period of 1985 to 1995, except for the southeast corner (in the area of Taylor Slough) where water quality conditions reportedly have improved. The 1997 Everglades Annual Report (SFWMD, 1998b) indicates that phosphorus concentrations entering the Park are lower than the interim and long-term limits established by the 1992 Settlement Agreement. The annual report also states that significant increases in pesticide concentrations in water and sediment were not evident for the period 1996 to 1997. However, field studies have detected the presence of endosulfan and other pesticides in Florida Bay, especially near the C-111 basin (Scott et al. 1994; Scott et al. 1995). No significant trends in annual average mercury concentrations in water, sediment, or fish have been observed for the past five years. The annual report indicates that outflow concentrations of total mercury and methylmercury are less than inflow concentrations and upstream reference site concentrations; that total mercury concentrations are below Class III standards; and that outflow concentrations in largemouth bass are much less than the reference site and the Florida “limited consumption” action level of 0.5 mg/L. Although the Florida Department of Health and Rehabilitative Services recommends no consumption of largemouth bass throughout most of the eastern two thirds of the Park, this recommendation is being modified to a recommendation of limited consumption for the southeast east corner of the Park.

Some parts of Florida Bay have experienced a massive seagrass and mangrove die-off in the late 1980's and early 1990's. Researchers estimate that 9,880 acres of seagrass have died and another 66,690 acres have been affected to a lesser extent. The problem likely stems from a lack of flushing from hurricanes, high water temperatures, and high levels of salinity (recorded as high as 70 ppt (SFWMD, 1998b)). Chlorophyl-*a* levels in the bay generally were higher in the western areas (>1.0 ppb) than in the eastern portion of the basin (<1.0 ppb). Mercury contamination in seatrout collected from Florida Bay also is reported to be a cause for concern.

Florida Keys

According to the 1996 305(b) report (FDEP, 1996), the island waters open to the Atlantic or Gulf as having good water quality; however, many man-made canals and marinas have water-quality problems that are exacerbated by decreased flushing. A 1986 205(j)study in the Keys indicated that most pollution came from the following sources (excerpted: FDEP, 1996):

- Wastewater plants and small "package plants" discharging to poorly flushed, man-made waterways;
- Thousands of septic tanks and cesspools;
- Marinas lacking facilities to pump out waste from boats;
- Fish processors;
- Storm water runoff, especially into the canals.

The general water quality index for the Keys is reported to be good by the 305(b) report. The water quality trends indicate one site is stable. The worst water quality conditions are found in the urban canals and marinas. The best conditions are found in the open ocean and bay waters. Major pollution sources in the Keys are construction, septic tanks, marinas, live-aboard vessels, and storm water runoff.

Big Cypress Region

The general water quality indices for this basin range from good in the western portion of the basin to fair conditions in the east (FDEP, 1996). Water quality trends indicate there are five stable sites and two improving sites located in the Everglades west coast basin. There were no recently sample poor sites in this basin. The major sources of pollution include hydrologic modifications and agriculture.

Caloosahatchee River Region

A 1988-1989 study reported in the 1996 305(b) report (FDEP, 1996) showed that the upper portions of the region near Lake Okeechobee frequently violated dissolved oxygen standards and had high conductivity and nutrient levels from low flows and agricultural drainage (mostly sugar cane). Nine-Mile Canal, which drains agricultural fields, has very poor water quality. Pollution-tolerant species dominated biological samples. Although no algal blooms were seen during the sample period, they have been reported.

Although wastewater discharges remain a problem, the estuary is presently more seriously affected by high-nutrient waters from the river and tributaries, and storm water runoff from cities. Nutrient and chlorophyll levels are high, and small algal blooms occur regularly. The Orange River, a tributary entering the Caloosahatchee below the locks, is a favored wintering place for manatees because a nearby power plant discharges warm water. A fish kill and clam die-off occurred in 1990 because of high-temperature water discharges and low dissolved oxygen levels.

In general, good water quality conditions exist in the central portions of the basin. The best water quality indices are reported for Orange Creek. Water quality indices decline to fair in the easternmost area of the basin; specifically in the areas north and west of Lake Hicpochee; in the westernmost area of the basin, specifically around Trout Creek; and in the tidal areas of the Caloosahatchee River. Poor water quality indices were shown for the areas south and southeast of Lake Hicpochee, for the Daughtrey Creek sub-basin. Billy Creek, in the western portion of the basin, is reported as having the worst water quality in the basin. Overall, the monitoring stations were stable at three sites, and worse at one site. Major pollution sources were reported to be hydrologic modifications, agriculture, and urban areas, specifically Fort Myers.

H.1.2 WATER QUALITY REGULATIONS AND STANDARDS APPLICABLE TO REGION

Several federal, State and Tribal regulations and standards are relevant to the C&SF Restudy region. Summaries of the Federal Clean Water Act, the State of Florida Everglades Forever Act, and the Seminole Tribe of Florida Tribal Water Code and the Miccosukee Tribe of Indians of Florida Environmental Protection Code are presented in this section. Additional federal and State regulations and standards are presented in Attachment C**.**

H.1.2.1 Federal Regulations and Standards

H.1.2.1.1 Federal Clean Water Act

The Federal Clean Water Act (CWA) is the principle statute governing the quality of the Nation's waterways. The Act was initially called the Federal Water Pollution Control Act upon its inception in 1948. Since 1948, the Act has been amended on a regular basis. Major amendments were enacted in 1961, 1966, 1970, 1972, 1977, 1981, and 1987. It was reauthorized in 1991. The 1977 Amendments gave the Act its current name.

Prior to the 1972 Amendments, the Act relied largely on the States for achieving water pollution control. The 1972 Amendments, however, gave the Act a new regulatory and enforcement approach and created a strong federal enforcement program. These amendments were the federal government's response to a growing awareness that reform was needed—as evidenced by ready examples of water pollution. The 1972 Amendments declared that "the objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." National goals of the elimination of the discharge of pollutants into the Nation's waters by 1985, and that all waters be safe for fishing and swimming by 1983, were established.

The new approach combined the setting of state water quality standards based on desired water use objectives with the establishment of individual facility effluent limitations. The use of discharge permits was established to require point source dischargers to be in compliance with technology-based standards. Large sums of money were made available for construction grants for municipal sewage treatment plants which would aid municipalities in reaching compliance. In addition, Section 404 created a new permitting program to regulate the discharge of dredged material into waters of the U.S., including wetlands.

More specifically, states are authorized to develop ambient water quality standards and water quality management plans. States must determine maximum daily allowable pollutant loads for waters where the desired water quality cannot be met with technology-based standards. The States must then establish effluent limits and compliance schedules for point source dischargers to assure the attainment of the desired water quality.

Pursuant to Section 402 of the CWA, National Pollutant Discharge Elimination System (NPDES) permits are required for all new and existing point sources from which pollutants are discharged to navigable waters. Permits stipulate the amount of pollutant permitted to be discharged, compliance schedules for dischargers who cannot meet current standards, and monitoring, testing and reporting requirements. Effluent limitations are to be imposed and enforced in NPDES permits by several means. They are:

- Best Practicable Control Technology (BPT) - an average of the best treatment technology currently available.
- Best Available Technology Economically Achievable (BAT) - applies to toxic pollutants.
- Best Conventional Pollution Control Technology (BCT) - applies to conventional pollutants.
- Best Management Practices (BMPs) - designed to minimize the discharge of toxic and hazardous substances.

New pollution sources in an industry must meet a separate set of standards, called New Source Performance Standards (NSPS). These standards limit the discharge of pollutants by new sources based on Best Available Demonstrated Control Technology (BDT). The storm water permit program attempts to reduce pollutants to the maximum extent practicable for municipalities, and to technology-based requirements for industry. Immediate corrective actions must be taken when a discharge contributes to a violation of a water quality standard, or is a significant contributor of pollutants to the Nation's waters.

A discharge monitoring report must be submitted regularly by the NPDES permittee, providing a summary of the discharger's records on a monthly or quarterly basis. Periods of legal non-compliance would require the submission of a quarterly report stating the cause and period of non-compliance, the expected return to compliance, and plans to reduce the chance of future non-compliance. Non-compliance involving the discharge of toxic pollutants, a threat to drinking water, or injury to human health requires that the USEPA be notified within 24 hours. Intentional non-compliance may be allowed if necessary to prevent loss of life or serious property damage. Temporary non-compliance due to factors beyond reasonable control of the permittee must be promptly reported.

Two classes of pretreatment standards exist for new and existing industrial users who discharge to Publicly Owned Treatment Works (POTWs). Categorical pretreatment standards are intended to control toxic pollutants in specific industries and to prevent interference with the effective treatment of sewage. General pretreatment standards prohibit interference, fire or explosion hazards, corrosivity, solid or viscous obstructions, and heat sufficient to inhibit biological activity at POTWs.

Nonpoint Source (NPS) pollution is discussed under Section 303 (regulatory) and Section 319 (voluntary) of the CWA. States are to establish planning bodies to develop area-wide pollution control plans and identify waters which are unlikely to comply with state standards without additional nonpoint source controls. NPDES permits cannot be issued where the permit may conflict with an approved plan.

Specific to the State of Florida, the USEPA has recently (May 1, 1995) authorized the State of Florida to administer the NPDES Permit Program for all operational NPDES permits (except for federal facilities) with USEPA oversight. Coverage for storm water (construction) NPDES permitting in Florida is regulated via a General Permit issued by the USEPA on September 25, 1992.

Section 404 of the CWA regulates discharges of dredged and/or fill material into waters of the United States, including wetlands, through permits issued by the USACE. The USEPA is authorized to comment on these permits, elevate unaddressed concerns, and in certain cases, issue a determination that a site is not suitable for the discharge of dredged and/or fill material. Under regulations developed by the USEPA, permit applicants are required to first avoid, minimize, then mitigate the effects of their projects on wetlands. The relative significance of the functions and values of the wetland, and the availability of alternative sites must be considered. The CWA promotes the functional replacement of any unavoidable project wetland losses through wetland enhancement, restoration and/or creation, or the purchase of wetlands for their preservation in perpetuity.

Discharges of oil or hazardous substances in quantities that may be harmful to waters of the United States are prohibited. The cleanup of spills are provided for and Spill Prevention, Control and Countermeasure (SPCC) plans are required. Over 300 substances have been defined as hazardous by the Clean Water Act.

H.1.2.1.2 Other Federal Regulations and Standards

In addition to the CWA, the Federal Safe Drinking Water Act is relevant to the water quality of the study area. A summary of this statute is provided in Attachment C**.** In addition, Section H.1.4.1 presents USEPA and/or State of Florida aquatic life criteria for several of the suite of water quality parameters identified in Section H.1.1 that are of concern in the study area. USEPA human health risk criteria are also presented for some parameters.

H.1.2.2 State of Florida Regulations and Standards

H.1.2.2.1 Everglades Forever Act

The State of Florida's Everglades Forever Act (EFA), Florida Statute 373.4592, was passed in 1994 by the Florida Legislature. In addition to legislative findings that the Everglades ecosystem was a unique ecological treasure which is "endangered as a result of adverse changes in water quality, and in water quantity, distribution, and timing of flows" and that "waters flowing into the Everglades contain excessive levels of phosphorus," the legislature also stated their intention to "preserve natural values in the Everglades while also maintaining the quality of life for all residents of South Florida, including those in agriculture, and to minimize the impact on South Florida jobs, including agricultural, tourism, and natural-resource related jobs..."

The EFA sets out an iterative process to lead towards restoration of the Everglades. The first step is set out in Section 373.4592(4). The EFA mandates a comprehensive program ("Everglades Program") of scientific research, monitoring, construction, implementation of agricultural BMPs, regulation, and funding to achieve the State's objectives for Everglades restoration and protection. The principal elements of the Everglades Program include:

- construction and operation of the Everglades Construction Project (ECP) which is to consist of six large-scale Stormwater Treatment Areas (STAs) designed to treat EAA runoff prior to discharge to the Everglades;

- implementation of agricultural BMPs in the Lake Okeechobee drainage basin, the EAA, and the C-139 Basin (west of the EAA);

- extensive research and monitoring activities to determine numerically the concentration at which total water column phosphorus creates an imbalance in natural populations of aquatic flora and fauna in the Everglades.

The FDEP is to initiate administrative rule-making adopting the numeric phosphorus criterion no later than December 31, 2001. If, however, FDEP has not adopted a numeric phosphorus criterion by December 31, 2003; the legislature determined a default concentration of 10 parts per billion (ppb) for waters in the Everglades Protection Area (EPA). Section 373.4592(2)(h) of the Act defines the EPA as consisting of the Arthur R. Marshall Loxahatchee National Wildlife Refuge; Water Conservation Areas 1, 2A, 2B, 3A, and 3B; and Everglades National Park. Furthermore, in addition to numerically interpreting the State's narrative nutrient water quality standard for phosphorus in the Everglades, the EFA requires that all other water quality standards applicable to the EPA and EAA canals be evaluated. Research necessary to complete this evaluation is to be completed by December 31, 2001. By 2003, the SFWMD must submit a prompt modification to incorporate proposed changes to the ECP to achieve compliance with the new phosphorus criterion and other State water quality standards by December 31, 2006.

Construction of the ECP is to be completed by October 1, 2003. Construction of the first STA (STA6-Section 1) was completed in October 1997. After a brief start-up period, full operation of STA6-Section 1 began in December 1997. Construction of STA1 West and Inflow and Distribution Works, STA2, and STA5 is scheduled to be completed by January 1, 1999. Construction of the largest STA,

STA 3/4, is scheduled to begin after January 1, 1999 and is to be completed by October 1, 2003. By December 31, 2006, the ECP is to be operated to achieve compliance with all applicable State water quality standards, including the numeric phosphorus criterion. Furthermore, by that same date, all other existing (and future) SFWMD-controlled structures discharging water into the EPA (the so-called "Non-ECP Structures") are to be operated to achieve compliance with all applicable State water quality standards. The SFWMD has already developed schedules and strategies for evaluating these structures and for implementing water quality improvements where necessary.

H.1.2.2.2 State Water Quality Regulations

In addition to the EFA statute, additional State of Florida water quality regulations and standards are discussed in Attachment C**.** These regulations and standards are the:

- Florida Statutes 373 (Water Resources) and 403 (Environmental Control)
- Surface Water Standards
- Beneficial Use Classifications (Class I-V)
- Ground Water Standards
- Drinking Water Standards.

H.1.2.3 Tribal Water Codes

H.1.2.3.1 Seminole Tribe of Florida Tribal Water Code

The Seminole Tribe of Indians, being a federally-recognized Tribe of Indians, has the right under federal law to set water quality standards for its tribal lands. The Seminole Tribe has enacted a Tribal Water Code which includes water quality standards for controlling both point and nonpoint sources of pollutants for the Big Cypress and Brighton Reservations, last amended on March 13, 1998. The Code, which is applicable to the Big Cypress Reservation, has been approved by the USEPA. Currently, the USEPA is reviewing the latest revision.

The water quality standards state that all Reservation surface waters be free from substances that (excerpted: Tribal Code):

- settle to form objectionable deposits
- float as debris, scum, oil or other matter forming nuisances
- produce objectionable color, odor, taste, or turbidity
- cause injury to or are chronically toxic to, or produce adverse physiological responses in humans, wildlife, plants, or fish and other aquatic life
- are unsuitable for aquatic life propagation and maintenance
- support balanced indigenous populations of aquatic life.

Moreover, the Tribe has enacted two additional standards for a special class of waters called Class II-A waters. These standards state that Class II-A waters be free from substances that "disturb, injure or in any way jeopardize the continued existence of the unique diverse plant and wildlife used in the religious ceremonies and customs of the Tribe; or impair the biological community as it naturally occurs in the designated area due to physical, chemical or hydrologic changes."

The Tribal Council has adopted the goals and policy in the CWA. In particular, the Tribal Council endorses the national goal of the elimination of the discharge of pollutants into the Nation's waters; protecting fish, shellfish, and wildlife; providing for recreation in and on the water; the elimination of the discharge of toxic pollutants in toxic amounts; and the development of nonpoint sources of pollution control.

In addition to the declaration of goals and policy in the CWA, the Tribal Council has adopted its own water quality policies. These include (excerpted: Tribal Code):

- protecting water quality to pursue economic development;
- conserve the habitat of culturally important fish, wildlife, and plant life in order to provide for hunting, fishing, and other traditions;
- prohibit the degradation of groundwater because groundwater is important for human consumption and because it is costly and difficult to restore contaminated groundwater;
- protect the values and functions of wetlands and provide appropriate mitigation measures for unavoidable adverse impacts.

The Seminole Tribe has established these policies in order to protect the health and welfare of the Tribe's members and others within the Reservation; provide appropriate protection for aquatic life and wildlife; protect aspects of the natural environment important for carrying out traditional cultural activities; and ensure that development activities be carried out.

The Tribe has adopted a narrative criterion for nutrients and phosphorus. The USEPA has reviewed and approved this criterion in fiscal year 1997 (FY97).

H.1.2.3.2 Miccosukee Tribe of Indians of Florida Environmental Protection Code

The Miccosukee Tribe of Indians, being a federally-recognized Tribe of Indians, has the right under federal law to set water quality standards for its tribal lands. According to the Tribe, "(t)he ecological integrity and ultimately the very survival of the Miccosukee Tribe's lands in the Everglades are threatened by the inflow of water containing excess nutrients, especially phosphorus. In order to preserve the unique flora and fauna of Tribal lands, and to preserve the natural balances of Tribal lands", the Miccosukee Tribe established the Miccosukee Tribe of Indians Water Quality Standards. These standards were adopted by the Tribe on December 19, 1997, and amended on March 4, 1998. Currently, the USEPA is conducting a formal review of the water quality standards.

The standards call for all Reservation surface waters to be free from substances other than natural ones that (excerpted):

- settle to form objectionable deposits;
- float as solids, oil and grease;
- cause objectionable color, odor, taste, nuisance conditions, turbidity, temperature, salinity, dissolved solids, chlorides, pH, dissolved oxygen levels, and bacteriological quality;
- affect biological integrity and nutrient concentrations; or
- are toxic substances or pathogens.

The Tribe finds that excessive nutrients (including total phosphorus) constitute one of the most severe water quality problems threatening the Everglades. The Tribe's policy is (excerpted):

> *"to limit the introduction of nutrients from anthropogenic sources into waters of the Tribe. Particular consideration shall be given to the protection from further nutrient enrichment of waters which are presently high in nutrient concentrations or sensitive to further nutrient concentrations and to further nutrient loadings. It is the intent of the Miccosukee Tribe to prevent adjacent water users from using Tribal waters or vegetative communities within Tribal jurisdiction as a biological filter with respect to nutrient removal. These water quality standards take into consideration the water quality standards of downstream waters and provide for the attainment and maintenance of downstream waters. The Miccosukee Tribe's waters in the areas of the North Grass, South Grass, and Gap (WCA-3A) shall have a nutrient standard consistent with natural oligotrophic levels (including a total phosphorus limitation of 10 parts per billion of water). The most stringent nutrient standards will be applied to the most upstream reaches of the Tribal waters."*

The Miccosukee Tribe's Class III-A waters have a nutrient standard that is protected by a TP criterion of 10 ppb. For Class III-B waters, the Tribe has adopted a narrative criterion.

The objective of the Miccosukee Tribe's Water Quality Standards is to "provide that contamination that may result from the use of water shall not lower the quality of the water below that which is required for recreation and protection and propagation of fish, shellfish, wildlife, and native plants consistent with preservation of the Everglades Ecosystem within Water Conservation Area 3-A and Everglades National Park." The Miccosukee Tribe's Water Quality Standards have been enacted to establish goals for specific water bodies on the Miccosukee Reservation, to assign uses to water bodies for which protection is required, and to prescribe water quality criteria needed to meet and sustain those uses. The standards aim to protect threatened and endangered species listed by the U.S. Fish and Wildlife Service (USFWS), to promote the health, social welfare, and economic well-being of the Miccosukee Tribe, to provide a legal basis for regulatory controls, and to provide a basis for the Clean Water Act Section 401 certification. An overriding concern, in addition to the above-mentioned agenda items, is the desire to assure that the degradation of existing water quality does not occur.

The standards apply to all Tribal Reservation surface waters within the exterior boundaries of the Tribe's Reservation, including water situated wholly or partly within, or bordering upon Tribal Reservation lands. The standards shall be the basis for regulatory enforcement against discharges so as to protect the water within the Reservation.

The Tribe hopes to accomplish these goals by incorporating the standards into a permitting and management process for point and nonpoint source discharges, by using the standards to determine when a designated use is threatened, and by using current treatment technologies to control point sources and BMPs to control nonpoint sources of pollution. The Tribe recognizes the need to mediate regulatory actions with the technological progress and the social and economic well-being of Tribal members. No compromise will be allowed, however, when it comes to protecting human health or the preservation of the Everglades.

H.1.2.3.3 1992 Settlement Agreement

In 1988, the federal government filed a lawsuit against the SFWMD and the FDEP, alleging that water discharged into Everglades National Park and the Loxahatchee National Wildlife Refuge violated State water quality standards. In particular, the lawsuit alleged that the farm runoff from the EAA contained excessive levels of nutrients such as phosphorus that were causing imbalances in natural populations of flora or fauna, a violation of State Class III water quality standards.

The lawsuit was settled in 1991, with the parties agreeing that the ecological integrity, and ultimately the survival, of the Park and the Refuge are threatened by inflows of water containing excess nutrients. The settlement agreement, which the federal court entered as a Consent Decree in 1992, requires several affirmative steps to remedy these problems. First, it requires the state parties to achieve interim and long-term phosphorus concentration levels and limits in the Park and

Refuge. Second, the parties agreed that phosphorus loads discharged from the EAA will be reduced by approximately 80% to the WCAs and the Park, and by 85% to the Refuge as compared to mean levels measured from 1979 to 1988. Third, the state parties agreed to construct Stormwater Treatment Areas (STAs) to remove phosphorus from farm runoff before it enters the WCAs. Fourth, the state parties agreed to initiate a regulatory program requiring the use of BMPs in the EAA that are designed to reduce phosphorus levels in farm runoff. Fifth, the parties agreed to take all actions within their authority necessary to provide adequate flows to meet water quantity, distribution, and timing needs of the Park and Refuge. Finally, the parties agreed to a research and monitoring program, and specifically agreed to numerically interpret the narrative Class III nutrient water quality criteria.

In 1993 and 1994, the federal and State governments agreed to augment the program required by the Consent Decree, primarily by increasing the size and number of STAs and delineating the process for the State to establish a numeric Class III nutrient water quality criterion for phosphorus. The Florida Legislature passed the Everglades Forever Act in 1994, F.S. 373.4592, to authorize the implementation of the augmented program. In 1995, the parties moved the Court to modify the Consent Decree to accommodate the new program and the revised deadlines associated with it. The motion, which the Court has not yet ruled upon, asked the Court to modify the deadlines in the Consent Decree to require compliance with the phosphorus interim levels and limits in the Refuge to 1999 and in the Park to 2003; require the load reductions for the Refuge by 1999 and for all of the WCAs by 2003; and require the STAs to be completed between 1997 through 2003.

H.1.2.4 Federal Monitoring

H.1.2.4.1 United States Geological Survey

The United States Geological Survey (USGS) has conducted extensive long-term monitoring of surface water and ground-water quality at hundreds of locations throughout the South Florida ecosystem. This monitoring has included water physical parameters, nutrients, ions, metals, pesticides and other organic compounds. An overview of available information on surface water and ground water quality for water bodies throughout the ecosystem is provided in USGS (1996b). In 1993, the USGS initiated a National Water Quality Assessment (NAWQA) Program effort in South Florida. This effort includes analysis of historical data, surface and ground-water assessments, and ecological studies. Sampling includes streambed sediment, game fish, surface water and ground water (USGS, 1996b). Ongoing ecosystem studies include extensive Everglades mercury geochemical cycling research, including work on methylmercury degradation, dissolved organic carbon-mercury interactions, sulfur cycling, mercury accumulation and processes in peat, biological uptake of mercury, and ground water-surface water exchange (USGS, 1996c).

H.1.2.4.2 United States Environmental Protection Agency

The Regional Environmental Monitoring and Assessment Program (REMAP) initiated in 1993 is the only system-wide monitoring of the freshwater Everglades ecosystem (USEPA, 1996). This program monitors nutrient, phosphorus, mercury, water management, and habitat indicators. This information is important for assessing ecosystem health and tracking the effectiveness of the Restudy and other efforts directed at ecosystem protection or restoration. This monitoring should continue using the Environmental Monitoring and Assessment Program (EMAP) design with revisions to include compliance monitoring, and fixed or process study stations. It is important to continue monitoring water, soil/sediment, periphyton, and fish in order to develop a time series which will allow a trend analysis in the future to provide for the assessment of changes in the system due to management and restoration actions. In addition, future monitoring will also determine plant biomass estimates across the system and make quantitative habitat assessments and food chain analyses to support a mercury cycling model of the ecosystem. A comparative ecological risk assessment will be completed in order to better understand and control ecosystem threats. This monitoring is designed to compliment the USGS site-specific Everglades mercury process research.

H.1.2.4.3 United States Army Corps of Engineers

The USACE has historically conducted water quality monitoring at key locations throughout South Florida. Monitoring efforts have been undertaken around Lake Okeechoobee, the Loxahatchee National Wildlife Refuge, Water Conservation Areas (WCAs), and the Upper St. Johns portion of the C&SF project. Water quality data including field parameters, nutrients, metals, pesticides, and inorganic constituents, are available from those programs. Funding and manpower considerations have changed the scope of this program several times in the last several years from long term operation-and-maintenance efforts to more short term synoptic studies associated with specific events or projects. As part of a long term effort, the USACE continues to maintain several water quality monitoring stations at: 1) inflows to the Everglades National Park (ENP), 2) stations required for operation of some of the features of the Modified Water Deliveries to the ENP project, and 3) in the Upper St. Johns Project.

H.1.2.4.4 United States Department of the Interior

The USDOI has several water quality monitoring programs underway within its South Florida units. Monitoring objectives are many, and may include: 1) determine water quality conditions; 2) determine water quality trends; 3) determine the presence of external water quality threats; 4) determine the effect of various land uses on water quality; 5) determine the effect of C&SF Project water management practices on water quality; 6) determine the effectiveness of water quality control measures such as agricultural BMPs; 7) assess compliance with water quality standards, the Everglades Forever Act, various Memoranda of Agreement, and the 1992 Settlement Agreement; 8) aid in development of new water quality criteria; and 9) guide resource management decisions directed at protecting or restoring ecology and aquatic resources.

Since 1994, the SFWMD and USFWS have been monitoring 14 interior marsh stations within Loxahatchee National Wildlife Refuge for nutrients, physical parameters, ions, and metals. A similar long-term joint National Park Service (NPS within the USDOI) and SFWMD monitoring program has been in place since about 1985 at nine interior marsh stations within the ENP. The SFWMD also monitors the quality of water at about 50 WCA water control structures. Some of these structures discharge into the Park or Refuge and have been monitored since the 1970's. Water quality within the Big Cypress National Preserve has been monitored cooperatively with SFWMD since 1994 at 14 marsh stations. The SFWMD, Miami-Dade County, and Florida International University (FIU) are all involved in long-term water quality monitoring at over 90 stations within Biscayne National Park. More detail about the above monitoring programs can be found in SFWMD (1998a).

In addition to the above efforts, other collaborative efforts with the USDOI include extensive monitoring performed by FIU. A large amount of other historic water quality data and publications also exist for these areas. For example, the USGS began monitoring water quality within the ENP in 1953. Historic data were collected by USGS, SFWMD, USDOI, or various universities. In addition, periodic special studies or research efforts have gathered additional water quality data throughout these USDOI units such as information on pesticides, mercury, or phosphorus impacts.

H.1.2.4.5 General

Because of the historical impacts and the difficulty in finding a concise, yet comprehensive, water quality data set addressing the entire system, phosphorus has been the Restudy's primary focus. Understanding is incomplete about the types, concentrations and loads of pollutants that are causing ecological problems and likely to create future ecological problems at critical locations. This lack of understanding exists in spite of a significant collective monitoring effort. A number of different agencies routinely collect large quantities of water quality data in the region, yet these data are seldom collected in conjunction with important events such as agricultural pesticide and fertilizer applications, major storm water discharges or pumping activities. Many monitoring programs are localized efforts collecting data at fixed locations at scheduled times which are then stored in databases and seldom used. When pollution impacts do become evident, existing monitoring efforts are often unable to identify the source or cause of the impacts. A detailed water quality monitoring program that is well coordinated among the collecting agencies is necessary to adequately ensure that water quality considerations are included in the stages of the design process for project features.

H.1.2.5 State of Florida Monitoring

State of Florida water quality monitoring is conducted by the FDEP and the SFWMD. Monitoring includes surface water, ground water and atmospheric deposition. Florida counties also have various monitoring programs.

References used to develop this water quality monitoring section were SFWMD (1998a), the FDEP internet website searched in 1998 (FDEP, 1998: internet), and 1998 personal communication with the SFWMD (R. Pfeuffer). Figures and tables incorporated in this section and Attachment D were excerpted from SFWMD (1998a), which was coordinated with the District (G. Germain: SFWMD, 1998 personal communication).

H.1.2.5.1 Surface Water

The FDEP's water quality monitoring, assessment, and data management responsibilities and authorities are promulgated in the State of Florida's 1983 Water Quality Assurance Act (Section 373.026, F.S.), Section 403.061 F.S., and State Water Policy (Section 62-40.540, F.A.C.). In addition, the USEPA has delegated the state additional responsibilities pursuant to the Federal Clean Water Act (CWA).

Historically, FDEP has pursued an ambient monitoring strategy of fixed station networks to characterize water quality. Monitoring efforts were expanded with the initiation of the Surface Water Ambient Monitoring Program. Started in 1991, SWAMP was an effort to revitalize monitoring programs at FDEP to better address federal (305[b] reporting requirements) and state water quality management and assessment requirements. An important component of SWAMP was an effort to formalize biological assessment protocols.

SWAMP was intended as an interagency collaborative effort to better coordinate Florida's monitoring efforts. It also was FDEP's primary surface water quality monitoring program and central repository for surface water quality data. SWAMP had a three-tiered approach with the following goals for each tier:

- Water Chemistry Status Network - The objective of status monitoring was to define the existing conditions of a waterbody and provide background information to support other programs. The initial program was short lived, from 1991-1994, however, during this time the program added over 500 new watersheds for evaluation in the 1994 and 1996 305(b) assessments. FDEP selected waterbodies for monitoring based on two criteria. The first was their identification by the 1990 and 1992 305(b) assessments as having poor, fair, or unknown water quality. The second criterion applied to the selection process was a lack of recent data. This was defined as no new data over the preceding five years. For waterbodies classified as unknown, priority was given to areas with expected threats or impairments. Presently, the Division of Water Facilities Integrated Water Resource Monitoring Network is incorporating the concepts of status monitoring into its design.

- Water Chemistry Trend Network - Designed to determine trends in surface water quality and to determine adequate sampling frequency. Expanded historical permanent and fixed station networks.
- Special SWAMP Projects - Designed as problem-specific or waterbody-specific monitoring programs.

The stated overall program goal of SWAMP was to provide information to the public, elected officials, and FDEP managers about the health of Florida's waterbodies; whether they meet standards and criteria; and the occurrence of changes in quality in a technically sound, timely manner; in an easily understandable format using water chemistry, sediment, and biological data.
SWAMP's stated objectives were (excerpted: FDEP, 1998: internet):

- Identifying and documenting the existing condition of the State's surface waters through a status network;
- Determining support of State water quality criteria;
- Identifying changes in water quality over time of significant waterbodies through a trend network;
- Documenting potential problem areas;
- Establishing stream and lake eco-region reference sites for comparison purposes;
- Collecting biological data at eco-region references sites to establish preliminary biological integrity measurement techniques; and
- Providing information for management, legislators, other agencies, and the general public primarily through 305(b) reporting.

The SWAMP Program ended in 1996 with the merger of FDEP’s ground water and surface water monitoring programs. Elements of SWAMP have been incorporated into FDEP’s Integrated Water Resource Monitoring Program (IWRM) and basin management framework.

IWRM uses a three tiered approach to integrate monitoring to address point and nonpoint sources of pollution, BMPs, pesticides, habitat area, atmospheric deposition, land use/land cover, and the interactions of surface and ground waters.

It will be conducted on a rotating five-year basin cycle, where 20% of the State's basins are monitored intensively during year one, while the remaining 80% would be monitored at a less intense level. During year two, a second and different 20% would be intensively monitored, and the remaining 80% would be monitored at a less intense level. This would continue for five years until 100% of the state was intensively monitored, and then the cycle could begin again.

The first tier of IWRM will provide a broad assessment of the status of Florida’s water resources. It is not designed to identify causes of pollution, monitor compliance of point sources, or allow a thorough detailed understanding of an ecosystem. The second tier is directed to supporting providing more detailed information about a basin. Information generated from this tier can be used for development of Total Maximum Daily Loads (TMDLs: also see Section H.1.5.1.2), identify waterbodies for more detailed studies, and potentially identify water bodies for restoration and rehabilitation. The third tier is directed toward monitoring that supports regulatory programs, such as compliance and enforcement monitoring.

The SFWMD has the responsibility to manage water and related resources for the benefit of the public and to stay updated with the needs of the C&SF Restudy region. The District uses various approaches to protect water quality, including monitoring, testing and researching those water quality parameters related to the District's operations, land management activities, and regulatory functions. The general scope of the water quality monitoring programs currently managed by the District include monitoring points in lakes, rivers, canals, wetlands, dairies, the intracoastal waterway, estuaries, rainfall, and water control structures. The SFWMD Department of Water Resources Evaluation (WRE) is responsible for collecting and maintaining a database of surface water quality and hydrologic information. Specific goals related to water quality monitoring programs administered by WRE include the following (excerpted FDEP, 1998: internet):

- To provide water quality data and evaluations from a network of sampling stations to support water resource management decision-making;
- To optimize the efficiency of data collection monitoring networks, and ensure data accuracy through rigorous quality control; and,
- To develop and maintain a water quality database to provide efficient data access.

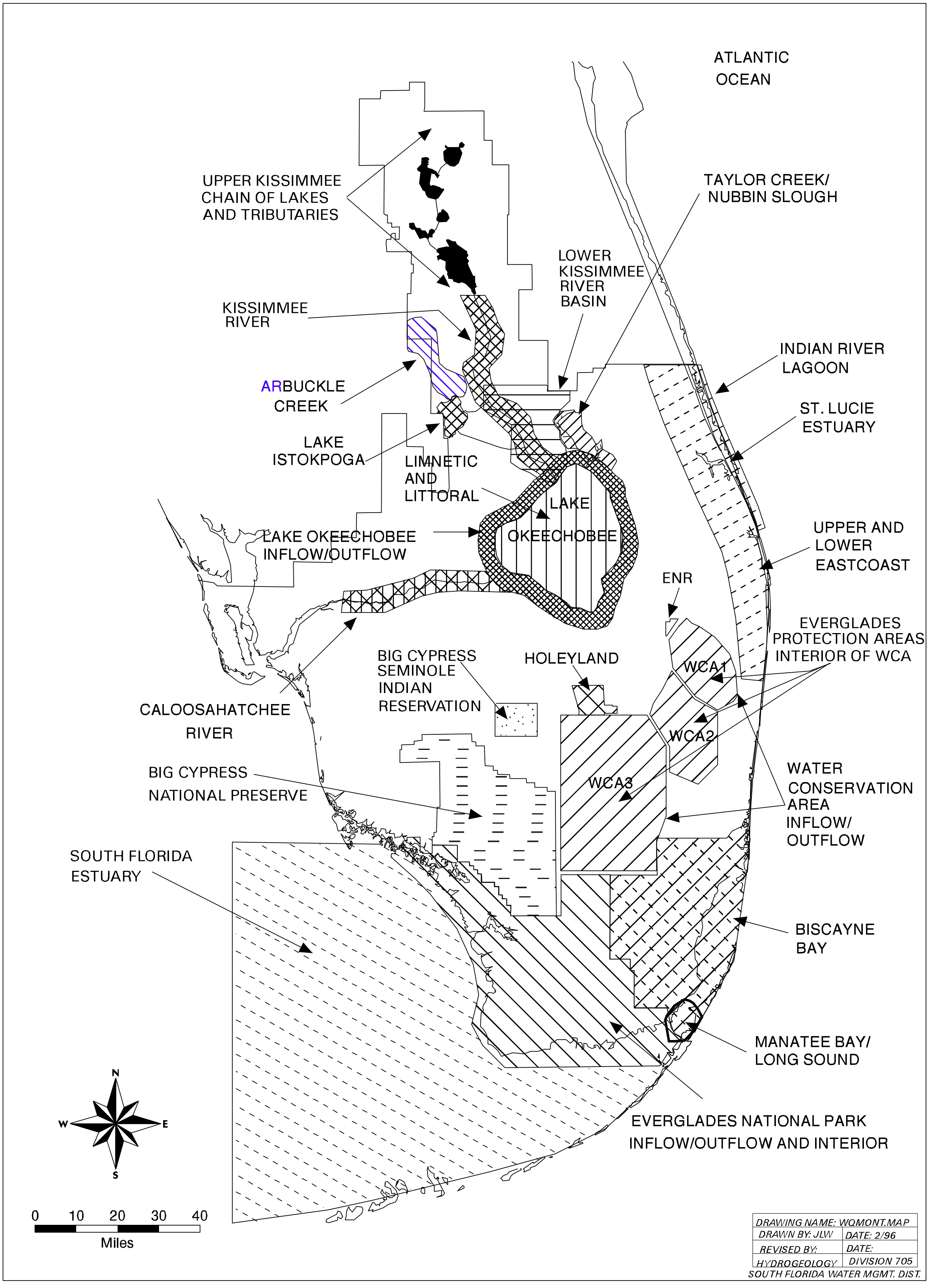
There are 40 major water quality monitoring programs that incorporate 991 sampling locations within the SFWMD region, including the following (excerpted: SFWMD, 1998a):

- Surface Water Improvement and Management (SWIM) Act of 1987.
- Permits issued by the Florida Department of Environmental Protection (FDEP), and the Environmental Protection Agency (EPA) [USEPA].

- Memorandum of Agreement (MOA) between the Everglades National Park (PARK), the District, and the United States Army Corps of Engineers (COE).
- MOA's between the District and the Miccosukee and Seminole Indian Tribes of Florida.
- MOA between the District, the United States Department of Agriculture, and the Environmental Protection Agency [USEPA].

Depending on the specific program and/or parameter, the sampling frequencies range from weekly to biannually. In addition, some sampling is conducted only during storm events. The parameters analyzed include basic inorganics (e.g., nutrients, cations, anions and metals), organics (e.g., pesticides and their derivatives, and base neutral/acid extractable and purgeable compounds), and physical parameters (e.g., temperature, dissolved oxygen, pH, specific conductance, etc.).

The areal extent of the SFWMD surface water quality monitoring program is shown in ***Figure H.1.3.2.1-1***. The SFWMD monitored water quality parameters are listed in ***Table H.1.3.2.1-1***, the pesticides analyzed for surface water and sediments listed in ***Table H.1.3.2.1-2,*** and the priority pollutants analyzed for surface water and sediments are listed in ***Table H.1.3.2.1-3***.


ATLANTIC OCEAN
UPPER KISSIMMEE CHAIN OF LAKES AND TRIBUTARIES
TAYLOR CREEK/ NUBBIN SLOUGH
LOWER KISSIMMEE RIVER BASIN
KISSIMMEE RIVER
ARBUCKLE CREEK
INDIAN RIVER LAGOON
ST. LUCIE ESTUARY
LAKE ISTOKPOGA
LIMNETIC AND LITTORAL
LAKE OKEECHOBEE
LAKE OKEECHOBEE INFLOW/OUTFLOW
UPPER AND LOWER EASTCOAST
ENR
EVERGLADES PROTECTION AREAS INTERIOR OF WCA
BIG CYPRESS SEMINOLE INDIAN RESERVATION
HOLEYLAND
WCA1
WCA2
WCA3
CALOOSAHATCHEE RIVER
BIG CYPRESS NATIONAL PRESERVE
WATER CONSERVATION AREA INFLOW/ OUTFLOW
SOUTH FLORIDA ESTUARY
BISCAYNE BAY
MANATEE BAY/ LONG SOUND
EVERGLADES NATIONAL PARK INFLOW/OUTFLOW AND INTERIOR
N
W
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0 10 20 30 40
Miles
DRAWING NAME: WQMONT.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

TABLE H.1.3.2.1-1
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
LIST OF PARAMETERS AND UNITS BY MAJOR GROUPINGS

PHYSICAL/CHEMICAL	UNITS
Temperature	C
Dissolved Oxygen	mg/L
Specific Conductance	umhos/cm
pH	pH units
Turbidity	NTU
Color	Color units
Total Suspended Solids	mg/L
Total Dissolved Suspended Solids	mg/L
Secchi	meters
Salinity	PPT
Photosynthetically Active Radiation(PAR)	umol s-1 m-2 per microamp
NUTRIENTS	**UNITS**
Nitrite	mg/L
Nitrate	mg/L
Nox	mg/L
Ammonia	mg/L
Inorganic Nitrogen	mg/L
Organic Nitrogen	mg/L
Total Nitrogen	mg/L
Total Kjeldahl Nitrogen	mg/L
Ortho Phosphorus	mg/L
Total Phosphorus	mg/L
Inorganic Phosphate Fractioning	mg/L
Organic Phosphate Fractioning	mg/L
Hydrolyzable Phosphate	mg/L
Alkaline Phosphatase(APA)	nmo/min-m
MAJOR IONS	**UNITS**
Alkalinity	mg/L
Chloride	mg/L
Silica	mg/L
Sulfate	mg/L
Sodium	mg/L
Potassium	mg/L
Calcium	mg/L
Magnesium	mg/L

TRACE METALS	UNITS
Total Aluminum	mg/L
Total Manganese	mg/L
Total Mercury	mg/L
Total Cadmium	mg/L
Total Copper	mg/L
Total Zinc	mg/L
Total Arsenic	mg/L
Total Lead	mg/L
Total Iron	mg/L
Methyl Mercury	mg/L
Chromium VI	mg/L
Chromium III	mg/L
OTHER	**UNITS**
Chlorophyll	
Carotenoid	mg/m^3
Chlorophyll a	mg/m^3
Chlorophyll a2	mg/m^3
Chlorophyll b	mg/m^3
Chlorophyll c	mg/m^3
Pheophytin a	mg/m^3
Total Coliform	cfu/100ml
Fecal Coliform	cfu/100ml
Heterotrophic Plate Count	cfu/100ml
Fecal Streptococci	cfu/100ml
Fecal Coliform Most Probable Number(FCMPN)	mpn/100ml
Total Coliform Most probable Number(TCMPN)	mpn/100ml
Dissolved Inorganic Carbon(DIC)	mg/L
Dissolved Organic Carbon(DOC)	mg/L
Total Inorganic Carbon(TIC)	mg/L
Total Organic Carbon(TOC)	mg/L

- = No Units

TABLE H.1.3.2.1-2
SOUTH FLORIDA WATER MANAGEMENT DISTRICT PESTICIDES ANALYZED IN SURFACE WATER AND SEDIMENT SAMPLES**

2,4-D	Ethion
2,4,5-T	Ethoprop
2,4,5-TP (Silvex)	ethylene thiourea*
acephate*	fenamiphos (nemacur)
alachlor	fonophos (dyfonate
aldicarb	gamma BHC (lindane)
aldrin	glyphosate*
alpha BHC	heptachlor
alpha endosulfan	heptachlor epoxide
ametryn	hexazinone*
atrazine	linuron
azinphos methyl (guthion)	malathion
benomyl	metalaxyl*
beta endosulfan	methamidaphos
beta BHC	methomyl
bromacil	methoxychlor
butylate*	metolachlor
carbaryl	metribuzin
carbofuran	mevinphos
carbophenothion (trithion)	mirex
chlordane	monocrotophos (azodrin)
chloropyrifos ethyl	naled
chloropyrifos methyl	norflurazon*
chlorothalonil	oxamyl
delta BHC	paraquat
demeton	parathion ethyl
diazinon	parathion methyl
dicofol (kelthane)	phorate
dieldrin	p,p'-DDD
dimethoate*	p,p'-DDE
diquat	p,p'-DDT
disulfoton	prometryn
diuron	simazine
endosulfan sulfate	toxaphene
endrin	trifluralin
endrin aldehyde	zinc phosphide*

* = Analyzed Only in Surface Water
** = Units are ug/l for water samples and ug/kg for sediment samples

TABLE H.1.3.2.1-3
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
PRIORITY POLLUTANTS ANALYZED IN WATER AND SEDIMENT*

Base Neutral and Acid Extractable Compounds	
acenaphthene	Hexachlorobenzene
acenaphthylene	Hexachlorobutadiene
anthracene	Hexachloroethane
benzo(a)anthracene	indeno(1,2,3-cd)pyrene
benzo(b)fluoranthene	isophorone
benzo(k)fluoranthene	naphthalene
benzo(a)pyrene	nitrobenzene
benzo(g,h,i)perylene	n-nitrosodi-n-propylamine
bis(2-chloroethyl)ether	phenanthrene
bis(2-chloroethoxy)methane	pyrene
bis(2-ethylhexyl)phthalate	1,2,4-trichlorobenzene
bis(2-chloroisopropyl)ether	4-chloro-3-methylphenol
4-bromophenyl-phenyl-ether	2-chlorophenol
2-chloronaphthalene	2,4-dichlorophenol
4-chlorophenyl-phenyl ether	2,4-dimethylphenol
chrysene	2,4-dinitrophenol
dibenz(a,h)anthracene	2-methyl-4,6-dinitrophenol
di-n-butylphthalate	2-nitrophenol
1,3-dichlorobenzene	4-nitrophenol
1,2-dichlorobenzene	pentachlorophenol
1,4-dichlorobenzene	phenol
3,3'-dichlorobenzidine	2,4,6-trichlorophenol
diethyl phthalate	benzidine
dimethyl phthalate	hexachlorocyclopentadiene
2,4-dinitrotoluene	n-nitrosodimethylamine
2,6-dinitrotoluene	n-nitrosodiphenylamine
di-n-octylphthalate	1,2-diphenylhydrazine
fluoranthene	2,3,7,8-TCDD
fluorene	
Organochlorine Pesticides and PCB's	
aldrin	PCB-1221
beta BHC	PCB-1232
delta BHC	PCB-1242
chlordane	PCB-1248
p,p'-DDD	PCB-1254
p,p'-DDE	PCB-1260
p,p'-DDT	Toxaphene
dieldrin	Endrin
endosulfan sulfate	alpha BHC
endrin aldehyde	gamma BHC
heptachlor	endosulfan alpha (I)
heptachlor epoxide	endosulfan beta (II)
PCB-1016	

* = Units are ug/l for water samples and ug/kg for sediment samples

TABLE 3(Continued)

PRIORITY POLLUTANTS ANALYZED IN WATER AND SEDIMENT*

Purgeables	
acrolein	1,1-dichloroethene
acrylonitrile	trans-1,2-dichloroethylene
benzene	1,2-dichloropropane
bromodichloromethane	cis-1,3-dichloropropene
bromoform	trans-1,3-dichloropropene
bromomethane	ethyl benzene
carbon tetrachloride	methylene chloride
chlorobenzene	1,1,2,2-tetrachloroethane
chloroethane	tetrachloroethylene
2-chloroethylvinyl ether	toluene
chloroform	1,1,1-trichloroethane
chloromethane	1,1,2-trichloroethane
dibromochloromethane	trichloroethene
1,2-dichlorobenzene	trichlorofluoromethane
1,3-dichlorobenzene	vinyl chloride
1,4-dichlorobenzene	cis-1,2-dichloroethylene
1,1-dichloroethane	o-chlorotoluene
1,2-dichloroethane	

Metals
Mercury
Antimony
Beryllium
Chromium
Copper
Nickel
Zinc
Aluminum
Iron
Arsenic
Cadmium
Lead
Selenium
Silver
Thallium
Total Organic Carbon **
Particle Size **
CaCO3 analysis **

* = Units are ug/l for water samples and ug/kg for sediment samples
** = Analyzed for only in sediment samples.

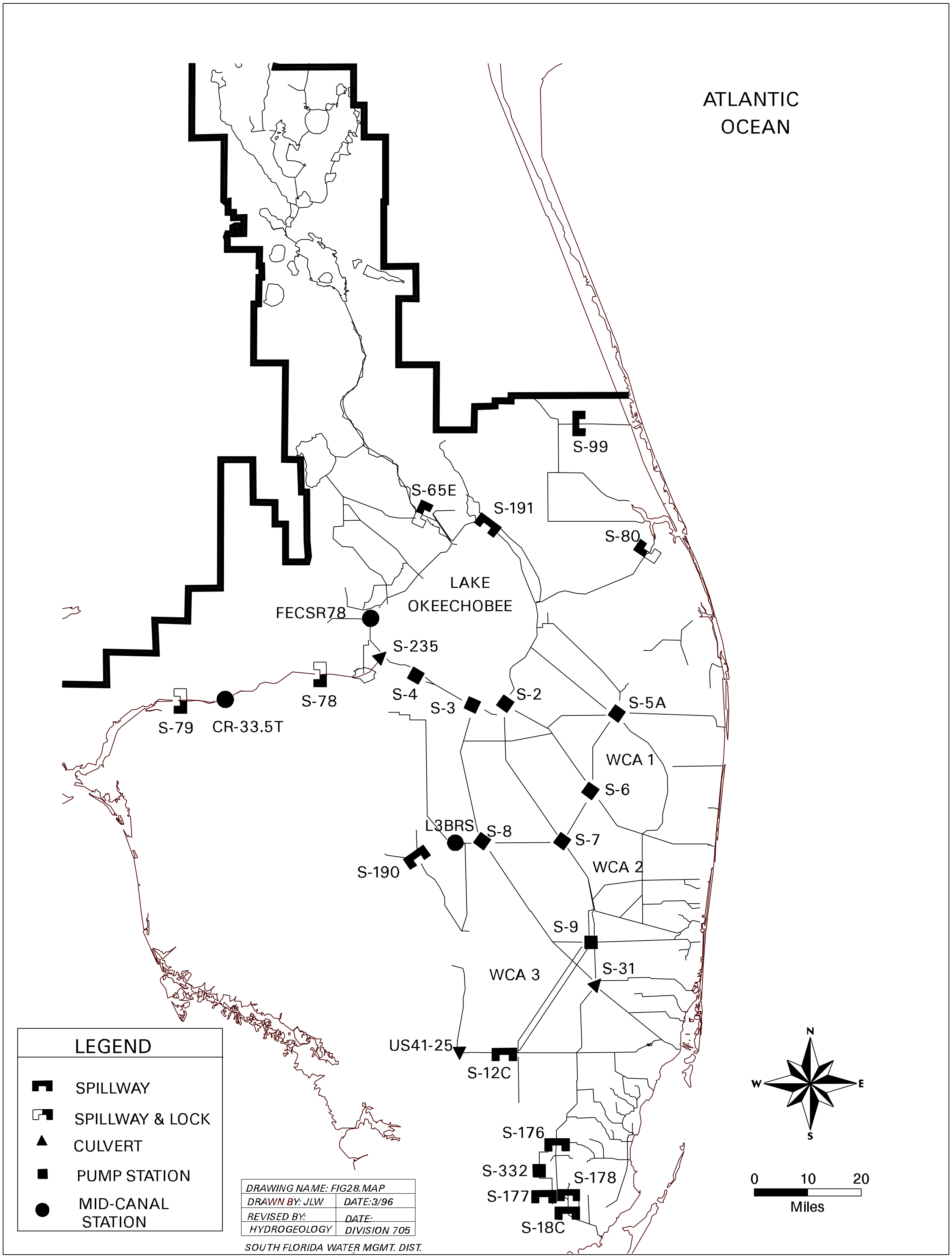
The 40 individual monitoring programs are grouped together under 24 main networks with 22 geographic areas and two (pesticide and atmospheric deposition) District-wide monitoring programs. The 24 geographic networks are (excerpted: SFWMD, 1998a):

1. Upper Kissimmee Chain of Lakes and Tributaries
    a. Upper Kissimmee River Chain of Lakes
    b. Tributaries of the Upper Kissimmee
2. Kissimmee River
    a. Kissimmee River
    b. Tributaries of the Kissimmee River
3. Arbuckle Creek
4. Lake Istokpoga
5. Lower Kissimmee River Basin
6. Taylor Creek/Nubbin Slough
7. Indian River Lagoon
8. St. Lucie Estuary
9. Upper and Lower East Coast
10. Works of the District Compliance Monitoring
11. Lake Okeechobee
    a. Inflows and Outflows
    b. Limnetic and Littoral Zones
12. Caloosahatchee River
13. Everglades Nutrient Removal
14. Holey Land
    a. Permitted Inflows and Outflows
    b. Interior Marsh Sites
15. Everglades Protection Area
16. Big Cypress Seminole Indian Reservation
17. Water Conservation Areas Inflows and Outflows
18. Biscayne Bay Monitoring
19. Everglades National Park
    a. Inflows and Outflows
    b. Interior Monitoring
20. Routine Pesticide Monitoring Network
21. Precipitation Monitoring Network
22. Manatee Bay/Long Sound
23. South Florida Estuarine Monitoring Network
24. Big Cypress National Preserve

The locations of sampling sites within most of these networks are depicted in Figures D-1 through D-28 in Attachment D. In addition, the two District-wide monitoring programs (the Routine Pesticide Water and Sediment Monitoring Program and the Atmospheric Deposition Monitoring Program) are discussed below.

The SFWMD Routine Pesticide Water and Sediment Monitoring Program is depicted in ***Figure H.1.3.2.1-2***. As discussed in Section H.1.5.2.1.3.2, the only long-term pesticide monitoring in the C&SF Restudy project area is being conducted by the SFWMD (R. Pfeuffer: SFWMD, 1998 personal communication). The District has maintained a pesticide monitoring program in South Florida since 1984. The pesticide monitoring network includes sites designated in the Everglades National Park Memorandum of Agreement, the Miccosukee Tribe Memorandum of Agreement, the Lake Okeechobee Operating Permit, and the Non-ECP Structure Permit. The monitoring provides data to determine the condition or changes in the quality of water being delivered to Lake Okeechobee, ENP, the WCAs, and Florida Bay. Additional pesticide residue data are collected to determine water quality conditions at the major water control structures throughout the District. The data collected for each sampling event provide information on potential short-term, acute environmental effects for any of the compounds detected. An indication of possible fish toxicity, bioaccumulation for wildlife, or human health impacts can also be inferred from the data. The program has been dynamic over time, as concerns arise about pesticide use within the District, to accommodate sampling for new pesticides and the addition of sampling sites to the network. The current monitoring program consists of analyses for 66 pesticides at 37 sites within District boundaries. This set of compounds includes chemicals currently utilized in the associated agricultural areas, chemicals regulated by Florida's Surface Water Quality Standards (F.A.C. 62-302), and restricted-use pesticides.

The SFWMD also maintains a District-wide Atmospheric Deposition Monitoring Program. This program is related to water quality given the air deposition of mercury and other contaminants in South Florida on waterbodies and upland areas prone to storm water runoff. The location of sampling stations for this program are presented in ***Figure H.1.3.2.1-3***.



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S-99
S-65E
S-191
S-80
LAKE
OKEECHOBEE
FECSR78
S-235
S-78
S-79
CR-33.5T
S-4
S-3
S-2
S-5A
WCA 1
S-6
L3BRS
S-8
S-7
S-190
WCA 2
S-9
S-31
WCA 3
US41-25
S-12C
S-176
S-332
S-178
S-177
S-18C
LEGEND
SPILLWAY
SPILLWAY & LOCK
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DIVISION 705
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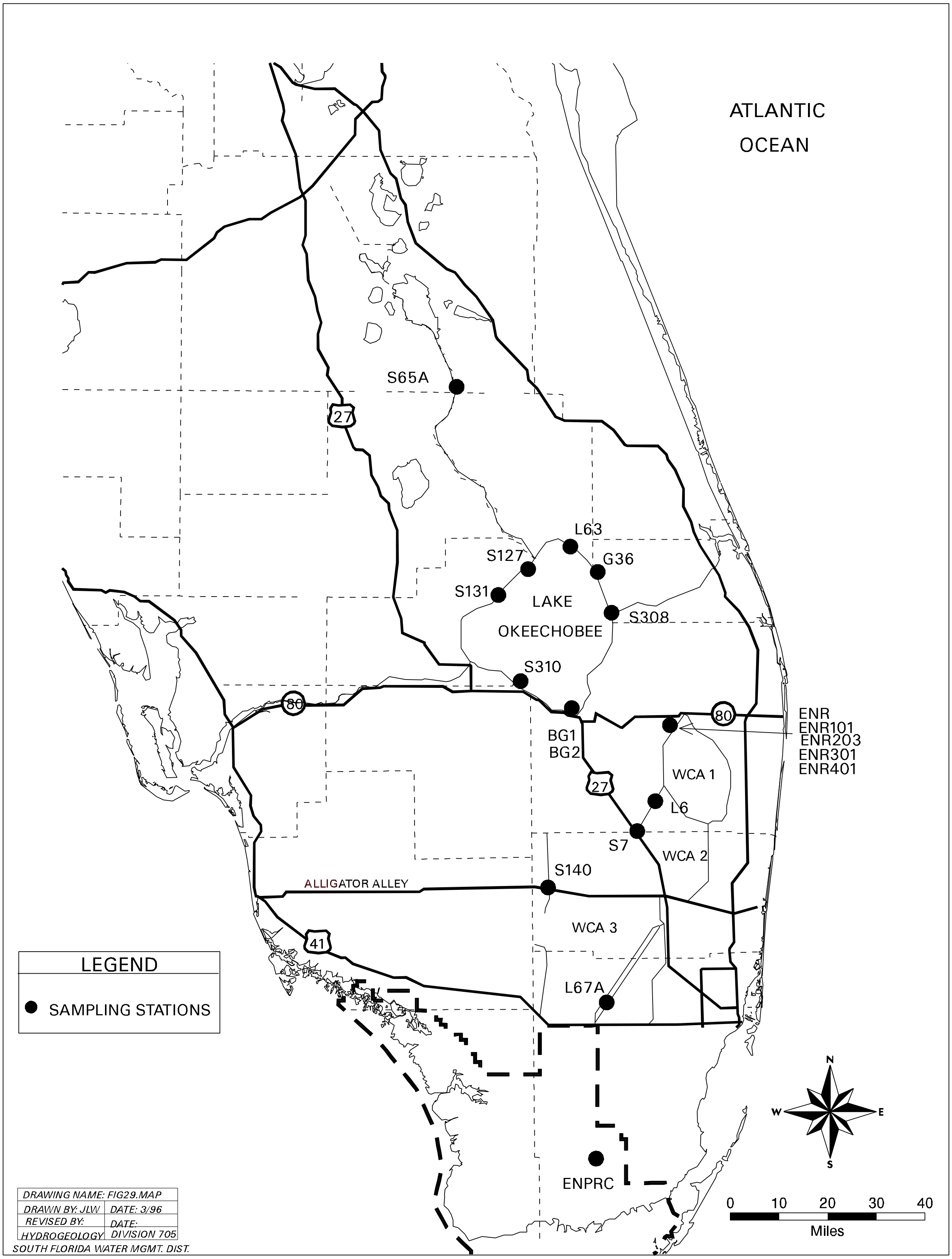

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ENR101
ENR203
ENR301
ENR401
BG1
BG2
WCA 1
27
L6
S7
WCA 2
S140
ALLIGATOR ALLEY
WCA 3
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SOUTH FLORIDA WATER MGMT. DIST.

H.1.2.5.2 Ground Water

In 1983, the Florida Legislature passed the Water Quality Assurance Act, a portion of which required the FDEP to "establish a ground water quality monitoring network designed to detect or predict contamination of the state's ground water resources" (Florida Statutes, Chapter 403.063). To facilitate this effort, the act requires that the FDEP work cooperatively with other federal and state agencies, including the five Water Management Districts and other government agencies in the establishment of the network.

The goal of the Ground Water Quality Monitoring Network (GWQMN) is to provide scientifically defensible, statewide information on the important chemical and physical characteristics of water from the three major aquifer systems of the State. The objectives of the program are (excerpted: FDEP 1998: internet):

- To establish the baseline water quality of major aquifer systems in the state
- To determine significant trends in ground water quality
- To detect and predict changes in ground water quality resulting from the effects of various land use activities and potential sources of contamination
- To disseminate to the Department, local governments and the public, water quality data and interpretations generated by the network.

FDEP is the lead agency in the network, determining goals and strategies, setting priorities and coordinating the effort. Contracts were developed with the five Water Management Districts and other government agencies to carry out most of the necessary field work. The network consists of two major sub-networks, each of which has unique monitoring priorities and goals. These are (excerpted: FDEP, 1998: internet):

- Background Network - designed to help define background water quality through a network of approximately 1700 wells that tap all major potable aquifers within the state;
- VISA (Very Intense Study Area) Network - designed to monitor the effects of various land uses on ground water quality within aquifers in selected areas.

The Background Network is designed to help define background water quality through a network of over 1,700 wells that tap the three aquifer systems in the state. The first sampling of each well in the network involves the measurement of a comprehensive set of field and chemical parameters. These analyses, combined with historical data, can be used to estimate background ground-water quality. In this case, background water quality refers to water quality in an area of the aquifer which is representative of the general ground-water quality of the region, and is not designed to be associated with degradation from contamination sources.

After the initial samples are collected and analyzed, background monitoring wells are periodically sampled for a standard list of aquifer characterizing parameters, as well as an extended group or series of parameters, that can act as indicators of contamination or degradation. These extended parameter groups are pesticides, trace metals, volatile organic compounds (VOCs), and base neutral acid extractables (BNAs).

H.1.3 REGIONAL WATER QUALITY PARAMETERS AND POLLUTANTS OF CONCERN

H.1.3.1 Listing of General Regional Parameters of Concern

A suite of water quality parameters of concern in the study area was identified in Section H.1.1. These metal, nutrient, biological, physical, and other water quality parameters are listed in Table H.1.4.1-1. This table further presents USEPA and/or State of Florida acute and/or chronic criteria for freshwater and/or saltwater aquatic life for several of the suite of water quality parameters of concern. The State of Florida criterion was listed in the absence of a USEPA aquatic criterion or if the State of Florida criterion was more stringent than the USEPA criterion. In addition, USEPA human health risk criteria are also presented for some parameters. The table was developed from updates of USEPA (1986) and also references the State of Florida F.A.C. 62-302 for State pesticide criteria.

With the exception of the mercury, phosphorus, and pesticides parameters which are described below, the rest of the suite of water quality parameters area also listed in ***Table H.1.4.1-1*** (plus the terms "bioaccumulation" and "biomagnification") and are described in detail in Attachment A.

H.1.3.2 Description of Major Regional Parameters of Concern

Mercury, phosphorous, and pesticides are considered three of the most important water quality parameters in the region. They are described below in detail.

Table H.1.4.1-1.

Water Quality Parameters of Concern for the Ten South Florida Regions in the Study Area of the C&SF Restudy Project, Showing USEPA and/or State of Florida Aquatic Life Criteria and/or USEPA Human Health Risk Criteria (Modified From Updates of USEPA, 1986)

Parameters	Units	Freshwater Aquatic Life Acute Toxicity	Freshwater Aquatic Life Chronic Toxicity	Saltwater Aquatic Life Acute Toxicity	Saltwater Aquatic Life Chronic Toxicity	Human Health Criteria Risk (10^{-6})
METALS						
Mercury (Hg)~TR	µg/L=ppb	2.40	0.012	2.1	0.025T	0.050
Copper (Cu)~TR	µg/L=ppb	9.22*	6.54*	2.9	2.9 (Florida Criterion)	
Cadmium (Cd)~TR	µg/L=ppb	1.79*	0.66*	43	9.3	5 MCL
Lead (Pb) ~TR	µg/L=ppb	33.78*	1.32*	220	5.6 (Florida Criterion)	
Zinc (Zn)~TR	µg/L=ppb	65.04*	58.91*	95	86	
Arsenic (As) III~TR	µg/L=ppb	360	190	69	36	0.018
Tributlytin (TBT)	µg/L=ppb					
PESTICIDES						
DDT DDD DDE	µg/L=ppb	** ** **				0.00059 (Florida Criterion)
Atrazine	µg/L=ppb	**				
Simazine	µg/L=ppb	**				
Ametryn	µg/L=ppb	**				
Endosulfan-a Endosulfan-b	µg/L=ppb	0.22, ** **	0.056	0.034	0.0087	0.93
Ethion	µg/L=ppb	**				
Bromacil	µg/L=ppb	**				
2,4-D	µg/L=ppb	**				
Aldecarb	µg/L=ppb	**				
Fenamiphos	µg/L=ppb	**				
NUTRIENTS						
Phosphorus	µg/L=ppb				0.1	
Nitrite/Nitrate (NO_3-NO_4, or NOx)	mg/L=ppm					10 MCL
Ammonia/Unionized	mg/L=ppm	Varies	0.02			

Parameters	Units	Freshwater Aquatic Life Acute Toxicity	Freshwater Aquatic Life Chronic Toxicity	Saltwater Aquatic Life Acute Toxicity	Saltwater Aquatic Life Chronic Toxicity	Human Health Criteria Risk (10^{-6})
Ammonia (NH_4)		Depending on pH, Temp	(Florida Criterion)			
BIOLOGICALS						
Fecal Coliforms	MPN/100 ml		200 monthly average (Florida Criterion)		200 monthly average (Florida Criterion)	
Chlorophyll-*a*	µg/L=ppb mg/m^3					
PHYSICAL						
Temperature	°C, °F					
Salinity	ppt (=%)					
pH	IU		6.0 - 8.5 (Florida Criterion)		6.5 - 8.5 (Florida Criterion)	
Dissolved Oxygen (DO)	mg/L=ppm		water-body dependent; often avg. 5 mg/L, 4 mg/L min (Florida Criterion)		water-body dependent; often avg. 5 mg/L, 4 mg/L min (Florida Criterion)	
Conductivity	µmho/cm		50% above background or 1275; whichever is greater (Florida Criterion)		50% above background or 1275; whichever is greater (Florida Criterion)	
Turbidity	NTU		29 above background (Florida Criterion)		29 above background (Florida Criterion)	
Oil & Grease	mg/L=ppm		5.0 (mg/L) (Florida Criterion)		5.0 (mg/L) (Florida Criterion)	
OTHER						
Polycyclic Aromatic Hydrocarbons (PAHs)	µg/L=ppb					0.03, annual avg. (Florida Criterion)
Dioxin (TCDD)	µg/L=ppb					0.000000013 (Florida Criterion)
Furans	µg/L=ppb					
Sulfate	mg/L=ppm					
Chloride	mg/L=ppm	860000	23000			
Polychlorinated Biphenyls (PCBs)	µg/ L=ppb					0.000045 (Florida Criterion)
Volatile Organic	µg/L=ppb					

Parameters	Units	Freshwater Aquatic Life Acute Toxicity	Freshwater Aquatic Life Chronic Toxicity	Saltwater Aquatic Life Acute Toxicity	Saltwater Aquatic Life Chronic Toxicity	Human Health Criteria Risk (10^{-6})
Carbons (VOCs)						

MCL	=	Maximum Contaminant Level	ppq	=	Parts Per Quadrillion	mg/L	=	Milligrams Per Liter
IU	=	International Units	ppb	=	Parts Per Billion	µg/L	=	Micrograms Per Liter
NTU	=	Nephelometric Turbidity Units	ppm	=	Parts Per Million	*	=	Based on 100 mg/L hardness
MPN	=	Most Probable Number	ppt	=	Parts Per Thousand	III	=	Valence of +3

** = State aquatic life criterion for a specific pesticide may be determined (numeric criterion) from F.A.C. 62-302 or calculated using procedures in F.A.C. 62-302.200.

H.1.3.2.1 Mercury

Mercury cycles between the atmosphere, land and water undergoing a series of complex chemical and physical transformations. These scientific issues were addressed in the *Mercury Study Report to Congress* (USEPA, 1997) which provided the following summary (excerpted):

> *Mercury cycles in the environment as a result of natural and human activities. The amount of mercury released into the biosphere has increased since the beginning of the industrial age. Most of the mercury in the atmosphere is elemental mercury vapor, which circulates in the atmosphere for up to a year, and hence can be widely dispersed and transported thousands of miles from likely sources of emission. Most of the mercury in water, soil, sediments or plants and animals is in the form of inorganic mercury salts and organic mercury (e.g. methylmercury). The inorganic form of mercury, when either bound to airborne particles or in a gaseous form, is readily removed from the atmosphere by precipitation and is also dry deposited. As it cycles between the atmosphere, land, and water, mercury undergoes a series of complex chemical and physical transformations, many of which are not completely understood.*
>
> *Mercury accumulates most efficiently in the aquatic food web. Predatory organisms at the top of the food web generally have higher mercury concentrations. Nearly all of the mercury that accumulates in fish tissue is methylmercury.*
>
> *Fish consumption dominates the pathway from human and wildlife exposure to methylmercury. The Mercury Report to Congress (USEPA, 1997) supports a plausible link between anthropogenic releases of mercury from industrial and combustion sources in the United States and methylmercury in fish. However, these fish methylmercury concentrations also result from existing background concentrations of mercury (which may consist of mercury from natural sources, as well as*

mercury which has been re-emitted from the oceans or soils) and deposition from the global reservoir (which includes mercury emitted by other countries). Given the current scientific understanding of the environmental fate and transport of this element, it is not possible to quantify how much of the methylmercury in fish consumed by the U.S. population is contributed by U.S. emissions relative to other sources of mercury (such as natural sources and re-emissions from the global pool).

The typical U.S. consumer eating fish from restaurants and grocery stores is not in danger of consuming harmful levels of methylmercury from fish and is not advised to limit fish consumption. The levels of methylmercury found in the most frequently consumed commercial fish are low, especially compared to levels that might be found in some non-commercial fish from fresh water bodies that have been affected by mercury pollution. While most U.S. consumers need not be concerned about their exposure to methylmercury, some exposures may be of concern. Those who regularly and frequently consume large amounts of fish -- either marine species that typically have much higher levels of methylmercury than the rest of seafood, or freshwater fish that have been affected by mercury pollution -- are more highly exposed. Because the developing fetus may be the most sensitive to the effects from methylmercury, women of child-bearing age are regarded as the population of greatest interest.

Cost-effective opportunities to deal with mercury during the product life-cycle, rather than just at the point of disposal, need to be pursued. A balanced strategy which integrates end-of-pipe control technologies with material substitution and separation, design-for-environment, and fundamental process change approaches is needed. In addition, international efforts to reduce mercury emissions as well as greenhouse gases will play an important role in reducing inputs to the global reservoir of mercury.

Description

Mercury in South Florida

Since the initial detection of elevated levels of mercury in freshwater fish in 1989 (Ware *et al.*, 1990), it has become increasingly apparent that South Florida has an extensive mercury contamination problem. The State of Florida has issued human health fish consumption advisories due to mercury contamination that either ban or restrict the consumption of largemouth bass and other freshwater species from over two million acres encompassing the Everglades and Big Cypress

National Preserve. The maximum concentrations found in largemouth bass (4.4 mg/kg) and bowfin (over 7 mg/kg) collected from the Everglades are the highest concentrations found in Florida to date. Mercury contamination has also been found at levels of concern in largemouth bass throughout Florida's surface waters (Lange *et al*., 1993). Mercury accumulation through the food web may reduce the breeding success of wading birds (Frederick and Spalding, 1994) and the viability of the endangered Florida panther (Roelke *et al*., 1991). For additional background information on the mercury issue affecting the Everglades, USACE (1996) may be referenced.

The sources, distribution, magnitude, transport, transformations and pathways of mercury through the Everglades ecosystem are poorly understood. Among the possible mercury sources in South Florida are natural mineral and peat deposits (Rood *et al*., 1995), and atmospheric deposition from global, regional and local (e.g., fossil-fuel-fired electrical generating plants, municipal waste incinerators, and medical waste incinerators) sources. Although there are multiple interactions among these sources and several possible pathways for mercury transport and bioaccumulation through the Everglades ecosystem, none of these individual sources appear to adequately explain the vast area of contamination.

The issues of mercury contamination of Everglades biota are extremely complex. Various hypotheses have been put forward to account for the apparent susceptibility of the Everglades to mercury impacts, including:

- High historical accumulations of readily methylatable mercuric ion in the downstream sediment attributable to the historical oxidation of peat in the EAA;
- A high mobilization rate of readily methylatable mercuric ion from the sediment associated with the dry-wet cycles in the EAA and some locations in the WCAs;
- A high atmospheric deposition flux of methylatable mercuric ion from local, regional, and global sources;
- A high rate of net methylation of mercuric ion associated with high concentrations of conducive factors in water and sediment pore water;
- A high bioavailable fraction of methyl mercuric ion;
- The absence of a freeze-thaw cycle and high average annual temperatures that accelerate aquatic metabolic processes;
- High bioaccumulation and biomagnification factors resulting from the complex aquatic and terrestrial food webs;
- The interaction of mercury methylation and bioaccumulation with water quality gradients in total phosphorus, total organic carbon and sulfate; or
- Combinations of the above.

Each of these hypotheses is the subject of intensive scientific investigation under the multi-agency South Florida Mercury Science Program (SFMSP, 1996). In order to guide the development of this integrated scientific approach for understanding mercury contamination in the South Florida ecosystem, USEPA Region 4 developed seven policy-relevant assessment questions to be addressed by the SFMSP (USEPA, 1993; 1996a; 1998: draft):

(1) Magnitude - What is the magnitude of the problem(s) in the Everglades?
(2) Extent - What is the extent of the problem(s)?
(3) Trend - Is the problem(s) getting better, worse, or staying the same?
(4) Cause - What factors are associated with or causing the problem(s)?
(5) Source -What are the sources contributing to the causes and what is the importance of different sources to the problem(s)?
(6) Risk - What are the risks to different ecological systems and species from the stressors or factors causing the problem)s)?
(7) Solutions - What management alternatives are available to ameliorate or eliminate the problem(s)?

Understanding South Florida mercury risks, sources and bioaccumulation, and identifying management appropriate actions has been the subject of an extensive interagency scientific effort (USEPA, 1996a; USGS, 1996c).

Potential Sources and Transport Pathways of Mercury to the Everglades

The sources, distribution, and pathways of transport and transformation of mercury through the South Florida ecosystem are beginning to be understood. Mercury has been sequestered in the vast deposit of oligotrophic, circumneutral Everglades peat over its approximately 5,000 years of natural accumulation. Oxidation and subsidence of these soils following drainage, perhaps enhanced by agricultural cultivation and fertilization, maybe mobilizing this geochemical mercury reservoir. The thousands of miles of man-made canals in the Everglades, with their typically low oxygen concentrations, may provide a primary locale for methylation of mercury and serve as a conduit for its transport through the system in a dissolved form or in association with organic matter. Possible external mercury sources include atmospheric deposition from global background; and deposition resulting from local atmospheric emissions such as fossil-fuel electric power plants, waste incinerators, and paint and agricultural operations.

It is believed that there are six primary transport pathways of mercury species and biogeochemical factors in the Everglades system that warrant consideration in the initial conceptual model of mercury transport:

(1) direct wet and dry atmospheric deposition of soluble and particle-bound mercury species;
(2) exchange of mercury vapor across the air:water interface with and without plant-mediated transport;
(3) plant-mediated mercury vapor deposition;
(4) canal transport of Lake Okeechobee releases and EAA storm water runoff;
(5) ground-water transport of Lake Okeechobee, EAA, and WCA seepage to interior marsh discharge zones;
(6) release from the sediment reservoir.

Atmospheric Deposition

Significant quantities of mercury cycle through air, water and solid phases of the global environment. Mercury cycling through the atmosphere is estimated at about 6 million kilograms/year (Fitzgerald 1986, 1989; Porcella *et al.*, 1992), and additional research indicates that this amount has increased at about 1.5 percent per year over the North Atlantic Ocean (Slemr and Langer, 1992). Deposition of atmospheric mercury has increased since 1850 in lake sediments taken in mid-continental North America (Swain *et al.*, 1992). The rate closely parallels that documented for greenhouse gases, which suggests dependence of both quantities on industrial inputs. Within this global background, regional areas exist which may exhibit higher atmospheric concentrations due to the proximity of urban or industrial activity. The entire southeast coast of Florida is an urban area inhabited by about 6 million people. The operation of solid waste incinerators and fossil-fuel power plants has increased significantly since 1940 (Newman, 1992), presenting the prospect that regional atmospheric mercury might have increased similarly over this same time period.

The predominant wind directions in southeast Florida are from the east-southeast, which cause air masses to be transported from above the Atlantic Ocean, westward over the urban area and across the Everglades. There are many mercury emission sources in the urban areas along the east coast. Mercury is emitted into the atmosphere as a mixture of gases and particulates. As the mercury from individual sources mixes together, the mass of air containing mercury may be transported over the Everglades where it is then potentially deposited through a variety of mechanisms. The most likely mechanism is through wet deposition, with the mercury being washed out by rainfall. The other mechanisms are dry deposition with particulates dropping into the Everglades and gaseous mercury coming into contact with the water or vegetation. The speciation of mercury emissions from local sources and atmospheric chemistry, must be evaluated to determine the depositional contributions to the Everglades ecosystem. The atmospheric mercury flux was monitored across the South Florida peninsula by the Florida Atmospheric Mercury Study (FAMS). The emissions from three atmospheric point sources located in the urban area (municipal waste incinerator, medical waste incinerator and a coal-fired cement kiln) were monitored and modeled by the South Florida Atmospheric Mercury Monitoring Pilot Study (SOFAMMS).

A summary of the general findings of the FAMS, SOFAMMS, and other atmospheric studies are listed below.

- The average annual mercury emissions for South Florida (0.48 kg/m^2/yr) are three times higher than the state average (KBN, 1992; Baker and Roberson, 1994; KBN, 1994).
- Mercury in precipitation in South Florida is twice as high as in other rural areas of North America (W. Landing: Florida State University (FSU), 1995 personal communication).
- Point source monitoring in the urban area showed mercury concentrations in rain at three to five times levels found in industrial areas near the Great Lakes (Dvonch *et al*., 1995).
- Local sources in the urban area are emitting mercury primarily as ionic mercury. In this form, the mercury is capable of rapid deposition to nearby areas (J. Keeler, University of Michigan, 1997 personal communication).
- The contribution from local anthropogenic sources of mercury in wet deposition into the Everglades has been estimated to range from 30 percent (W. Landing: FSU, 1997 personal communication) to 100 +/- 18 (Dvonch, 1998) percent.

Using the mean annual rainfall rate for the Everglades of 53 inches (SFWMD, 1992) and a volume- and spatially-weighted average total mercury concentration in Everglades rainfall of about 13 micrograms/cubic meter (J. Guentzel: FSU, 1995 personal communication), it can be calculated that about 150 kg per year of mercury are being deposited by rainfall for the remnant Everglades. Dustfall would further contribute to mercury atmospheric deposition.

Water Discharge From the Everglades Agricultural Area

Surface flow of water may be an important transport mechanism which moves sediment, phosphorus, and inorganic and organic mercury off the EAA via canals to the downstream WCA and the ENP. Mercury loading to the public Everglades was estimated from bi-weekly monitoring of water samples that were collected at S-5, S-6, S-7 and S-8; the structures bordering the EAA; during 1994, 1995, and 1996 (USEPA, 1998: draft). Sampling at these four structures was used to estimate the mass transport of mercury through the canal system from the EAA to the publicly-owned system downstream. The loading of total mercury in the water flowing south through the structures was estimated at 0.5 to 0.6 kg during the dry season and 1.3 to 2.7 kg during the wet season. Annual estimates of total mercury loadings from the EAA ranged from 1.8 to 3.3 kg/yr. Estimates of the loading of methylmercury flowing through the structures was 0.1 to 0.2 kg during the dry season and 0.2 to 0.4 kg during the wet season. Annual estimates of methylmercury loading from the EAA ranged from 0.3 to 0.6 kg/yr. Potential mercury transport through levee seepage, ground-water movement, or particle transport has not been assessed; however, it is clear that water transport of mercury from the EAA into the public Everglades is much less significant than that deposited from the air.

Water Quality Patterns

The methylation of inorganic mercury to its bioaccumulated form methylmercury occurs under a unique set of environmental conditions. These conditions include anoxia (Matilianen, 1995), moderate sulfate concentrations (Gilmour *et al*., 1993), moderate dissolved organic carbon concentrations (Driscoll *et al*., 1995; 1997), and low pH and/or alkalinity concentrations (Rudd 1995; Rudd *et al*., 1997). In general, oligotrophic, rather than eutrophic, aquatic ecosystems have mercury contamination problems. Wetlands are particularly conducive to mercury methylation (Rudd *et al*., 1997; Zillioux *et al*., 1993). In general, southern and southeastern aquatic ecosystems under fish consumption advisories have these water quality characteristics (Southern States Mercury Task Force, 1997). The FDEP, SFWMD, USEPA and USGS, along with other agencies and universities, have been and are continuing to actively study the South Florida mercury contamination problem. USEPA (1996a; 1998: draft) has been monitoring mercury conditions throughout the Everglades and Big Cypress in fish, water, soil, and periphyton. The USGS has been conducting extensive Everglades mercury geochemical cycling research, including work on methylmercury degradation, carbon-mercury interactions, sulfur cycling, mercury accumulation and processes in peat, and biological mercury uptake (USGS, 1996c). The SFWMD has been investigating mercury behavior in the Everglades Nutrient Removal (ENR) Project, a research project similar to the STAs, constructed and managed to remove phosphorus.

Mercury Measurement

Due to the extremely low ultra trace levels of total mercury (THg) and methylmercury (MeHg) occurring in water, clean sampling and analytical techniques must be used to make valid measurements. Total and methylmercury concentrations in water are reported in nanograms per liter (ng/L, which equates to parts per trillion: ppt). Total and methylmercury concentrations in soil and periphyton are reported in g/kg (parts per thousand: ppt). Tissue concentrations of total mercury in mosquitofish are reported in µg/kg (ppb) while largemouth bass and other top aquatic predators are reported in mg/kg (parts per million: ppm) indicating the extremely efficient bioaccumulation of mercury up the aquatic food chain.

H.1.3.2.2 Phosphorus

Phosphorus is a nutrient that often controls primary productivity in aquatic systems. It occurs naturally in water bodies throughout the world. Elevated phosphorus loading to water bodies often results in biological changes. These effects may include increased primary productivity, loss of water column dissolved oxygen, algal blooms, and changes in biodiversity. This may result in the loss of a water body's usefulness for recreation or as habitat for wildlife.

Description

Phosphorus exists in a dissolved or solid state. The source and ultimate depository for it is in sediments. Water concentrations are reported in milligrams per liter (mg/L), which equates to parts per million (ppm), or micrograms per liter (µg/L), which equates to parts per billion (ppb). Unpolluted fresh waters tend to be relatively low in total phosphorus with almost no detectable inorganic phosphorus. For example, in unimpacted Everglades wetlands, the long-term surface water total phosphorus concentration has an average of 10 µg/L or less (Walker, 1995). Phosphorus has been identified as a primary cause of eutrophication and in recent years has been the focus of intense management efforts. Natural sources of phosphorus to surface waters include wet and dry atmospheric deposition and ground water. Excess phosphorus enters natural systems as a result of many human activities, with runoff (urban, agriculture, construction, development), sewage, and sewage treatment effluents being chief among them. At this time, there are no Florida numeric water quality standards for phosphorus.

H.1.3.2.3 Pesticides

Florida's economy is anchored to a large extent on the year-round growing season that allows agriculture to flourish. A key to agricultural success is the ability to protect the agricultural crop from pests such as insects, weeds, fungi, bacteria, etc. through the use of pesticides. In addition to the use of pesticides to control agricultural pests, Florida also uses pesticides to battle the aquatic weed problem which is so pervasive in Florida waterways. Movement of surface water and use of these waters could be severely impacted, were it not for the use of aquatic herbicides. Another key use of pesticides in Florida involves mosquito control—both for nuisance and public health. Mosquito control districts in Florida utilize both larvacides and adulticides to control this pest, which is so prevalent in the state. Application of these pesticides may be either by ground or air and are many times adjacent to centers of high population as well as sensitive environments where the mosquito is breeding. Lastly, it should be remembered that Florida's population and its tourism industry has grown tremendously over the recent years.

Many of the attractions (e.g., theme parks, golf courses) rely on pesticides to ensure that these properties do not succumb to pests that are pervasive in the Florida climate and thus remain attractive to residents and visitors.

Pesticides are registered by the USEPA after extensive testing results have been submitted by the registrant regarding impacts on human health and the environment. Once registered by the USEPA, a pesticide must be used in accordance with the registered label, as prescribed by the USEPA. When used in accordance with the label directions, the USEPA does not expect that any unreasonable adverse effects on either human health or the environment will occur. This does not mean, however, that adverse effects do not happen. The USEPA has a requirement that registrants must report these adverse effects to the Agency so determinations about future registration and/or labeling requirements can be made.

An extensive array of pesticides is being applied to (or persists in) South Florida waters, sediments and/or soils. These pesticides include those in the following sections.

Description

DDT and Derivatives

DDT (dichlorodiphenyltrichloroethane) is no longer registered for use in the United States, although it is still used in other (primarily tropical) countries. It is in USEPA Toxicity Class II. It is moderately toxic and was banned from use in the United States in 1972, barring a public health emergency (e.g., outbreak of malaria).

DDT is an organochlorine insecticide used mainly to control mosquito-borne malaria; use on crops has generally been replaced by less persistent insecticides. It was extensively used during the Second World War among Allied troops and certain civilian populations to control insect typhus and malaria vectors. It was extensively used as an agricultural insecticide after 1945. DDT was banned for use in Sweden in 1970 and in the United States in 1972.

Technical grade DDT is actually a mixture of three isomers of DDT, principally the p,p'-DDT isomer (ca. 85%), with the o,p'-DDT and o,o'-DDT isomers typically present in much lesser amounts.

DDT may be slightly toxic to practically non-toxic to birds. In birds, exposure to DDT occurs mainly through the food web through predation on aquatic and/or terrestrial species having body burdens of DDT, such as fish, earthworms and other birds.

There has been much concern over chronic exposure of bird species to DDT and effects on reproduction, especially eggshell thinning and embryo deaths. The mechanisms of eggshell thinning are not fully understood. It is thought that this may occur from the major metabolite, DDE, and that predator species of birds are the most sensitive to these effects.

DDT is very highly toxic to many aquatic invertebrate species as well as to fish species. In addition to acute toxic effects, DDT may bioaccumulate significantly in fish and other aquatic species, leading to long-term exposure. This occurs mainly through uptake from sediment and water into aquatic flora and fauna, and also fish.

The reported bioconcentration factor for DDT is 1,000 to 1,000,000 in various aquatic species. Bioaccumulation may occur in some species at very low environmental concentrations. Bioaccumulation may also result in exposure to species which prey on fish or other aquatic organisms (e.g., birds of prey).

DDT is very highly persistent in the environment, with a reported half-life of between 2-15 years. It is immobile in most soils. Routes of loss and degradation include runoff, volatilization, photolysis and biodegradation (aerobic and anaerobic). Breakdown products in the soil environment are DDE and DDD, which are also highly persistent and have similar chemical and physical properties.

Due to its extremely low solubility in water, DDT will be retained to a greater degree by soils and soil fractions with higher proportions of soil organic matter. It may accumulate in the top soil layer in situations where heavy applications are (or were) made annually. Generally, DDT is tightly absorbed by soil organic matter, but it (along with its metabolites) has been detected in many locations in soil and ground water where it may be available to organisms. This is probably due to its high persistence. Although it is immobile or only very slightly mobile, over very long periods of time it may be able to eventually leach into ground water, especially in soils with little soil organic matter.

Numerous references searched in 1998 from the web site of the University of Oregon's Extension Toxicology Network (EXTONET, 1998: internet) were used to compile this DDT and derivatives description. These references were: Augustijn-Beckers *et al.* (1994), the Agency for Toxic Substances and Diseases Registry (ATSDR)/U.S. Public Health Service (1994), Meister (1992), the Royal Society of Chemistry Information Services (1991), the World Health Organization (WHO) (1989), USEPA (1989a), Hudson, *et al.* (1984), and Johnson and Finley (1980).

Atrazine

Atrazine is a selective triazine herbicide used to control broadleaf and grassy weeds in corn, sorghum, sugarcane, pineapple, Christmas trees and other crops, and in conifer reforestation plantings. It is also used as a non-selective herbicide on non-cropped industrial lands and on fallow lands. A shelf life of three years can be expected under environmental conditions in unopened, undamaged original containers.

Atrazine is only slightly toxic to birds, fish and other pond or stream life and is noted as being non-toxic to bees.

Atrazine is moderately-to-highly mobile in soils, especially where soils have low clay or organic matter content. Because it does not absorb strongly to soil particles and it has a lengthy soil half-life, it is expected to have a high potential for ground-water contamination, even though it is only moderately soluble in water. Atrazine, however, is not normally found below the first foot of soil, even after years of continuous use.

Atrazine is not very water soluble. Chemical hydrolysis, followed by biodegradation, may be the most important route of disappearance from aquatic environments. Hydrolysis is rapid under acidic or basic conditions, but is slower at neutral pHs. Addition of humic material increases the rate of hydrolysis. Atrazine is not expected to strongly adsorb to sediments.

The Florida Department of Agriculture and Consumer Services (FDACS) is currently reviewing a copy of a registrant's drinking water well survey which encompassed 52 wells in the south Florida area predominated by sugarcane production. The registrant has also supplied FDACS with a report on atrazine in shallow ground water associated with sod production in Florida. This pesticide will be addressed by Florida in the Pesticide State Management Plan (PSMP) as required by the USEPA.

Relevant references for this Atrazine section searched from EXTONET (1998: internet) were Meister (1992), U.S. Department of Agriculture, Soils Conservation Service (USDA/SCS) (1990), Weed Science Society of America (WSSA) (1989), and USEPA (1988a).

Simazine

Simazine is a selective triazine herbicide. It is used to control broad-leaved weeds and annual grasses in field, berry fruit, vegetable and ornamental crops, on turfgrass, and in orchards and vineyards. At higher rates, it is used for nonselective weed control in industrial areas. Before 1992, simazine was used to control submerged weeds and algae in large aquariums, farm ponds, fish hatcheries, swimming pools, ornamental ponds, and cooling towers.

Simazine is persistent and does not adsorb strongly to soil particles (K_{oc} = 138 g/mL). In combination with a lengthy soil half-life, these factors suggest that simazine is likely to contaminate ground water. Its tendency to leach is limited by its low solubility in water (6.2 µg/mL). Simazine is subject to decomposition by ultraviolet radiation, but this effect is small under normal field conditions. Loss from volatilization is also insignificant. In soils, microbial activity probably accounts for decomposition of a significant amount of simazine. Simazine has little if any lateral movement in soil, but can be washed along with soil particles.

The average half-life of simazine in ponds where it has been applied is 30 days, with the actual half life dependent on the level of algae present, the degree of weed infestation, and other factors.

Simazine has been found in surface water in 16 states and in ground water in 8 states. The maximum levels detected were 1,300 µg/L in surface water and 800 µg/L in ground water.

A drinking water well survey of 47 wells was conducted by a registrant and results were provided to FDACS. This pesticide must also be addressed by Florida under the PSMP.

Literature consulted through an EXTONET (1998: internet) search in 1998 to develop this Simazine description was Meister (1992), USDA/SCS (1990), WSSA (1989), and USEPA (1988b).

Ametryn

Ametryn is a selective herbicide used to control annual broadleafs and grassy weeds. Possible crop uses in Florida include grapefruit, orange, sugarcane and corn. This herbicide is a member of the Triazine chemical family and inhibits photosynthesis and other enzymatic processes.

Ametryn is only slightly toxic to birds and bees, moderately toxic to fish and mollusks and highly toxic to crustaceans.

Ametryn's half life in soils is 70 to 250 days, depending on the soil type and weather conditions. Loss from the soil is principally by microbial degradation. Ametryn moves both vertically and laterally in soil due to its high water solubility. Because it is persistent, it may leach as a result of high rainfall, floods, and furrow irrigation.

In a study of surface and ground-water contaminants in the U.S., ametryn was found in six states, in very few surface water samples and in 4% of the ground-water samples. The maximum concentration found was 0.1 µg/L in surface water and 450 µg/L in ground water.

Information for this ametryn summary was compiled from an EXTONET (1998:internet) search in 1998. References used were the Royal Society of Chemistry Information Systems (1994), Meister (1992), Briggs (1992), USEPA (1989b), USEPA (1987a), and Thompson (1982).

Endosulfan Compounds

Endosulfan is a chlorinated hydrocarbon insecticide of the cyclodiene subgroup which acts as a contact poison in a wide variety of insects and mites. It can also be used as a wood preservative. It is used primarily on food crops like tea, fruits, vegetables, and on grains.

The commercial product is made up of a mixture of two separate parts (isomers): the alpha and beta configurations.

Endosulfan does not easily dissolve in water. It does stick to soil particles readily. Transport of this pesticide is most likely to occur if endosulfan is attached to soil particles in surface runoff. Large amounts of endosulfan can be found in surface water near areas of application. It has also been found in surface water throughout the country at very low concentrations and has been detected in the air at minute levels. It is not expected to pose a threat to ground water.

In raw river water at room temperature and exposed to light, both isomers disappeared in four weeks. A breakdown product first appeared within the first week. The breakdown in water is faster (five weeks) under neutral conditions than at more acidic conditions (five months). Under strongly alkaline conditions the half life of the compound is one day.

The two isomers have different degradation times in soil. Under neutral conditions, the half life for the alpha isomer is 35 days, and 150 days for the beta isomer. These two isomers will persist longer under more acidic conditions. The compound is broken down in soil by fungi and by bacteria.

The breakdown product, endosulfan sulfate, has been observed in several field studies involving plants. The sulfate is more persistent than the parent compound, accounting for 90% of the residue in 11 weeks. Sulfate formation increases as temperatures increase. However, sunlight may play a role in the reaction, perhaps in starting the process. On most fruits and vegetables, 50% of the parent residue is lost within three to seven days.

An interagency study, funded by the USEPA, is ongoing in south Miami-Dade county to assess the impact endosulfan might have on local waters. Pesticide detection data collection from monitoring programs and surface water studies is still ongoing. Mitigation strategies, including retrofitting of open irrigation wells, additional monitoring at particular structures where multiple detections have been reported, and minimizing runoff have been addressed. NOAA is also continuing to work on an ecotoxicological assessment of endosulfan and other potential endocrine-disrupting chemicals on living marine resources in Florida Bay (Scott et al. 1994; Scott et al. 1995).

References reviewed through an EXTONET (1998: internet) search in 1998 for the development of this description of endosulfan were Howard (1991), U.S. Department of Health and Human Resources (USHHR) (1990), and the National Research Council Canada (1975).

Ethion

Ethion is an organophosphate pesticide used to kill aphids, mites, scales, thrips, leafhoppers, maggots and foliar feeding larvae. It may be used on a wide variety of food, fiber and ornamental crops, including greenhouse crops, lawns and turf. Ethion is often used on citrus and apples. It is mixed with oil and sprayed on dormant trees to kill eggs and scales. Ethion may also be used on cattle. It is available in dust, emulsifiable concentrate, emulsifiable solution, granular and wettable powder formulations.

Ethion adsorbs strongly to soil particles and it is nearly insoluble in water. It is therefore unlikely to leach or contaminate ground water. In open waters, it is likely to adsorb to suspended particles and bottom sediments.

Ethion is very highly toxic to freshwater and marine fishes and to freshwater invertebrates.

Several references used via an EXTONET (1998: internet) search in 1998 to prepare this description for ethion: Meister (1992), Howard (1991), USDA/SCS (1990), USEPA (1989c), Worthing (1987), Van Driesche (1985), USEPA (1984: unpublished), Hartley and Kidd (1983), and Clayton and Clayton (1981).

Bromacil

Bromacil is one of a group of compounds called substituted uracils. These materials are broad spectrum herbicides used for nonselective weed and brush control on non-cropland; as well as for selective weed control on a limited number of crops, such as citrus fruit and pineapple. The herbicide is preferably sprayed or spread dry on the soil surface just before, or during, a period of active weed growth.

Bromacil binds, or adsorbs, only lightly to soil particles (K_{oc} = 32 g/mL), is soluble in water, and has a relatively lengthy soil half-life (60 days). For these reasons, bromacil is expected to move (leach) quite readily through the soil and it can contaminate ground water. The amount of leaching is dependent on the soil type and the amount of rainfall or irrigation water. The potential for bromacil to leach and contaminate ground water is greatest in sandy soils. In regular soils, it can be expected to leach to a depth of 2-3 ft. Bromacil was found in Florida's ground water at 300 parts per billion (ppb). Bromacil should not be used near drinking water reservoirs or in well recharge areas because of its mobility in soil. Directions and precautions listed on product labels must be followed to minimize potential bromacil movement into ground water.

Studies conducted in 1995 indicated that bromacil was present in wells around the Lake Wells ridge area. Although the detections were less than the guidance concentration, the State promulgated a rule which limited the use of this pesticide in certain areas.

The reference used for this bromacil description accessed through an EXTONET (1998: internet) search in 1998 was USEPA (1988c).

2,4-D

The herbicide 2,4-D is a chlorinated phenoxy compound that functions as a systemic herbicide and is used to control many types of broadleaf weeds. There are many forms or derivatives (esters, amines, salts) of 2,4-D and these vary in solubility and volatility. This compound is used in cultivated agriculture, pasture and rangeland applications, forest management, home and garden situations, and for the control of aquatic vegetation.

The 2,4-D herbicide was a major component (about 50%) of the product *Agent Orange* used extensively throughout Vietnam. However, most of the problems associated with the use of Agent Orange were associated with a contaminant (dioxin) in the 2,4,5-T component of the defoliant. The association of 2,4-D with Agent Orange has prompted a vast amount of study on the herbicide.

The herbicide is slightly toxic to wildfowl. Some formulations of this pesticide may be highly toxic to fish.

Despite its short half life in soil and in aquatic environments, the compound has been detected in ground-water supplies in at least five States and in Canada. It has also been detected in surface waters throughout the U.S. at very low concentrations.

Although recently-manufactured 2,4-D technical acids have consistently been free of dioxin contamination, the amine and ester products may have measurable levels of some forms of dioxin. According to a study of 2,4-D manufactured in Canada, 8 were positive of the 26 amine samples tested. The levels ranged from 5 ppb to nearly 500 ppb. Several different forms of dioxin were present in the different products. All but one of 21 ester samples were positive.

References relevant for this section on 2,4-D were available through an EXTONET (1998: internet) search made in 1998. They were: Howard (1991), USEPA (1987b), and the National Research Council Canada (1978).

Other Pesticides

Arsenic (Pesticides-Derived)

A study is under review by FDACS in which shallow monitor wells at municipal golf courses in Miami-Dade County were tested for pesticides. Thirty wells on five golf courses were sampled. The focus of the study was: fenamifos, metribuzin, MSMA (total arsenic), prodiamine and chlorothanlonil. Samples indicated the presence of arsenic (MSMA) in shallow ground water, with several wells above the draft Mean Contaminant Level (MCL) of 50 µg/L.

Aldicarb

Aldicarb is used as a systemic insecticide, acaricide, and nematicide. It is applied to soils to control insects, mites and nematodes on citrus, cotton, dry beans, peanuts, sorghum, soybeans, and pecans. The registrant, due to monitor well detections, filed a 6(a)(2) report with USEPA in 1996 regarding adverse effects.

Fenamiphos

Fenamiphos is a systemic nematicide used to control the major genera of nematodes attaching many field, vegetable, fruit, turf, and ornamental crops. Elevated levels of fenamiphos sulfoxide led the registrant to submit label changes to USEPA to prohibit use at selected counties in the Central Ridge area of Florida.

H.1.4 GENERAL OVERVIEW OF CURRENT REGIONAL WATER QUALITY CONDITIONS

H.1.4.1 Ground-Water Conditions

H.1.4.1.1 Introduction

Ground water in South Florida consists of the surficial Biscayne aquifer and the Floridan aquifer. Both are critical to the ecology and economy of South Florida.

The Biscayne aquifer has been classified as a Sole Source Aquifer under the Safe Drinking Water Act based on the aquifer's susceptibility to contamination and the fact that it is a principal source of drinking water. The aquifer underlies an area of about 4,000 square miles and is the principal source of water for all of Miami-Dade and Broward Counties and the southeastern part of Palm Beach County in southern Florida. Major population centers that depend on the Biscayne aquifer for water supply include Boca Raton, Pompano Beach, Fort Lauderdale, Hollywood, Hialeah, Miami, Miami Beach and Homestead. The Florida Keys also are supported primarily by water from the Biscayne aquifer that is transported from the mainland by pipeline.

The Biscayne aquifer fluctuates in direct and rapid response to variations in recharge (precipitation), natural discharge, and pumpage from wells. Natural discharge is by seepage into streams, canals, or the ocean, and by evaporation or transpiration by plants.

The Floridan aquifer system is one of the most productive aquifers in the world. The aquifer underlies an area of about 100,000 square miles in southern Alabama, Georgia, South Carolina, and Florida. The Floridan is a multiple-use aquifer system. Where it contains freshwater, it is the principal source of water supply. In several places where the aquifer contains saltwater, such as along the southeastern coast of Florida, treated sewage and industrial wastes are injected into it. Near Orlando, drainage wells are used to divert surface runoff into the Floridan. South of Lake Okeechobee, the aquifer contains saltwater. Some of this saltwater is withdrawn for industrial cooling purposes and some is withdrawn and converted to freshwater by desalinization plants. Desalinization is especially important in the Florida Keys, which have no other source of freshwater except that which is imported by pipeline.

H.1.4.1.2 Ground-Water Contamination

Because the Biscayne aquifer is highly permeable and is at or near the land surface in many locations, it is readily susceptible to ground-water contamination. Because of the high permeability of the aquifer, most contaminants are rapidly flushed. Major sources of contamination are saltwater encroachment and infiltration of contaminants carried in canal water. Additional sources include direct infiltration of contaminants, such as chemicals or pesticides applied to or spilled on the land; or fertilizer carried in surface runoff; leachate from landfills, septic tanks, sewage-plant treatment ponds; and wells used to dispose of storm water runoff or industrial waste. Most disposal wells are completed in aquifers containing saltwater that underlie the Biscayne aquifer, but they are a potential source of contamination where they are improperly constructed. Numerous hazardous waste sites (e.g., Superfund and Resource Conservation and Recovery Act [RCRA] sites) have been identified in the area underlain by the Biscayne aquifer. Remedial action to cleanup existing contamination is underway at many of these sites. Waste management practices at these sites are generally monitored to prevent further contamination.

As indicated above, Superfund sites can contribute to ground-water quality degradation through the leaching of site pollutants into ground water (as well as to surface water quality degradation through storm water runoff). The USEPA has completed environmental evaluations which indicate that 24 sites in the general Restudy area pose environmental threats which warrant inclusion on the National Priorities List (NPL). No additional federal cleanup action is necessary at 295 sites. Evaluations continue to be conducted by the USEPA at an additional 225 sites. The evaluation process includes a ground water component to insure protection of the ground water resources in the southern Florida area. The Superfund Program has made significant progress towards environmental cleanup in South Florida since the creation of the program in 1980.

The majority of the sites in the South Florida area are in Miami-Dade and Broward Counties followed by Polk, Palm Beach and Orange Counties. (Urban areas of these counties are located within regions designated in this PEIS as the “Lower East Coast and Biscayne Bay” region, and the “Kissimmee River Region”.) Miami-Dade and Broward Counties currently have 10 and 7 NPL sites, respectively. Although each site poses unique environmental threats, trichloroethylene (TCE) and vinyl chloride are generally identified as contaminants of concern in ground water at these sites. Both of these organic compounds are carcinogens associated with degreasing agents which have enforceable drinking water standards (3 ppb for TCE and 1 ppb for vinyl chloride).

To address area-wide, ground-water contamination in the Miami area, the Superfund Program assisted the City of Miami in the construction of 64 air stripping towers for TCE/vinyl chloride remediation. The Superfund program is currently in the process of developing remediation options to protect the Peele-Dixie Wellfield in Broward County.

The RCRA facilities which Treat, Store and/or Dispose (TSDs) of hazardous waste may contribute to ground-water contamination through past spills and poor waste management practices resulting in the leaching of pollutants into the subsurface. There are approximately 22 TSDs in the general Restudy area, seven (7) of which are in operation. Fourteen of the 22 TSDs are undergoing either closure or post-closure care and the remaining TSD has not yet been permitted. Eleven (11) of the 21 operating, closing, or post-closure-care TSDs required investigation of potential contamination. The investigation of the TSDs included a ground-water component to evaluate potential ground-water contamination and to ensure protection of the ground-water resources in the South Florida area through containment and treatment of the contaminated ground water.

The majority of the RCRA TSDs in the South Florida area: Palm Beach, Broward and Miami-Dade Counties, with 5, 4 and 4 TSDs, respectively; followed by Orange and Monroe Counties with 3 and 2, respectively; and one facility each in Highland, Lee, Osceola and Polk Counties (these counties are located within regions designated in this PEIS as the “Kissimmee River Region,” “Caloosahatche River Region,” “Everglades Agricultural Area,” “Water Conservation Areas,” “Big Cypress Region,” “Lower East Coast and Biscayne Bay” and/or “Everglades National Park and Florida Bay”). As with Superfund sites, though each facility presents unique environmental threats, Non-Aqueous Phase Liquids (NAPLs) and TCE and its daughter products, particularly vinyl chloride, are of greatest concern with respect to ground-water contamination. This is due to the prevalence of these contaminants, the difficulty of remediating and preventing further degradation of the ground water, and the toxicological effects of the contaminants.

In addition to the 22 TSDs in the general Restudy area, there are approximately 450 large quantity hazardous waste generators and 9,000 small quantity generators in the area. These generators are regulated through RCRA by addressing the hazardous waste management standards of the generators. Though it is possible that these generators may contribute to ground-water contamination, data do not exist to confirm this.

H.1.4.2 Surface Water Conditions

H.1.4.2.1 Major Regional Water Quality Concerns

Perhaps the three most important water quality parameters of concern in the C&SF Restudy region are mercury, phosphorus, nitrates, and pesticides. These are discussed below from a regional perspective.

Mercury

Several scientific efforts are underway that are focused at understanding how and why mercury bioaccumulates in Everglades biota. Numerous factors have been implicated as having some influence on mercury cycling within the Everglades marsh system. Among the key factors are complex inter-relationships involving sulfate, sulfide, phosphorus, oxygen, carbon, calcium, peat chemical characteristics, periphyton biomass, macrophyte biomass, biodilution, and aquatic food web structure. At present there is no scientific consensus as to which of these factors dominate, and whether the dominant factors are constant throughout all habitats within the 4,000 square mile Everglades ecosystem. No single factor can explain the mercury concentrations observed in Everglades fish or wildlife. Scientific efforts and the current leading hypotheses and findings can be found in: USEPA (1998: draft); Ambrose *et al*. (1998: in prep); USGS (1996c); and Gilmour *et al*. (1998).

The USEPA (1998: draft) review of mercury water quality conditions in selected portions of the project area considers canal versus marsh areas. It also specifically compares existing mercury conditions in the ENP, WCAs, Big Cypress National Preserve and EAA regions based on the draft results from the South Florida Ecosystem Assessment (REMAP) project. This system-wide (4,000 square mile) research and monitoring project of the Everglades ecosystem was conducted to address mercury contamination, eutrophication, habitat alterations, and hydropattern modification issues (USEPA, 1998: draft). This project strongly supports the federal and State Everglades restoration efforts and will provide a means to evaluate present and future management actions. This project is focused on the ecological risk assessment process and is guided by a set of policy relevant questions. A statistical Environmental Monitoring and Assessment Program (EMAP) survey design was used to select 200 canal and 500 marsh sampling stations, a quarter of which were sampled during successive wet and dry seasons from 1993-96. These data allow quantitative estimation of the relative risk to the ecological resources from multiple interacting environmental threats. The greatest threat to the Everglades ecosystem is to assume that these issues are independent. REMAP strongly supports the federal and State Everglades restoration efforts and will provide a means to evaluate present and future management actions. This effort compliments the mercury biogeochemical research being conducted by the USGS (1996c).

Bioaccumulation and Biomagnification

Wet deposition is thought to be the primary mechanism by which mercury emitted to the atmosphere is transported to surface waters and land, although dry deposition may also contribute substantially. Once deposited, mercury enters aquatic and terrestrial food chains and wetland environments are particularly conducive to the methylation of mercury (Zillioux *et al*., 1993 and Rudd *et al*., 1997). Mercury concentrations increase at successively higher trophic levels as a result of bioconcentration, bioaccumulation and biomagnification. Of the various forms of mercury in the environment, methylmercury has the highest potential for bioaccumulation and biomagnification. Predators at the top of these food chains are potentially at risk from consumption of methylmercury in contaminated prey. The available information shows that piscivorous (fish-eating) birds and mammals are particularly at risk from mercury emissions. This risk is likely to be greatest in areas that receive high levels of mercury deposition, although local and regional factors can substantially impact the amount of total mercury that is translocated from watersheds to waterbodies and undergoes chemical transformation to the methylated species (USEPA, 1997).

Frederick *et al*. (1997) studied the effects of methylmercury exposure on the health, reproduction and survival of wading bird populations in the Florida Everglades. The concern for wading birds arose because this group of animals are, by virtue of their high metabolism and position in the food chain, at high risk of mercury exposure. Concern has also derived from the extreme reduction in breeding numbers in the Everglades observed during the past four decades, and the view that increased breeding numbers is a key goal for the restoration of the ecosystem. Most of these studies were carried out in WCA-3 where the vast majority of the wading bird nesting has occurred in recent decades. Frederick *et al*. (1997) found significant differences in the blood and feather mercury concentrations in great egret chicks among colonies within WCA-3, with samples from a colony in north-central WCA-3 consistently showing the highest mercury values. The distribution among colonies seemed to match the geographic distribution of mercury concentrations in mosquitofish reported by USEPA (1996a; 1998: draft).

Results from both field and laboratory studies showed the cumulative effects of mercury on juvenile and post-fledging birds at levels of mercury intake common in the Everglades (0.33 - 0.75 mg/kg), are likely to result in reduced survival of offspring through reduced body mass, decreased red cell numbers, increased lethargy, increased susceptibility to disease, and increased time to capture fish (Frederick *et al*., 1997); however, they were not able to estimate the magnitude of population level effects.

The risk of mercury contamination to the Florida panther was considered by USEPA (1997). All of the panther's range falls within an area of high mercury deposition. Mercury levels found in tissues obtained from dead panthers are similar to levels that have been associated with frank toxic effects in other feline species. The most highly exposed individuals have been those in the east Everglades which have preyed more intensively on raccoons. The State of Florida has taken measures to reduce the risk to panthers posed by mercury by trying to increase the availability of deer which are not a part of the aquatic food chain. Raccoons frequently feed at or near the top of aquatic food webs and can accumulate substantial tissue burdens of mercury. An evaluation of the risk posed by mercury to the Florida panther is complicated by the possible impacts of other chemical stressors, habitat loss, and in-breeding.

Recent research in the Everglades ecosystem has clearly demonstrated the Bioaccumulation Factors (BAFs) for methylmercury in fish for trophic level 3 (prey fish, mosquitofish) (USEPA, 1998: draft) and level 4 (top predator, e.g., largemouth bass) (Lange *et al.* 1993) are nominally 10^5 or 10^6. However, the Everglades BAFs are strongly influenced by the gradients in total phosphorus, total organic carbon and sulfate entering the system from the north. This results in an inverse relationship in the median BAFs for mosquitofish ranging from 0.6 x 10^5 in WCA-1 to 8.5 x 10^5 in southern ENP. The risk of exposure to higher trophic levels in the system increases to the south. USEPA (1997) estimated a species-specific Wildlife Criteria (WC) for methylmercury over several selected avian and mammalian wildlife. A final WC was then calculated as the lowest mean of WC values for each of the two taxonomic classes (birds and mammals). The final WC for methylmercury was based on individual WC values calculated for mammalian species, and was estimated to be 50 picograms (pg) methylmercury/L in water. Median methylmercury concentrations in water for the Everglades marsh range from 0.538 to 0.151 ng/L or 10 to 3 times higher, respectively, than this proposed criterion. However, high methylmercury concentrations in water are not bioaccumulated into fish due to biodilution and associated changes in the food chain. The stimulatory effects of TP in this system on the methylating microbes is a key component, for it is apparent when the fertilizing effect is minimal in southern ENP the available methylmercury declines in both the water and biota.

Phosphorus

Historically, South Florida waters were low-nutrient waters (i.e., an oligotrophic system). Due to anthropogenic activities, including the ditching and draining of wetlands and the expansion of agricultural practices employing fertilizers, waterbodies from the Kissimmee River southward have become nutrient-enriched to various degrees. This is due to water body receipt of agricultural runoff from such land uses as pastures, truck farming, and sugar cane fields. The Everglades Agricultural Area (EAA) is one such area of farming, although the farming areas surrounding Lake Okeechobee in general have contributed to elevated nutrients in the Kissimmee River, Lake Okeechobee, the Caloosahatchee River, and the Everglades. In addition, urban storm water runoff is another potential source of phosphorus to the Everglades or South Florida coastal systems. Elevated phosphorus loading of waterbodies and the resulting increased water phosphorus concentrations (eutrophication) may have various ecological effects. These effects may include increased primary productivity, loss of water column dissolved oxygen, algal blooms, and changes in vegetation and biodiversity. The significance of such phosphorus loading may be the reduction or loss of water body habitat and/or recreational value.

The nutrient of greatest ecological concern in South Florida is phosphorus. In general, the trend for phosphorus concentrations is a decrease from north

(Kissimmee River and EAA) to south (ENP) since the major anthropogenic sources are in the agricultural areas. Nutrient removal from marsh water is due to the natural water quality treatment processes associated with South Florida wetlands, notably the Everglades. According to the Florida SWIM Plan (SFWMD, 1997), the highest average concentrations of phosphorus for 1990 to 1994 are in water discharged from the Lower Kissimmee River (S-65D basin = 770 ppb), Taylor Creek/Nubin Slough (S-154 basin = 610 ppb), and the EAA (East Beach Drainage District = 560 ppb) the EAA. The lowest concentrations (about 10 ppb) are reported for marsh stations within the ENP (USGS (1996d)). The Florida EFA specifies that a yet-to-be-established numeric phosphorus criterion is to be established for the Everglades by the State of Florida and then approved by the USEPA (no later than December 31, 2003), or a default level of 10 ppb will be implemented. Currently, six (6) Stormwater Treatment Areas (STAs), which are established by the EFA and total 44,000 acres, are being implemented by the SFWMD as part of the USACE Everglades Construction Project (ECP). These STAs are designed to reduce phosphorus levels in agricultural runoff, in addition to the agricultural BMPs being implemented. A research project similar to the STAs, the Everglades Nutrient Removal (ENR) Project, is currently functioning and reducing phosphorus levels to less than 30 ppb. Additional STA treatment (Phase 2) would be needed to reduce concentrations to levels in the range of the 10 ppb default level.

Region-Specific Conditions

The following summary presents a brief description of the current phosphorus conditions in portions of the study area of C&SF Restudy Project:

Kissimmee River Region

The Kissimmee River is the major tributary to Lake Okeechobee and is a major source of lake phosphorus. The major external source of phosphorus in this region is dairy farms and beef cattle farms (SFWMD, 1989). A dairy buy-out program and other efforts are underway to reduce the river phosphorus load. Average phosphorus concentration in the Kissimmee River Basin has been consistently below the target concentration of 0.18 mg/L since June 1991. (ref: SFWMD, 1998a)

Lake Okeechobee

Phosphorus targets for each Lake tributary basin were established in the 1989 Lake Okeechobee Interim Surface Water Improvement and Management (SWIM) Plan (SFWMD, 1989). These targets were set up to reduce phosphorus loading to the lake. Under this SWIM Plan, each basin must either not exceed a total phosphorus (TP) concentration of 0.18 mg/L or maintain its 1989 discharge concentration, whichever is less. Over the past decade, several programs have been initiated to reduce phosphorus loads to Lake Okeechobee. These programs include agricultural BMPs, dairy buy-outs, a regulatory program for non-dairy use of lands, and limiting backpumping to the lake from the EAA. These programs have reduced the phosphorus load from a five-year moving average annual load of about 600 metric tons in the early 1980's to about 450 tons in the mid-1990's. The TP load has not reached target levels, however, since the mid-1990's, load remains about 100 metric tons above the target load. Additional reduction measures may be required. (Refs: SFWMD, 1989; 1998)

Upper East Coast and Indian River Lagoon

Based on the 1996 305(b) report (FDEP, 1996), the average TP concentration in the St. Lucie River within the Upper East Coast region was 0.15 mg/L in the south Fork, 0.31 mg/L in the north, and 0.2 mg/L in the estuary. Woodward-Clyde (1994) report that the mean TP concentration in the south Indian River Lagoon (IRL) was 0.034 mg/L (with a standard deviation of 0.02 mg/L) for the period of 1989 to 1991, while the maximum and minimum concentrations for the same period were 0.18 mg/L and 0.004 mg/L, respectively. (Refs: FDEP, 1996; Woodward-Clyde, 1994).

Everglades Agricultural Area

The EAA is a major source of external phosphorus loading to the Everglades Protection Area (EPA). A program of agricultural BMPs and STAs has been implemented by the State of Florida in order to decrease the load of phosphorus passing from the EAA into the Everglades. The goal of the BMP program is a 25% annual total phosphorus reduction from the EAA relative to a base period, 1979-1988 (pre-BMP implementation in the EAA). The first years during which all lands within the EAA had fully implemented BMPs were 1996 and 1997. According to SFWMD, from 1995 to 1997, the EAA BMP program resulted in a three-year average phosphorus load reduction of 51%, with an annual TP reduction statistical variability of plus or minus 18%. (SFWMD, 1997)

Water Conservation Areas

Eutrophication due to anthropogenic phosphorus poses a long-term threat to the oligotrophic Everglades marsh, including the Everglades Water Conservation Areas WCAs). Walker (1995) summarized phosphorus data from 1973-1991 which clearly shows a gradient with high phosphorus concentrations of 100 to 250 ppb at WCA inflows from the EAA, decreasing downstream to below 10 ppb at remote marsh stations within the ENP. Phosphorus impacts that have been documented in the WCAs include effects on microbial populations, major changes in periphyton species composition, reduced algal species diversity, increases in algal growth rates, loss of water column dissolved oxygen, increases in soil phosphorus concentrations, and marsh vegetation changes such that cattails replace sawgrass. A major focus of the BMP and STA program mentioned above is preventing further phosphorus impacts in the WCAs. (SFWMD, 1992a)

Lower East Coast and Biscayne Bay

Biscayne Bay is a shallow subtropical estuary with an urban watershed. Much of the bay has been designated as a national park. The bay receives storm water and surface water runoff delivered by flood control canals along the urban Lower East Coast. Phosphorus levels are low to moderate in the central and southern bay and are slightly higher in the northern bay. (SFWMD, 1994)

Everglades National Park and Florida Bay

Environmental problems occurring recently in Florida Bay include sea grass die-offs, sponge die-offs, and algal blooms. Extensive data exist on Florida Bay nutrient sources and the relationships of nutrients to sea grass die-offs and algal blooms. Much uncertainty remains as to the relative importance of internal nutrient cycling versus external nutrient sources. Once the sources are clearly understood, mechanisms for controlling the nutrient sources and sinks must be identified. Considerable research and monitoring is directed at understanding these Florida Bay nutrient issues. (Boesch *et al.*, 1997)

Florida Keys

Adjacent to the Florida Keys land mass are a variety of marine environments, including sea grass meadows, mangrove islands, and extensive living coral reefs. These environments support rich biological communities. Water quality plays a critical role in the preservation of these sensitive natural resources. Among the phosphorus-related water quality concerns in the Keys are: septic leachate from on-site disposal systems, sewage discharges from live-aboard vessels, discharges from sewage treatment plants, and storm water runoff. Federal, State and local officials are working to implement identified corrective actions for these anthropogenic sources of nutrient loading. (USEPA, 1996b)

Big Cypress Region

The Big Cypress Swamp was set aside as a national preserve (Big Cypress National Preserve) in order to assure the preservation, protection and conservation of the natural, hydrologic, floral and faunal, and recreational values of the watershed. This wetland system receives much of its surface water from outside its political boundary. As such, the Big Cypress Swamp depends upon upstream areas for surface water. A recent analysis of available water quality data, including phosphorus, did not indicate any clear problems within the Preserve. However, expanding agricultural operations upstream in the Big Cypress watershed presents a continual and potentially serious threat to the integrity of the quality of waters entering the Preserve. (Ref: USDOI, 1996).

Caloosahatchee River Region

Urban land use can be an important influence on water quality. The USGS (1996a) reports that urban storm water runoff from Fort Myers and La Belle have contributed significant amounts of nutrients to the Caloosahatchee River. (Ref: USGS, 1996a). Agricultural land uses (citrus, ranch, and fruit and vegetables) in the basin also contribute point and non-point sources of pollution to basin waters.

Pesticides

The South Florida region is unique in that a very large and sensitive ecosystem exists in the midst of an evergrowing urban population and an extensive and intensive agricultural production area. A variety of pesticides are used in this area for a number of different reasons. Major uses are ground and/or aerial applications related to agricultural production, mosquito control, aquatic plant growth in local waterways, golf course maintenance, and homeowner lawn and vegetation maintenance.

Pesticides used in the above situations are effective in controlling the pest at hand; however, the use of pesticides may also pose possible threats to the sensitive ecosystems in Florida due to the intense year-round agriculture, coupled with the shallow water tables and the ever-increasing urban sprawl that demands an increasing supply of quality water.

Three major areas of agricultural production are present in South Florida:

(1) Miami-Dade County (which, relevant to agriculture, is located in the region designated in this PEIS as the Lower East Coast and Biscayne Bay);

(2) the agricultural areas surrounding Lake Okeechobee (consisting of Palm Beach, Hendry, Glades and Martin Counties, which, relevant to agriculture, are located in the regions designated in this PEIS as the Kissimmee River Region, Upper East Coast and Indian River Lagoon, Lower East Coast and Biscayne Bay, Everglades Agricultural Area, Big Cypress Region, and Caloosahatchee River Region);

(3) Collier County (which is located in the regions designated in this PEIS as the Big Cypress Region and the Caloosahatchee River Region).

Miami-Dade County ranks among the top counties in winter vegetable production in the U.S. and is number one in tropical fruit production. Agriculture in the four EAA counties include sugar cane and truck farming. Collier County has approximately one-third of its land utilized for agricultural purposes. Pesticide transport to the ENP (which is the region designated in this PEIS as the Everglades National Park and Florida Bay) from these three major agricultural areas can occur through hydrological connection to the Park from all three areas.

Pesticide Monitoring and Other Studies

The only long-term pesticide monitoring in the C&SF Restudy project area is being conducted by the SFWMD (R. Pfeuffer: SFWMD, 1998 personal communication). The District has maintained a pesticide monitoring program in South Florida since 1984. The pesticide monitoring network includes sites designated in the Everglades National Park Memorandum of Agreement, the Miccosukee Tribe Memorandum of Agreement, the Lake Okeechobee Operating Permit and the Non-ECP Structure Permit. The monitoring provides data to determine the condition or changes in the quality of water being delivered to Lake Okeechobee, ENP, and the WCAs and Florida Bay. Additional pesticide residue data are collected to determine water quality conditions at the major water control structures throughout the District. The data collected for each sampling event provide information on potential short-term, acute environmental effects for any of the compounds detected. An indication of possible fish toxicity, bioaccumulation for wildlife, or human health impacts can also be inferred from the data. The program has been dynamic over time, as concerns arise about pesticide use within the District, to accommodate sampling for new pesticides and the addition of sampling sites to the network. The current monitoring program consists of analyses for 66 pesticides at 37 sites within District boundaries. This set of compounds includes chemicals currently utilized in the associated agricultural areas, chemicals regulated by Florida's Surface Water Quality Standards (F.A.C. 62-302), and restricted-use pesticides.

SFWMD pesticide monitoring data for 1992-1997 are presented in Table H.1.5.2.1.3.2-1. Data are for monitoring sites in various areas in South Florida, including regions and subregions designated in this PEIS (e.g., St. Lucie River, Indian River Lagoon, Everglades Agricultural Area, Caloosahatchee River). This table discusses changes in the rate of pesticide detections at monitoring sites between 1992 and 1997 in the context of a flexible monitoring program that is frequently adjusted to define the types and amounts of pesticides entering the South Florida environment. It should be noted that the existing Florida Criteria for Surface Water Quality Classifications, F.A.C. Section 62-302.530, does not list many contemporary pesticides such as ametryn, atrazine, hexazinone, bromacil, norflurazon, and simazine. These six pesticides rank in the top 10 for number of detections between 1992 and 1997. For pesticides not specifically listed, the acute or chronic toxicity criteria under Surface Waters, Minimum Criteria (F.A.C. 62-

302.500) are utilized. The acute and chronic toxicity standards are calculated as one-third and one-twentieth, respectively, of the amount lethal to 50% of the test organisms in 96 hours, where the 96-hour LC50 (i.e., Lethal Concentration for 50% of the test subjects) is the lowest value which has been determined for a species significant to the indigenous aquatic community (F.A.C. 62-302.200). It is noted, however, that finding LC50 data for aquatic species indigenous to South Florida aquatic ecosystems can be difficult.

A snapshot of the SFWMD pesticides monitoring program is presented by Miles and Pfeuffer (1997). This publication describes the results of the monitoring program between November 1991 through June 1995, while estimating pesticide usage during this same period in the South Florida area. Sugarcane, citrus and vegetable crops comprise the major crops in this area, based on acreage, with approximately 428,000, 213,000 and 155,000 cultivated acres, respectively. This accounts for all of Florida's sugarcane and approximately 38% of the citrus and 42% of the vegetables. Estimated pesticide usage in the area was approximately 14,590 tons per year, which exceeded a USEPA estimate of 10,500 tons per year. The difference is most likely related to the large amount of agricultural area in the SFWMD. Of the 14,590 tons of pesticides used in this area, approximately 38% were insecticides, 20% were herbicides, 19% were fungicides and nematicides, and 24% were fumigants. Atrazine, ametryn, bromacil, simazine, and norflurazone were the most frequently detected pesticides in surface water samples, while DDE, DDD and ametryn were the most frequently detected in the sediment samples. Previous pesticides work in this general area was conducted by Scheidt (1989) who identified a total of 88 compounds (including 41 insecticides, 29 herbicides, 15 fungicides and 3 fumigants) as being used in agricultural production in this area.

In addition, monitoring of ground water for pesticides by the FDACS has been ongoing since the early 1980's. FDACS seeks to maximize the probability of identifying pesticide residues in existing drinking water wells by:

- concentrating efforts on pesticides identified as being mobile and known to be used in Florida agricultural production

- selecting counties that possess significant agricultural production overlying susceptible soils and ground-water hydrology

- carefully targeting the wells sampled based on documented historical use of one or more of the listed pesticides.

During 1983-1987, FDACS monitored 897 wells in 21 counties for aldicarb and its metabolites, aldicarb sulfone, and aldicarb sulfoxide. Twenty-four of the wells were positive for aldicarb and/or one of its metabolites. A Collier County study conducted by FDACS in 1986-87 reviewed pesticide use in an area where tomatoes and other vegetables were major crops, with citrus also becoming a major crop. Only bromacil was reported above the level of detection and was found in a citrus grove.

NOAA is also working on an ecotoxicological assessment of endosulfan and other potential endocrine-disrupting chemicals on living marine resources in Florida Bay (Scott et al. 1994; Scott et al. 1995).

H.1.4.2.2 Regional 303(d) Impaired Waters

Section 303(d) of the Federal Clean Water Act and the USEPA Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for their water bodies that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream water quality conditions, so that states can establish water-quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources. The Section 303(d) list, which is prepared every two years, is based on priority water bodies identified as part of the Florida Surface Water Improvement and Management (SWIM) Act and data from the 1996 FDEP 305(b) report (FDEP, 1996).

The SWIM Act directed the state to develop management and restoration plans for preserving or restoring priority water bodies. The legislation designated a number of SWIM water bodies. The SWIM water bodies in Southwest Florida are Tampa Bay, Rainbow River, Crystal River/Kings Bay, Lake Panasoffkee, Charlotte Harbor, Lake Tarpon, Lake Thonotosassa, Winter Haven Chain of Lakes, and Sarasota Bay. In South Florida the water bodies are Lake Okeechobee/Kissimmee River, Biscayne Bay, Indian River Lagoon, Everglades/East Everglades/Holey Land/Rotenberger, Upper Kissimmee Chain of Lakes, and the Florida Keys. For all of the water bodies listed above except the Upper Kissimmee Chain of Lakes and the Florida Keys, the SWIM plan has been approved and the SFWMD has begun restoration.

Impaired Section 303(d) Waters

Table H.1.5.2.2.2-1 presents the regions and associated waters (waterbodies/water segments) that are listed as impaired on the 1998 Section 303(d) list pursuant to Section 303(d) of the CWA. Over 160 waterbodies/water segments within the study area are so listed. The table lists both the nomenclature of the regions as designated in Section 303(d)of the CWA, as well as the corresponding regions (or parts of regions) as designated in this PEIS. These regions and corresponding regions are: Kissimmee River Basin (PEIS: Kissimmee River

Region), Lake Okeechobee (PEIS: Lake Okeechobee), Caloosahatchee River Basin (PEIS: Caloosahatchee River Region), Everglades-West Coast or Big Cypress (PEIS: Big Cypress Region and Everglades National Park and Florida Bay), and Southeast Florida Basin (PEIS: Upper East Coast and Indian River Lagoon, Everglades Agricultural Area, Water Conservation Areas, Lower East Coast and Biscayne Bay, Everglades National Park and Florida Bay, and Florida Keys). Specific water quality concerns are discussed below for each of these regions. It may be noted that portions of the ENP are located in both the Everglades-West Coast or Big Cypress region and the Southeast Florida Basin presented in the 1996 305(b) report.

Table H.1.5.2.2.2-1
Constituents of Section 303(d) Concern for Regions in South Florida.

Region § 303(d) and (PEIS)	Number of Water Segments listed on § 303(d) list	Primary Constituents of Concern
Kissimmee River Basin (Kissimmee River Region)	25	DO, nutrients, and coliforms
Lake Okeechobee (Lake Okeechobee)	12	nutrients, DO, coliforms
Caloosahatchee River Basin (Caloosahatchee River Region)	8	nutrients, coliforms, DO, Biochemical Oxygen Demand (BOD)
Everglades-West Coast or Big Cypress (Big Cypress Region and Everglades National Park and Florida Bay)	13	nutrients, DO, and BOD
Southeast Florida Basin (Upper East Coast and Indian River Lagoon, Everglades Agricultural Area, Water Conservation Areas, Lower East Coast and Biscayne Bay, and Everglades National Park and Florida Park)	87	nutrients, DO, mercury, BOD, coliforms
Florida Keys (Florida Keys)	1	NA

Kissimmee River Basin (PEIS: Kissimmee River Region)

The major land uses in the Kissimmee River Basin are agriculture, rangeland and urban development. The pollution sources are hydrologic modification, dairies, and ranching. Water quality in the river between Lake Kissimmee and Lake Okeechobee varies from north to south. From Lake Kissimmee to near Lake Okeechobee, water quality is fairly good. As the river approaches Lake Okeechobee, cattle and dairies grow more numerous. Along the channel, water rich in nutrients and BOD flows quickly to Lake Okeechobee, exacerbating eutrophication. Recently, efforts were made to restore parts of the river to its natural, meandering course by strategically placing weirs in the channel. In those sections, the river has returned to its original floodplain, effectively re-creating the buffering wetlands.

Land purchases, design plans, and monitoring continue toward the restoration goal of 32,000 acres. The governor supports a multimillion-dollar plan to return the Kissimmee River to its natural state, but funding has not been fully established. In 1992, President George Bush allocated $5 million for restoration. Plans included backfilling part of the canal, excavating some of the channel, and raising the regulated levels of the upper basin's lakes to allow more natural water flows. The USACE has prepared an Environmental Impact Statement (EIS) on the restoration of the Kissimmee River. The USACE, together with the SFWMD, have initiated project construction.

Twenty-five water segments in the Kissimmee Basin are listed on the 1998 Section 303(d) list. Several water segments are slated for TMDL development in 1999. The TMDL scheduled to be developed is for phosphorus only. The segments include: Chandler Slough, S-65D, Oak Creek, and a southern segment of Kissimmee River. The SFWMD has completed a Pollutant Load Reduction Goal (PLRG) for nutrients for these segments (*Note*: a PLRG is similar to a TMDL and will ultimately be transformed into a TMDL).

Lake Okeechobee (PEIS: Lake Okeechobee)

The major land uses in the Lake Okeechobee Basin are agriculture, wetlands, and improved pasture. The major pollution sources are dairies and agriculture. In recent years, several widespread algal blooms and at least one major fish kill launched the environmental community and governmental agencies into intense investigation and analysis of the lake's problems. The SFWMD has initiated a number of biological, chemical, and ecological research studies, and plans are being submitted to stem lake pollution. An FDEP dairy rule requires BMPs for dairies. By 1991, all 52 dairies in the Lake Okeechobee drainage basin had to sell and remove their cattle or else comply with the rule.

Lake Okeechobee benefitted from Florida's Everglades Forever Act because about 20 tons of phosphorous, 500 tons of nitrogen, and a number of other pollutants were diverted from the lake annually. Despite these efforts, phosphorus limits established for the lake by the legislature in 1992 have not been met. SFWMD research indicates that because the lake's phosphorus is internally recycled and a vast reservoir of the nutrient is stored in lake sediments as well as lake wetland and canal sediments, phosphorus may not reach acceptable levels for many decades or even a century. New actions will be needed to reduce pollution where tributaries enter the lake.

TMDLs for phosphorus are slated to be developed for all 12 listed water segments in Lake Okeechobee in 1998. The SFWMD has completed a PLRG for nutrients for all segments.

Caloosahatchee River Basin (PEIS: Caloosahatchee River Region)

The major land uses in the Caloosahatchee River Basin are rangeland, agriculture, wetlands, and urban development. The major pollution sources are hydrologic modification, agriculture, and urban areas.

The upper portions of the river near Lake Okeechobee frequently violate DO standards and has high conductivity and nutrient levels from low flows and agricultural drainage. Nine-Mile Canal, which drains agricultural fields, has very poor water quality, and pollution-tolerant species dominate biological samples. Water quality improves down-river near Alva where the river has more natural tributaries and old channels. The estuary portion of the river is affected by high-nutrient waters from the river and tributaries and storm water runoff from cities. Nutrient and chlorophyll levels are high, and small algal blooms occur regularly.

Eleven water segments in the Caloosahatchee River Basin are listed as high or low priorities on the 1998 Section 303(d) list.

Big Cypress Region (PEIS: Big Cypress Region and Everglades National Park and Florida Bay)

The major land uses in the Big Cypress region are wetlands, agriculture, rangeland, and urban development. The major pollution sources are hydrologic modification and agriculture.

The western half of the Tamiami Canal is threatened or moderately impaired from nutrients, algal and weed growth, and pesticides. Canals draining urban areas are also affected by urban runoff and septic tank leachate. Naples Bay and parts of Estero Bay are threatened or moderately impaired. Lake Trafford near Immokalee, which is severely impaired from agriculture, urbanization and septic tank runoff, experiences algal blooms, weed growth, and occasional fish kills. The basin's most disturbing, ecologically destructive problem is severely altered freshwater flows from drainage canals with inadequate or nonexistent control structures. The canals cause excess fresh water to drain into the estuaries in the wet season and increase saltwater intrusion in the dry season. The bays at the mouth of the main canals are the most seriously threatened. The drought of the last few years has severely stressed the region's plants and animals. The potential for widespread, disastrous fires is great. Water-use restrictions have been implemented in much of the basin.

Fourteen low priority waters are listed in the Big Cypress region on the 1998 Section 303(d) list.

Southeast Florida Basin (PEIS: Upper East Coast and Indian River Lagoon, Everglades Agricultural Area, Water Conservation Areas, Lower East Coast and Biscayne Bay, and Everglades National Park and Florida Bay)

Ninety-five waters in the Southeast Florida Basin are listed on the 1998 303(d) list. Several of the water segments are slated for TMDL development in the next couple of years. They are: the North New River Canal, West Palm Beach Canal, M canal, 715 Farms, S-3, South Bay, East Beach, L-8. Bessey Creek is slated for 1999, and C-24, North St. Lucie, St. Lucie, and C-25 are slated for TMDL development in the year 2000.

The major land uses are wetlands, agriculture, and urban development. The major pollution sources are urban runoff, agriculture, boat discharges, and sewage overflows.

Some basin-wide generalizations can be made. On the heavily urbanized eastern coast, most pollution comes from storm water. Most wastewater treatment plants either use deep-well injection or ocean outfalls, but where they do discharge to surface waters, water quality is usually degraded. Intensive agricultural development affects the western portions of the basin, particularly south of Lake Okeechobee. In the southern basin, between the agricultural and urban areas, lie the WCAs which are vast diked wetlands used for aquifer recharge. Although these areas absorb some nutrients, the canal water quality depends heavily on water quantity.

The extensive network of canals has diminished water quality. DO levels are often low, with fish kills resulting. Controversy has been considerable over agriculture's effect on water quality in the Southeastern Florida Basin. To date, FDEP has identified four major violations of Class III criteria caused by nutrients: imbalances of aquatic flora and fauna, dominance by nuisance species, diminished biological integrity, and low levels of DO.

Ninety-five high or low priority waters are listed in the Southeast Florida Basin on the 1998 Section 303(d) list.

Upper East Coast and Indian River Lagoon

Water quality in the northeastern basin is relatively good. The major problems are found near Port St. Lucie. Five-Mile and Ten-mile creeks, which receive citrus grove runoff, have poor water quality with high pesticide levels that may be harming the North Fork of the St. Lucie River and Estuary. Along the Savannas State Preserve concentrations of mercury in fish tissue were high enough to warrant a no-consumption advisory for largemouth bass. Uncontrolled storm water runoff may also be harming the water quality, plant communities, and biological diversity. An addendum to the Indian River Lagoon SWIM Plan contains projects that will improve the situation.

Everglades Agriculture Area

The L-8, West Palm Beach, Hillsboro, North New River, and Miami canals from Lake Okeechobee to the L4-L7 canals, which roughly define the EAA, have poor water quality with extremely high nutrient and low DO levels. Other problems include pesticides, BOD, bacteria, and suspended solids. Fish kills occur periodically in the West Palm Beach Canal after heavy rains drain from the Chemair Spray hazardous waste site.

Water Conservation Areas

Canals bordering the Water Conservation Areas generally have very low DO levels typical of marsh waters. Nutrient levels at the marsh perimeter are elevated, probably from the breakdown of organic debris as well as agricultural drainage.

Lower East Coast and Biscayne Bay

Farther east, the North New River Canal joins the South Fork of the New River near Fort Lauderdale. The Miami Canal joins the Miami River near Miami. Both rivers are in heavily urbanized areas and have been channeled and bulkheaded. Several major Class I Solid Waste Disposal Facilities are located along major canal systems, including: the North Miami-Dade, South Miami-Dade, Lantana, and Martin County landfills, as well as Glades Road Resources Recovery of Miami-Dade and Munisport Landfill. All have the potential to pollute surface waters.

The most serious problems confronting the Miami River are chronic and acute coliform bacteria contamination and heavy metal and organic pollution in sediments. Chronic contamination results from illegal sewer connections to storm water pipes, leaking pipes and joints, and broken pipes. Acute contamination occurs when raw sewage flows from either emergency overflows or manholes. The Miami River's bacterial problems and their impact on Biscayne Bay have been a concern since the 1940s. In 1984, the Miami River Management Committee was established to develop a coordinated plan for improving the river. The committee was able to raise funds that were used to improve storm water outfalls, establish a state and local pollution control enforcement program, monitor pollution controls, and rank drainage basins for retrofitting.

Fort Lauderdale is particularly plagued with water quality problems from urban runoff and historical wastewater treatment discharges. The westernmost stations on the canals often have the worst water quality from agricultural runoff. Canals are often choked with weeds that must be mechanically removed or treated with herbicide. An FDEP study of major Miami-Dade County canals in 1985 showed poor water quality, low biological diversity, and many exotic plants and animals.

Twenty federal Superfund hazardous waste sites exist in the basin. About 50 more sites contaminated by heavy metals, solvents, or pesticides will need assessment and remediation. Although the sites will mostly affect ground water, they all have the potential to affect surface waters (and ground waters are near the land surface in many urban locations of the LEC). In addition, Miami-Dade, Broward, Palm Beach, Okeechobee, and St. Lucie counties contain about 5,150 petroleum-contaminated sites. They also contain approximately 10,000 regulated petroleum facilities, all of which have the potential for contamination.

In Miami-Dade, Broward, and Palm Beach counties, ten major public drinking-water well fields have shown petroleum contamination, including the cities of Riviera Beach, Delray Beach, Hallandale, Daniea, Deerfield Beach, and north Miami Beach, as well as Fort Lauderdale's Peele-Dixie Wellfield, Miami Springs' Preston Wellfields, and Fort Lauderdale's Executive Airport Wellfield. Major petroleum assessments, and cleanups are also in progress at Port Everglades, Miami International Airport, and Homestead Air Force Base, among others.

Biscayne Bay, although polluted by canal discharges and port activities, has fairly good water quality because of flushing from the Atlantic Ocean, especially south of Key Biscayne.

Everglades National Park and Florida Bay

Some parts of Florida Bay have experienced a massive seagrass and mangrove die-off in the late 1980's and early 1990's. Fisheries have declined as a result. Researchers estimate that 9,880 acres of seagrass have died and another 66,690 acres have been affected. The problem likely stems from a lack of flushing from hurricanes, high water temperatures, high levels of salinity, and disruptions in the quantity and quality of freshwater flows to the bay from channelized mainland waterways.

No water segments in Florida Bay are listed on the 1998 Section 303(d) list.

Florida Keys (PEIS: Florida Keys)

The major land uses are urban development, recreation, and sportfishing. The major pollution sources are wastewater plants, septic tanks, marinas lacking facilities to pump out waste from boats, fish processors, and storm water runoff.

For years the City of Key West discharged raw sewage directly to the ocean. The FDEP and the USEPA issued a consent order requiring that a treatment facility be built. It began operating in 1989 and appears to be functioning well.

The coral reefs on the ocean side have been damaged by careless divers, boat anchors, and several commercial ship groundings and spills. To protect the reefs and the Everglades, the State is attempting to block offshore oil drilling and to move shipping channels farther offshore. The Florida Marine Research Institute (FMRI) and National Oceanic and Atmospheric Administration (NOAA) are carrying out an extensive monitoring and assessment project in the Keys.

No water segments in the Florida Keys are listed on the 1998 Section 303(d) list.

H.1.5 APPROACH TO BASELINE WATER QUALITY DATA COMPILATION

A suite of baseline water quality parameters potentially affected by the existing conditions of the study area were introduced in Section H.1.1 and described in Section H.1.4 (mercury, phosphorus, and pesticides) and in Attachment A**.** A subset of these parameters of potential concern were considered key degraded parameters for the study area. Those considered "key" for each of the ten regions designated in this PEIS and are presented below by region in ***Table H.1.6-1***. These key parameters were selected based on the perceived relevance to the regions and study area and the reasonable availability and accessibility of published data. As such, the parameters associated with each region varied and data were not provided for the entire suite of parameters considered in Section H.1.1.

Water quality data compilations were provided for the "key" parameter subsets as well as for additional "other" parameter subsets. Data for key parameters are detailed below by region in Section H.1.7, while data for other parameters are detailed by region in Attachment B**.**

The established baseline year for this PEIS is 1995. Baseline water quality conditions described in this section were primarily taken from SFWMD, FDEP, and USEPA references. Data in published references were chiefly relied upon, as opposed to more recent but raw sampling data. The notable exception to this approach was the SFWMD raw database (SFWMD, 1998: unpublished) used to compile water quality data for the Florida Bay and Whitewater Bay (subregions of

Table H.1.6-1. Listing of Key Water Quality Parameters Considered Degraded in the Study Area of the C&SF Restudy Project.

South Florida Region / Subregion	Key Water Quality Parameters Considered Degraded in the Study Area
Kissimmee River Region	TP, No_x, DO
Lake Okeechobee	TP, NO_x , chlorophyll-*a*, turbidity, chloride
Upper East Coast & Indian River Lagoon St. Lucie River	TP, pesticides, DO, mercury and other heavy metals, NO_x , salinity
Indian River Lagoon	TP, pesticides, NO_x , turbidity, salinity, heavy metals, coliforms
Everglades Agricultural Area	TP, pesticides, mercury, NO_x , DO, conductivity
Water Conservation Areas Loxahatchee Natl Wildlife Refuge WCA 2A/2B WCA 3A/3B	 TP, DO, conductivity, mercury, NO_x TP, DO, conductivity, mercury, NO_x TP, DO, conductivity, mercury, NO_x
Lower East Coast & Biscayne Bay Loxahatchee River Aquatic Preserve Lake Worth Biscayne Bay	 TP, DO, mercury, NO_x, coliforms, salinity TP, NO_x , DO, turbidity, heavy metals, VOCs, salinity, coliforms TP, NO_x , DO, TBT, heavy metals, coliforms VOCs
Everglades Natl Park & Florida Bay Shark River Slough/Taylor Slough Florida Bay Whitewater Bay Ten Thousand Islands	 TP, mercury Salinity, TP, mercury, chlorophyll-*a* Salinity, TP, mercury, chlorophyll-*a* Salinity
Florida Keys	TP, NO_x , DO, turbidity, chlorophyll *a*, coliforms
Big Cypress Region	TP, NO_x , DO
Caloosahatchee River Region	TP, pesticides, NO_x , DO, conductivity, coliforms

DO = Dissolved Oxygen
NO_x = Nitrite/Nitrate Nitrogen
TP = Total Phosphorus
TBT = Tributyltin
VOCs = Volatile Organic Compounds

the Everglades National Park and Florida Bay region designated in this PEIS). This database (1991-1997) was made available by the SFWMD through personal communication (M. Slayton, SFWMD) in 1998 and was reduced to means and medians by a USEPA contractor. In addition, summarized pesticide monitoring data (1992-1997) were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Reliance on published data resulted in the typical period of record for the data being from the late 1980's to the early 1990's. However, the specific period of record ranged from 1973 to 1997 and included some very recent publications such as the USEPA mercury data (USEPA, 1998: draft), the SFWMD Everglades data (SFWMD, 1998b), and the Florida International University Florida Keys data (Boyer and Jones, 1998).

Data interpretations made in the following water quality data sections and in Attachment B discussing "trends" and "significance" were non-statistical observations. They were based on the data in the reference cited, which may or may not have been statistically treated.

H.1.6 REGIONAL DATA SUMMARIES

H.1.6.1 Kissimmee River Region

References used to compile the Kissimmee River Region data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were SFWMD (1998a**,** 1982) and USACE (1991).

H.1.6.1.1 Key Region-Specific Water Quality Parameters

Key water quality parameters for the Kissimmee River Region are considered to be phosphorus nitrite/nitrate, and dissolved oxygen (see Table H.1.6-1). Data for these parameters are detailed below.

Phosphorus

Total phosphorus (TP) concentrations in the main drainages of the Kissimmee Valley ranged between less than detectable and 2.46 mg/L and generally increased from north to south. Along the river channel itself (C-38), TP ranged from 0.025 to 0.50 mg/L, reflecting decreasing water quality conditions resulting from intensive land uses, primarily agricultural, in more southerly sub-basins. TP concentrations at structure S-65E, the last water control structure on C-38 approximately 7 miles north of Lake Okeechobee, vary from 0.011 to 0.441 mg/L, averaging 0.109 mg/L. Orthophosphate or Soluble Reactive Phosphorus (SRP) ranged from 0 to 90% of TP, averaging about 60% at the S-65E structure. Increases in phosphorus concentration from north to south are associated primarily with the increase in SRP concentrations to the south. Areas of increased phosphorus levels along C-38 correspond to areas downstream of the tributaries displaying the highest phosphorus concentrations.

Nitrite/Nitrate

Mean nitrite/nitrate (NO_x) concentrations for six sampling stations along the Kissimmee River for the period from 1973-1978 averaged between 0.032 and 0.058 mg/L. More recent NO_x data for the river averaged 0.107 mg/L, ranging between undetectable and 1.369 mg/L. There was not a steady increase in concentrations north to south (downstream) but significantly higher values are found in the extreme southern end of C-38, with the rest of the river showing very similar low average values.

Dissolved Oxygen

Low DO levels along C-38 constitute a primary water quality concern for the Kissimmee River Basin. DO decreased during periods of low flow during both wet and dry seasons, with average concentrations falling below 3.0 mg/L. During periods of high discharge, the water column was well mixed. Seasonal patterns were also present, with wet season (May - October) DO values at the top and bottom of the water column lower on average (4.4 mg/L and 2.7 mg/L, respectively) than dry season values (7.1 and 6.1 mg/L, respectively), possibly as a result of high temperatures during the wet period of the year. Averages at sites along the length of the river ranged from 38 mg/L to 5.8 mg/L, with no apparent trend from north to south.

H.1.6.1.2 Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the Kissimmee River Region are detailed in Attachment B. These parameters are pH, conductivity, turbidity, and oil and pesticides.

H.1.6.2 Lake Okeechobee

References used to compile Lake Okeechobee water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were SFWMD (1998a), FDEP (1996), James *et al.* (1995), and Pfeuffer (1989). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

H.1.6.2.1 Key Region-Specific Water Quality Parameters

Key water quality parameters for Lake Okeechobee are considered to be phosphorus, nitrite/nitrate, chlorophyll-*a*, turbidity, and chloride (see Table H.1.6-1). With the exception of chloride, data for these parameters are detailed below.

Phosphorus

Phosphorus concentrations reported in the 1996 305(b) report (FDEP, 1996) ranged from 0.03 mg/L to 0.14 mg/L within the lake, with an overall mean concentration of 0.065 mg/L for the lake (for the period of 1990 to 1995). TP conditions in the basin were generally worse than those observed in the lake as shown below:

S-135 (current 1990-1995)	TP=0.08 mg/L
S-135 (historic 1980-1995)	TP=1.25 mg/L
Lettuce Creek	TP=0.40 mg/L
Myrtle Creek	TP=0.28 mg/L

Data collected and reported by the SFWMD (1998a) summarizes the TP concentrations entering the lake at thirty-five locations. During the period of period from 1989 to 1991, the mean TP concentrations entering and leaving the lake ranged from a low of 0.48 mg/L to a high of 0.545 mg/L. SFWMD (1998a) data for limnetic and littoral zone monitoring stations indicated the in-lake mean TP concentrations ranged from a low of 0.0099 mg/L to a high of 0.194 mg/L for the same period of time.

James *et al.* (1995) analyzed historical trends in the lake and reported that the mean TP concentration for the period of 1973 to 1992 was 0.080 mg/L, with an associated standard deviation of 0.032 mg/L. The median concentration for the lake was reported as 0.076 mg/L, with minimum and maximum values of 0.027 mg/L and 0.193 mg/L, respectively.

The three databases are not sufficient to develop trend analyses; however, the stations reporting the highest values within the SFWMD (1998a) database do not correspond to the monitoring zone reporting the highest TP concentration in the 1996 305(b) report. This may be attributed to the greater number of monitoring stations within the SFWMD (1998a) than those reported in the 305(b) report.

Nitrite/Nitrate

Data collected and reported by the SFWMD (1998a) summarizes the NO_x concentrations entering the lake at thirty-five locations. During the period from 1989 to 1997, the mean NO_x concentrations entering and leaving the lake ranged from a low of 0.0274 mg/L to a high of 1.596 mg/L. SFWMD (1998a) data for limnetic and littoral zone monitoring stations indicated the in-lake mean NO_x concentrations ranged from a low of 0.0108 mg/L to a high of 0.1964 mg/L for the same period of time. The SFWMD (1998a) report did not attempt to correlate the inflow, outflow, and in-lake NO_x concentrations, nor can a similar relationship be developed using the 1996 305(b) report.

James *et al.* (1995) reported that the mean NO_x concentration for the period of 1973 to 1992 was 0.130 mg/L, with an associated standard deviation of 0.113 mg/L. The median concentration for the lake was reported as 0.106 mg/L, with minimum and maximum values of 0.004 mg/L and 0.618 mg/L, respectively.

Chlorophyll-*a*

The mean chlorophyll-*a* concentration in the lake for the period of 1973 to 1992 was 23.9 mg/m^3, with an associated standard deviation of 8.4 mg/m^3 (James *et al*., 1995). The median concentration for the lake was reported as 23.1 mg/m^3, with minimum and maximum values of 4.9 mg/m^3 and 52.8 mg/m^3, respectively.

Turbidity

The 1996 305(b) report (FDEP, 1996) shows in-lake turbidity concentrations ranged from a high of 24.8 mg/L to a low of 2.0 mg/L. There were no apparent trends in the lake related to turbidity. The turbidity of water in the lake basin were generally lower than those observed in the lake, ranging from 3.7 mg/L in Myrtle Slough to 4.5 mg/L at S-135.

According to James *et al*. (1995), the mean turbidity concentration for the period of 1973 to 1992 was 20.5 mg/L, with an associated standard deviation of 14.4 mg/L. The median concentration for the lake was reported as 16.8 mg/L, with minimum and maximum values of 0.6 mg/L and 85 mg/L, respectively.

> (Note: Units for turbidity data for Lake Okeechobee were inadvertently reported in FDEP (1996) as "mg/L" as opposed to "NTU". This was apparently was also the case for James *et al*. (1995)).

H.1.6.2.2 Other Region-Specific Water Quality Parameters

Data for other water quality parameters for Lake Okeechobee are detailed in Attachment B. These parameters are pH, dissolved oxygen, ammonia/unionized ammonia, conductivity, temperature, and pesticides.

H.1.6.3 Upper East Coast and Indian River Region

The discussion of the Upper East Coast (UEC) region was divided into two subregions of interest: the St. Lucie River and the Indian River Lagoon.

H.1.6.3.1 St. Lucie River Subregion

References used to compile the St. Lucie River subregion water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996) and Woodward-Clyde (1994). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the St. Lucie River subregion are considered to be phosphorus, pesticides, dissolved oxygen, mercury and other heavy metals, nitrite/nitrate, and salinity (see Table H.1.6-1). With the exception of nitrite/nitrate and salinity, data for these parameters are detailed below.

Phosphorus

The average TP concentration in the St. Lucie River was 0.15 mg/L in the south Fork, 0.31 mg/L in the north, and 0.2 mg/L in the estuary.

Pesticides

Table H.1.5.2.1.3.2-1 (see Section H.1.5.2.1.3.2) lists the pesticides detected at Monitoring Site S80 of the SFWMD pesticide monitoring program, which is the only monitoring location draining into the St. Lucie River (R. Pfeuffer: SFWMD, 1998 personal communication). During this time period (1992-1997), nine pesticides were detected. Of the four detections of ethion at Site S80, three (4/6/92, 7/27/92, 11/2/92) exceeded the 48-hour LC_{50} of 0.06 µg/L, reported for *Daphnia magna*, a sensitive indicator species for aquatic macroinvertebrate. The fourth detection (8/18/97) exceeds the chronic toxicity level (0.003 µg/L) for *D. magna*, calculated according to promulgated procedure (F.A.C. 62-302.200). At this level, long-term exposure can cause impacts to the macroinvertebrate populations. Although detected, endosulfan residues have not exceeded the Florida Criteria for Class III Waters (F.A.C. Section 62-302.530).

Dissolved Oxygen

The mean DO level for the river was 4.7 mg/L in the south Fork, 5.5 mg/L in the north, and 6.3 mg/L in the estuary.

Mercury and Other Heavy Metals

For the heavy metal mercury, some general mercury data from USEPA (1998: draft) were provided in sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the St. Lucie River subregion are detailed in Attachment B. These parameters are pH, conductivity, and turbidity.

H.1.6.4 Indian River Lagoon Subregion

The reference used to compile the Indian River Lagoon (IRL) subregion water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B was Woodward-Clyde (1994). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the IRL subregion are considered to be phosphorus, pesticides, nitrite/nitrate, turbidity, salinity, heavy metals, and coliforms (see Table H.1.6-1**.** With the exception of coliforms, data for these parameters are detailed below.

Phosphorus

The mean TP concentration in the south IRL was 0.034 mg/L (with a standard deviation of 0.02 mg/L) for the period of 1989 to 1991. The maximum and minimum concentrations for the same period were 0.18 mg/L and 0.004 mg/L, respectively.

Pesticides

Based on FDEP and SFWMD data from ongoing monitoring programs, C-25 in the IRL is known to transport pesticides into the estuary and offshore. Specifically, bromacil, chlorpyrifos ethyl, ethion, diuron, hexazinone, malathion, metalaxyl, norflurazon, dicofol, 2,4-D, and simazine pesticides were detected in water samples taken from C-25. Moreover, 12 state water quality standards violations have been documented for malathion and ethion from 1992 to 1997 (R. Pfeuffer: SFWMD, 1998 personal communication). For sediments, the pesticides dicofol, diuron, ethion, and p,p'-DDE were found in C-25 sediments, while diuron and ethion at probable toxic levels have also been documented.

Nitrite/Nitrate

The mean NO_x concentration in the south IRL was 0.15 mg/L for the period of 1989 to 1991.

Turbidity

The mean turbidity concentration in the south IRL, as reported in FDEP(1996), was 3.17 mg/L (with a standard deviation of 1.63 mg/L) for the period of 1989 to 1991. The maximum and minimum concentrations for the same period were 7.7 mg/L and 1.0 mg/L, respectively.

(Note: Units for turbidity were inadvertently reported in FDEP (1996) as “mg/L” as opposed to “NTU”.)

Salinity

The mean salinity of the south IRL was 24.5 ppt (with a standard deviation of 4.88 ppt) for the period of 1989 to 1991. The maximum and minimum concentrations for the same period were 37 ppt and 10 ppt, respectively.

Heavy Metals

For the heavy metal mercury, some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the IRL subregion are detailed in Attachment B. These parameters are dissolved oxygen and PAHs.

H.1.6.5 Everglades Agricultural Area

References used to compile the Everglades Agricultural Area (EAA) water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996), USACE (1996), Limno-Tech (1995), and SFWMD (1992a). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

H.1.6.5.1 Key Region-Specific Water Quality Parameters

Key water quality parameters for the EAA are considered to be phosphorus, pesticides, mercury, nitrite/nitrate, dissolved oxygen, and conductivity (see Table H.1.6-1). Data for these parameters are detailed below.

Phosphorus

Water quality in the EAA is considered poor with respect to phosphorus concentrations. Phosphorus in the EAA waters constitutes a significant water quality problem, and is a primary focus of agricultural BMPs and storm water runoff cleanup efforts. The high phosphorus concentrations result from a combination of oxidation and mineralization of the peat soils and fertilizer use.

Discharges from several EAA basins monitored between 1979 and 1988 averaged 0.169 mg/L (volume-weighted concentration) TP, ranging between 0 .067 and 0.232 mg/L. Orthophosphate makes up the majority of TP. The lowest values were generally associated with minor discharge volumes and did not greatly affect the mean value. The phosphorus-laden water is discharged to the WCAs and is back-pumped to Lake Okeechobee, and has been a primary source of eutrophication for both areas.

Pesticides

Pesticides monitoring data for the EAA is presented in Table H.1.5.2.1.3.2-1 (see Section H.1.5.2.1.3.2) for 1992-1997. Seven monitoring sites were sampled by the SFWMD (1998 personal communication, R. Pfeuffer). During this period (1992-1997), 18 pesticides were detected with nine being detected only once. Only endosulfan (sum of endosulfan alpha and beta) was found to exceed its Class III criterion of 0.056 µg/L. Exceedances occurred at site L3BRS on 1/27/93 (0.063 µg/L). The only diazinon detection at Monitoring Site S2 (0.34 µg/L, 8/8/95) exceeded the acute and chronic toxicity levels for *Daphnia magna* (0.3 and 0.04 µg/L, respectively), a sensitive indicator species for aquatic macroinvertebrates, calculated according to promulgated procedure (F.A.C . 62-302.200). At these levels, exposure can cause impacts to the macroinvertebrate populations. The only diazinon detection at Site S4 (1.9 µg/L, 1/26/93) exceeded the 48-hour LC_{50} of 0.06 µg/L, reported for *D. magna*. At these levels, exposure can cause impacts to the macroinvertebrate populations. The only chlorpyrifos ethyl detection at Site S6 (0.023 µg/L, 4/17/96) exceeded the calculated chronic toxicity level for *D. magna* (0.005 µg/L). The only parathion methyl detection at Site S8 (0.022 µg/L, 10/11/95) exceeded the calculated chronic toxicity level for *D. magna* (0.007 µg/L).

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Nitrite/Nitrate

Nitrate concentrations were found to range up to 2.4 mg/L in studies of EAA water quality conducted in the 1940's. Mean NO_X concentrations for the period 1977-1989 at four major pump stations draining the EAA ranged from 0.771 to 1.21 mg/L, primarily nitrate. These elevated values are derived primarily from the biological oxidation and mineralization of organic muck soils.

Dissolved Oxygen

DO levels in EAA waters often violate Class III water quality standards, averaging between 3.2 mg/L and 4.9 mg/L for four major pump stations sampled between 1977 and 1989.

Conductivity

EAA waters tend to have relatively high specific conductance due to contact with underlying limestone bedrock in the canal system that drains the basin. Long-term average conductivities at four major pump stations draining the EAA ranged from 788 µmhos/cm to 1,241 µmhos/cm. The data sets were relatively consistent with coefficient of variation values ranging between 25% and 36%.

H.1.6.5.2 Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the EAA are detailed in Attachment B**.** These parameters are pH, temperature, ammonia/unionized ammonia, and turbidity.

H.1.6.6 Water Conservation Areas

Discussion of the Water Conservation Areas (WCAs) region was divided into three subregions of interest: the Loxahatchee National Wildlife Refuge (LNWR), the WCA-2A/2B, and the WCA-3A/3B.

H.1.6.6.1 Loxahatchee National Wildlife Refuge Subregion

References used to compile the LNWR water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996), Limno-Tech (1995), and SFWMD (1992b). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the LNWR are considered to be phosphorus, dissolved oxygen, conductivity, mercury, and nitrite/nitrate (see Table H.1.6-1). With the exception of nitrite/nitrate, data for these parameters are detailed below.

Phosphorus

The mean TP concentration collected at thirty-three stations in the LNWR was 0.063 mg/L for the period from 1979 to 1993. The lowest mean concentration observed at any station in the LNWR was 0.11 mg/L, while the highest concentration was 0.171 mg/L. The lowest concentration observed in the basin was 0.001 mg/L and the highest observation was 0.494 mg/L.

Dissolved Oxygen

The mean DO concentration collected at thirty-three stations in the LNWR was 4.8 mg/L for the period from 1979 to 1993. The lowest mean concentration observed at any station in the LNWR was 2.6 mg/L, while the highest concentration was 7.7 mg/L. The lowest concentration observed in the basin was 0.1 mg/L and the highest observation was 10.7 mg/L.

Conductivity

The mean specific conductance value collected in the LNWR was 937.1µmhos/cm for the period from 1979 to 1993. The mean conductivity values observed in the LNWR ranged from 90.3 µmhos/cm to 1418.9µmhos/cm.

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the LNWR are detailed in Attachment B**.** These parameters are ammonia/unionized ammonia, pH, turbidity, temperature, and pesticides.

H.1.6.6.2 Water Conservation Area 2A/2B Subregion

References used to compile the WCA-2A/2B subregion water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996), Limno-Tech (1995), and SFWMD (1992b). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the WCA-2A/2B subregion are considered to be phosphorus, dissolved oxygen, conductivity, mercury, and nitrite/nitrate (see Table H.1.6-1). With the exception of nitrite/nitrate, data for these parameters are detailed below.

Phosphorus

The mean TP concentration collected in the WCA-2A basin was 0.061 mg/L, and in the WCA-2B basin was 0.021 mg/L, for the period 1979 to 1993. The lowest mean concentration observed at any station in the WCA-2A basin was 0.010 mg/L and in the WCA-2B basin was 0.018 mg/L, while the highest concentration was 0.245 mg/L in WCA-2A and 0.025 mg/L in WCA-2B. The lowest concentration observed in the WCA-2A basin was 0.001 mg/L and in the WCA-2B basin was 0.001 mg/L, while the highest observation was 4.190 mg/L in WCA-2A and 0.148 mg/L in WCA-2B.

Dissolved Oxygen

The mean DO concentration collected in WCA-2A was 3.1 mg/L, and in WCA-2B was 4.3 mg/L, for the period from 1979 to 1993. The lowest mean concentration observed at any station in WCA-2A was 1.2 mg/L, while the lowest level observed in WCA-2B was 3.0 mg/L. The highest mean DO concentration observed in WCA-2A was 5.0 mg/L, and in WCA-2B was 5.2 mg/L. The lowest concentration observed in the WCA-2A basin was 0.0 mg/L and the highest observation was 12.4 mg/L. The lowest DO concentration recorded in the WCA-2B basin was 0.3 mg/L, while the highest was 12.2 mg/L.

Conductivity

The mean specific conductance value collected in WCA-2A was 1,157.5 µmhos/cm, and in WCA-2B was 892.1 µmhos/cm, for the period from 1979 to 1993. The mean specific conductance values observed in WCA-2A ranged from 752.5 µmhos/cm to 2,720 µmhos/cm, and in WCA-2B ranged from 861 µmhos/cm to 931.7 µmhos/cm.

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced

H.1.6.6.3 Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the WCA-2A/2B subregion are detailed in Attachment B**.** These parameters are ammonia/unionized ammonia, pH, turbidity, temperature, and pesticides.

H.1.6.6.4 Water Conservation Area 3A/3B Subregion

References used to compile the WCA-3A/3B subregion water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996), Limno-Tech (1995), and SFWMD (1992b). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the WCA-3A/3B subregion are considered to be phosphorus, dissolved oxygen, conductivity, mercury, and nitrite/nitrate (see Table H.1.6-1). With the exception of nitrite/nitrate, data for these parameters are detailed below.

Phosphorus

The mean TP concentration collected in the WCA-3A basin was 0.032 mg/L, and in the WCA-3B basin was 0.013 mg/L, for the period from 1979 to 1993. The lowest mean concentration observed at any station in the WCA-3A basin was 0.004 mg/L and in the WCA-3B basin was 0.006 mg/L, while the highest concentration was 0.211 mg/L in WCA-3A and 0.031 mg/L in WCA-3B. The lowest concentration observed in the WCA-3A basin was 0.001 mg/L and in the WCA-3B basin was 0.002 mg/L, while the highest observation was 0.593 mg/L in WCA-3A and 0.435 mg/L in WCA-3B.

Dissolved Oxygen

The mean DO concentration collected in WCA-3A was 4.8 mg/L, and in WCA-3B was 3.7 mg/L for the period from 1979 to 1993. The lowest mean concentration observed at any station in WCA 3A was 1.7 mg/L, while the lowest level observed in WCA-3B was 1.9 mg/L. The highest mean DO concentration observed in WCA-3A was 8.8 mg/L, and in WCA-3B was 9.4 mg/L. The lowest concentration observed in the WCA-3A basin was 0.1 mg/L and the highest observation was 15.4 mg/L. The lowest DO concentration recorded in the WCA-3B basin was 0.0 mg/L, while the highest was 12.2 mg/L.

Conductivity

The mean specific conductance value collected in WCA-3A was 718.4 µmhos/cm, and in WCA-3B was 686.4 µmhos/cm, for the period from 1979 to 1993. The mean conductivity values observed in WCA-3A ranged from 240 µmhos/cm to 1,096.7 µmhos/cm, and in WCA-3B ranged from 460.9 µmhos/cm to 794.3 µmhos/cm.

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the WCA-3A/3B subregion are detailed in Attachment B. These parameters are ammonia/unionized ammonia, pH, turbidity, temperature, and pesticides.

H.1.6.7 Lower East Coast Region

The discussion for the Lower East Coast (LEC) region was divided into three subregions of interest: the Loxahatchee River Aquatic Preserve (LRAP), Lake Worth Lagoon, and Biscayne Bay.

H.1.6.7.1 Loxahatchee River Aquatic Preserve Subregion

References used to compile the LRAP subregion water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996) and SFWMD (1980).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the LRAP are considered to be phosphorus, dissolved oxygen, mercury, nitrite/nitrate, coliforms, and salinity (see Table H.1.6-1). With the exceptions of nitrite/nitrate, coliforms and salinity, data for these parameters are detailed below.

Phosphorus

The mean TP concentration in the estuarine section of the river was 0.03 mg/L.

Dissolved Oxygen

The mean DO concentration for the estuarine section of the river was 6.5 mg/L.

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the WCA-3A/3B subregion are detailed in Attachment B**.** These parameters are pH, conductivity, and turbidity.

H.1.6.7.2 Lake Worth Subregion

References used to compile the Lake Worth subregion data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were SFWMD (1998a) and FDEP (1996). Water quality data were for canal stations near Lake Worth that influence its water quality, as opposed to Lake Worth itself.

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the Lake Worth subregion are considered to be phosphorus, nitrite/nitrate, dissolved oxygen, turbidity, heavy metals, VOCs, salinity, and coliforms (see Table H.1.6-1)**.** With the exceptions of VOCs, salinity and coliforms, data for these parameters are detailed below.

Phosphorus

The SFWMD (1998a) reports the mean TP concentration recorded at the S-44 structure on the C-17 canal was 0.0726 mg/L, where the minimum and maximum TP concentrations were 0.021 mg/L and 0.284 mg/L, respectively. The mean TP concentration recorded at the S-155 structure on the C-51 canal was 0.1108 mg/L, where the minimum and maximum TP concentrations were 0.029 mg/L and 0.384 mg/L, respectively.

Nitrite/Nitrate

According to the SFWMD (1998a), the mean NO_x concentration recorded at the S-44 structure on the C-17 canal was 0.1887 mg/L, where the minimum and maximum NO_x concentrations were 0.004 mg/L and 1.98 mg/L, respectively. The mean NO_x concentration recorded at the S-155 structure on the C-51 canal was 0.2447 mg/L, where the minimum and maximum TP concentrations were 0.004 mg/L and 1.768 mg/L, respectively.

Dissolved Oxygen

The 1996 305(b) report (FDEP, 1996) shows the mean DO concentration measured at for the West Palm Beach Canal was 4.6 mg/L.

Turbidity

The 1996 305(b) report (FDEP, 1996) shows the mean turbidity concentration measured for the West Palm Beach Canal was 16.8 mg/L.

(Note: Units for turbidity data for the Lake Worth subregion were inadvertently reported by FDEP (1996) as “mg/L” as opposed to “NTU”.)

Heavy Metals

For the heavy metal mercury, some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the Lake Worth subregion are detailed in Attachment B. These parameters are pH and conductivity.

H.1.6.7.3 Biscayne Bay Subregion

References used to compile the Biscayne Bay subregion data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996), SFWMD (1995a), and Uhler (1993).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the Biscayne Bay subregion are considered to be phosphorus, nitrite/nitrate, dissolved oxygen, tributyltin (TBT), heavy metals, coliforms, and VOCs (see Table H.1.6-1). With the exceptions of coliforms and VOCs, data for these parameters are detailed below.

Phosphorus

The mean TP concentrations measured in Biscayne Bay ranged from 0.006 mg/L to 0.171 mg/L. The median TP concentrations ranged from 0.003 mg/L to 0.181 mg/L. TP concentrations changed significantly at nine monitoring stations: two stations indicated an increasing trend while TP concentrations decreased at seven other stations. The two stations showing increasing trends were associated with Goulds Canal and Aerojet Canal. Most of the decreasing trends were observed in the North Bay including Biscayne Canal.

Nitrite/Nitrate

The mean NO_x concentration observed for the Bay ranged from 0.01 to 3.58 mg/L. NO_x concentrations changed significantly at ten stations: increasing at seven and decreasing at three others. All increasing trends were observed in the tributaries to the Bay including Arch Creek, Miami Canal, Wagner Creek, Black Creek, Goulds Canal, and Military Canal.

Dissolved Oxygen

The mean DO concentrations, as measured at 1.0 meter below the surface, ranged from 1.6 mg/L to 8.0 mg/L.

Tributyltin (TBT)

TBT was sampled from oyster flesh (*Crassostrea virginica*) at several U.S. east coast sites (from Maine to Florida) at NOAA stations (Uhler *et al.*, 1993) as part of the NOAA National Status and Trends Mussel Watch Project. Three sample sets were taken, one each in 1989-1990, 1988-1989, and 1987-1988. Four Florida stations were sampled, including two stations within the Lower East Coast and Biscayne Bay region designated in this PEIS: North Miami (Maule Lake) and Biscayne Bay (Gould's Canal). In the most recent sampling (1989-1990), TBT, dibutlytin (DBT) monobutyltin (MBT), and total butyltin (Total) were analyzed. TBT at the North Miami site in 1989-1990 was 3.35 µg/l, while the Total was 4.42 µg/l. TBT at the Biscayne Bay site during this period was 4.03 µg/l, while the Total was 5.93 µg/l. The Total for the 1988-1989 sampling at the North Miami site was 7.66 µg/l. No Total data were recorded for the other two sample sets or for the Biscayne Bay site in general. These concentrations were the highest recorded for the sampled four Florida stations and the east coast stations in general.

Heavy Metals

For the heavy metal mercury, some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the Biscayne Bay subregion are detailed in Attachment B. These parameters are ammonia/unionized ammonia and salinity.

H.1.6.8 Everglades National Park and Florida Bay

The Everglades National Park and Florida Bay region is divided into four subregions of interest: Shark River Slough/Taylor Slough, Florida Bay, Whitewater Bay, and Ten Thousand Islands. These four subregions are discussed below.

H.1.6.8.1 Shark River Slough/Taylor Slough Subregion

References used to compile the Shark River Slough/Taylor Slough subregion data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were SFWMD (1998a), FDEP (1996), and Limno-Tech (1995). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the Shark River Slough/Taylor Slough subregion are considered to be phosphorus and mercury (see Table H.1.6-1). Data for these parameters are detailed below.

Phosphorus

Analysis of data (SFWMD, 1998a) for four sites in Shark River Slough and one in Taylor Slough indicated that TP concentrations ranged from 0.003 mg/L to 0.546 mg/L for the period 1985 to 1997. The mean TP concentrations ranged from 0.0067 mg/L to 0.0403 mg/L for the same time period.

Limno-Tech (1995) found a median TP concentration of 0.011 mg/L after analyzing 1,685 records at five stations (period of record was 1979 to 1993). The same report shows the mean TP concentrations in this basin ranged from 0.007 mg/L to 0.053 mg/L.

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the Shark River Slough/Taylor Slough subregion are detailed in Attachment B. These parameters are nitrite/nitrate, ammonia/unionized ammonia, pH, dissolved oxygen, conductivity, turbidity, temperature, and pesticides.

H.1.6.8.2 Florida Bay Subregion

The references used to compile the Florida Bay subregion water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were SFWMD (1998b) and a SFWMD raw database (SFWMD, 1998: unpublished) made available through personal communication in 1998 (M. Slayton, SFWMD). The database for the period of record from 1991-1997 was then reduced to means and medians by a USEPA contractor and divided into an east basin and west basin data set. The dividing line between the two sub-basins was just east of Whipray Basin. In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the Florida Bay subregion are considered to be salinity, phosphorus, mercury, and chlorophyll-*a* (see Table H.1.6-1). Data for these parameters are detailed below.

Salinity

The mean salinity were higher in the west basin than in the east basin. The mean concentration in the east basin was 21.4 ppt for the period of record, with a corresponding standard deviation of 10.3 ppt. The median salinity level in the east basin was 23.3 ppt, with minimum and maximum values of 0.01 ppt and 53 ppt, respectively. The 53 ppt maximum is well about normal seawater (35 ppt).

The mean salinity concentration in the west basin was 33.3 ppt for the period of record, with a corresponding standard deviation of 6.2 ppt. The median salinity value in the west basin was 33.5 ppt, with minimum and maximum values of 8.7 ppt and 63 ppt, respectively.

Phosphorus

The mean total phosphorus concentrations were higher and showed greater variability in the west basin than the east basin. The mean concentration in the east basin was 0.0095 mg/L for the period of record, with a corresponding standard deviation of 0.0047 mg/L. The median phosphorus concentration in the east basin was 0.0082 mg/L, with minimum and maximum values of 0.001 mg/L and 0.04 mg/L, respectively.

The mean phosphorus concentration in the west basin was 0.0204 mg/L for the period of record, with a corresponding standard deviation of 0.0157 mg/L. The median phosphorus concentration in the west basin was 0.016 mg/L, with minimum and maximum values of 0.003 mg/L and 0.13 mg/L, respectively.

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Chlorophyll-*a*

The mean chlorophyll-*a* concentrations were higher and showed greater variability in the west basin than the east basin. The mean value in the east basin was 0.71 mg/m^3 for the period of record, with a corresponding standard deviation of 0.4341 mg/m^3. The median chlorophyll-*a* level in the east basin was 0.7 mg/m^3, with minimum and maximum values of 0.02 mg/m^3 and 4.07 mg/m^3, respectively.

The mean chlorophyll-*a* level in the west basin was 2.07 mg/m^3 for the period of record, with a corresponding standard deviation of 1.91 mg/m^3. The median chlorophyll-*a* concentration in the west basin was 1.32 mg/m^3, with minimum and maximum values of 0.1 mg/m^3 and 11.6 mg/m^3, respectively.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the Florida Bay subregion are detailed in Attachment B**.** These parameters are nitrite/nitrate, ammonia/unionized ammonia, dissolved oxygen, turbidity, temperature, and pesticides.

H.1.6.8.3 Whitewater Bay Subregion

The reference used to compile the Whitewater Bay subregion water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Appendix I was a SFWMD raw database (SFWMD, 1998: unpublished) made available through personal communication with the SFWMD in 1998 (M. Slayton, SFWMD). The database for the period of record from 1991-1997 was then reduced to means and medians by a USEPA contractor. In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameters for the Whitewater Bay subregion are considered to be salinity, phosphorus, mercury, and chlorophyll-*a* (see Table 3.1.10.5.3-1). Data for these parameters are detailed below.

Salinity

The mean concentration in the bay was 13.8 ppt for the period of record (1991-1997) with a corresponding standard deviation of 9.0 ppt. The median salinity level in the bay was 11.9 ppt, with minimum and maximum values of 0.3 ppt and 35 ppt, respectively.

Phosphorus

The mean concentration in the bay was 0.024 mg/L for the period of record, with a corresponding standard deviation of 0.0118 mg/L. The median phosphorus concentration in the bay was 0.022 mg/L, with minimum and maximum values of 0.0007 mg/L and 0.094 mg/L, respectively.

Mercury

Some general mercury data from USEPA (1998: draft) were provided in Sections H.1.4.2.1 and H.1.5.2.1.1, with additional draft or published mercury data sources also being referenced.

Chlorophyll-*a*

The mean value in the bay was 3.4 mg/m^3 for the period of record, with a corresponding standard deviation of 2.6 mg/m^3. The median chlorophyll-*a* level in the bay was 2.6 mg/m^3, with minimum and maximum values of 0.3 mg/m^3 and 17.8 mg/m^3, respectively.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the Whitewater Bay subregion are detailed in Attachment B. These parameters are nitrite/nitrate, ammonia/unionized ammonia, dissolved oxygen, turbidity, temperature, and pesticides.

H.1.6.8.4 Ten Thousand Islands Subregion

The 1996 305(b) report (FDEP, 1996) was the reference used to compile the Ten Thousand Islands water quality data for the key water quality parameter discussed below and other water quality parameters discussed in Attachment B**.** In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

Key Subregion-Specific Water Quality Parameters

Key water quality parameter for the Ten Thousand Island subregion is considered to be salinity (see Table H.1.6-1)**.** In lieu of salinity data, conductivity data are provided below.

Salinity/Conductivity

No salinity data were reported in the 1996 305(b) report (FDEP, 1996). However, a related parameter, conductivity, was presented. The mean specific conductivity level recorded at the referenced station was 41,250 µmhos/cm.

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the Ten Thousand Islands subregion are detailed in Attachment B**.** These parameters are phosphorus, nitrite/nitrate, pH, dissolved oxygen, conductivity, turbidity, and pesticides.

H.1.6.9 Florida Keys

The reference used to compile the Florida Keys water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were Boyer and Jones (1998) and FDEP (1996).

H.1.6.9.1 Key Region-Specific Water Quality Parameters

Key water quality parameters for the Florida Keys are considered to be phosphorus, nitrite/nitrate, dissolved oxygen, turbidity, chlorophyll-*a*, and coliforms (see Table H.1.6-1). With the exceptions of chlorophyll-*a* and coliforms, data for these parameters are detailed below.

Phosphorus

The mean TP concentrations ranged from 0.01 mg/L in Harrison Canal to 0.13 mg/L in Blackwater Sound and 0.14 mg/L in Barnes Sound.

Nitrite/Nitrate

The median NO_x concentrations for surface segments 1, 2, 4, 5, 6, 7 and 9 ranged from 0.09 µM to 0.26 µM. The maximum NO_x concentrations for the same segments ranged from 0.55 µM to 4.57 µM, while the minimum concentrations ranged from 0.0 µM to 0.03 µM.

Dissolved Oxygen

The mean DO concentrations for the Keys basin ranged from 5.5 mg/L at Marathon to 8.4 mg/L at Plantation Key. The mean DO value for all reported stations was 6.8 mg/L.

Turbidity

According to the 1996 305(b) report (FDEP, 1996), the mean turbidity results for the Keys basin ranged from 1.0 mg/L at Plantation Key, Harrison Canal, and Barnes Sound to 2.2 mg/L at Marathon.

(Note: Units for turbidity data for the Florida Keys were inadvertently reported by FDEP (1996) as “mg/L” as opposed to “NTU”.)

H.1.6.9.2 Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the Florida Keys are detailed in Attachment B. These parameters are ammonia/unionized ammonia, pH, conductivity, temperature, and salinity.

H.1.6.10 Big Cypress Region

The reference used to compile the Big Cypress Region water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were FDEP (1996) and the U.S. Department of the Interior/ National Park Service (USDOI/NPS: 1996).

H.1.6.10.1 Key Region-Specific Water Quality Parameters

Key water quality parameters for the Big Cypress Region are considered to be phosphorus, nitrite/nitrate, and dissolved oxygen (see Table H.1.6-1). With the exception of dissolved oxygen, data for these parameters are detailed below.

Phosphorus

TP concentrations ranged from below detection limits to 0.11 mg/L and averaged 0.02 mg/L for the period from 1969-1970. For the period from 1966-1980, TP ranged from 0.006 to 0.14 mg/L, averaging 0.03 mg/L.

Nitrite/Nitrate

Total nitrites and nitrates ranged from 0.004 mg/L to 0.25 mg/L.

H.1.6.10.2 Other Region-Specific Water Quality Parameters

No other water quality parameters for the Big Cypress Region are detailed in Attachment B.

H.1.6.11 Caloosahatchee River Region

The references used to compile the Caloosahatche River Region water quality data for the key water quality parameters discussed below and the other water quality parameters discussed in Attachment B were SFWMD (1998, 1980) and FDEP (1996). In addition, summarized pesticide data were obtained through 1998 personal communication with the SFWMD (R. Pfeuffer).

H.1.6.11.1 Key Region-Specific Water Quality Parameters

Key water quality parameters for the Caloosahatchee River Region are considered to be phosphorus, pesticides, nitrite/nitrate, dissolved oxygen, conductivity, and coliforms (see Table H.1.6-1)**.** With the exception of coliforms, data for these parameters are detailed below.

Phosphorus

TP values were widely variable over the basin, with the lower values more likely being associated with relatively undeveloped areas. Primarily agricultural drainages tended to have higher values. Samples from 19 sites in the basin collected in 1978 and 1979 averaged 0.108 mg/L with a standard deviation of 0.289. Orthophosphate accounted on average for 61% of TP in those samples. Data for four sites in the basin from the late 1970's and early 1980's to 1994 averaged 0.200 mg/L, with one site draining a basin near Lake Okeechobee averaging double the other sites. The maximum value recorded, 1.737 mg/L, was also from this site. The next highest value was 0.495 mg/L, and low values for the four sites ranged between 0.039 and 0.157 mg/L. Orthophosphate accounted for 64% of TP on average, but at the site with the highest values accounted for 71% of TP. Orthophosphate averaged 55% of TP at the other sites. Average sample values increased at two of the four sites for data collected between 1989 and 1991, with an overall mean of 0.265 mg/L. Orthophosphate accounted for 64% of TP on the average for these samples.

Pesticides

SFWMD pesticides monitoring data exists for the Caloosahatchee River Region (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2). Three monitoring sites have been sampled by SFWMD. During this period (1992-1997), 12 pesticides were detected with four being detected only once (R. Pfeuffer: SFWMD, 1998 personal communication). The only detection of ethion at CR33.5T, (0.035 µg/L, 6/5/95) exceeded the acute toxicity level (0.02 µg/L) reported for *Daphnia magna*, a sensitive indicator species for aquatic macroinvertebrate, calculated according to promulgated procedure (F.A.C. 62-302.200. At this level, short-term exposure can cause impacts to the macroinvertebrate populations. The remainder of pesticides detected did not exceed any numeric or calculated F.A.C. 62-302 criteria.

Nitrite/Nitrate

NO_x concentrations in the basin showed no clear pattern of change down the basin toward the west. Concentrations at several sites sampled in 1978 and 1979 ranged from less than detection to 1.133 mg/L, with an average sampling site mean of 0.206 mg/L. Mean values for NO_x at four sites in the basin for data from the late 1970's and early 1980's to 1994 averaged 0.208 mg/L, with individual site means ranging between 0.125 mg/L and 0.303 mg/L. Minimum values were below detection limits and maximum values ranged between 0.69 mg/L and 1.113 mg/L. The highest values were associated with an agriculturally developed area.

Dissolved Oxygen

DO concentrations varied widely over the planning area and seasonally at the various sites sampled. For all data, the mean DO was 5.2 mg/L with a standard deviation of 1.8 mg/L. Mean saturation level for the area was 60%, with a standard deviation of 21%.

Conductivity

Specific conductance varied greatly with season, and was also associated with saltwater mixing near the coast and rainfall dilution effects. The mean conductance over the planning area was 1,201 µmhos/cm with a standard deviation of 1,094 µmhos/cm.

Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the Caloosahatchee River Region are detailed in Attachment B. These parameters are pH, turbidity, and temperature.

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H.3 LIST OF ACRONYMS AND ABBREVIATIONS

% - Percent

ATSDR - Agency for Toxic Substance and Disease Registry

BAF - Bioaccumulation Factor

BAT - Best Available Technology Economically Achievable

BCF - Bioconcentration Factor

BCT - Best Conventional Pollution Control Technology

BMP - Best Management Practice

BOD - Biochemical Oxygen Demand

BPT - Best Practicable Control Technology

C - Canal (e.g., C-25)

Cd - Cadmium (elemental)

Cu - Copper (elemental)

CWA - Clean Water Act

CWAA - Clean Water Act Amendments

DBT - Dibutyltin

DDD - a DDT derivative (metabolite)

DDE - a DDT derivative (metabolite)

DDT - Dichlorodiphenyltrichloroethane

DNA - Deoxyribonucleic Acid

DO - Dissolved Oxygen

EAA - Everglades Agricultural Area

ECP - Everglades Construction Project

EFA - Everglades Forever Act

EMA - Ecosystem Management Areas

EMAP - Environmental Monitoring and Assessment Program

ENP (= Park) - Everglades National Park

EPA - Everglades Protection Area

EXTONET - Extension Toxicology Network

FAC - Florida Administrative Code

FAMS - Florida Atmospheric Mercury Study

FDACS - Florida Department of Agriculture and Consumer Services

FDEP (=Department) - Florida Department of Environmental Protection

Fe - Iron (elemental)

FMRI - Florida Marine Resource Institute

FS - Florida Statute

FSU - Florida State University

ft - feet

FY - fiscal year

g/ml - Grams Per Milliliter

GWQMN - Groundwater Quality Monitoring Network

Hg - Mercury (elemental)

IRL - Indian River Lagoon

IU - International Units

kg/yr - Kilograms Per Year

K_{OC} - Soil Organic-Carbon Coefficient

L - Levee (e.g., L-67)

LC50 - Lethal Concentration for 50% of test subjects

LEC - Lower East Coast (Region)

LNWR - Loxahatchee National Wildlife Refuge

LRAP - Loxahatchee River Aquatic Preserve

MBT - Monobutyltin

MCL - Maximum Contaminant Level

MDN - National Mercury Deposition Network

MeHg - Methylmercury

mg/L - Milligrams Per Liter

MOA - Memorandum of Agreement

MPN - Most Probable Number

MSL - Mean Sea Level

MSMA - Monosodium Methanearsonate

NAWQA - National Water Quality Assessment Program

NEP - National Estuary Program

NEPA - National Environmental Policy Act

NFWMD - Northwest Florida Water Management

ng TBT - Sn/Kg - Dry weight TBT measurement nanograms per kilogram

ng Sn/L (ppt) - Nanograms of Tin per Liter of Water ng/L - Nanograms Per Liter

NH_3 - Ammonia

NOAA - National Oceanic and Atmospheric Administration

NO_x - Nitrogen Oxides (Air Quality)

NO_x - Nitrites (NO_3) and Nitrates (NO_4) (Water Quality)

NPDES - National Pollutant Discharge Elimination System (permit)

NPL - National Priorities List

NPS - Non-Point Source (pollution)

NSPS - New Source Performance Standards

NTU - Nephelometric Turbidity Units

PAH - Polycyclic Aromatic Hydrocarbon

Pb - Lead (elemental)

PCBs - Polychlorinated Biphenyls

PEIS - Programmatic Environmental Impact Statement

pH - Hydrogen Ion Concentration

PLRG - Pollutant Load Reduction Goal

POTW - Publicly Owned Treatment Works

ppb - Parts Per Billion

ppm - Parts Per Million

ppq - Parts Per Quadrillion

ppt (= $^0/_{00}$) - Parts Per Thousand (salinity) ppt - Parts Per Trillion

PSMP - Pesticide State Management Plan

PVC - Polyvinyl Chloride

RCRA - Resource Conservation and Recovery Act

REMAP - Regional Environmental Monitoring and Assessment Program

S - Structure (e.g., S-9)

SDWA - Safe Drinking Water Act

SFMSP - South Florida Mercury Science Program

SFWMD - South Florida Water Management District

SJRWMD - St. John's River Water Management District

SO_4 - Sulfate

SOFAMMS - South Florida Atmospheric Mercury Monitoring Pilot Study

SPCC - Spill Prevention, Control and Countermeasure

SRP - Soluble Reactive Phosphorus

SRWMD - Suwanee River Water Management District

STA - Stormwater Treatment Area

SWAMP - Surface Water Ambient Monitoring Program

SWFWMD (=District) - Southwest Florida Water Management District

SWIM - Surface Water Improvement and Management Act

TBT - Tributyltin

TCDD - 2, 3, 7, 8-tetrachloro-dibenzo-p-dioxin

TCE - Trichloroethylene

THg - Total Mercury

TOC - Total Organic Carbon

TP - Total Phosphorus

TSD - Treat, Store and/or Dispose

UEC - Upper East Coast (Region)

UIC - Underground Injection Control

USACE - U.S. Army Corps of Engineers

USDA/SCS - U.S. Department of Agriculture, Soil Conservation Service

USDOI - U.S. Department of the Interior

USDW - Underground Sources of Drinking Water

USEPA - U.S. Environmental Protection Agency

USFWS - U.S. Fish and Wildlife Service

USGS - U.S. Geological Survey

USHHR - U.S. Department of Health and Human Resources

WCA - Water Conservation Area (WCA-1, WCA-2, WCA-2A, WCA-2B, WCA-3)

WHO - World Health Organization

WMD - Water Management District

WRE - Water Resources Evaluation

WSSA - Weed Science Society of America

Zn - Zinc (elemental)

°C - Centigrade

°F - Fahrenheit

µg/kg - Micrograms Per Kilogram

µg/L - Micrograms Per Liter

µg/ml - Micrograms Per Milliliter

µgSn/L (ppb) - Micrograms of Tin per liter of water

µgTBT-Sn/L - Micrograms of TBT Tin Per Liter

µgTBT-Sn/kg (ppb) - Dry weight TBT measurement - micrograms per kilogram

µM - Micromole (typically converted to mg/L or ppb)

µmhos/cm - Micromhos Per Centimeter

ATTACHMENT A

WATER QUALITY
ADDITIONAL PARAMETER DESCRIPTIONS

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ATTACHMENT A
ADDITIONAL PARAMETER DESCRIPTIONS

In addition to mercury, phosphorus, and the suite of pesticides described in Appendix H, descriptions of the remaining water quality parameters potentially affected by the existing conditions of the C&SF study area are presented below. These are grouped as metals, biologicals, nutrients, physical parameters, and other parameters.

H-A.1 METALS

Metals can be released to the environment through natural processes such as volcanic activity and the weathering of soil and rock. Metals are also released to the environment through anthropogenic activities such as mining, smelting, plating, and other activities that involve the extraction or processing of metals. Some metals, such as iron, calcium, and zinc are essential human micro-nutrients. However, other metals, such as arsenic, mercury, and lead may be highly toxic and can cause serious human health effects (Goyer, 1991). Effective treatment of water resources contaminated with heavy metals may usually be accomplished by binding the metals to particulates and removing the particulates from the water stream through sedimentation, flocculation and filtration processes (Laws, 1993). A discussion of specific metals that may be contaminants in aquatic environments is presented in the following sections.

H-A.1.1 Copper

Copper is a reddish metal that is naturally occurring in rock, spoil, sediment, and air. Copper also occurs naturally in plants and animals, and is an essential nutrient for humans and animals. Several human enzymes require copper in order to function properly in the body. Forms of anemia can result from copper deficiency. Copper is commonly found in the U.S. penny, electrical wires, and some water pipes. Copper is also a component of some metal alloys, such as brass and bronze. Copper may additionally be found in natural and anthropogenic compounds, the most common of which is copper sulfate. Copper compounds are commonly used in agriculture to treat plant diseases and as a water treatment (ATSDR, 1990).

Copper can enter the body through ingestion, inhalation, and dermal contact. A common route of exposure is through the ingestion of drinking water that becomes contaminated through standing in copper and brass plumbing pipes and fixtures. Once in the body, some of the copper is absorbed by the bloodstream, but control mechanisms limit the amount that can be absorbed. Excess copper is removed from the body in urine and feces (ATSDR, 1990; Goyer, 1991).

Much of the copper that is found in the environment is strongly bound to particulates, and is not easily able to affect human health. Less tightly bound copper, such as copper that forms water soluble compounds, can more easily affect human health, but even these compounds tend to quickly bind to particulates when released to the environment (ATSDR, 1990). Therefore, sedimentation, flocculation, and filtration can be very effective methods of removing copper from water resources.

Although an essential human micro-nutrient, at very high concentrations copper can have serious human health effects. Mild copper poisoning can result in nausea and vomiting, while very high concentrations may result in damage to the liver and kidneys, and in some cases, death. Copper is not believed to be a human carcinogen (ATSDR, 1990; Goyer, 1991).

Additional information on copper may be found in the USEPA Fact Sheet entitled *EPA Facts About Copper* (USEPA, 1992a).

H-A.1.2 Iron

Iron is a relatively abundant element in the universe. It is the fourth most abundant element by weight that makes up the crust of the earth. The pure metal is very reactive chemically and rapidly corrodes. Iron is hard, brittle, and is generally used in industrial settings to produce alloys, including steel. Iron found in the environment may be the result of natural processes or from human activity surrounding its extraction from ore and subsequent industrial uses (CST, 1997(internet)).

Iron most readily enters the body through ingestion and inhalation. Typically, iron is poorly absorbed in the digestive tract. The body requires a relatively long period of time to replenish depleted stores of iron. Average absorption of dietary iron is 8-10% of the total intake. The “heme” form of iron, found in flesh foods (e.g. beef, liver), is more rapidly absorbed at a rate of approximately 10-30% of dietary uptake. Most of the iron absorbed by the body is bound by the protein transferrin, and is transported to the bone marrow where it can be used to create red blood cells. Iron concentrations in the body are highly regulated to maintain homeostasis (Goyer, 1991; Haas, 1998).

Iron is necessary for the formation of red blood cells and the transport of oxygen in blood. Iron also plays a role in DNA synthesis, in the functioning of neurotransmitters, and in several other essential biochemical processes. A deficiency of iron can result in a form of anemia. Because of the human body’s iron requirements and its internal regulation of iron, iron toxicity is relatively rare. Most cases of iron toxicity involve cases of accidental ingestion of large amounts of dietary supplements by children, excess dietary iron by adults, and in individuals who have a genetic inability to process iron or receive frequent blood transfusions. Acute iron toxicity may result in vomiting, while chronic iron toxicity can result in liver damage. Ingestion of iron from water systems is not typically a pathway that results in iron toxicity (Brookes, 1997(internet); Haas, 1998; Goyer, 1991).

H-A.1.3 Cadmium

Cadmium is a naturally occurring element in the earth's crust. Its pure form is a soft silvery-white metal. Cadmium is most commonly found in the environment as a compound. Cadmium can also be released to the environment as a by-product of smelting operations involving zinc, lead, or copper. Cadmium has a variety of industrial uses, but because of its non-corrosive properties its main use is in electroplating and galvanizing. Cadmium is also used as a pigment in paints, a component of batteries, and in plastics. Cadmium in the environment may be either naturally occurring or a waste product of human industrial activities (ATSDR, 1993).

Cadmium can be absorbed by the body through ingestion or inhalation, but is poorly absorbed through dermal contact with contaminated material. Only a fraction of the cadmium ingested approximately 1-5% is actually absorbed by the bloodstream. The remainder is excreted. The absorption rate of cadmium through inhalation is considerably higher, approximately 30-50%. Once absorbed by the body, cadmium binds very strongly to soft bodily tissues, particularly the kidneys, and tends to accumulate in the body over time. The half-life for eliminating cadmium from the body is estimated to be approximately 30 years (ATSDR, 1993; Goyer, 1991).

Inhalation of cadmium can lead to diseases of the lung. The level of impairment corresponds to the length of exposure and the amount inhaled. Inhalation can cause chronic bronchitis, which may lead to obstructive lung disease, and ultimately emphysema with prolonged exposure. Accumulation of cadmium in the body through ingestion of contaminated water or soil or through inhalation can also cause damage to the kidneys. Cadmium interferes with calcium metabolism and, as a result, can cause skeletal problems, such as bone pain and osteoporosis. Recent studies also suggest that cadmium may play a role in the development of essential hypertension. Cadmium is believed to be a probable human carcinogen (Goyer, 1991).

Additional information on cadmium may be found in the USEPA Fact Sheet entitled *EPA Facts About Cadmium* (USEPA, 1992b).

H-A.1.4 Lead

Lead is a naturally occurring metal that is found within the earth's crust in small quantities. In its metallic form, lead is unable to dissolve in water or burn. Lead salts, which are formed when lead combines with other chemicals, are soluble in water. Most of the lead that exists in the environment is the result of anthropogenic activities. The concentration of lead in the environment has declined significantly since the ban of leaded gasoline. Presently, lead is used in the manufacture of batteries, electronics, and various types of ammunition (ATSDR, 1997; Goyer, 1991).

Lead can enter the body through inhalation or ingestion. Dermal absorption of lead is not a significant pathway of exposure. Almost all of the lead that is inhaled into the lungs is absorbed and transported to other parts of the body. In adults, lead is not well absorbed from the digestive tract, and only small amounts of the lead ingested in contaminated food or water is transported to other parts of the body. However, the digestive tracts of children are able to absorb much more lead from ingestion of contaminated food, soil, water, paint chips, and other contaminated media. Children are also more sensitive to the effects of lead. Therefore, lead contamination of water systems is of much greater concern for children than for adults (ATSDR, 1997; Goyer, 1991).

Lead is stored in the body, primarily in bone, but is also stored in the brain and in neural tissues. The half life of lead in bone is approximately 20 years. Age, nutrition, body burden (i.e., the amount already stored in bodily tissues), and exposure duration can influence the absorption and excretion of lead (Goyer, 1991).

In recent years a great deal of medical research has focused on the adverse health effects associated with exposure to lead. Some studies have observed changes in certain blood lead enzymes and children's neurological development at concentrations that suggest that a threshold level of effect may not exist. Based upon sufficient animal evidence, lead is considered to be a probable human carcinogen. Rodent studies have shown a statistically significant increase in renal tumors with subcutaneous and dietary exposure to soluble lead salts. However, the human carcinogenicity data that is available at this time is inadequate to demonstrate that similar effects occur in humans (ATSDR, 1997).

Additional information on lead may be found in the USEPA Fact Sheet entitled *EPA Facts About Lead* (USEPA, 1992c).

H-A.1.5 Zinc

Zinc is a bluish-white, lustrous metal that is brittle at normal temperatures. Zinc has many industrial uses, such as a component of alloys (e.g., brass). Large quantities of zinc are used to create die-castings for heavy industry, and are often used to galvanize other metals to prevent corrosion. Zinc is ubiquitous in the environment and is found in virtually all foods, in water, and in air. Zinc is an essential human micro-nutrient that is required for the proper functioning of more than 70 human enzymes. Zinc deficiency can result in a variety of symptoms depending upon age and developmental factors (ATSDR, 1994).

Humans are exposed to zinc in small amounts on a daily basis. Zinc is almost universally present in our food, water, and air. Absorption of zinc through the skin is relatively inefficient and is not generally an important pathway of exposure. Inhalation of zinc fumes appears to produce the most severe health effect - temporary neurologic impairment. Ingestion of zinc in water or dietary supplements at many times the recommended daily allowance is needed to produce toxic effects. Therefore, zinc poisoning is not very common. Excess zinc is typically removed from the body in urine and feces (ATSDR, 1994; Goyer 1991).

A common route of exposure is through ingestion of drinking water or other liquids that are stored in galvanized metal containers, flow through galvanized pipes, or are contaminated from industrial waste sites or sources. Symptoms include vomiting and diarrhea (ATSDR, 1994).

Additional information on zinc may be found in the USEPA Fact Sheet entitled *EPA Facts About Zinc* (USEPA, 1992d).

H-A.1.6 Arsenic

Arsenic is an element that occurs naturally in the environment but may increase to toxic levels as a result of anthropogenic activities. Concentrations in soils typically range from 0.1 to 40 ppm, with an overall average of 2 ppm (Bohn *et al.*, 1985). Its natural occurrence is due to the presence and weathering of minerals found in local geologic settings, and from volcanic emissions. Major anthropogenic sources of arsenic result from the combustion of fossil fuels and petroleum-based products, metal and non-metal smelting processes, and glass manufacturing, all of which generally disperse to low concentrations over large areas via atmospheric deposition. Localized high concentrations of arsenic can occur in and near industrial sites where arsenic-containing waste products were improperly disposed with respect to present standards (Bohn *et al.*, 1985). Prevalent use of arsenic in our society includes use as an additive in pressure treated wood and in agricultural pesticides. Arsenic can therefore enter the aquatic environment through nonpoint-source runoff, point source discharges, and atmospheric deposition.

Elemental arsenic does not occur in nature nor is it readily contributed by anthropogenic activities to the environment. More commonly, arsenic is found in one or both oxidation states, As^{+3} or As^{+5}, which are typically found in combination with oxygen as arsenite (AsO_2^{-1}) and arsenate (AsO_4^{-3}) anions. The two oxidation states are relatively stable in natural environments; but may be converted to either depending on the redox conditions (and the presence of catalysts) in the environment (Pourbaix, 1958). The two anions are tightly bound in soils and sediments to organics, clays, iron and aluminum oxides, and sulfides; thereby reducing their mobility into surface waters (Bohn *et al.*, 1985). However, at high soil concentrations or at low pH (< 3.5), the arsenic ions may be mobilized and released into surface waters or taken up by plants and animals.

Human exposure is principally through ingestion of food and water that contain the arsenic ions or organic complexes. To a lesser degree, human exposure from inhalation of fugitive dust (e.g., wind-blown soils) containing arsenic complexes can occur. The body absorbs most ingested arsenic. At normal exposures, absorbed arsenic is converted to less-toxic forms that are excreted from the body as wastes. At high exposures, arsenic can accumulate in the body and result in a variety of acute toxicological effects such as nausea, diarrhea, reduced blood production, and liver and/or kidney damage. Elevated exposures can also increase the risk of cancer in the liver, kidneys, and lungs. Arsenic is also toxic to aquatic life causing acute toxicity (i.e., mortality) to freshwater test species in the range from 0.8 to 97 mg/l (ppm) for soluble arsenate. Long-term exposures result in toxicological effects at much lower concentrations. To protect aquatic life and drinking water supplies, the Florida Department of Environmental Protection (FDEP) promulgated numeric surface water quality criteria for arsenic of 50 µg/L (as total arsenic) and 36 µg/L (as As^{+3}).

Additional information on arsenic may be found in the USEPA Fact Sheet entitled *EPA Facts About Arsenic* (USEPA, 1992e).

H-A.1.7 Tributyltin (TBT)

Tributyltin (TBT) is not a compound in its own right, but only a constituent part of molecules in this class of organotin substances. Commercial products are typically available as bis(tributyltin) oxide (TBTO), acetate (TBT-OAc), halides (TBTF, TBTCl), and as a copolymer with methylmethacrylate (TBTM). Industrial applications of TBT compounds followed the recognition of its biocidal properties, first noted in the 1950s. Although present applications include molluscicides, stone preservation, and disinfectants; the most important usage remains in wood preservatives and anti-fouling paints. The main use of tributyltin compounds, with direct introduction to water, is as anti-fouling agents on ships, boats, docks, and cooling towers. There are other known uses, such as material preservatives (textiles, paper, leather, electrical equipment), joinery wood preservatives, remedial wood preservatives, wood preservative stains, and slimicides.

Butyltin species are not produced biologically, and therefore their environmental presence is due to anthropogenic (manmade) input. TBT has been found in power plant discharges, and sewage treatment plant influents and effluents. Dibutyltin and monobutyltin compounds are also used as stabilizers for polyvinyl chloride (PVC), and can therefore be found in industrial plant discharges through the leaching of organotin-stabilized PVC pipe.

For the aquatic environment, tin-based anti-fouling paint represents the most important source of TBT. For a given location, the highest concentrations of TBT are generally found close to drydock and shipyard facilities where TBT-based paints are stripped from ships and yachts. However, anti-foulant paints work by slow release of a toxin that forms a thin veneer around the hull, thereby repelling nuisance organisms in the water. Thus, TBT continually leaches from vessels using this anti-fouling agent.

Organotins are measured by extraction from the medium (water, sediment, tissues) followed by analysis through a separation technique that does not destroy the chemical forms. This usually involves liquid chromatography, gas chromatography, or cold trapping techniques. Results are expressed in a variety of ways, but usually in units expressed as parts per trillion (ppt) or parts per billion (ppb). For example, tributyltin in water may be reported as micrograms of tin per liter of water, µg Sn/L (ppb). TBT may be reported as nanograms of tin per liter of water, ng Sn/L (ppt). It also may be reported as µg TBT-Sn/L, indicating the form measured. TBT in sediments and tissues will be reported on a dry-weight basis, that is, µg TBT-Sn/kg (ppb) or ng TBT-Sn/kg (ppt).

TBT antifouling paints are applied to inhibit the growth of barnacles, tubeworms, algae and seaweed, and other fouling target organisms, which slow a vessel's movement through the water. Non-target species which appear to be highly sensitive to TBT include bivalves molluscs (oysters, clams, scallops and mussels), gastropods (snails), and fish.

Once released into the environment, TBT appears to be removed from the water column principally by adsorption to lipids (fats) and particulate matter and through assimilation and metabolism by plants and animals. From its octanol-water partition coefficient, TBT partitions to particulate organic matter in suspended sediments in marine and fresh waters. The binding of a polar molecule such as TBT is a function both of its hydrophobicity, associated with the bulky butyl groups, and its polarity, and on this basis organic carbon content of sediments may not be the only control on adsorption. Sediment particle size, or more correctly surface area of the sediments, is likely to be important. Differences in TBT degradation rates between the dissolved and particulate phases, can also be important.

In deeper anoxic sediments, the sediment-to-interstitial water ratio is high. Also, the diffusion of pore water, especially in clayey sediments, is slow. The persistence of TBT in deeper, anoxic sediments is considerably longer than in surface sediments. Half lives in surficial sediments may range from 360-775 days. In anaerobic sediments, the half-life appears to be in the order of tens of years, possibly prolonged by limited biotic degradation activity. Because TBT is rapidly adsorbed into suspended particles, it accumulates in the sediments where degradation rates are very slow. TBT has been detected in sediments deposited nearly 20 years ago. Since TBT is not completely adsorbed to particulate matter, slow release into the overlying waters may occur for a long time, facilitated by bioturbation, or resuspension by storms or dredging.

Organotin compounds are more toxic than inorganic tin compounds, with the triorganotin compounds being the most toxic. However, within the class of triorganotin compounds there are considerable variations in toxicity with the nature of the organic subtituents. For insects, trimethyltin compounds are the most toxic; for mammals, the triethyltin compounds; for Gram-negative bacteria, the tri-n-propyltin compounds; for Gram-positive bacteria—yeasts, fungi and fish—the tri-n-butyltin compounds. Triphenyltin compounds are particularly toxic to phytoplankton.

TBT concentrations can cause disturbances to aquatic organisms. Specifically, contamination levels in excess of the values provided below are likely to induce disturbances for the following organisms (De Mora, 1996):

>0.4 ng TBT-Sn/L effects on phytoplankton and zooplankton

>0.8 ng TBT-Sn/L effects on calcification anomalies in oysters (*Crassostrea gigas*)

>8 ng TBT-Sn/L effects on reproduction of *C. gigas*

0.4-4 µg TBT-Sn/L effects on fish reproduction

0.4-40 µg TBT-Sn/L modification of fish behavior (avoidance response, rheotaxis)

>200 µg TBT-Sn/L effects on exuviation (molting) of crustacean species

In regard to the control of TBT, the U.S. has enacted the Organotin Antifouling Paint Control Act of 1988, which prohibits use of TBT paints on vessels less than 25 meters (82 feet) in length, and requires a maximum daily leach rate of 4 µg TBT/cm^2/day on all vessels larger than 25 m in length (Champ and Seligman, 1996). All anti-foulings must be registered, and since March 1, 1990, TBT-based anti-fouling paints can only be purchased and applied or removed by certified pesticide applicators. Similar regulations have been enacted by most countries throughout the world.

Specific to Florida, it should also be noted that an Interagency TBT Working Group was formed in 1988, consisting of representatives from the FDEP, the Florida Department of Agriculture and Consumer Services, and the Governor's Office of Planning and Budgeting, to provide a thorough review of statewide TBT issues. The group recommended that Florida:

- determine the amount of TBT in water, sediments and shellfish
- develop water quality standards for TBT compounds
- review the registration of TBT compounds
- work with the USEPA in its special review of organotin
- review marina permitting to consider potential TBT loading and overall environmental effects
- distribute information on the proper use and disposal of TBT paints and current TBT regulations.

TBT is most likely to be found in sediments and waters associated with marinas, harbors, and ports, particularly in harbors with large vessel traffic; and with ship/boat refurbishing facilities.

H-A.2 BIOLOGICALS

H-A.2.1 Fecal Coliforms and Pathogens

A variety of pathogens and parasites that pose human health concerns may be present in surface and ground water from their contamination with fecal matter from treated and untreated domestic wastewater and nonpoint source runoff from agricultural sources (e.g., cattle, hog, and chicken farms). According to Craun (1988), approximately 75 percent of waterborne disease outbreaks during the period from 1971 to 1985 were the result of untreated or inadequately disinfected or filtered surface and ground water. This indicates the importance of adequate water treatment (e.g., disinfection and filtration) in the prevention of transmission of waterborne diseases.

The variety of pathogens and parasites that can be found in domestic and agricultural wastewaters can be grouped into four major categories:

1. bacterial pathogens including *Salmonella*, *Shigella*, virulent strains of *E. coli* (e.g., 0157:H7), *Campylobacter*, and *Yersinia* that cause gastrointestinal (enteric) infections such as typhoid, shigellosis and cholera;

2. viral pathogens comprised of at least 140 different types of enteric viruses causing diseases such as gastroenteritis, hepatitis, meningitis and respiratory infections;

3. protozoan parasites such a *Giardia lamblia*, *Cryptospridium*, *Entamoeba histolytica* and *Naegleria* that cause gastrointestinal ailments (diarrhea, nausea, loss of appetite, and low-grade fevers), amoebic dysentery, and amoebic meningoencephalitis; and

4. helminth (nematode and trematode worms) parasites that infect the gastrointestinal system causing a variety of enteric ailments (Bitton, 1994).

Monitoring surface and ground water for all of the above pathogens is not practical or economical. To identify the potential for pathogens to be present and determine safety of drinking waters, two bacterial groups are most commonly monitored. These are total coliforms and fecal coliforms.

Total coliforms are a group of aerobic and facultative anaerobic, rod-shaped, Gram-negative bacteria that ferment lactose at 35°C (American Public Health Association *et al.*, 1989). This group of bacteria is present in human and animal fecal matter and may be an indicator of fecal contamination and the presence of pathogenic agents. However, this group also contains bacteria that are not related to fecal matter (i.e., soil bacteria) and may only be an indicator of surface water runoff or surface water contamination of ground water. Total coliforms are most frequently monitored in water treatment as a way to evaluate overall disinfection performance, but have also been used to assess the safety of potable water supplies, shellfish harvesting beds, recreational swimming areas, and reclaimed wastewater.

Fecal coliforms are a subgroup within the total coliforms group that can ferment lactose at 44.5°C (APHA *et al.*, 1989). Recent refinements in testing permits direct detection for *E. coli* only. This subgroup contains bacteria, such as *E. coli* and *Klesiella pneumonae*, that are found in fecal matter of warm-blooded animals only. The fecal coliforms reflect contamination of surface and ground water with untreated or inadequately treated domestic wastewaters and nonpoint source agricultural runoff that contain fecal matter. This characteristic also makes fecal coliforms a good indicator for the presence of pathogenic bacteria. However, its usefulness in evaluating the presence of other pathogenic groups is limited because of differences in survival from exposure to environmental factors (e.g., disinfection).

To protect the public from potential pathogenic hazards the FDEP promulgated numeric criteria for both total and fecal coliforms for the various water classifications. Class I waters are not permitted to contain more than a monthly average (using log-normal statistics) of 200 fecal coliforms and 1,000 total coliforms in a 100-ml sample. Class II waters are not permitted to contain more than a median of 14 fecal coliforms and 70 total coliforms in a 100-ml sample. Class III waters are not permitted to contain more than a monthly average (using log-normal statistics) of 200 fecal coliforms and 1,000 total coliforms in a 100-ml sample.

H-A.2.2 Chlorophyll-*a*

Chlorophyll-*a* is a photosynthetic pigment in plants and algae. It is typically measured to estimate phytoplankton biomass in lakes and estuaries since planktonic algae contain a number of chlorophyll pigments including chlorophyll-*a*. Planktonic algae are comprised of between one and two per cent chlorophyll-*a* on a dry weight basis (APHA *et al.*, 1989). Biomass of algae in surface waters generally responds to nutrient loading (nitrogen and phosphorous) and as a result, chlorophyll-*a* can be used as an indicator of the trophic status of the water body and the severity of cultural eutrophication. Generally, the higher the chlorophyll-*a* concentration, the greater the productivity of the lake or other surface water. The National Academy of Science and National Academy of Engineering (1972), as reported in Thomann and Mueller (1987), have suggested lake trophic status for concentrations of chlorophyll-*a* that are less than 4 µg/L are oligotrophic, between 4 and 10 µg/L are mesotrophic, and greater than 10 µg/L are eutrophic.

Eutrophication is the natural aging process of lakes and estuaries. Cultural eutrophication is the acceleration of this aging process, or increased productivity, associated with increased loading of nutrients to the water body (Cole, 1979). Excess productivity associated with cultural eutrophication can result in deleterious consequences to lakes and estuaries. The large algal biomass can produce substantial organic material that when decomposed by bacteria in the waters, will consume dissolved oxygen and can potentially produce anoxia (i.e., DO less than 2 mg/L). This low DO is detrimental to aquatic life (e.g., fish and insect larvae), causing their avoidance of low DO areas and/or their mortality. Other water quality problems associated with excess productivity include floating algal mats, loss of submerged aquatic vegetation, fish kills, and odor problems from the anaerobic decay of organic matter. In addition, the excess productivity may impart taste and odor problems to the water if used as a drinking water supply.

H-A.3 NUTRIENTS

H-A.3.1 Nitrite/Nitrate

Nitrites (NO_3) and nitrates (NO_4), conveniently identified together as NO_X, because of the rapid biochemical transformation of the former into the latter in natural systems under aerobic conditions, are a significant form of nitrogen pollution in the aquatic environment. Nitrate is the final result of biological nitrification and in sufficient quantity can pose a significant health risk in drinking water. As an essential nutrient for photosynthesis, its presence in excessive amounts can create water quality problems through excessive plant growth. In undisturbed freshwater systems, nitrates and nitrites are usually undetectable or nearly so, with nitrate nitrogen taken up by plants very rapidly and measurable nitrogen existing almost completely in organic forms. While nitrates may be oxidized to nitrites under anaerobic conditions, this occurs primarily in the sediments and the results of these reactions are rarely seen in the water column of natural systems. Nitrite and nitrate are reported in milligrams per liter (mg/L) or micrograms per liter (µg/L) for convenience in reporting varying levels. The most significant sources of NO_X pollution include sewage effluents and agricultural runoff, although storm water runoff from development can also contain high levels of these compounds.

H-A.3.2 Ammonia/Unionized Ammonia

Ammonia is typically found in waters as ammonium (NH_4^+) which is formed as an intermediate bacterial decay product in the mineralization of organic nitrogen, principally proteins, to nitrate (NO_4). Ammonia may also be formed from the reduction of nitrate in organic sediments (e.g., wetlands) where anaerobic conditions prevail. In natural undisturbed aqueous environments, ammonia is typically found at very low concentrations (less than 1 mg/L) but may become temporarily elevated in surface waters during seasonal influx of detrital vegetative matter or from periodic turnover in freshwater lakes.

As a pollutant, ammonia can be released into waterbodies from agricultural runoff, fertilizers, animal waste, and treated municipal wastewater. Municipal wastewater treatment often incorporates nitrification, i.e., the process where ammonia is oxidized to nitrate, to minimize ammonia concentrations in the effluent to less than 2 mg/L (Metcalf and Eddy, Inc., 1979). As a nitrogen source, ammonia can act as a nutrient for primary productivity (i.e., algae and plants) and may be an agent in cultural eutrophication of surface waters. Nitrogen is frequently the limiting nutrient in surface waters, although the importance of nitrogen can be minimized in freshwater by blue-green algae (*Cyanobacter*) not found in saline environments, which are capable of fixing atmospheric nitrogen (N_2).

At elevated ammonia levels, the concentration of unionized ammonia (NH_3), a fraction of the total ammonia based on water temperature and pH, may increase to levels that may be toxic to aquatic life. The FDEP has propagated an ambient water quality standard of 0.02 mg/L, a concentration below which no toxic effects are likely for unionized ammonia, which equates to a total ammonia of approximately 3.5 mg/L for freshwater with a pH=7 and 1.3 mg/L for saltwater (salinity=35 ppt) with a pH=7.7, calculated at a temperature of 25°C and 1 atmosphere using information in Emerson *et al.*, 1975 and Stumm and Morgan, 1981. Elevated concentrations are typically only found in areas of high nonpoint source runoff or non-nitrified point source discharges.

Additional information on ammonia may be found in the USEPA Fact Sheet entitled *EPA Facts About Ammonia* (USEPA, 1992f).

H-A.4 PHYSICAL PARAMETERS

H-A.4.1 pH

The pH parameter reflects the intensity of the acidic or alkaline (basic) condition of water. By definition, pH is the negative logarithm of hydrogen ion concentration:

$$pH = -\log_{10} [H^+]$$

Typically, pH in natural waters ranges from about pH=6.0 to pH=8.5 expressed as (often assumed as) International Units (I.U.). However, there are many specific exceptions. Hypereutrophic lakes may range above a pH=9 as a result of intense photosynthetic activity which generates hydroxyl ions $[OH^-]$. Softwater systems, particularly those high in dissolved organic acids (so-called blackwater systems) may maintain pH levels well below pH=6. Organic sediments may exhibit very low pH due to the presence of humic acids and anaerobic bacterial oxidation of sulfur compounds as an energy pathway. The effects of pH changes to natural systems as a result of very acidic or basic pollution inputs are generally localized, and dramatic pH shifts of entire systems are most often the result of biological changes produced by other pollutants. Class III water quality standards for pH include 8.5> pH >= 6.0 in freshwater and 8.5> pH >= 6.5 in marine waters, with a variation of less than 1 unit from background value.

H-A.4.2 Dissolved Oxygen

Dissolved Oxygen (DO) is the amount of oxygen dissolved in the water column. Potential oxygen saturation levels are related to the water temperature and salinity (warmer water and higher salinity waters hold less oxygen). DO is a measure of the balance between theoretical oxygen concentration at saturation and the oxygen production and consumption of the water column. Photosynthetic activity produces oxygen during daylight hours, but also has a respiratory component (which is continuous, but is pronounced at night). Heterotrophic activity, from bacterial decay processes to vertebrate respiration, consume oxygen. Organic loading demands from sewage and other organic pollution sources (e.g., storm water runoff) likewise decrease DO. Physical re-aeration through the action of wind and turbulent mixing is an important oxygen pathway for DO increases in lakes and rivers, but much less important in emergent marshes. DO in marshes generally fluctuates widely and often approaches anoxia for short periods of time. Such conditions in lakes and rivers are unusual unless they are polluted. The water quality standard for DO is waterbody-dependent but often is set at a minimum of 5.0 mg/L.

H-A.4.3 Specific Conductance (Conductivity)

Specific Conductance or Conductivity (also known as electrical conductivity and abbreviated “cond.”) is a reflection of the total ionic strength of an aqueous solution, measured in µmhos/cm. It is the reciprocal of the resistance resulting between two platinum electrodes 1 cm^2 in area, placed 1 cm apart in solution. It is properly reported as adjusted to a temperature of 25°C, since temperature is a significant factor in the measured value. Conductivity is particularly useful as a convenient measure of salinity. However, it may be a relatively inaccurate description of hydrologic effects (rainfall, evapotranspiration, runoff) in wetlands because concentrations of dominant ionic salts there are altered by biological and physical conditions in the wetlands as well as by physical dilution and concentration. Conductivity of natural inland surface waters usually ranges from about 10µmhos/cm to 500 µmhos/cm . Conductivity in full seawater is about 3,500 µmhos/cm and conductance in salt pans can reach over 60,000 µmhos/cm. Changes in conductivity are particularly relevant to the effects of freshwater as a pollutant in estuarine and marine systems, when such inflows reduce salinity and affect natural and commercial animal populations such as shellfish. Class II criteria for specific conductance is less than or equal to the maximum of 50% above background or a value of 1,275 µmhos/cm.

H-A.4.4 Turbidity

Suspended and colloidal matter causes turbidity in water. It is generally measured as the amount of light scattered by a sample as compared to a reference sample of clear water, referred to as the nephelometric method. Values are reported in Nephelometric Turbidity Units (NTU). Freshwaters generally range between 0 NTU and 20 NTU. Nutrient-polluted waters tend to be more turbid as a result of increased algal biomass, resuspension and transport of sediments, and suspended bottom materials. Runoff from development and construction activities can significantly contribute to turbidity, particularly as a result of soil disturbance and erosion. Increased turbidity can result in the loss of submersed vegetation and reduced emergent vegetation growth and expansion. Turbidity standards for permitted activities adjacent water bodies are generally set to the ambient turbidity conditions. The turbidity Class III Water Quality Standard is <=29 units above background conditions.

H-A.4.5 Oil and Grease

Oil and grease is only rarely considered a component of natural ecosystems and never in Florida. These pollutants enter the environment from road and parking lot runoff, from industrial and commercial sources, and from leaking storage tanks both above and below ground. Oil and grease is processed slowly by living systems and after entry into a natural system, it tends to coat, smother, and poison the bottom communities, plants and animals with which they come into contact before they are degraded. Oil and grease is measured in mg/L and as one parameter (i.e., water chemistry analysis).

H-A.4.6 Temperature

Temperature, measured as degrees Celsius (°C) or degrees Fahrenheit (°F) is a physical characteristic of water that is influenced by the climate, the nature of the water body (e.g., ocean, estuary, river, lake or wetland), and ground-water inputs. Local air temperatures set the basic range for temperature, which is then modified by specific conditions. Water bodies with greater volumes and depth, tend to fluctuate less than shallow waterbodies such as wetlands. The water temperature in a marsh may reach the daily low in all except extreme cases and approach daily highs. Temperature is an important factor in DO and specific conductance measurements. Water temperature may be an important local effect around industries using water as a coolant (e.g., power plants) and where freshwater flows enter estuarine/marine systems.

H-A.4.7 Salinity

Salinity is a measurement of the mass of total dissolved ions in a water sample and is most often used as a descriptor of estuarine and marine ecosystems. It is reported as parts per thousand (ppt = $^0/_{00}$), which is the number of grams of salt dissolved in 1 kg of water. Salinity is inversely and non-linearly related to oxygen saturation, with saltwater DO saturation about 86% of the freshwater saturation value at 20°C. Seawater is considered to be about 35 ppt, and freshwater is often defined as having less than 0.05 ppt. Salinity is primarily of concern as an indicator of freshwater pollution by dilution of normal estuarine or marine salinities resulting from storm water management practices, or the saltwater intrusion of estuarine or marine waters into inland fresh waters due to increased inland freshwater usage or decreased rainfall. Salinity water quality standards are generally system specific.

H-A.5 OTHER PARAMETERS

H-A.5.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Based on the USEPA Fact Sheet entitled *EPA Facts About Polycyclic Aromatic Hydrocarbon* (USEPA, 1992g), PAHs "are a group of chemicals formed during the incomplete burning of coal, oil, gas, refuse, or other organic substances." They are a class of chemicals that have a similar molecular structure, which is comprised solely of carbon and hydrogen atoms that form rings of various configurations. PAHs, as pure chemicals, are generally colorless, white, or pale-green solids that mostly occur as mixtures or compounds of two or more PAHs. Over 100 different PAH compounds have been identified. PAHs are not readily water soluble, can evaporate into the air, adhere to soil and dust particles, resist burning, and will persist for months to years in the environment (ATSDR, 1995).

PAHs are typically formed as combustion by-products from sources as common as car engines, wood burning stoves, cigarettes, industrial soot, and charbroiled foods. Creosote-treated wood also contains PAHs. Other sources include wood-preserving facilities and former gas-manufacturing sites. Natural sources of PAHs include volcanos, forest fires, and shale oil. Typical PAHs include the following compounds:

- acenapthene
- acenaphthylene
- anthracene
- benzo(a)anthracene
- benzo(a)pyrene
- benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(k)fluoranthene
- chrysene
- dibenz(a,h)anthracene
- fluoranthene
- fluorene
- indeno(1,2,3-cd)pyrene
- phenanthrene
- pyrene

PAHs can enter the human body through several routes of exposure, including inhalation, ingestion, and contact with skin. The rate at which PAHs are able to be absorbed by the body is increased when the compounds are found in oily mixtures. Once absorbed into the body, PAHs tend to be stored in fatty tissues. Most PAHs are eliminated from the body within a few days, primarily through bodily wastes (Andrews and Snyder, 1991; ATSDR, 1995).

Although most PAHs do not readily dissolve in water, PAHs have been identified in some U.S. drinking water supplies. As such, PAHs can become a water quality concern. In response to toxicological data for benzo(a)pyrene, federal guidelines have been developed to protect the public from potential health effects of PAHs in drinking water.

Various PAH treatment methods exist. PAHs in solution that bind to particles (some one-third of the PAHs) can be removed by sedimentation, flocculation and filtration processes. The rest of the dissolved PAHs can be partially removed or transformed by oxidation. Also, specific PAHs can be destroyed by rotary kiln incineration (1,500^{B} F to 3,000^{B} F), while others can be oxidated with concentrated sulfuric acid. Anthracene, a PAH form that may be a water contaminant, can be destroyed by sorption (activated charcoal), filtration (activated charcoal bed) and oxidation (chemical) (USEPA, 1992g).

H-A.5.2 Sulfate

Sulfate (SO_4^{-2}) is an anion found in fresh and saltwater. In freshwater, sulfate is usually the second most common anion after carbonate with concentrations typically ranging from 0 to 500 mg/L. In seawater, sulfate is the second most common anion after chloride with mean seawater sulfate concentrations averaging 2,600 mg/L (Thurmann, 1981). Sources of sulfate in waters can be attributed to natural and anthropogenic sources. In Florida, natural sources of sulfate in freshwater include geologic formations (i.e., connate water or gypsum-bearing strata), atmospheric entrained aerosols from sea spray, and volcanic activity. Anthropogenic inputs of sulfate to freshwater include fossil fuel combustion, agricultural fertilizers, industrial wastewater and treated municipal wastewater (sulfate surfactants in detergents).

Sulfate is the most oxidized form of sulfur but can be changed (reduced) to other oxidation states via a number of chemical and biologically-mediated reactions. Assimilatory sulfate reduction is a metabolic process performed by various biota to reduce sulfate to incorporate the reduced sulfur, as a sulfhydryl group (SH), into amino acids (cysteine, cystine, and methionine) which are important building blocks in many proteins (Atlas, 1984). Dissimilatory sulfate reduction is a bacterially-mediated process that occurs in anaerobic environments (e.g., wetland and lake sediments) in which sulfate is used as an electron acceptor producing sulfide during the decomposition of organic substances. The bacteria, known collectively as sulfate-reducing bacteria (SRB), and the sulfide end-product have been implicated in the biogeochemical cycling of various trace and toxic metals (e.g., iron, copper, lead and mercury) in the environment. Typically, metals have a very low solubility in the presence of sulfide but may be mobilized in a bacterially-mediated process known as methylation (Stumm and Morgan, 1981).

Sulfate is generally an indicator of ground-water pollution from saltwater intrusion along coastal waters or from influx of deep confined brackish aquifers into overlying fresh ground water. In coastal surface water tidal estuaries, sulfate may also be an indicator of salinity and seawater intrusion into predominately freshwater areas resulting from inadequate freshwater flow into the estuary. This estuary intrusion can have deleterious consequences on freshwater biota if salinity is increased above tolerances levels. Slight increases in sulfate concentrations are frequently associated with human activities but the increases tend not to have any direct deleterious consequences.

H-A.5.3 Chloride

Chlorine is a halide that is most commonly found as the chloride (Cl^-) ion in water. In freshwater, chloride is usually the third most common anion after carbonate and sulfate with concentrations typically below 250 mg/L. In seawater, sulfate is the most common anion with the mean seawater chloride concentration averaging 19 g/L (Thurmann, 1981). Sources of chloride in waters can be attributed to natural and anthropogenic sources. In Florida, natural sources of chloride in freshwater include geologic formations (i.e., connate water and evaporite minerals) and atmospheric entrained aerosols from sea spray. Anthropogenic inputs of chloride to freshwater include industrial and process wastewater, agricultural runoff, and treated municipal wastewater; human and animal excretions contain about 5 g/L of chloride (Cole, 1979).

Similar to sulfate, chloride is generally an indicator of saltwater intrusion into ground water along coastal waters or from influx of deep confined brackish aquifers into overlying fresh ground water. In coastal surface water tidal estuaries, chloride may also be an indicator of salinity and seawater intrusion into predominately freshwater areas resulting from inadequate freshwater flow into the estuary. This estuary intrusion can have deleterious consequences on freshwater biota if salinity is increased above tolerances of freshwater biota. In public drinking waters, chloride levels may be of human health concern because of its relationship with sodium concentrations.

H-A.5.4 Dioxins and Furans

Dioxins and furans are closely related chlorinated organic compounds that cause cancer in animals, are toxic to aquatic life at very low levels, and may affect immune, reproductive, and hormonal systems in humans. There are 75 different dioxin compounds (7 are toxic) and 135 different furan compounds (10 are toxic). The specific dioxin compound 2,3,7,8-tetrachloro-dibenzo-p-dioxin (TCDD) is the most potent of all the dioxins/furans and is classified as a probable human carcinogen by the USEPA. Sources to the environment are incinerators, cement kilns, smelters, and by-products from various manufacturing processes such as paper mills**.** In the environment, dioxins and furans can enter aquatic areas, are highly persistent, and have a strong affinity to attach to sediments, soils, and fatty tissue. The main routes of human exposure are thought to be via atmospheric deposition on plants and soil and subsequent ingestion through animals and fish.

The USEPA has developed water quality criteria for TCDD to protect against bioaccumulation in fish to levels that could cause cancer in humans. The USEPA believes that if water column values for TCDD do not exceed 0.014 parts per quadrillion (ppq), then there is less than one chance in a million that a person will develop cancer based on a lifetime of consuming fish from a given waterbody. To date, the USEPA has not developed aquatic life or sediment criteria for dioxin (USEPA, 1984). In December 1992, the USEPA promulgated 0.014 ppq as the water quality criterion for the State of Florida for all surface waters. However, based on the best available analytical methods, TCDD can be only detected in water down to levels of 1-5 ppq. To ensure that bioaccumulation is not occurring, the USEPA recommends that fish/shellfish tissue dioxin levels also be assessed. Since 1992, the USEPA has been reassessing the sources and health implications of dioxin in the environment and is expected to finalize its results by the end of 1998.

Additional general information on dioxin may be found in the USEPA Fact Sheet entitled *EPA Facts About Dioxin* (USEPA, 1992h).

H-A.5.5 Polychlorinated Biphenyls (PCBs)

PCBs are another class of chlorinated organic compounds that bioaccumulate in and are toxic to fish. They are classified by the USEPA as probable human carcinogens. Production of PCBs has been banned in the U.S. since the mid-1970's. Due to their long half-life and extensive use as heat transfer fluids and lubricants in capacitors and transformers, environmental contamination is ongoing. There are 10 classes or mixtures of PCBs, comprising 209 separate compounds. In the environment, PCBs can enter aquatic areas, are highly persistent and have a strong affinity to attach to sediments, soils, and fatty tissue.

The USEPA initially developed PCB water quality criteria in October 1980, but revised them in May 1989: for freshwater aquatic life - 0.014 ppb; for saltwater aquatic life - 0.03 ppb; and for human health from consumption of contaminated water and organisms - 0.000044 ppb. Florida has adopted the above criteria values. However, based on the best available analytical methods, PCBs can be only detected in water down to levels of 0.0065 ppb. To ensure that bioaccumulation is not occurring, the USEPA recommends that fish/shellfish tissue dioxin levels also be assessed. The USEPA is currently reassessing the PCB human health criteria and may be revising them in the near future.

Additional general information on PCBs may be found in the EPA Fact Sheet entitled *EPA Facts About Polychlorinated Biphenyl* (USEPA, 1992i).

H-A.5.6 Volatile Organic Compounds (VOCs)

According to the USEPA Fact Sheet entitled *EPA Facts About Air Stripping* (USEPA, 1992j), VOCs are "chemicals which tend to vaporize rapidly when heated or disturbed." A common example is gasoline fumes, which can be easily smelled during car fueling. Other VOCs include 1,1,1-trichloroethane, trichloroethylene, dichlorothylene, chlorobenzene, and vinyl chloride. VOCs can be associated with hazardous waste sites and the combustion of various fuels and materials relative to cars, incinerators, refineries, fossil fuel power plants, etc. VOCs can also be found in industrial products, such as pesticides, solvents, degreasers, and fumigants.

VOCs may also be released into the environment from vehicle exhaust, incinerators, and manufacturing processes. They can be found in soil, air, and water as a result of human activity. VOCs can enter the body through ingestion of drinking water, inhalation of airborne particulates, and dermal contact with contaminated soil containing these contaminants. Water supplies from nearly every region in the United States contain concentrations of VOCs. Generally, they are found in greater concentrations in groundwater than surface water. This is due to the exposure of surface water to air, which results in volatilization of these chemicals. VOCs enter the water supply from agricultural runoff, industrial processes, accidental chemical spills, and improper disposal of chemical substances. VOCs may also be introduced into the water supply as a byproduct of chlorine disinfection treatment (Domenico and Schwartz, 1990).

There is a wide range of health effects associated with exposure to VOCs due to the different chemical properties of each of these substances. VOCs have been associated with adverse health effects on the nervous, reproductive, and immune systems. Short-term exposure to VOCs may cause headaches, dizziness, and nausea. Long-term effects associated with exposure include kidney and liver dysfunction. In addition, some VOCs, such as benzene, have been categorized as human carcinogens (Andrews and Snyder, 1991).

Water sources containing high concentrations of VOCs may require water treatment to meet the established Federal Drinking Water Standards for these chemicals. An effective technology for the removal of VOCs from water is granular activated carbon (GAC). During this treatment process, the treated activated carbon material binds with these chemicals and removes them from the water supply. Another treatment method that is utilized for VOC removal is air stripping. This process involves the use of large quantities of air to eliminate the chemicals by evaporation. VOC contamination of water can be remediated (cleaned up) via the "air stripping" process, which essentially revaporizes and collects the VOCs out of a disturbed water stream and into an air stream (USEPA, 1992j). This process may or may not need to be supplemented by another process to completely remove the VOC contaminants. VOCs in soils can be removed by a soil vapor extraction (SVE) system (Domenico and Schwartz, 1990).

According to the USEPA Fact Sheet entitled *EPA Facts About Air Stripping* (USEPA, 1992j), air stripping has been successfully used at the Sydney Mine site in Valrico, FL and a municipal well site in Tacoma, WA. The air stripping method has been commonly used in association with pump-and-treat methods for treating ground water contaminated with VOCs.

In addition to air, VOCs can also eventually enter the water medium, both into surface water and ground water. VOC concentrations in water are typically measured in parts per million (ppm) or parts per billion (ppb). VOC contamination of water can be remediated (cleaned up) via the “air stripping” process, which essentially revaporizes and collects the VOCs out of a disturbed water stream and into an air stream. This process may or may not need to be supplemented by another process to completely remove the VOC contaminants. VOCs in soils can be removed by a soil vapor extraction (SVE) system.

H-A.5.7 Bioaccumulation and Biomagnification

Bioaccumulation is the process where the level of pollutants (e.g., metals, toxins, pesticides) in aquatic organisms increase through uptake from the water column and via food. Biomagnification is the process where the pollutant levels in aquatic organisms increase up the food chain. Both bioaccumulation and biomagnification are measured in parts ppm or ppb through analysis of flesh tissue or wholebody samples.

Chemicals that are absorbed by the body through inhalation, ingestion, or dermal contact are either removed from the body through elimination, are bound to bodily tissues, or a combination of the two. Some compounds, once absorbed by the body, may remain stored within bodily tissues for a period of several years or longer. Because the process of removal for these compounds is very slow, any new ingestion of the chemical adds to the overall “body burden,” or amount stored in bodily tissues. This process is known as bioaccumulation (USEPA, 1998: internet).

There are two factors that favor the bioaccumulation of certain chemicals. The first involves the persistence of chemicals in the environment, such as heavy metals and halogenated hydrocarbons. These chemicals are nonbiodegradable and many organisms lack the appropriate enzymes necessary to break them down. Another factor that affects the bioaccumulation of substances is their ability to be absorbed by the organism. Some substances readily enter the body, but are very slowly excreted. For example, heavy metals become tightly bound with proteins and cannot be easily removed. This is also true of halogenated hydrocarbons that are fat-soluble and unable to be removed from biological processes in the body and excreted. The strength of the bonds formed and the body's regulation of the chemical determines the length of time that the stored compound will remain within the body. Over time, the concentration of a contaminant stored within the body of an organism may exceed the concentration found in the environment (USEPA, 1998: internet).

Bioaccumulation can be especially important to organisms that live within a contaminated medium. For example, fish will bioaccumulate concentrations of mercury that can be orders of magnitude higher than the concentrations found in the water in which they swim. As a concentration bioaccumulates within an organism, it may eventually reach concentrations that are toxic to the organism.

In some cases it is possible for bioaccumulation to be compounded in a food chain. The concentrating effect that occurs through a food chain is referred to as biomagnifaction. Organisms at the bottom of the food chain exposed to contamination absorb chemical substances from the environment and store them within tissues. Organisms at the second trophic level (next level in the food chain) accumulate higher concentrations of the chemical within their tissues from feeding on these organisms, in addition to the concentrations that they are exposed to in their habitat. In some cases, organisms at the top of the food chain may accumulate levels that are as much as 100,000 times higher than environmental concentrations (USEPA, 1998: internet; Laws 1991).

USEPA's human-health-based water quality criteria are intended to protect against bioaccumulation. However, 30 of USEPA's 110 criteria cannot be detected by the best analytical methods that are available. That fact does not decrease their scientific validity. In such instances, USEPA recommends that fish or other aquatic organism tissue levels be assessed to ensure that bioaccumulation is not occurring.

It should be noted that although concentrations of water quality pollutants in the water column may be short termed or at low levels, these pollutants can be bioaccumulated and biomagnified to important levels over time in animals and can accumulate in sediments. As such, animals (particularly sessile species) and sediments can help provide a history of water quality conditions of a given project area.

ATTACHMENT B

WATER QUALITY
ADDITIONAL PARAMETER DESCRIPTIONS

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ATTACHMENT B
ADDITIONAL PARAMETER DATA

In addition to the water quality data discussed in **Appendix H** for those water quality parameters considered "key" to respective regions designated in this PEIS, additional "other" water quality data are presented below by region. References used for the data compilation of the key and other parameters are provided in **Appendix H**.

H-B.1 KISSIMMEE RIVER REGION

Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the Kissimmee River Region are presented below. These water quality parameters are pH, conductivity, turbidity, and pesticides.

H-B.1.1 pH

The pH level in the main channel of C-38 averaged 6.93 (range: pH=6.40 to pH= 7.75), while at the outflow from Lake Kissimmee in the north, pH averaged slightly though not significantly lower (pH=6.73) with a range from pH=5.6 to pH=7.45. There was not an apparent trend from north to south in the basin, and the circumneutral values are not indicative of any water quality problem with pH.

H-B.1.2 Conductivity

Specific conductance was generally low within the basin, averaging between 127 and 149 µmhos/cm along C-38 without any clear trend from north to south. The data suggest that tributaries had little influence on the quality of water with respect to conductivity. There were distinct seasonal changes, however, with typically lower values during discharges, which has been attributed to the dilution effect of rainfall. Different flow regimes affect the distribution of conductivity values with depth. During periods of high discharge, the water column is well mixed; however, during low-flow periods, gradients of 0 µmhos/cm to 10 µmhos/cm per meter depth develop.

H-B.1.3 Turbidity

Long-term mean turbidity values tended to be low throughout C-38, ranging from 2.8 NTU to 3.5 NTU at five points along the channel for the period 1973-1978. Tributary data showed similar values, with the maximum of 5.2 NTU.

H-B.1.4 Pesticides

Specific pesticides data exist for the Kissimmee River Region (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Three monitoring sites were sampled by SFWMD (R. Pfeuffer: SFWMD, 1998 personal communication). The S65A and S65E sites were only sampled from October 1995 through May 1997. For these sites, only three pesticides were detected. None of the pesticides exceeded any numeric or calculated F.A.C. 62-302 criteria.

H-B.2 LAKE OKEECHOBEE

Other Region-Specific Water Quality Parameters

Data for other water quality parameters for Lake Okeechobee are presented below. These water quality parameters are pH, dissolved oxygen, ammonia/ unionized ammonia, conductivity, temperature, and pesticides.

H-B.2.1 pH

The 1996 305(b) report (FDEP, 1996) shows in-lake pH values ranged from a high of pH=8.4 to a low of pH=7.4. There were no apparent trends in the lake related to pH. The pH of water in the lake basin were generally lower than those observed in the lake as shown below:

- S-135 (current) pH=7.6
- S-135 (historic) pH=7.0
- Lettuce Creek pH=6.7
- Myrtle Creek pH=6.1

The mean pH value reported in James *et al.* (1995) for the period from 1973 to 1992 was pH=8.2, with an associated standard deviation of pH=0.3. The median pH value for the lake was reported as pH=8.1, with minimum and maximum values of pH=7.2 and pH=9.0, respectively.

H-B.2.2 Dissolved Oxygen

The 1996 305(b) report shows in-lake DO levels ranged from a high of 8.7 mg/L to a low of 6.0 mg/L. All reported values appeared to comply with State of Florida water quality standards. The mean value of the reported DO levels was 7.8 mg/L, and there were no apparent trends in the lake related to DO. The DO level of water in S-135 during the current period of record (1990-1995) was 6.8 mg/L; however, the data collected at this station prior to the current period averaged 2.9 mg/L. DO levels of 4.1 mg/L and 0.5 mg/L were reported for Lettuce Creek and

Myrtle Slough, respectively. The 305(b) report indicated the poorest water quality was found in Myrtle Slough, which may be related to the DO levels.

The mean DO concentration for the period of 1973 to 1992 was 8.4 mg/L, with an associated standard deviation of 1.0 mg/L (James *et al.*, 1995). The median concentration for the lake was reported as 8.3 mg/L, with minimum and maximum values of 5.9 mg/L and 12.6 mg/L, respectively.

H-B.2.3 Ammonia/Unionized Ammonia

James *et al.* (1995) reported that the mean ammonium concentration for the period from 1973 to 1992 was 0.02 mg/L, with an associated standard deviation of 0.02 mg/L. The median concentration for the lake was reported as 0.01 mg/L, with minimum and maximum values of 0.01 mg/L and 0.2 mg/L, respectively.

H-B.2.4 Conductivity

James *et al.* (1995) reported the mean specific conductance for the period of 1973 to 1992 was 595.9 µmhos/cm, with an associated standard deviation of 82.7 µmhos/cm. The median conductivity for the lake was reported as 589.5 µmhos/cm, with minimum and maximum values of 427 µmhos/cm and 895 µmhos/cm, respectively.

H-B.2.5 Temperature

James *et al.* (1995) reported that the mean temperature for the period of 1973 to 1992 was 24.7°C, with an associated standard deviation of 4.6°C. The median temperature for the lake was reported as 25.6°C, with minimum and maximum values of 10.7°C and 31.7°C, respectively.

H-B.2.6 Pesticides

Six locations within Lake Okeechobee were sampled in 1987 (Pfeuffer, 1989). Neither the water nor sediment samples had any detectable residues of the 61 different pesticides and degradation products. In addition, specific SFWMD pesticides monitoring information also exists for the Lake Okeechobee Region (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). During this period (1992-1997), five pesticides were detected. None of the pesticides exceeded any numeric or calculated State of Florida F.A.C. 62-302 criteria (R. Pfeuffer: SFWMD, 1998 personal communication).

H-B.3 UPPER EAST COAST AND INDIAN RIVER REGION

Other Subregion-Specific Water Quality Parameters

H-B.3.1 St. Lucie River Subregion

Data for other water quality parameters for the St. Lucie River subregion are presented below. These water quality parameters are pH, conductivity, and turbidity.

H-B.3.1.1 pH

The mean pH value for the river was pH=7.2 in the south and north Fork, and pH=7.5 in the estuary.

H-B.3.1.2 Conductivity

The mean specific conductance of the river was 888 µmhos/cm in the south Fork, 9,194 µmhos/cm in the north, and 19,475 µmhos/cm in the estuary.

H-B.3.1.3 Turbidity

According to the 1996 305(b) report (FDEP, 1996), the mean turbidity level in the river was 4.5 mg/L in the south Fork, 6.2 mg/L in the north, and 4.9 mg/L in the estuary.

(Note: Units for turbidity data for the St. Lucie subregion were inadvertently reported by FDEP (1996) as “mg/L” as opposed to “NTU”.)

H-B.3.2 Indian River Lagoon Subregion

Data for other water quality parameters for the IRL subregion are presented below. These water quality parameters are dissolved oxygen and Polycyclic Aromatic Hydrocarbons (PAHs).

H-B.3.2.1 Dissolved Oxygen

The mean DO concentration in the south IRL was 7.33 mg/L (with a standard deviation of 1.57 mg/L) for the period of 1989 to 1991. The maximum and minimum concentrations for the same period were 14.7 mg/L and 2.8 mg/L, respectively.

H-B.3.2.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Based on FDEP and SFWMD data from ongoing monitoring programs, C-25 is known to transport PAHs into the estuary and offshore.

H-B.4 EVERGLADES AGRICULTURAL AREA

Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the EAA are presented below. These parameters are pH, temperature, ammonia/unionized ammonia, and turbidity.

H-B.4.1 pH

The mean pH value for all stations reported for the EAA was pH=7.22, while the recorded mean pH values for these same stations ranged from pH=6.61 to pH=7.75. The median pH value for all stations reported by Limno-Tech (1995) was pH=7.21, while the median values ranged from pH=6.2 to pH=7.63. The minimum and maximum pH values reported by Limno-Tech (1995) were pH=3.4 and pH=10.7, respectively.

H-B.4.2 Temperature

Long-term average water temperatures in EAA waters are typical of regional values, ranging from 23.7 to 24.7°C at four pump stations sampled between 1977 and 1989.

H-B.4.3 Ammonia/Unionized Ammonia

The mean unionized ammonia concentration reported by Limno-Tech (1995) was 0.0072 mg/L, while the mean concentrations ranged from 0.0001 mg/L to 0.0522 mg/L. The median concentration for all stations reported was 0.0012 mg/L, while the range of median concentrations were 0.0001 mg/L to 0.0266 mg/L. The minimum and maximum concentrations recorded were <0.0001 mg/L and 8.2193 mg/L, respectively.

H-B.4.4 Turbidity

Long-term average turbidity levels at four pump stations draining the EAA ranged from 3.8 NTU to 4.6 NTU. One of the pumps had a very high coefficient of variation (220) suggesting the potential for unusually high values at that site.

H-B.5 WATER CONSERVATION AREAS

Other Subregion-Specific Water Quality Parameters

H-B.5.1 Loxahatchee National Wildlife Refuge Subregion

Data for other water quality parameters for the LNWR are presented below. These water quality parameters are ammonia/unionized ammonia, pH, turbidity, temperature, and pesticides.

H-B.5.1.1 Ammonia/Unionized Ammonia

The mean ammonia (NH_3) concentration collected at thirty-three stations in the LNWR was 0.0041 mg/L for the period from 1979 to 1993. The lowest mean concentration observed at any station in the LNWR was 0.0000 mg/L, while the highest concentration was 0.0169 mg/L. The lowest concentration observed in the basin was <0.0001 mg/L and the highest observation was 0.2775 mg/L.

H-B.5.1.2 pH

The mean pH value collected at thirty-three stations in the LNWR was a pH=6.81 for the period from 1979 to 1993. The mean pH values observed in the LNWR ranged from a pH=5.75 to pH=7.78.

H-B.5.1.3 Turbidity

The mean turbidity value collected in the LNWR was 2.4 NTU for the period from 1979 to 1993. The mean specific conductance values observed in the LNWR ranged from 0.8 NTU to 8.3 NTU.

H-B.5.1.4 Temperature

The mean temperature reading collected in the LNWR was 23.1°C for the period from 1979 to 1993. The temperature readings observed in the LNWR ranged from 10°C to 34°C.

H-B.5.1.5 Pesticides

SFWMD pesticides monitoring data (1992-1997) exist for the WCAs in general (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Eleven inflow and outflow sites are currently sampled by SFWMD. None of the pesticides detected exceeded any numeric or calculated F.A.C. 62-302 criteria (R. Pfeuffer: SFWMD, 1998 personal communication).

H-B.5.2 Water Conservation Area 2A/2B Subregion

Data for other water quality parameters for the WCA 2A/2B subregion are detailed below. These parameters are ammonia/unionized ammonia, pH, turbidity, temperature, and pesticides.

H-B.5.2.1 Ammonia/Unionized Ammonia

The mean ammonia concentration collected in the WCA 2A basin was 0.0097 mg/L, and in the WCA 2B basin was 0.0024 mg/L, for the period from 1979 to 1993. The lowest mean concentration observed at any station in the WCA 2A basin was 0.0002 mg/L and in the WCA 2B basin was 0.0009 mg/L, while the highest concentration was 0.1041 mg/L in WCA 2A and 0.0045 mg/L in W2B. The lowest concentration observed in the WCA 2A basin was <0.0001 mg/L and in the WCA 2B basin was <0.0001 mg/L, while the highest observation was 0.6284 mg/L in WCA 2A and 0.0449 mg/L in WCA 2B.

H-B.5.2.2 pH

The mean pH value collected from WCA 2A was pH=6.98, and in WCA 2B was pH=7.34 for the period from 1979 to 1993. The mean pH values observed in WCA 2A ranged from pH=6.07 to pH=7.46, while in WCA 2B the pH ranged from pH=7.13 to pH=7.53.

H-B.5.2.3 Turbidity

The mean turbidity value collected in WCA 2A was 2.3 NTU, and for WCA 2B was 3.3 NTU for the period from 1979 to 1993. The mean values observed in WCA 2A ranged from 0.8 NTU to 9.5 NTU, while in WCA 2B these values ranged from 1.4 to 7.6 NTU.

H-B.5.2.4 Temperature

The mean temperature reading collected in WCA 2A was 24.8°C, and in WCA 2B was 25.2°C for the period from 1979 to 1993. The temperature readings observed in WCA 2A ranged from 12°C to 35.3°C, while those in WCA 2B ranged from 13°C to 33.2°C.

H-B.5.2.5 Pesticides

SFWMD pesticides monitoring data (1992-1997) exist for the WCAs in general (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Eleven inflow and outflow sites are currently sampled by SFWMD. None of the pesticides detected exceeded any numeric or calculated F.A.C. 62-302 criteria (R. Pfeuffer: SFWMD, 1998 personal communication).

H-B.5.3 Water Conservation Area 3A/3B Subregion

Data for other water quality parameters for the WCA 3A/3B subregion are presented below. These parameters are ammonia/unionized ammonia, pH, turbidity, temperature, and pesticides.

H-B.5.3.1 Ammonia/Unionized Ammonia

The mean ammonia concentration collected in the WCA 3A basin was 0.001 mg/L, and in the WCA 3B basin was 0.0013 mg/L, for the period from 1979 to 1993. The lowest mean concentration observed at any station in the WCA 3A basin was 0.0000 mg/L and in the WCA 3B basin was 0.0000 mg/L (Limno-Tech, 1995). The highest concentration was 0.0049 mg/L in WCA 3A and 0.0032 mg/L in WCA 3B. The lowest concentration observed in the WCA 3A basin was <0.0001 mg/L and in the WCA 3B basin was <0.0001 mg/L, while the highest observation was 0.1262 mg/L in WCA 3A and 0.0146 mg/L in WCA 3B.

H-B.5.3.2 pH

The mean pH value collected in WCA 3A was pH=7.12, and in WCA 3B was pH=7.20 for the period from 1979 to 1993. The mean pH values observed in WCA 3A ranged from pH=6.65 to pH=7.52, while in WCA 3B the pH ranged from pH=7.00 to pH=7.67.

H-B.5.3.3 Turbidity

The mean turbidity value collected in WCA 3A was 3.2 NTU, and for W3B was 2.8 NTU for the period from 1979 to 1993. The values observed in WCA 3A ranged from 0.7 NTU to 32.0 NTU, while in WCA 3B these values ranged from 2.0 NTU to 3.7 NTU.

H-B.5.3.4 Temperature

The mean temperature reading collected in WCA 3A was 24.4°C, and in WCA 3B was 25.8°C for the period from 1979 to 1993. The temperature readings observed in WCA 3A ranged from 12.3°C to 34°C, while those in WCA 3B ranged from 14.6°C to 34°C.

H-B.5.3.5 Pesticides

SFWMD pesticides monitoring data (1992-1997) exist for the WCAs in general (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Eleven inflow and outflow sites are currently sampled by SFWMD. None of the pesticides detected exceeded any numeric or calculated F.A.C. 62-302 criteria (R. Pfeuffer: SFWMD, 1998 personal communication).

H-B.6 LOWER EAST COAST REGION

H-B.6.1 Loxahatchee River Aquatic Preserve Subregion

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the WCA 3A/3B subregion are presented below. These parameters are pH, conductivity, and turbidity.

H-B.6.1.1 pH

The mean pH value for the estuarine section of the river was pH=7.8.

H-B.6.1.2 Conductivity

The mean specific conductance for the estuarine section of the river was 45,555 µmhos/cm.

H-B.6.1.3 Turbidity

According to the 1996 305(b) report (FDEP, 1996), the mean turbidity level for the estuarine section of the river was 2.4 mg/L.

(Note: Units for turbidity data for the LRAP were inadvertently reported by FDEP(1996) as “mg/L” as opposed to “NTU”.)

H-B.6.2 Lake Worth Subregion

Data for other water quality parameters for the Lake Worth subregion are presented below. These parameters are pH and conductivity.

H-B.6.2.1 pH

The 1996 305(b) report (FDEP, 1996) shows the mean pH reading recorded for the West Palm Beach Canal was pH=7.4.

H-B.6.2.2 Conductivity

According to the 305(b) report (FDEP, 1996), the mean specific conductivity level recorded for the West Palm Beach Canal was 704 µmhos/cm.

H-B.6.3 Biscayne Bay Subregion

Data for other water quality parameters for the Biscayne Bay subregion are presented below. These parameters are ammonia/unionized ammonia and salinity.

H-B.6.3.1 Ammonia/Unionized Ammonia

The mean ammonia concentration observed for the Bay ranged from 0.05 to 1.22 mg/L. Dade County has established a maximum concentration of 0.5 mg/L for total ammonia nitrogen for surface waters. Three stations in the bay exceeded this standard. Ammonia concentrations changed significantly at eleven stations during the period of record. Three stations showed declining trends in the Miami River.

H-B.6.3.2 Salinity

The mean salinity levels in the bay ranged from 0.1 ppt to 38.3 ppt. The extreme range for this parameter can be attributed to twenty-five percent of the monitoring stations being located upstream of salinity control barriers.

H-B.7 EVERGLADES NATIONAL PARK / FLORIDA BAY

Other Subregion-Specific Water Quality Parameters

H-B.7.1 Shark River Slough/Taylor Slough Subregion

Data for other water quality parameters for the Shark River Slough/Taylor Slough subregion are presented below. These parameters are nitrite/nitrate, ammonia/ unionized ammonia, pH, dissolved oxygen, conductivity, turbidity, temperature, and pesticides.

H-B.7.1.1 Nitrite/Nitrate

The SFWMD (1998a) indicated that NO_X concentrations ranged from 0.004 mg/L to 6.901 mg/L for the Shark River Slough and (one station in) Taylor Slough sub-basins. The mean NO_X concentrations ranged from 0.0279 mg/L to 0.1984 mg/L for the same time period.

H-B.7.1.2 Ammonia/Unionized Ammonia

The Limno-Tech (1995) report indicates that unionized ammonia concentrations ranged from 0.0011 mg/L to 0.01 mg/L for the period of record. The median concentrations ranged from 0.0002 mg/L to 0.0009 mg/L, while the minimum value recorded was <0.0001 mg/L and the maximum value reported was 0.2036 mg/L.

H-B.7.1.3 pH

The 1996 305(b) report FDEP (1996) indicates that the average pH value was pH=7.2 (Shark River Slough) and pH=7.3 (Taylor Slough). Limno-Tech (1995) reports that the mean pH values for this basin ranged from pH=7.28 to pH=7.48 for their period of record. The median pH values for the same period ranged from pH=7.2 to pH=7.5.

H-B.7.1.4 Dissolved Oxygen

The Limno-Tech (1995) reports shows the mean DO concentrations for this basin ranged from 4.0 mg/L to 6.4 mg/L. The median concentrations ranged from 3.8 mg/L to 6.5 mg/L, while the minimum and maximum concentrations reported were 1.2 mg/L and 11.6 mg/L, respectively.

H-B.7.1.5 Conductivity

The Limno-Tech (1995) reports shows the mean specific conductivity values for this basin ranged from 361.3 µmhos/cm to 756.7 µmhos/cm. The median values ranged from 340.5 µmhos/cm to 600 µmhos/cm, while the minimum and maximum concentrations reported were 94 µmhos/cm and 3,400 µmhos/cm, respectively.

H-B.7.1.6 Turbidity

The Limno-Tech (1995) report shows the mean turbidity level for this basin ranged from 1.7 NTU to 5.6 NTU. The median turbidity level ranged from 1.1 NTU to 4.7 NTU, while the minimum and maximum concentrations reported were 0.2 NTU and 106 NTU, respectively.

H-B.7.1.7 Temperature

Recorded water temperatures in the slough ranged from 23.6°C to 26.3°C (Limno-Tech, 1995). The median water temperature reported by Limno-Tech (1995) for the slough ranged from 24.5°C to 26.7°C, while the minimum and maximum recorded temperatures were 12.5°C and 36.5°C.

H-B.7.1.8 Pesticides

SFWMD pesticides monitoring data exist for the ENP in general (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Nine sites are currently monitored by the SFWMD (R. Pfeuffer: SFWMD, 1998 personal communication). During 1992-1997, only endosulfan (sum of endosulfan alpha and beta) was found to exceed its Class III criterion of 0.056 µg/L. Exceedances occurred at Monitoring Site S178 on six occasions between 3/18/93 and 1/25/96. The only detection of ethion at Site S178, (0.053 µg/L, 10/16/97) exceeded the acute toxicity level (0.02 µg/L) reported for *Daphnia magna*, a sensitive indicator species for aquatic macroinvertebrate, calculated according to promulgated procedure (F.A.C. 62-302.200). At this level, short-term exposure can cause impacts to the macroinvertebrate populations.

H-B.7.2 Florida Bay Subregion

Other Subregion-Specific Water Quality Parameters

Data for other water quality parameters for the Florida Bay subregion are presented below. These parameters are nitrite/nitrate, ammonia/unionized ammonia, dissolved oxygen, turbidity, temperature, and pesticides.

H-B.7.2.1 Nitrite/Nitrate

For the 1991-1997 period of record (SFWMD, 1998: unpublished), the mean NO_X concentrations were higher, and showed greater variability, in the east basin than the west basin. The mean concentration in the east basin was 0.0224 mg/L for the period of record (1991-1997), with a corresponding standard deviation of 0.0256 mg/L. The median NO_X concentration in the east basin was 0.012 mg/L, with minimum and maximum values of 0.001 mg/L and 0.163 mg/L, respectively.

The mean NO_X concentration in the west basin was 0.0064 mg/L for the period of record, with a corresponding standard deviation of 0.0079 mg/L. The median NO_X concentration in the west basin was 0.016 mg/L, with minimum and maximum values of 0.001 mg/L and 0.061 mg/L, respectively.

H-B.7.2.2 Ammonia/Unionized Ammonia

The mean ammonia concentrations were higher and showed greater variability in the west basin than the east basin. The mean concentration in the east basin was 0.0683 mg/L for the period of record (1991-1997), with a corresponding standard deviation of 0.075 mg/L. The median ammonia concentration in the east basin was 0.046 mg/L, with minimum and maximum values of 0.0026 mg/L and 0.69 mg/L, respectively.

The mean ammonia concentration in the west basin was 0.1077 mg/L for the period of record, with a corresponding standard deviation of 0.1685 mg/L. The median ammonia concentration in the west basin was 0.042 mg/L, with minimum and maximum values of 0.002 mg/L and 1.681 mg/L, respectively.

H-B.7.2.3 Dissolved Oxygen

The mean DO concentrations were comparable for the east and west basins. The mean concentration in the east basin was 6.73 mg/L for the period of record (1991-1997), with a corresponding standard deviation of 1.0179 mg/L. The median DO concentration in the east basin was 6.7 mg/L, with minimum and maximum values of 3.2 mg/L and 15.2 mg/L, respectively.

The mean DO concentration in the west basin was 6.37 mg/L for the period of record, with a corresponding standard deviation of 1.2 mg/L. The median DO concentration in the west basin was 6.3 mg/L, with minimum and maximum values of 2.8 mg/L and 12.3 mg/L, respectively.

H-B.7.2.4 Turbidity

The mean turbidity values were higher and showed greater variability in the west basin than the east basin. The mean value in the east basin was 4.49 NTU for the period of record (1991-1997), with a corresponding standard deviation of 6.99 NTU. The median turbidity level in the east basin was 2.16 NTU, with minimum and maximum values of 0.001 NTU and 85.59 NTU, respectively.

The mean turbidity value in the west basin was 7.3 NTU for the period of record, with a corresponding standard deviation of 12.2 NTU. The median turbidity value in the west basin was 3.3 NTU, with minimum and maximum values of 0.0 NTU and 125.6 NTU, respectively.

H-B.7.2.5 Temperature

The mean temperatures were comparable for the east and west basins. The mean temperature in the east basin was 26.1°C for the period of record, with a corresponding standard deviation of 3.6°C. The median temperature in the east basin was 26.5°C, with minimum and maximum values of 15.9°C and 32.9°C, respectively.

The mean temperature in the west basin was 26.5°C for the period of record (1991-1997), with a corresponding standard deviation of 3.8°C. The median temperature in the west basin was 26.6°C, with minimum and maximum values of 16.2°C and 35.3°C, respectively.

H-B.7.2.6 Pesticides

SFWMD pesticides monitoring data exist for the ENP in general (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Nine sites are currently monitored by the SFWMD (R. Pfeuffer: SFWMD, 1998 personal communication).

During 1992-1997, only endosulfan (sum of endosulfan alpha and beta) was found to exceed its Class III criterion of 0.056 µg/L. Exceedances occurred at Monitoring Site S178 on six occasions between 3/18/93 and 1/25/96. The only detection of ethion at Site S178, (0.053 µg/L, 10/16/97) exceeded the acute toxicity level (0.02 µg/L) reported for *Daphnia magna*, a sensitive indicator species for aquatic macroinvertebrate, calculated according to promulgated procedure (F.A.C. 62-302.200). At this level, short-term exposure can cause impacts to the macroinvertebrate populations.

H-B.7.3 Whitewater Bay Subregion

Data for other water quality parameters for the Whitewater Bay subregion are presented below. These parameters are nitrite/nitrate, ammonia/unionized ammonia, dissolved oxygen, turbidity, temperature, and pesticides.

H-B.7.3.1 Nitrate/Nitrite

The mean concentration in the bay was 0.029 mg/L for the period of record (1991-1997), with a corresponding standard deviation of 0.026 mg/L. The median NO_X concentration in the bay was 0.022 mg/L, with minimum and maximum values of 0.001 mg/L and 0.15 mg/L, respectively.

H-B.7.3.2 Ammonia/Unionized Ammonia

The mean concentration in the bay was 0.034 mg/L for the period of record (1991-1997), with a corresponding standard deviation of 0.072 mg/L. The median ammonia concentration in the bay was 0.014 mg/L, with minimum and maximum values of 0.002 mg/L and 1.046 mg/L, respectively.

H-B.7.3.3 Dissolved Oxygen

The mean concentration in the bay was 6.6 mg/L for the period of record (1991-1997), with a corresponding standard deviation of 1.4 mg/L. The median DO concentration in the bay was 6.6 mg/L, with minimum and maximum values of 2.2 mg/L and 10.7 mg/L, respectively.

H-B.7.3.4 Turbidity

The mean value in the bay was 6.3 NTU for the period of record (1991-1997), with a corresponding standard deviation of 10.6 NTU. The median turbidity level in the bay was 3.8 NTU, with minimum and maximum values of 0.2 NTU and 107.8 NTU, respectively.

H-B.7.3.5 Temperature

The mean temperature in the bay was 26°C for the period of record (1991-1997), with a corresponding standard deviation of 4.1°C. The median temperature in the bay was 26.5°C, with minimum and maximum values of 11.8°C and 32.3°C, respectively.

H-B.7.3.6 Pesticides

SFWMD pesticides monitoring data exist for the ENP in general (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Nine sites are currently monitored by the SFWMD (R. Pfeuffer: SFWMD, 1998 personal communication). During 1992-1997, only endosulfan (sum of endosulfan alpha and beta) was found to exceed its Class III criterion of 0.056 µg/L. Exceedances occurred at Monitoring Site S178 on six occasions between 3/18/93 and 1/25/96. The only detection of ethion at Site S178, (0.053 µg/L, 10/16/97) exceeded the acute toxicity level (0.02 µg/L) reported for *Daphnia magna*, a sensitive indicator species for aquatic macroinvertebrate, calculated according to promulgated procedure (F.A.C. 62-302.200). At this level, short-term exposure can cause impacts to the macroinvertebrate populations.

H-B.7.4 Ten Thousand Islands Subregion

Data for other water quality parameters for the Ten Thousand Islands subregion are presented below. These parameters are phosphorus, nitrite/nitrate, pH, dissolved oxygen, conductivity, turbidity, and pesticides.

H-B.7.4.1 Phosphorus

The mean TP concentration recorded for this station was 0.03 mg/L (FDEP, 1996).

H-B.7.4.2 Nitrite/Nitrate

The mean total nitrogen concentration recorded for this station was 0.64 mg/L.

H-B.7.4.3 pH

The mean pH reading recorded for this station was pH=7.8.

H-B.7.4.4 Dissolved Oxygen

The mean DO concentration measured at this station was 8.5 mg/L.

H-B.7.4.5 Conductivity

The mean specific conductivity level recorded at this station was 41,250 µmhos/cm.

H-B.7.4.6 Turbidity

According to the 1996 305(b) report (FDEP, 1996), the mean turbidity concentration measured for this station was 3.0 mg/L.

(Note: Units for the mean turbidity concentration at this station in the Ten Thousand Islands subregion were inadvertently reported in FDEP (1996) as “mg/L” as opposed to “NTU”.)

H-B.7.4.7 Pesticides

SFWMD pesticides monitoring data exist for the ENP in general (see Table H.1.5.2.1.3.2-1 in Section H.1.5.2.1.3.2 of Appendix H). Nine sites are currently monitored by the SFWMD (R. Pfeuffer: SFWMD, 1998 personal communication). During 1992-1997, only endosulfan (sum of endosulfan alpha and beta) was found to exceed its Class III criterion of 0.056 µg/L. Exceedances occurred at Monitoring Site S178 on six occasions between 3/18/93 and 1/25/96. The only detection of ethion at Site S178, (0.053 µg/L, 10/16/97) exceeded the acute toxicity level (0.02 µg/L) reported for *Daphnia magna*, a sensitive indicator species for aquatic macroinvertebrate, calculated according to promulgated procedure (F.A.C. 62-302.200). At this level, short-term exposure can cause impacts to the macroinvertebrate populations.

H-B.8 FLORIDA KEYS

Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the Florida Keys are detailed presented below. These parameters are ammonia/unionized ammonia, pH, conductivity, temperature, and salinity.

H-B.8.1 Ammonia/Unionized Ammonia

The median NH_4 concentrations for surface segments 1, 2, 4, 5, 6, 7, and 9 ranged from 0.24 µM to 0.49 µM. The maximum NO_X concentrations for the same segments ranged from 0.63 µM to 2.44 µM, while the minimum concentrations ranged from 0.02 µM to 0.13 µM.

H-B.8.2 pH

The mean pH values for the Keys monitoring stations ranged from pH=7.3 in Saddlebunch Key to pH=8.2 in Plantation Key. The mean pH value for all stations was pH=7.7.

H-B.8.3 Conductivity

The mean specific conductance for the Keys basin ranged from 52,600 µmhos/cm at Marathon Key to 69,350 µmhos/cm at Saddlebunch Key. The mean specific conductance for all reported stations was 59,743 µmhos/cm.

H-B.8.4 Temperature

The median temperature recorded for the surface monitoring stations in the Keys ranged from 26.8°C to 29°C, and from 25.5°C to 28.7°C for the bottom stations. The maximum surface temperature observed at any station was 39.6°C, while the minimum temperature was 21.1°C.

H-B.8.5 Salinity

The median salinity concentrations for surface segments 1,2,4,5,6,7, and 9 ranged from 36.2 ppt to 36.8 ppt. The maximum salinity concentrations for the same segments ranged from 36.6 ppt to 40.3 ppt, while the minimum concentrations ranged from 30.5 ppt to 35.7 ppt.

H-B.9 BIG CYPRESS REGION

Other Region-Specific Water Quality Parameters

No other water quality parameters for the Big Cypress Region are presented.

H-B.10 CALOOSAHATCHEE RIVER REGION

Other Region-Specific Water Quality Parameters

Data for other water quality parameters for the Caloosahatchee River Region are presented below. These parameters are pH, turbidity, and temperature.

H-B.10.1 pH

The pH values along the river and within the basin remained relatively constant, ranging from a high of pH=8.0 to a low value of pH=6.9. The mean value of all data points in the basin was pH=7.4, while the mean pH value in the river its tributaries was pH=7.4 in each area. No trends were apparent in the data presented in the 1996 305(b) report (FDEP, 1996).

H-B.10.2 Turbidity

According to the 1996 305(b) report (FDEP, 1996), the turbidity concentrations along the river and within the basin remained relatively constant, ranging from a high of 6.3 mg/L to a low value of 0.7 mg/L. The mean turbidity concentration of all data points in the basin was 2.7 mg/L, while the mean turbidity concentration in the river and its tributaries were 2.4 mg/L and 2.8 mg/L, respectively. No trends were apparent in the data presented in the 1996 305(b) report.

(Note: Units for turbidity data for the Caloosahatchee River Region were inadvertently reported by FDEP(1996) as “mg/L” as opposed to “NTU”.)

H-B.10.3 Temperature

Waters in the basin show a typical pattern of seasonal variation, ranging from 15.0°C to 21.1°C with a mean temperature of 24.3°C. There was only a minimal amount of variation between the sampling stations.

ATTACHMENT C

WATER QUALITY
ADDITIONAL REGULATIONS AND STANDARDS

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ATTACHMENT C
ADDITIONAL REGULATIONS AND STANDARDS

H-C.1 FEDERAL REGULATIONS AND STANDARDS

H-C.1.1 Federal Safe Drinking Water Act

The Safe Drinking Water Act of 1974 was the result of a nationwide study of community water systems, which revealed water quality as a potential health risk. The primary objectives of the Safe Drinking Water Act (SDWA) are to protect the nation's sources of drinking water, and to protect public health to the maximum extent possible.

The USEPA is required to impose national primary and secondary drinking water regulations on persons who own or operate a system which has at least 15 service connections or regularly serves at least 25 individuals at least 60 days per year. Primary drinking water regulations identify potential toxic contaminants and then set a Maximum Contaminant Level (MCL) for each contaminant if the contaminant can be measured. If the contaminant cannot be measured, then a treatment technique must be specified. Secondary drinking water regulations set MCLs for nontoxic contaminants that affect other factors, such as color and odor. Maximum contaminant levels are to be set at levels at which "no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety." All water suppliers must periodically sample the water they deliver to consumers and record and report their findings to the USEPA or to the state, whichever is appropriate. If all MCLs are not met, or if a supplier fails to sample or report, the supplier must publicly notify his consumers. Variances or exemptions are available for systems meeting certain qualifications. MCLs have been established for certain chemicals, coliform bacteria, turbidity, and radioactivity.

In order to protect underground sources of drinking water, any person who owns or operates a facility, which injects fluids below the surface of the ground must meet certain requirements. The USEPA's Underground Injection Control (UIC) protects Underground Sources of Drinking Water (USDW) by prohibiting injection if it results in the movement of fluid containing a contaminant that could cause a violation of a primary drinking water standard and adversely affect human health. Regulations are imposed that set different requirements for the different classes of injection wells, and impose sampling, record keeping and reporting requirements on all operators. The regulations also control the plugging and abandonment of inactive and abandoned wells.

On August 6, 1996, the Safe Drinking Water Act Amendments of 1996 became law. The amendments contain several key features. One is the drinking water source protection program, which funds state and local governments to protect their drinking water sources from pollution. Another is drinking water standards for cryptosporidium and certain carcinogens. Additionally, the amendments contain important right-to-know language which requires community water systems to notify customers every year of the levels of federally regulated contaminants and the presence of other suspicious but unregulated material.

H-C.2 STATE OF FLORIDA REGULATIONS AND STANDARDS

H-C.2.1 Florida Statutes 373 (Water Resources) and 403 (Environmental Control)

Chapter 373, F.S. was created by the Florida legislature with nine policies regulating the waters of the State of Florida. These policies are set forth to:

(1) provide for the management of water and related land resources
(2) to promote the conservation, development, and proper utilization of surface and ground water
(3) to develop and regulate dams, impoundments, reservoirs, and other works and to provide water storage for beneficial purposes
(4) to prevent damage from floods, soil erosion, and excessive drainage
(5) to minimize degradation of water resources caused by the discharge of stormwater
(6) to preserve natural resources, fish and wildlife
(7) to promote the public policy set forth within 403.021 (the Florida Air and Water Pollution Control Act)
(8) to promote recreational development, protect public lands, and assist in maintaining the navigability of rivers and harbors
(9) otherwise promote the health, safety, and general welfare of the people of the State.

The Florida Department of Environmental Protection (FDEP=Department) is the responsible agency for the administration of Chapter 373 at the State level. In 1976 the legislature divided the State into five Water Management Districts:

- St. John's River Water Management District (SJRWMD)
- South Florida Water Management District (SFWMD)
- Southwest Florida Water Management District (SWFWMD)
- Northwest Florida Water Management District (NFWMD)
- Suwanee River Water Management District (SRWMD)

The FDEP has delegated the implementation and regulation of much of the authority within Chapter 373 to the five regional Water Management Districts (not all Districts have been delegated the same responsibilities). The three largest Districts (SJRWMD, SFWMD, SWFWMD) have since implemented rules which govern the construction of surface water management systems. These have been defined as any storm water management system, dam, impoundment, reservoir, appurtenant work, or combination thereof. The storm water management system has also been defined to include dredging and filling activities within wetlands or surface water bodies. The implementation of this rule is designed to regulate any impacts that the construction of the storm water management facility may have on surface water quality, quantity, flow, wetland habitat and associated listed wildlife species, and ground water resources.

Chapter 403 provides the basis for pollution control (Florida Air and Water Pollution Control Act), environmental regulation (Florida Environmental Reorganization Act of 1975), and drinking water standards (Florida Safe Drinking Water Act). In general, this chapter defines the powers and duties granted to FDEP to control and prohibit pollution of air and water. The Florida Air and Water Pollution Control Act defines water resources restoration and preservation (also known as the Water Resources Restoration and Preservation Act); pollution control for underground, surface and coastal waters; ground water quality monitoring; the reuse of reclaimed waters; pollution prevention (Pollution Control Act); and sewage disposal facilities.

The Florida Reorganization Act of 1975 provides the basis for the determination/establishment of District boundaries, the issuance of dredge and fill permits, the sites for disposal of spoil from maintenance dredging, and the determination of the natural landward extent of waters for regulatory purposes. The Florida Safe Drinking Water Act provides the basis for the establishment of the drinking water standards.

H-C.2.2 Surface Water Quality Standards

On March 1, 1979, the State adopted water quality standards (Rule 62-302 F.A.C.) designed to protect the public health or welfare and to enhance the quality of waters of the State. These standards take into consideration the use and value of waters of the State for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes; as well as their use and value for navigation. Rule 62-302 F.A.C. requires FDEP to assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources, and all cost-effective and reasonable BMPs for nonpoint source control. The highest statutory and regulatory requirements for new and existing point sources are those which can be achieved through imposition of effluent limits required under Sections 301(b) and 306 of the Federal CWA (as amended in 1987) and Chapter 403, F.S. Cost-effective and reasonable BMPs for nonpoint source control are those nonpoint source controls authorized under Chapters 373 and 403, F.S., and Department rules.

Rule 62-302.300 defines the State's Antidegradation Policy for surface water quality. This section of the rule states that excessive nutrients (total nitrogen and total phosphorus) constitute one of the most severe water quality problems facing the State, and consequently, requires FDEP policy to limit the introduction of man-induced nutrients into waters of the State—with particular consideration given to the protection from further nutrient enrichment of waters which are presently high in nutrient concentrations or sensitive to further nutrient concentrations and sensitive to further nutrient loadings. The rule also requires the FDEP to give special consideration to the protection from nutrient enrichment of those waters presently containing very low nutrient concentrations: less than 0.3 mg/L total nitrogen or less than 0.04 mg/L total phosphorus.

If the FDEP determines that the applicant has caused degradation of water quality over and above that allowed through previous permits issued to the applicant, then the applicant shall demonstrate that this lowering of water quality is necessary or desirable under federal standards and under circumstances which are clearly in the public interest. These circumstances are limited to cases where it has been demonstrated that degradation of water quality is occurring due to the discharge. If the new or expanded discharge was initially permitted by the FDEP on or after October 4, 1989, and the Department determines that an antidegradation analysis was not conducted, then the applicant seeking renewal of the existing permit shall demonstrate that degradation from the discharge is necessary or desirable under federal standards and under circumstances which are clearly in the public interest.

Rule 62-302.400 defines the classification system for surface waters, their usage, reclassification, and classifies waters.

Rule 62-302.500 defines the minimum and general criteria for surface waters as follows:

Minimum Criteria

All surface waters of the State shall at all places and at all times be free from:

(a) Domestic, industrial, agricultural, or other man-induced non-thermal components of discharges which, alone or in combination with other substances or in combination with other components of discharges (whether thermal or non-thermal):

1. Settle to form putrescent deposits or otherwise create a nuisance; or
2. Float as debris, scum, oil, or other matter in such amounts as to form nuisances; or
3. Produce color, odor, taste, turbidity, or other conditions in such degree as to create a nuisance; or
4. Are acutely toxic; or
5. Are present in concentrations which are carcinogenic, mutagenic, or teratogenic to human beings or to significant, locally occurring, wildlife or aquatic species; unless specific standards are established for such components in Rules 62-302.500(2) or 62-302.530; or
6. Pose a serious danger to the public health, safety, or welfare.

(b) Thermal components of discharges which, alone, or in combination with other discharges or components of discharges (whether thermal or non-thermal):

1. Produce conditions so as to create a nuisance; or
2. Do not comply with applicable provisions of Rule 62-302.500(3), F.A.C.

(c) Silver in concentrations above 2.3 μg/L in predominately marine waters.

Effluent limits may be established for pollutants for which analytical detection limits are higher than the established water quality criteria based upon computation of concentrations in the receiving waters. Effluent limits will be established on site-specific conditions in the context of a Department permit. Monitoring reports and permit applications shall specify the detection limits and indicate non-detectable results in such cases. Unless otherwise specified, such non-detectable results shall be accepted as demonstrating compliance for that pollutant as long as specified effluent limits are met.

Notwithstanding the specific numerical criteria applicable to individual classes of water, dissolved oxygen (DO) levels that are attributable to natural background conditions or man-induced conditions which cannot be controlled or abated may be established as alternative DO criteria for a water body or portion of a water body. Alternative DO criteria may be established by the Secretary or a Director of District Management in conjunction with the issuance of a permit or other Department action only after public notice and opportunity for public hearing. The determination of alternative criteria shall be based on consideration of the factors described in Rule 62-302.800(2)(a)-(d), F.A.C. Alternative criteria shall not result in a lowering of DO levels in the water body, water body segment or any adjacent waters, and shall not violate the minimum criteria specified in Rule 62-

302.500(1), F.A.C. Daily and seasonal fluctuations in DO levels shall be maintained.

The surface water quality criteria are presented in Rule 62-302.530, F.A.C. A table within this rule contains both numeric and narrative surface water quality criteria to be applied except within zones of mixing. The left-hand column of the table is a list of constituents for which a surface water criterion exists. The headings for the water quality classifications are found at the top of the table. Applicable criteria lie within the table. The individual criteria should be read in conjunction with other provisions in water quality standards, including Rules 62-302.500 and 62-302.510, F.A.C. The criteria contained in Rules 62-302.500, F.A.C. or 62-302.510, F.A.C. also apply to all waters unless alternative or more stringent criteria are specified in Rule 62-302.530, F.A.C.

Rule 62-302.700 defines special protection, Outstanding Florida Waters, and Outstanding National Resource Waters. This section states the FDEP shall afford the highest protection to Outstanding Florida Waters and Outstanding National Resource Waters. No degradation of water quality, other than that allowed in Rule 62-4.242(2) and (3), F.A.C., is to be permitted in Outstanding Florida Waters and Outstanding National Resource Waters, respectively, notwithstanding any other Department rules that allow water quality lowering.

H-C.2.3 Beneficial Use Classifications (Class I-V)

Chapter 62-302.400, F.A.C. defines or classifies surface waters and their usage as follows:

- Class I - Potable Water Supplies
- Class II - Shellfish Propagation or Harvesting
- Class III - Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
- Class IV - Agricultural Water Supplies
- Class V - Navigation, Utility and Industrial Use

These water quality classifications are arranged in order of the degree of protection required, with Class I water having generally the most stringent water quality criteria and Class V the least. However, Class I, II, and III surface waters share water quality criteria established to protect recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The classification of a water body according to a particular designated use or uses does not preclude use of the water for other purposes. The criteria applicable to a classification are designed to maintain the minimum conditions necessary to assure the suitability of water for the designated use of the classification. In addition, applicable criteria are generally adequate to maintain minimum conditions required for the designated uses of less stringently regulated classifications. Therefore, unless clearly inconsistent with the criteria applicable, the designated uses of less stringently regulated classifications shall be deemed to be included within the designated uses of more stringently regulated classifications.

The surface waters of the State of Florida are classified as Class III - Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife, except for certain waters, which are described in Rule 62-302.400(12), F.A.C. A water body may be designated as an Outstanding Florida Water or an Outstanding National Resource Water in addition to being classified as Class I, Class II, or Class III. A water body may also have special standards applied to it. Outstanding Florida Waters and Outstanding National Resource Waters are listed in Rule 62-302.700, F.A.C. Classifications shall be interpreted to include associated water bodies such as tidal creeks, coves, bays and bayous.

Exceptions to Class III surface waters include all secondary and tertiary canals wholly within agricultural areas. These are classified as Class IV and are not individually listed as exceptions to Class III. "Secondary and tertiary canals" shall mean any wholly artificial canal or ditch which is behind a control structure and which is part of a water control system that is connected to the works (set forth in Section 373.086, F.S.) of a water management district created under Section 373.069, F.S., and that is permitted by such water management district pursuant to Section 373.103, Section 373.413, or Section 373.416, F.S. Agricultural areas shall generally include lands actively used solely for the production of food and fiber, which are zoned for agricultural use where county zoning is in effect. Agricultural areas exclude lands which are platted and subdivided or in a transition phase to residential use.

H-C.2.4 Ground Water Quality Standards

Ground waters within the State are classified according to designated uses as follows (Rule 62-520.410):

Class F-I Potable water use, ground water in a single source aquifer described in Rule 62-520.460, F.A.C. which has a total dissolved solids content of less than 3,000 mg/L and was specifically reclassified as Class F-I by the Commission.

Class G-I Potable water use, ground water in single source aquifers which has a total dissolved solids content of less than 3,000 mg/L.

Class G-II Potable water use, ground water in aquifers which has a total dissolved solids content of less than 10,000 mg/L, unless otherwise classified by the Commission.

Class G-III Non-potable water use, ground water in unconfined aquifers which has a total dissolved solids content of 10,000 mg/L or greater; or which has total dissolved solids of 3,000-10,000 mg/L and either has been reclassified by the Commission as having no reasonable potential as a future source of drinking water, or has been designated by the Department as an exempted aquifer pursuant to Rule 62-28.130(3), F.A.C.

Class G-IV Non-potable water use, ground water in confined aquifers which has a total dissolved solids content of 10,000 mg/L or greater.

The highest protection is afforded to single source aquifers. Ground water quality classifications are arranged in order of the degree of protection required, with Class G-I ground water having generally the most stringent water quality criteria and Class G-IV the least.

The minimum criteria for ground water are set forth in Rule 62-520.400. These criteria state that all ground water shall at all places and at all times be free from domestic, industrial, agricultural, or other man-induced non-thermal components of discharges in concentrations which, alone or in combination with other substances, or components of discharges (whether thermal or non-thermal):

(a) Are harmful to plants, animals, or organisms that are native to the soil and responsible for treatment or stabilization of the discharge relied upon by Department permits; or
(b) Are carcinogenic, mutagenic, teratogenic, or toxic to human beings, unless specific criteria are established for such components in Rule 62-520.420, F.A.C.; or
(c) Are acutely toxic within surface waters affected by the ground water; or
(d) Pose a serious danger to the public health, safety, or welfare; or
(e) Create or constitute a nuisance; or
(f) Impair the reasonable and beneficial use of adjacent waters.

These minimum criteria do not apply to Class G-IV ground water, unless the Department determines there is a danger to the environment, public health, safety or welfare.

Waters classified as Class G-I and Class G-II ground water shall meet the primary and secondary drinking water quality standards for public water systems established pursuant to the Florida Safe Drinking Water Act, in addition to the minimum criteria provided in Rule 62-520.400, F.A.C. (Rule 62-520.420), except as provided in Rule 62-520.520, F.A.C., and subsections (4) and (5) below, and except that the total coliform bacteria standard shall be 4 per 100 milliliters. In addition, the primary drinking water standard for public drinking water systems for asbestos shall not apply as a ground water standard. If the concentration for any constituent listed in subsection (l) above in the natural background quality of the ground water is greater than the stated maximum, or in the case of pH is also less than the minimum, the representative natural background quality shall be the prevailing standard for Class G-I and Class G-II ground water.

The minimum criteria (Rule 62-520.430) for Class G-III ground water established in Rule 62-520.400, F.A.C., shall apply to all Class G-III ground water except for an underground injection facility that has received an aquifer exemption pursuant to Rule 62-528.300(3), F.A.C., unless there is danger to the environment, public health, safety, or welfare. The minimum criteria shall apply to all other facilities discharging to an exempted aquifer.

Rule 62-520.440 states that for the standards for Class G-IV ground water FDEP shall specify applicable standards on a case-by-case basis. The minimum criteria in Rule 62-520.400, F.A.C., shall not apply unless the Department determines there is danger to the environment, public health, safety or welfare.

H-C.2.5 Drinking Water Quality Standards

The drinking water standards are designed to assure that public water systems supply drinking water, which meets minimum requirements. The Federal Government enacted PL 93-523, the "Safe Drinking Water Act." The intent of that law was to give primary responsibility for public water systems programs to states to implement a public water system program. Also, the legislature of Florida has enacted the "Florida Safe Drinking Water Act," sections 403.850-403.864, F.S. This chapter and chapters 62-555 and 62-560, F.A.C., are promulgated to implement the requirements of the Florida Safe Drinking Water Act and to acquire and maintain primacy for Florida under the Federal Act. This chapter and chapter 62-555 and 62-560, F.A.C., adopt national primary and secondary drinking water standards of the Federal Government where possible, and otherwise create additional rules to fulfill state and Federal requirements.

Rule 62-550.300, F.A.C. defines the application of quality standards to public water systems. The ultimate concern of a public drinking water program is the quality of piped water for human consumption when the water reaches the consumers. The following rules establish the maximum contaminant levels for the water within public water systems. Public water systems shall not exceed the maximum contaminant levels established herein unless granted a variance or exemption pursuant to Rules 62-560.510 or 62-560.520, F.A.C., or identified as excluded from the standards by this Chapter. Public water systems shall take necessary corrective action approved by the Department to meet all applicable standards. Treatment techniques in lieu of maximum contaminant levels for surface water systems or ground water systems under the direct influence of surface water are referenced in Rule 62-555.600, F.A.C., Scope of Additional Requirements for Surface Water Systems.

As referenced, it may be noted that the primary drinking water standards maximum contaminant levels, are defined in Rule 62-550.310, F.A.C. (These standards may also apply as ground water quality standards as referenced in Chapter 62-520, F.A.C). Also, the secondary drinking water standards, are defined in Rule 62-550.320, F.A.C. This section applies only to community water systems. (These standards may also apply as ground water quality standards as referenced in Chapter 62-520, F.A.C.).

ATTACHMENT D

WATER QUALITY
ADDITIONAL MONITORING FIGURES

ATTACHMENT D

Water Quality - Additional Monitoring Figures

The figures referenced in Appendix H (Section H.1.3.2) discussing State of Florida monitoring are provided below:

Figure D-1. South Florida Water Management District Location of Sampling Stations for the Upper Kissimmee River Chain of Lakes and Tributaries Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Kissimmee River Region.") (Source: SFWMD, 1998a)

Figure D-2. South Florida Water Management District Location of Sampling Stations for the Kissimmee River Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Kissimmee River Region.") (Source: SFWMD, 1998a)

Figure D-3. South Florida Water Management District Location of Sampling Stations for the Arbuckle Creek Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Kissimmee River Region.") (Source: SFWMD, 1998a)

Figure D-4. South Florida Water Management District Location of Sampling Stations for the Lake Istokpoga Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Kissimmee River Region.") (Source: SFWMD, 1998a)

Figure D-5. South Florida Water Management District Location of Sampling Stations for the Lower Kissimmee River Basin Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Kissimmee River Region.") (Source: SFWMD, 1998a)

Figure D-6. South Florida Water Management District Location of Sampling Stations for the Taylor Creek / Nubbin Slough Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Kissimmee River Basin.") (Source: SFWMD, 1998a)

Figure D-7. South Florida Water Management District Location of Sampling Stations for the Indian River Lagoon Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Upper East Coast and Indian River Lagoon.") (Source: SFWMD, 1998a)

Figure D-8. South Florida Water Management District Location of Sampling Stations for the St. Lucie Estuary Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Upper East Coast and Indian River Lagoon.") (Source: SFWMD, 1998a)

Figure D-9. South Florida Water Management District Location of Sampling Stations for the Upper and Lower East Coast Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Upper East Coast and Indian River Lagoon" and the "Lower East Coast and Biscayne Bay") (Source: SFWMD, 1998a)

Figure D-10. South Florida Water Management District Location of Sampling Stations for the Lake Okeechobee Inflow / Outflow Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as "Lake Okeechobee.") (Source: SFWMD, 1998a)

Figure D-11. South Florida Water Management District Location of Sampling Stations for the Lake Okeechobee Limnetic and Littoral Zone Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as "Lake Okeechobee.") (Source: SFWMD, 1998a)

Figure D-12. South Florida Water Management District Location of Sampling Stations for the Caloosahatchee River Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Caloosahatchee River Region.") (Source: SFWMD, 1998a)

Figure D-13. South Florida Water Management District Location of Sampling Stations for the Everglades Nutrient Removal Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Everglades Agricultural Area" (Source: SFWMD, 1998a)

Figure D-14. South Florida Water Management District Location of Sampling Stations for the Holey Land Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Water Conservation Areas.") (Source: SFWMD, 1998a)

Figure D-15. South Florida Water Management District Location of Sampling Stations in WCA1 for the Everglades Protection Area Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Water Conservation Areas.") (Source: SFWMD, 1998a)

Figure D-16. South Florida Water Management District Location of Sampling Stations in WCA2 for the Everglades Protection Area Monitoring Program.

(*Note*: These stations are within the region designated in this PEIS as the "Water Conservation Areas.") (Source: SFWMD, 1998a)

Figure D-17. South Florida Water Management District Location of Sampling Stations in WCA3 for the Everglades Protection Area Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Water Conservation Areas.") (Source: SFWMD, 1998a)

Figure D-18. South Florida Water Management District Location of Sampling Stations for the Big Cypress Seminole Indians Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Big Cypress Region.") (Source: SFWMD, 1998a)

Figure D-19. South Florida Water Management District Location of Sampling Stations for the Water Conservation Areas Inflow / Outflow Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Water Conservation Areas.") (Source: SFWMD, 1998a)

Figure D-20. South Florida Water Management District Location of Sampling Stations for the Tamiami Bridge Culverts Water Quality Monitoring Program. (*Note*: These stations are within the regions designated in this PEIS as the "Water Conservation Areas" and the "Everglades National Park and Florida Bay.") (Source: SFWMD, 1998a)

Figure D-21. South Florida Water Management District Location of Sampling Stations for the Biscayne Bay Water Quality Monitoring Program (Northern Part of Biscayne Bay Shown). (*Note*: These stations are within the region designated in this PEIS as the "Lower East Coast and Biscayne Bay.") (Source: SFWMD, 1998a)

Figure D-22. South Florida Water Management District Location of Sampling Stations for the Biscayne Bay Water Quality Monitoring Program (Southern Part of Biscayne Bay Shown). (*Note*: These stations are within the region designated in this PEIS as the "Lower East Coast and Biscayne Bay.") (Source: SFWMD, 1998a)

Figure D-23. South Florida Water Management District Location of the Inflow / Outflow Sampling Stations for the Everglades National Park Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Everglades National Park and Florida Bay.") (Source: SFWMD, 1998a)

Figure D-24. South Florida Water Management District Location of the Interior Sampling Stations for the Everglades National Park Water Quality

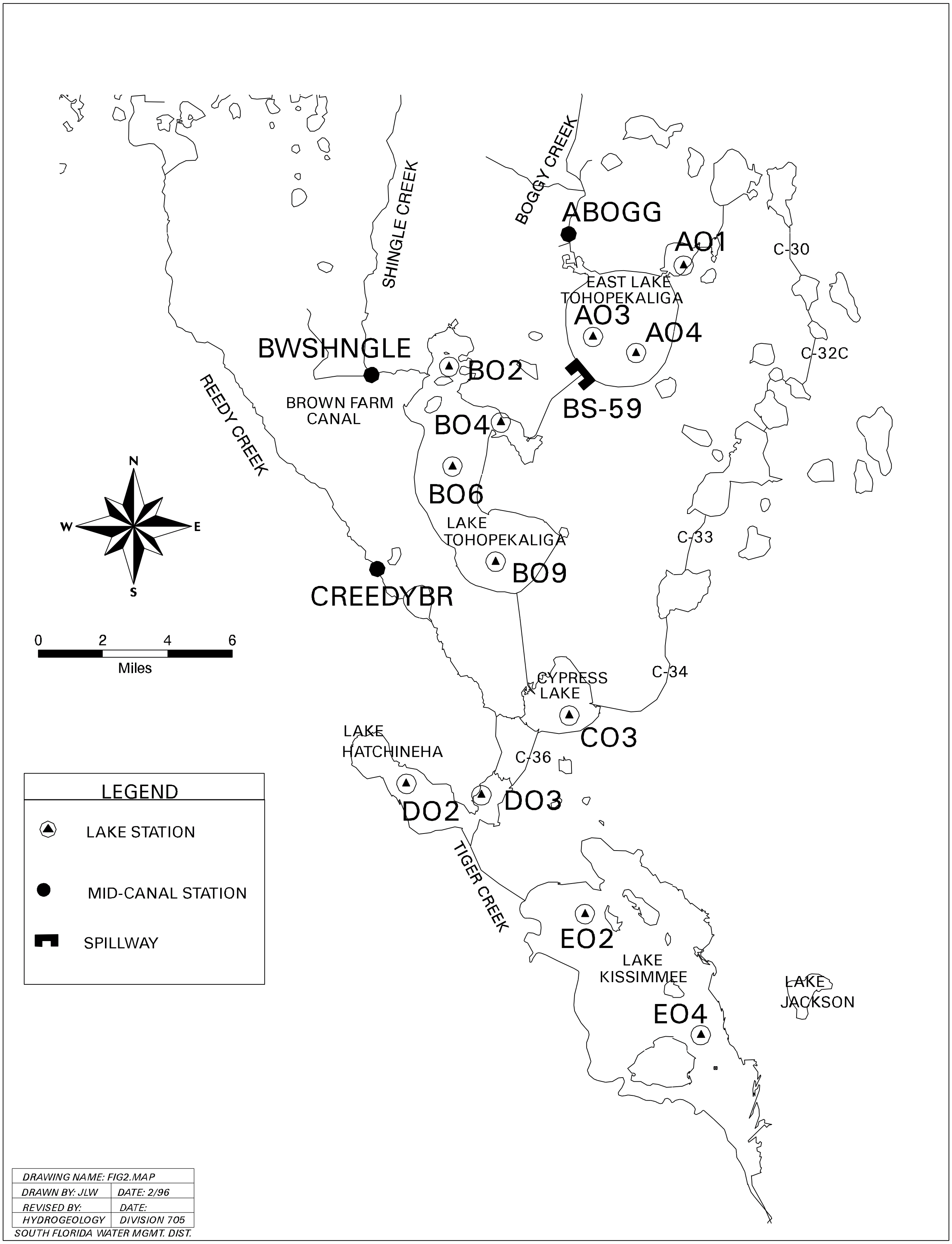
Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Everglades National Park and Florida Bay.") (Source: SFWMD, 1998a)

Figure D-25. South Florida Water Management District Location of Sampling Stations for the Manatee Bay / Long Sound Water Quality Monitoring Program. (*Note*: These stations are within the regions designated in this PEIS as the "Lower East Coast and Biscayne Bay" and the "Everglades National Park and Florida Bay.") (Source: SFWMD, 1998a)

Figure D-26. South Florida Water Management District Location of Sampling Stations for the South Florida Estuarine Water Quality Monitoring Program (Water Quality Monitoring Stations Shown). (*Note*: These stations are within the regions designated in this PEIS as the "Everglades National Park and Florida Bay" and the "Lower East Coast and Biscayne Bay.") (Source: SFWMD, 1998a)

Figure D-27. South Florida Water Management District Location of Sampling Stations for the South Florida Estuarine Water Quality Monitoring Program (Marine Hydrologic Monitoring Stations Shown). (*Note*: These stations are within the region designated in this PEIS as the "Everglades National Park and Florida Bay.") (Source: SFWMD, 1998a)

Figure D-28. South Florida Water Management District Location of Sampling Stations for the Big Cypress National Preserve Water Quality Monitoring Program. (*Note*: These stations are within the region designated in this PEIS as the "Big Cypress Region.") (Source: SFWMD, 1998a).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BS-59
REEDY CREEK
BROWN FARM
CANAL
BO4
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BO6
LAKE
TOHOPEKALIGA
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BO9
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HATCHINEHA
C-36
LEGEND
LAKE STATION
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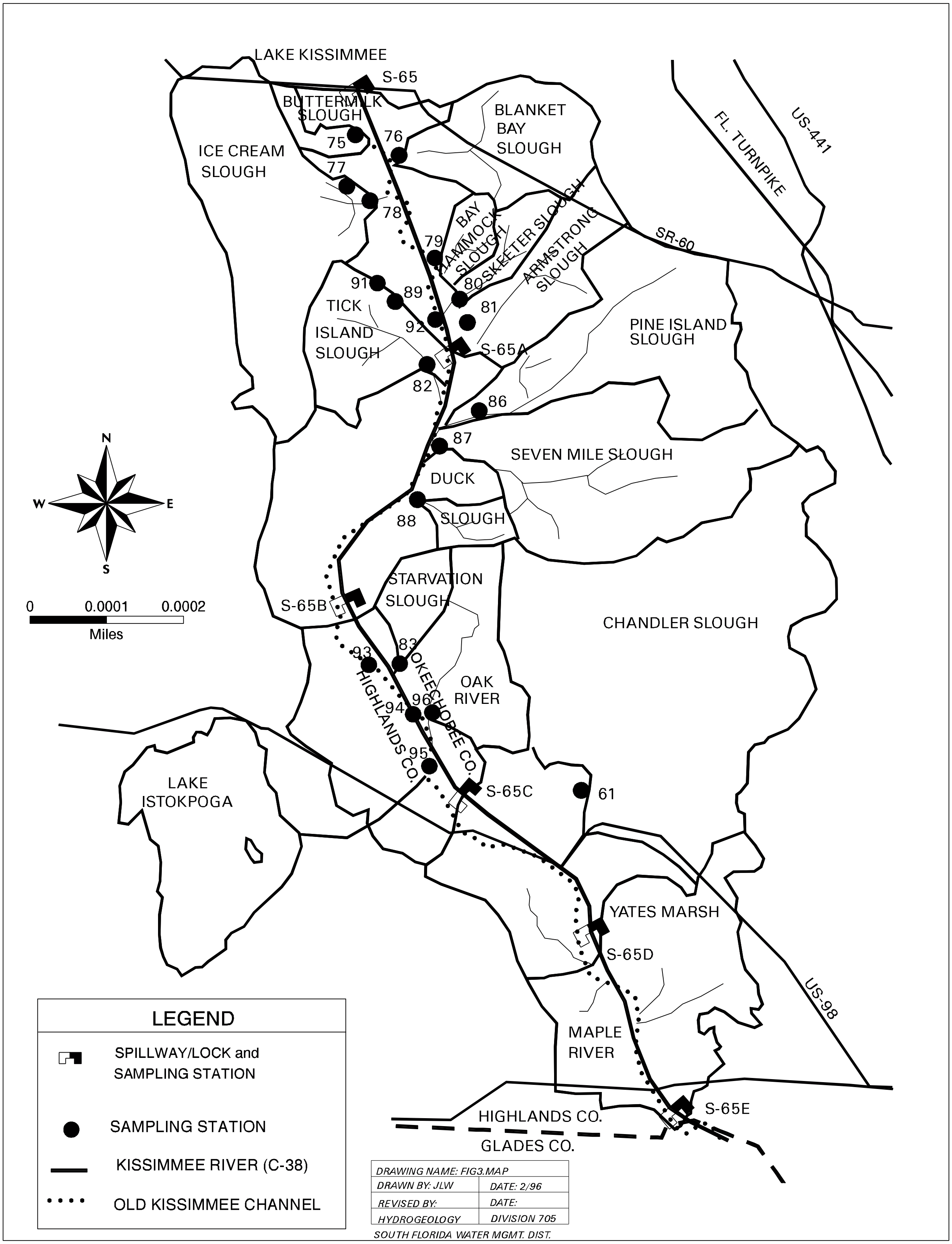
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BAY HAMMOCK SLOUGH
SKEETER SLOUGH
ARMSTRONG SLOUGH
SR-60
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80
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89
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TICK ISLAND SLOUGH
PINE ISLAND SLOUGH
S-65A
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SEVEN MILE SLOUGH
DUCK SLOUGH
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STARVATION SLOUGH
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Miles
CHANDLER SLOUGH
83
93
94
96
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OAK RIVER
HIGHLANDS CO.
OKEECHOBEE CO.
LAKE ISTOKPOGA
S-65C
61
YATES MARSH
S-65D
US-98
MAPLE RIVER
S-65E
HIGHLANDS CO.
GLADES CO.
LEGEND
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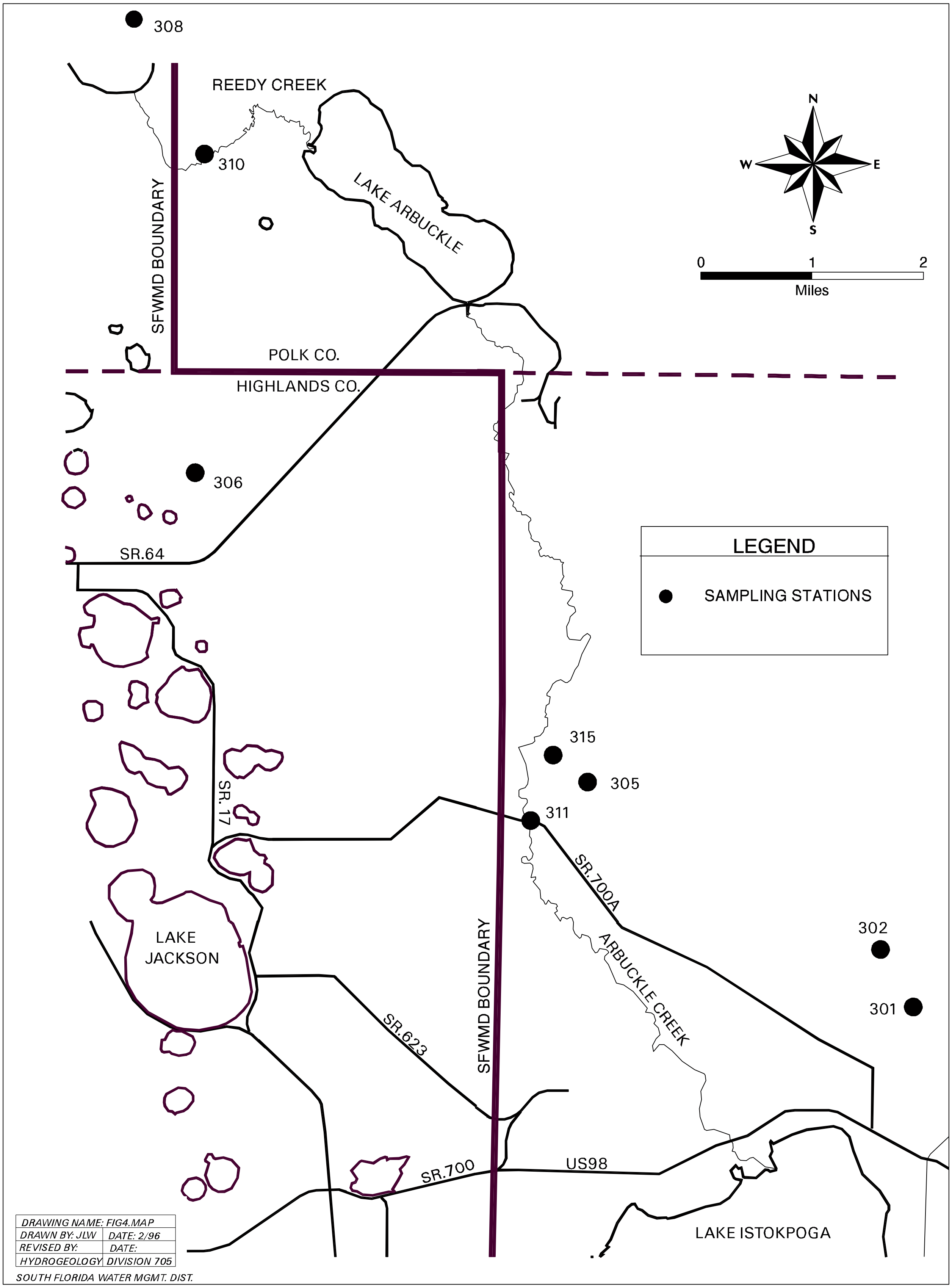
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SR.64
LEGEND
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SR. 17
311
SR.700A
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DRAWING NAME: FIG4.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
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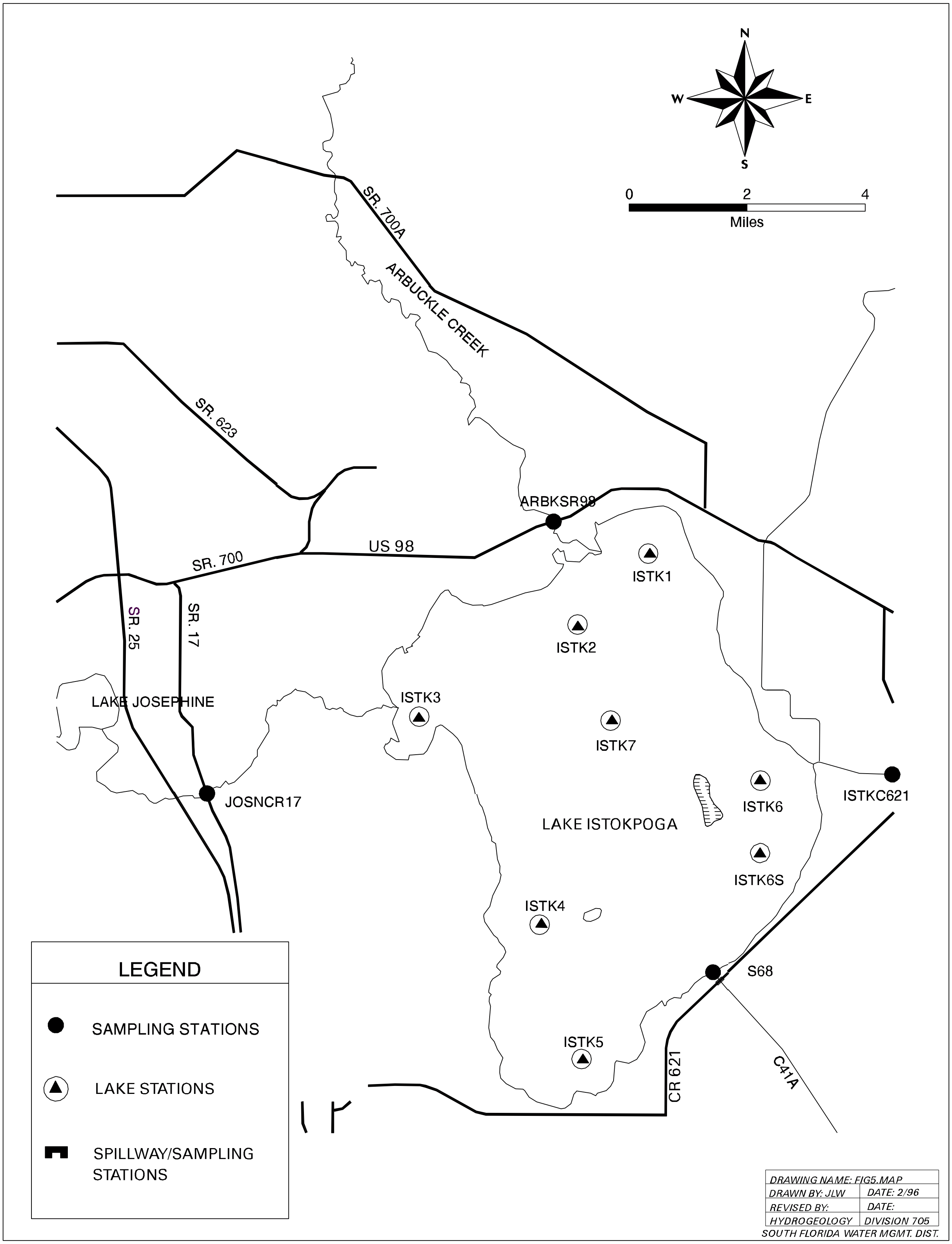
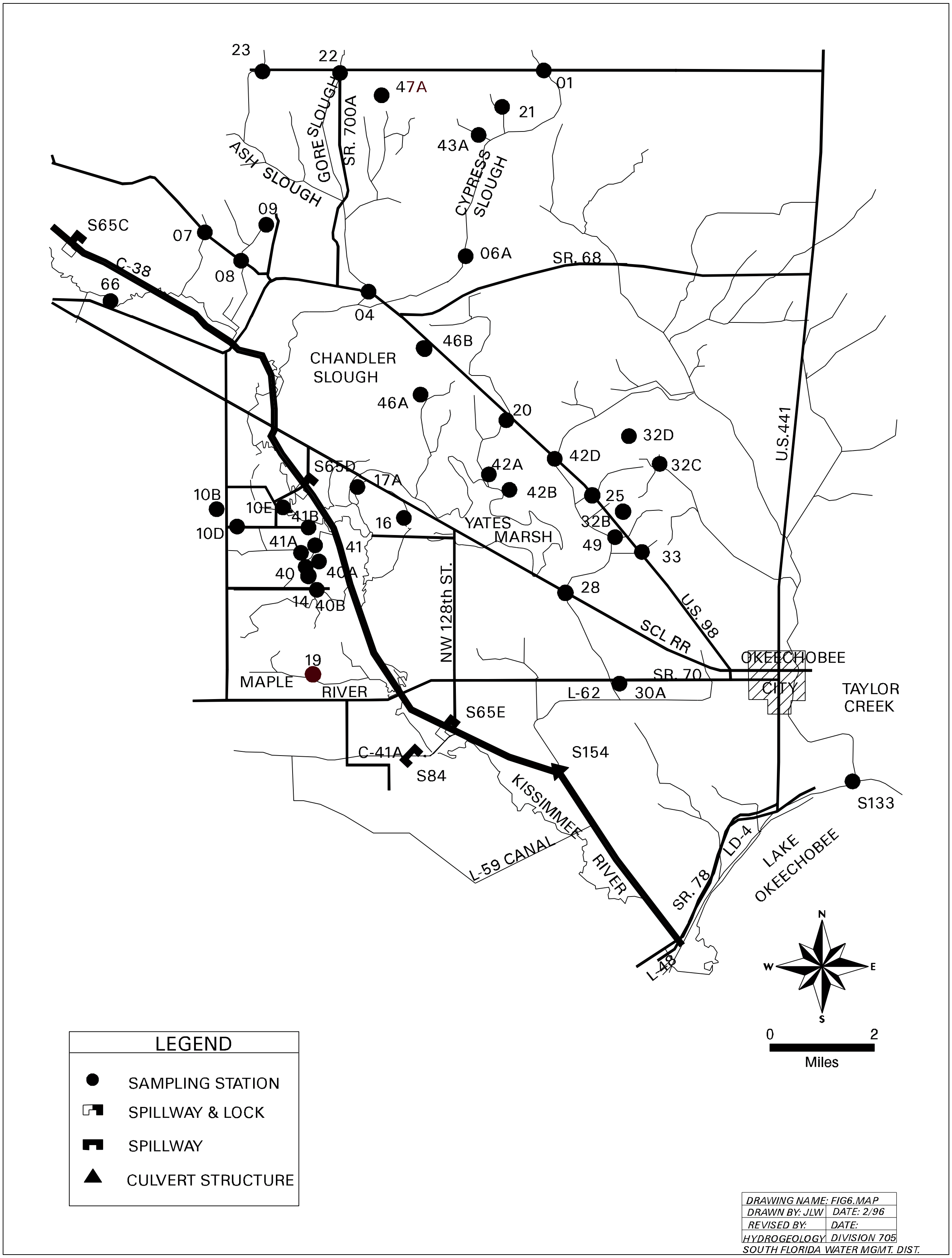
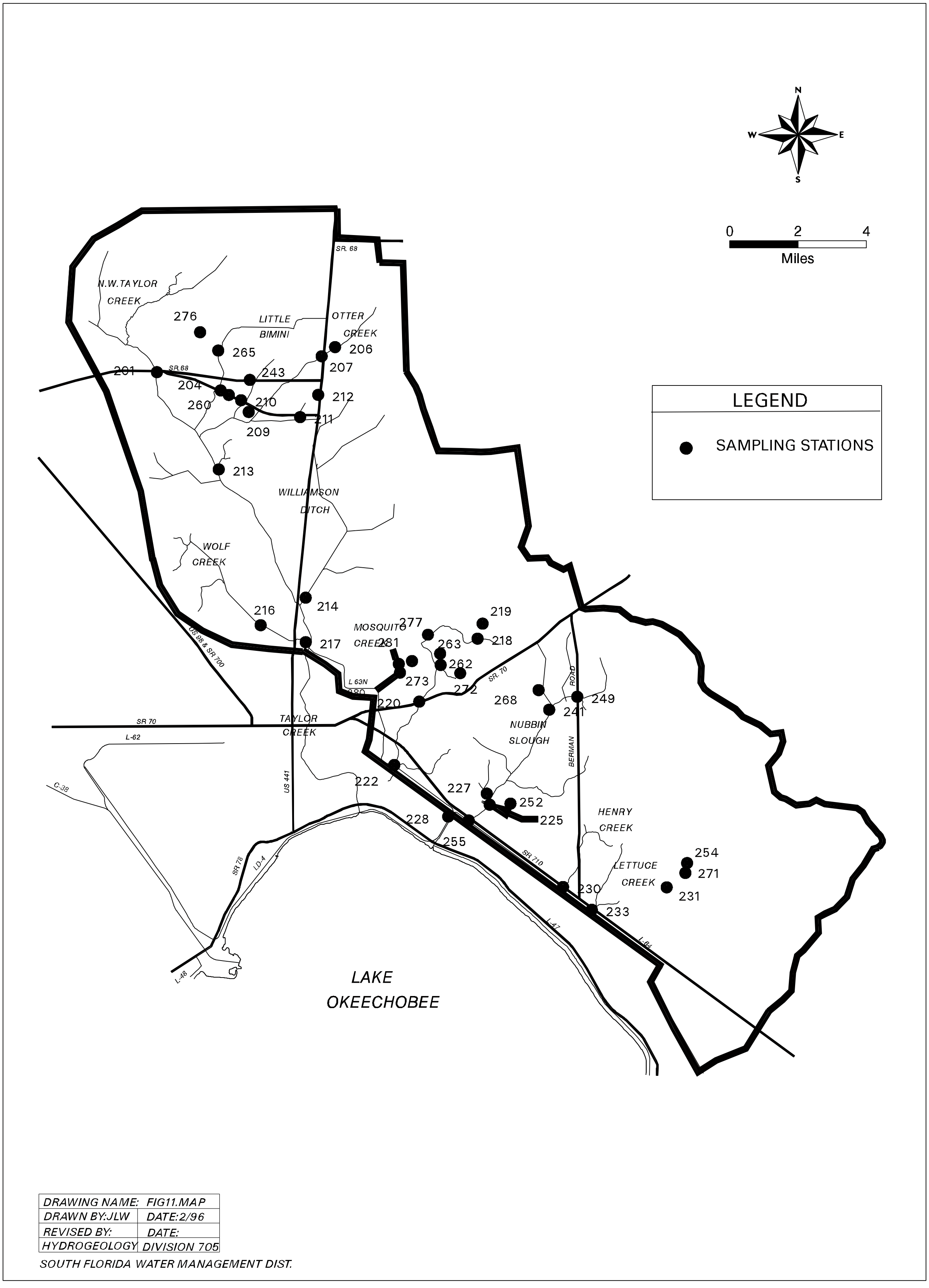
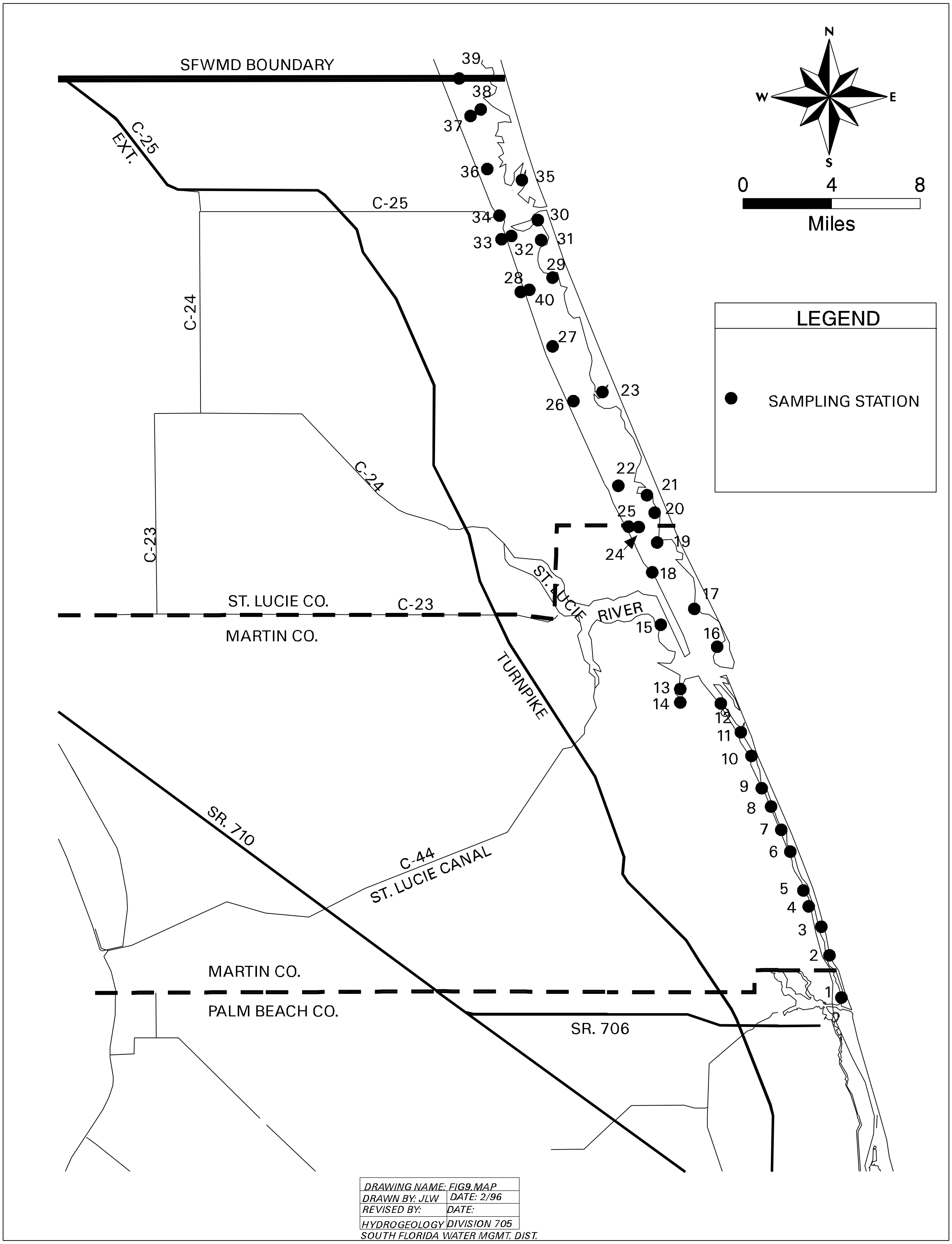
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

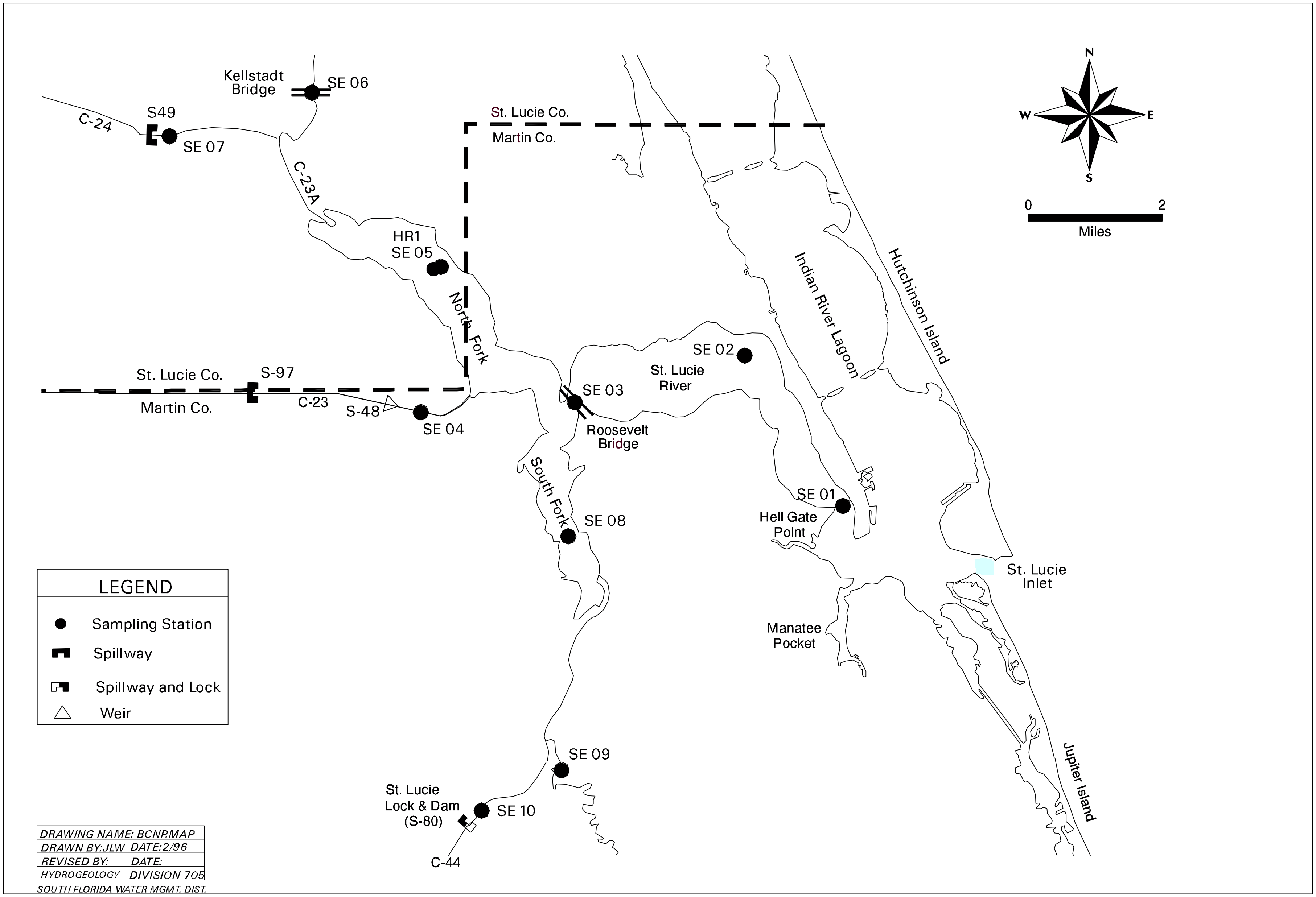

N
W
E
S
0
2
4
Miles
SR. 700A
ARBUCKLE CREEK
SR. 623
ARBKSR98
US 98
SR. 700
SR. 25
SR. 17
ISTK1
ISTK2
ISTK3
ISTK7
LAKE JOSEPHINE
JOSNCR17
ISTKC621
ISTK6
LAKE ISTOKPOGA
ISTK6S
ISTK4
S68
ISTK5
CR 621
C41A
LEGEND
SAMPLING STATIONS
LAKE STATIONS
SPILLWAY/SAMPLING STATIONS
DRAWING NAME: FIG5.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

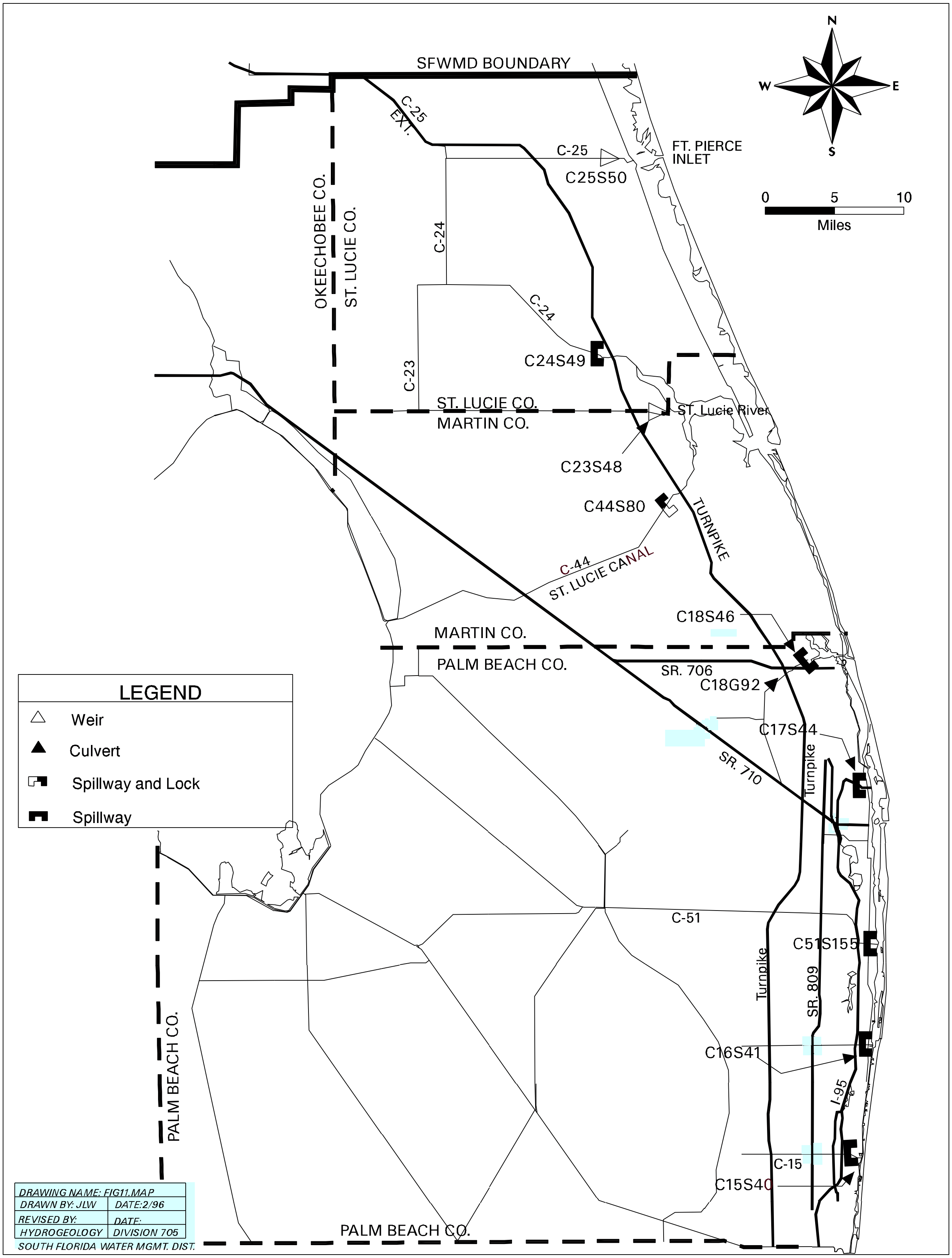


23
22
01
47A
21
43A
GORE SLOUGH
SR. 700A
ASH SLOUGH
CYPRESS SLOUGH
09
S65C
07
08
C-38
66
SR. 68
06A
04
CHANDLER SLOUGH
46B
46A
20
32D
42D
32C
S65D
17A
42A
42B
25
10B
10E
41B
16
YATES MARSH
32B
10D
41A
41
49
33
40
40A
14
40B
28
NW 128th ST.
U.S. 98
SCL RR
U.S.441
19
MAPLE
RIVER
SR. 70
L-62
30A
OKEECHOBEE CITY
TAYLOR CREEK
S65E
S154
C-41A
S84
KISSIMMEE RIVER
L-59 CANAL
S133
LD-4
LAKE OKEECHOBEE
SR. 78
L-48
N
W
E
S
0
2
Miles
LEGEND
SAMPLING STATION
SPILLWAY & LOCK
SPILLWAY
CULVERT STRUCTURE
DRAWING NAME: FIG6.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

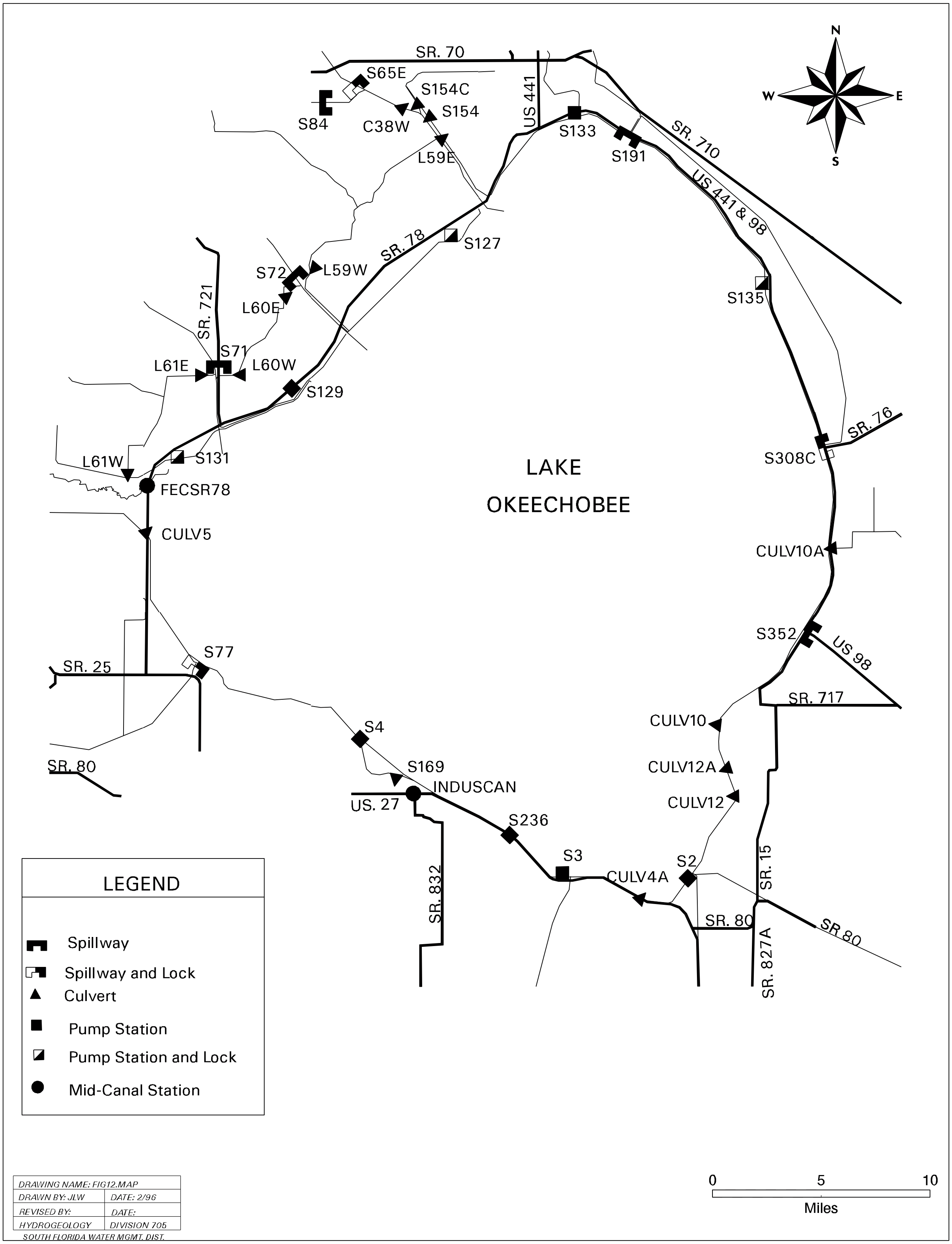

N
S
W
E
0 2 4
Miles
LEGEND
SAMPLING STATIONS
N.W.TAYLOR CREEK
LITTLE BIMINI
OTTER CREEK
WILLIAMSON DITCH
WOLF CREEK
MOSQUITO CREEK
TAYLOR CREEK
NUBBIN SLOUGH
HENRY CREEK
LETTUCE CREEK
LAKE OKEECHOBEE
SR. 68
SR 70
US 441
US 98 & SR 700
L-62
C-38
SR 78
L-D4
L-48
L-47
L-64
SR 710
L 63N
BERMAN ROAD
201
204
206
207
209
210
211
212
213
214
216
217
218
219
220
222
225
227
228
230
231
233
241
243
249
252
254
255
260
262
263
265
268
271
272
273
276
277
281
DRAWING NAME: FIG11.MAP
DRAWN BY:JLW DATE:2/96
REVISED BY: DATE:
HYDROGEOLOGY DIVISION 705
SOUTH FLORIDA WATER MANAGEMENT DIST.

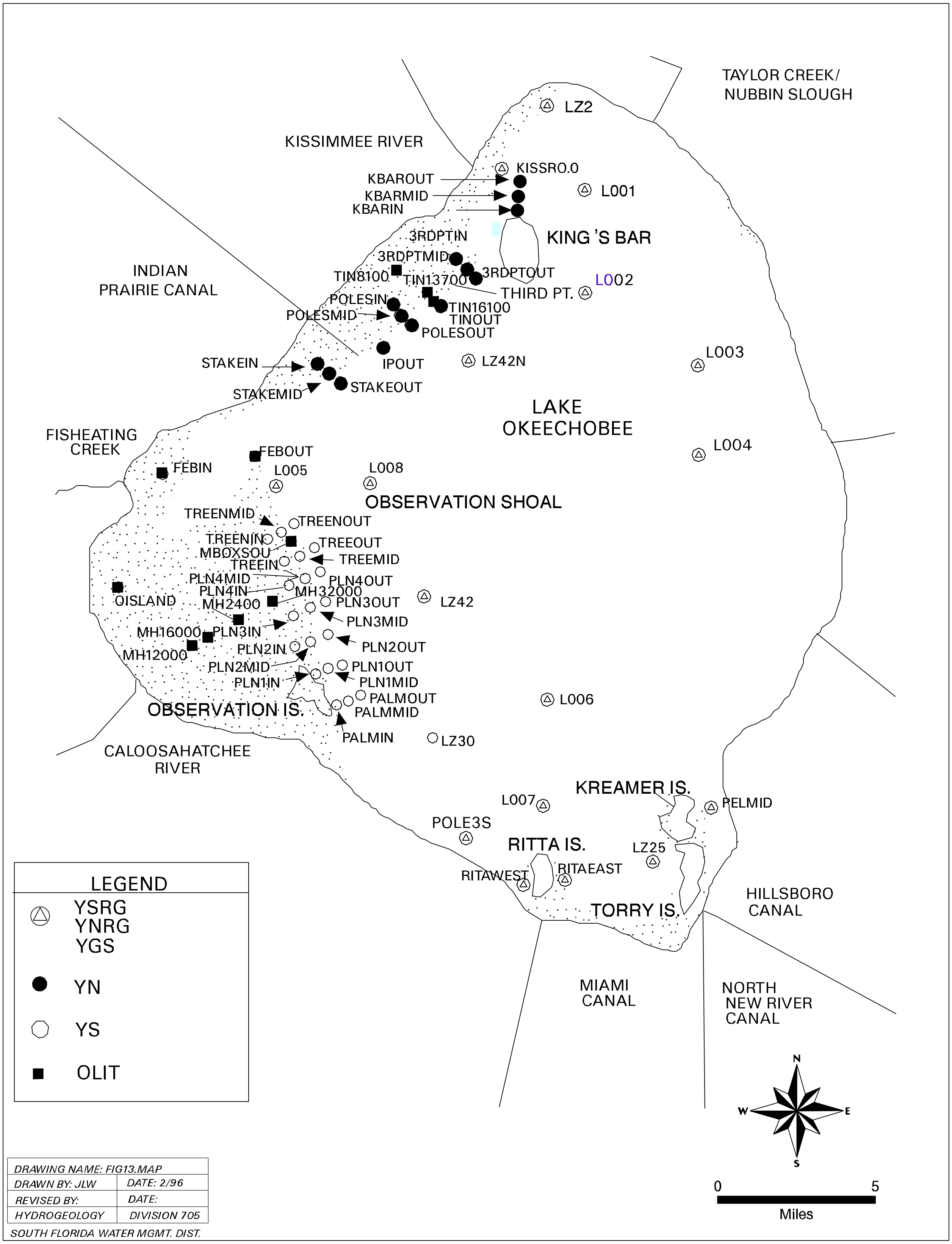

SFWMD BOUNDARY
C-25 EXT.
C-25
C-24
C-24
C-23
ST. LUCIE CO.
C-23
MARTIN CO.
ST. LUCIE RIVER
TURNPIKE
SR. 710
C-44 ST. LUCIE CANAL
MARTIN CO.
PALM BEACH CO.
SR. 706
N
S
W
E
0
4
8
Miles
LEGEND
SAMPLING STATION
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
DRAWING NAME: FIG9.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

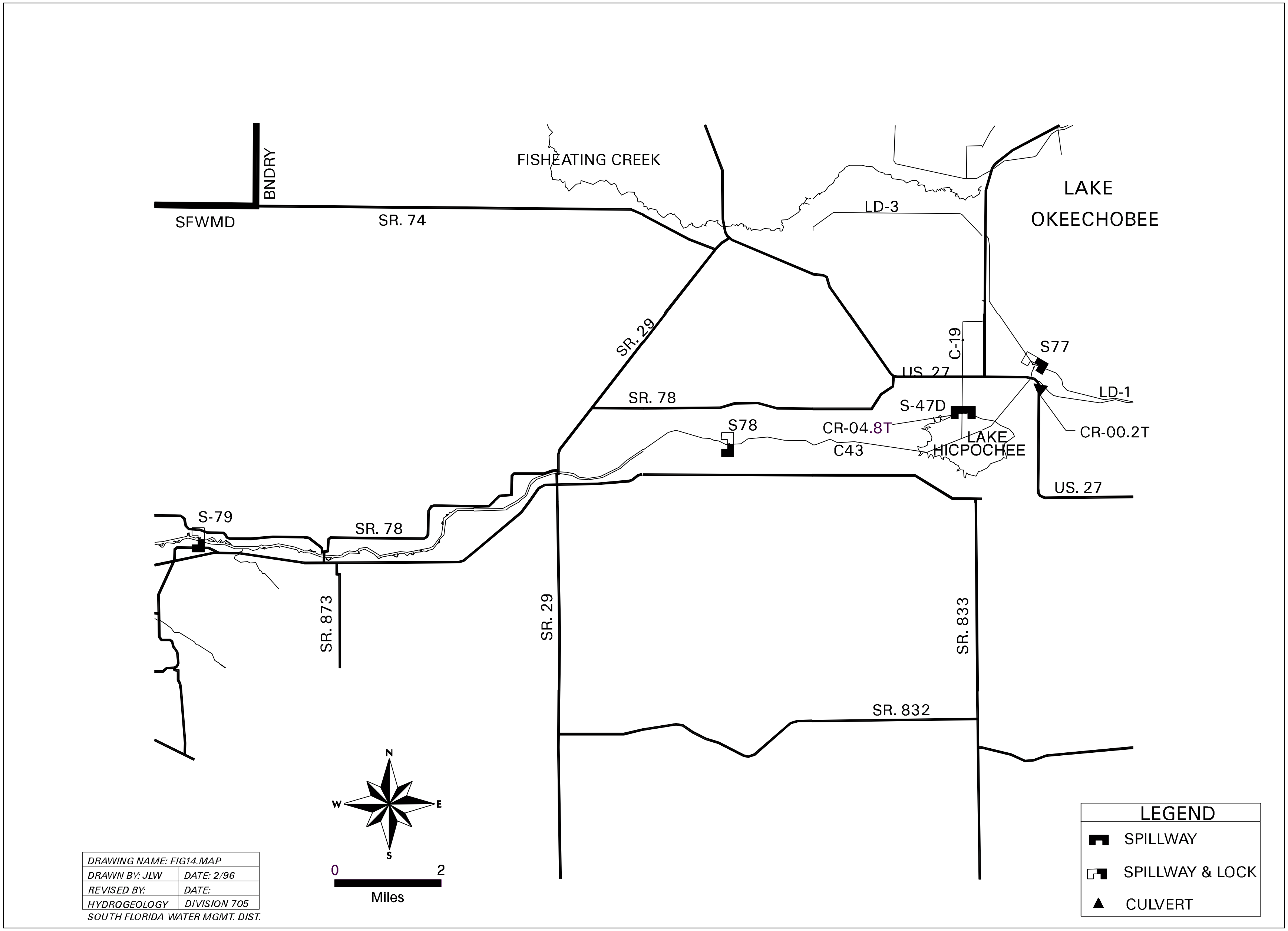

Kellstadt Bridge
SE 06
C-24
S49
SE 07
C-23A
St. Lucie Co.
Martin Co.
HR1
SE 05
North Fork
St. Lucie Co.
S-97
Martin Co.
C-23
S-48
SE 04
SE 02
St. Lucie River
SE 03
Roosevelt Bridge
South Fork
SE 08
Indian River Lagoon
Hutchinson Island
SE 01
Hell Gate Point
St. Lucie Inlet
Manatee Pocket
Jupiter Island
SE 09
St. Lucie Lock & Dam (S-80)
SE 10
C-44
N
W
E
S
0
2
Miles
LEGEND
Sampling Station
Spillway
Spillway and Lock
Weir
DRAWING NAME: BCNP.MAP
DRAWN BY:JLW
DATE:2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

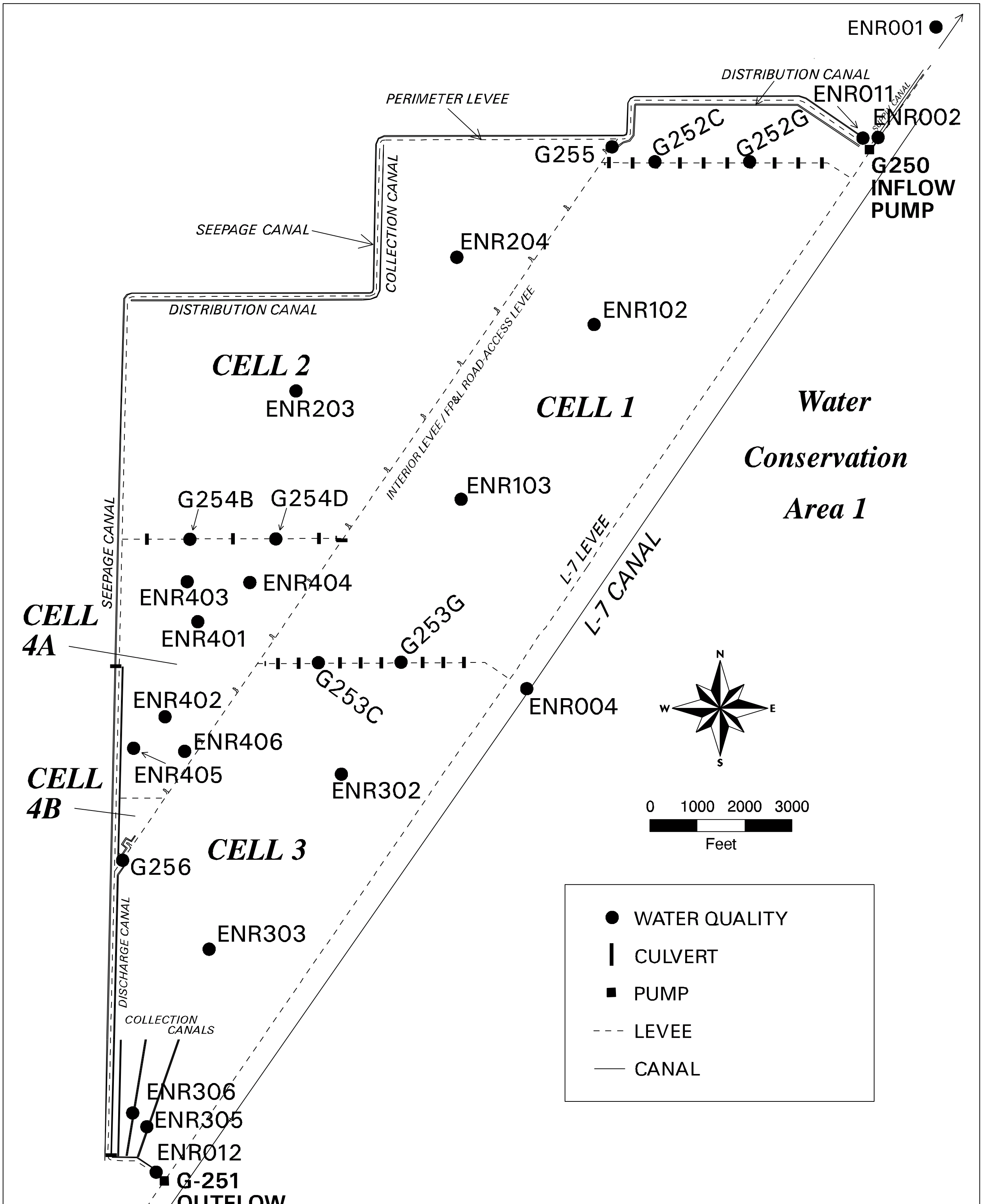


SFWMD BOUNDARY
N
S
E
W
FT. PIERCE INLET
0 5 10
Miles
C-25 EXT.
C-25
C25S50
C-24
OKEECHOBEE CO.
ST. LUCIE CO.
C-24
C24S49
C-23
ST. LUCIE CO.
MARTIN CO.
ST. Lucie River
C23S48
C44S80
TURNPIKE
C-44
ST. LUCIE CANAL
C18S46
MARTIN CO.
PALM BEACH CO.
SR. 706
C18G92
LEGEND
Weir
Culvert
Spillway and Lock
Spillway
C17S44
SR. 710
Turnpike
C-51
C51S155
Turnpike
SR. 809
C16S41
I-95
PALM BEACH CO.
C-15
C15S40
PALM BEACH CO.
DRAWING NAME: FIG11.MAP
DRAWN BY: JLW
DATE:2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.


N
E
S
W
SR. 70
S65E
S154C
S154
S84
C38W
L59E
US 441
S133
S191
SR. 710
US 441 & 98
S127
SR. 78
S72
L59W
L60E
S135
SR. 721
S71
L61E
L60W
S129
SR. 76
S308C
L61W
S131
FECSR78
LAKE
OKEECHOBEE
CULV5
CULV10A
S352
US 98
S77
SR. 25
SR. 717
S4
CULV10
SR. 80
S169
CULV12A
INDUSCAN
US. 27
CULV12
S236
SR. 832
S3
CULV4A
S2
SR. 15
SR. 80
SR 80
SR. 827A
LEGEND
Spillway
Spillway and Lock
Culvert
Pump Station
Pump Station and Lock
Mid-Canal Station
0
5
10
Miles
DRAWING NAME: FIG12.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

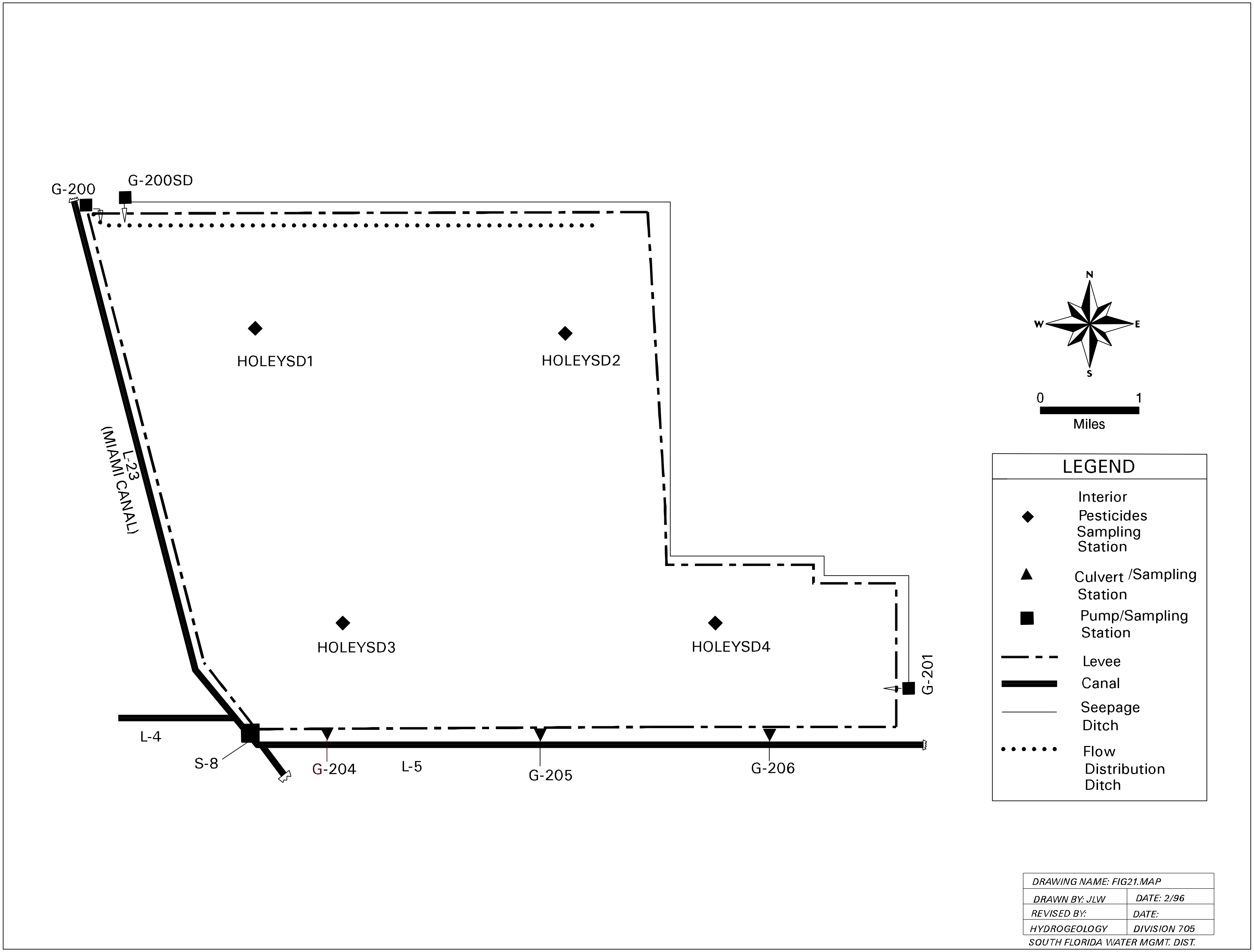

TAYLOR CREEK/
NUBBIN SLOUGH
LZ2
KISSIMMEE RIVER
KISSRO.0
KBAROUT
KBARMID
KBARIN
L001
KING 'S BAR
3RDPTIN
3RDPTMID
3RDPTOUT
INDIAN
PRAIRIE CANAL
TIN8100
TIN13700
THIRD PT.
L002
POLESIN
POLESMID
TIN16100
TINOUT
POLESOUT
IPOUT
LZ42N
L003
STAKEIN
STAKEMID
STAKEOUT
LAKE
OKEECHOBEE
FISHEATING
CREEK
FEBOUT
FEBIN
L005
L008
L004
OBSERVATION SHOAL
TREENMID
TREENOUT
TREENIN
TREEOUT
MBOXSOU
TREEMID
TREEIN
PLN4MID
PLN4OUT
PLN4IN
MH32000
OISLAND
MH2400
PLN3OUT
LZ42
PLN3MID
MH16000
PLN3IN
MH12000
PLN2IN
PLN2OUT
PLN2MID
PLN1OUT
PLN1IN
PLN1MID
PALMOUT
L006
OBSERVATION IS.
PALMMID
PALMIN
LZ30
CALOOSAHATCHEE
RIVER
L007
KREAMER IS.
PELMID
POLE3S
RITTA IS.
LZ25
RITAWEST
RITAEAST
HILLSBORO
CANAL
TORRY IS.
MIAMI
CANAL
NORTH
NEW RIVER
CANAL
LEGEND
YSRG
YNRG
YGS
YN
YS
OLIT
N
W
E
S
0
5
Miles
DRAWING NAME: FIG13.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

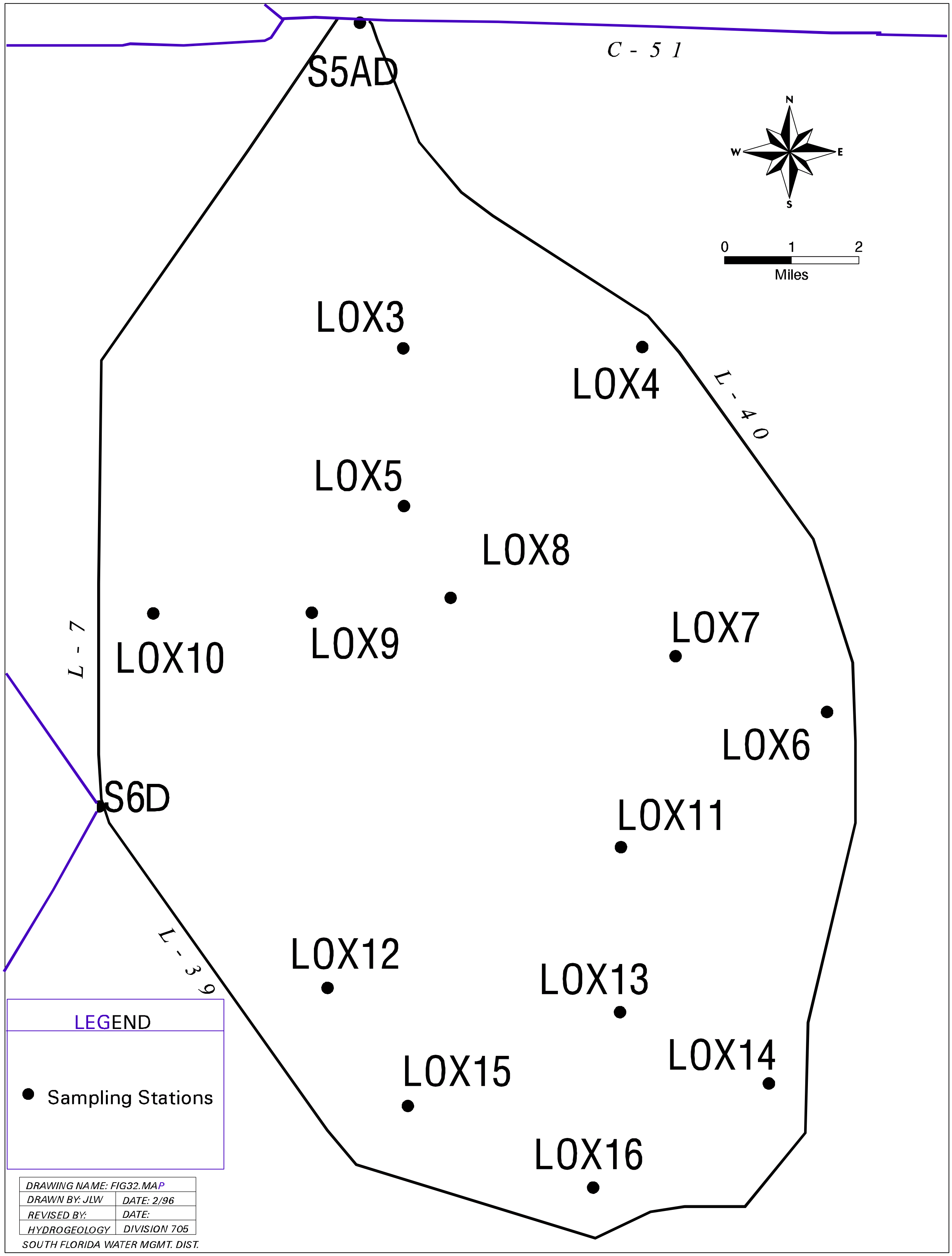

FISHEATING CREEK
BNDRY
SFWMD
SR. 74
LAKE OKEECHOBEE
LD-3
SR. 29
C-19
S77
US. 27
LD-1
SR. 78
S-47D
S78
CR-04.8T
LAKE HICPOCHEE
CR-00.2T
C43
US. 27
S-79
SR. 78
SR. 873
SR. 29
SR. 833
SR. 832
N
W
E
S
0
2
Miles
LEGEND
SPILLWAY
SPILLWAY & LOCK
CULVERT
DRAWING NAME: FIG14.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.



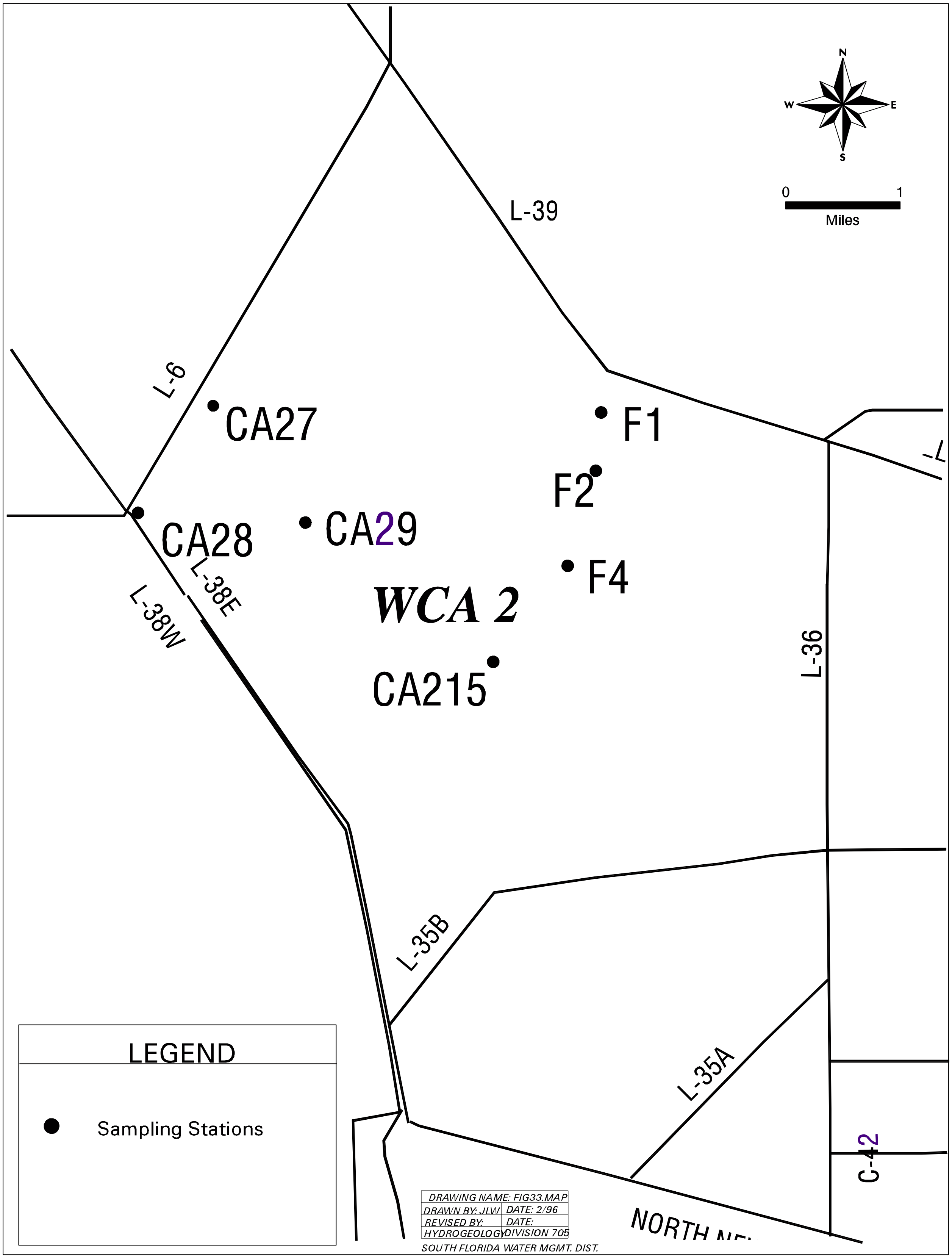
DRAWING NAME: FIG31.MAP	
DRAWN BY: JLW	DATE: 2/96
REVISED BY:	DATE:
HYDROGEOLOGY	DIVISION 705

SOUTH FLORIDA WATER MGMT. DIST.

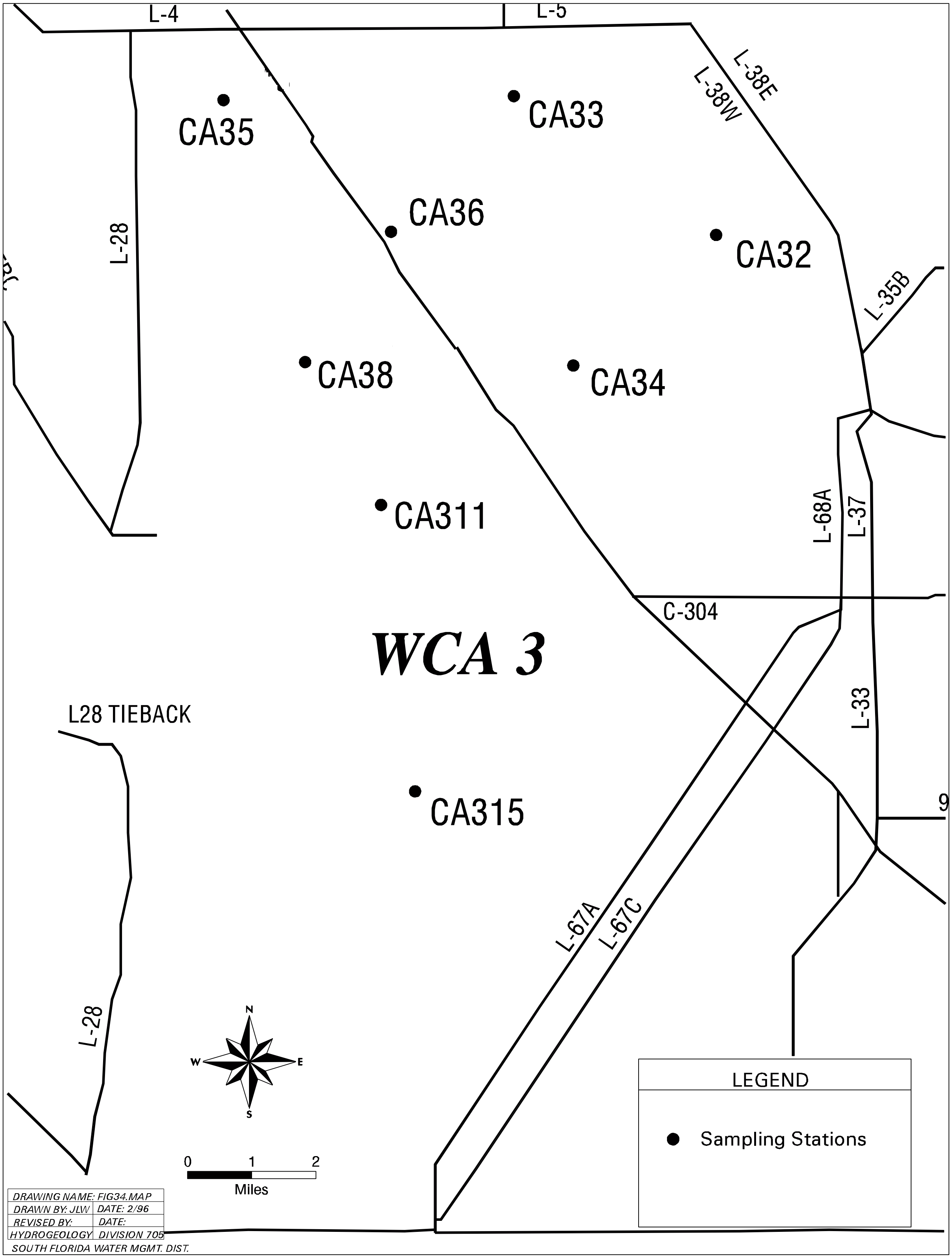

G-200
G-200SD
HOLEYSD1
HOLEYSD2
L-23
(MIAMI CANAL)
HOLEYSD3
HOLEYSD4
G-201
L-4
S-8
G-204
L-5
G-205
G-206
N
W
E
S
0
1
Miles
LEGEND
Interior Pesticides Sampling Station
Culvert /Sampling Station
Pump/Sampling Station
Levee
Canal
Seepage Ditch
Flow Distribution Ditch
DRAWING NAME: FIG21.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

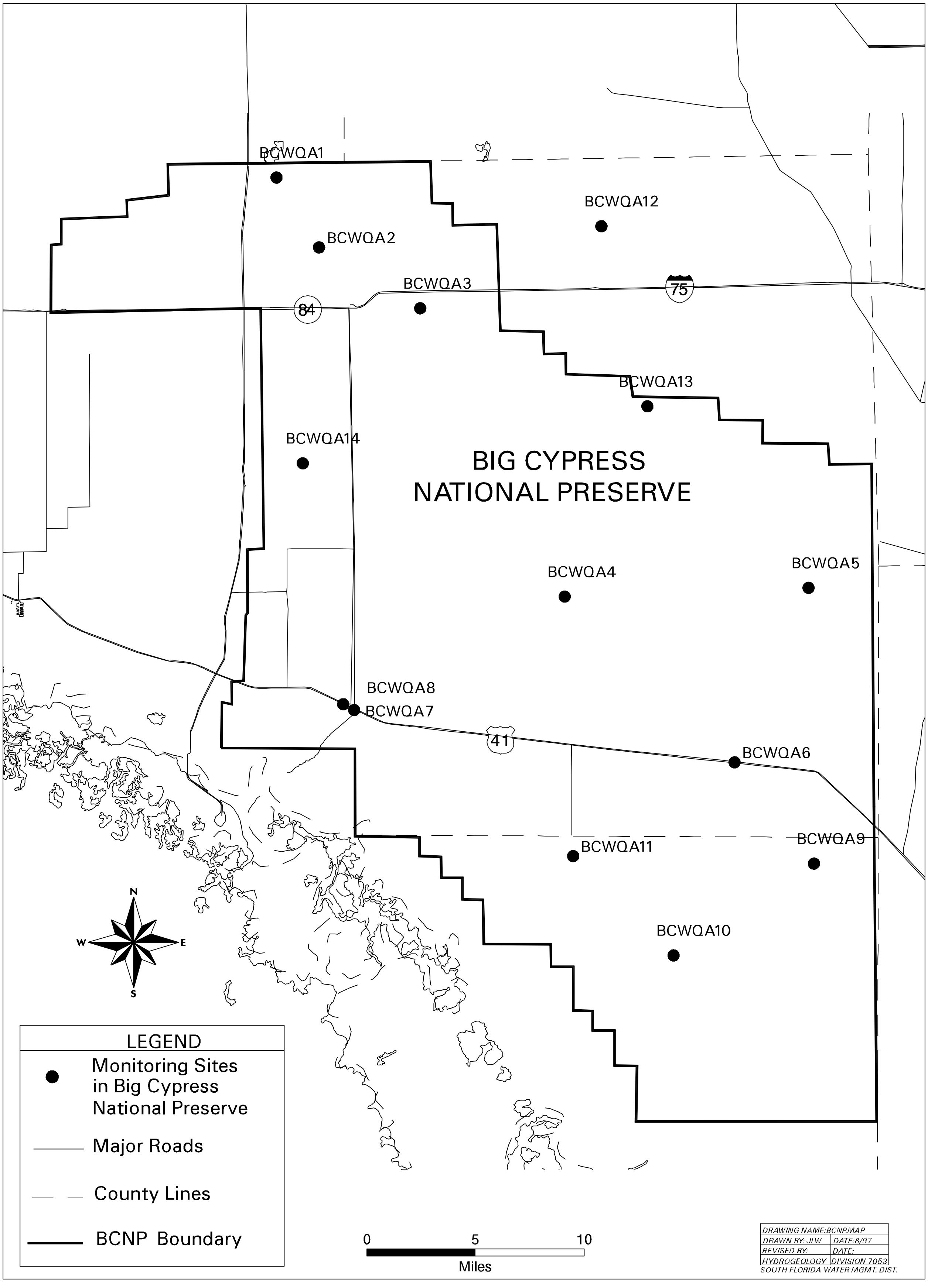


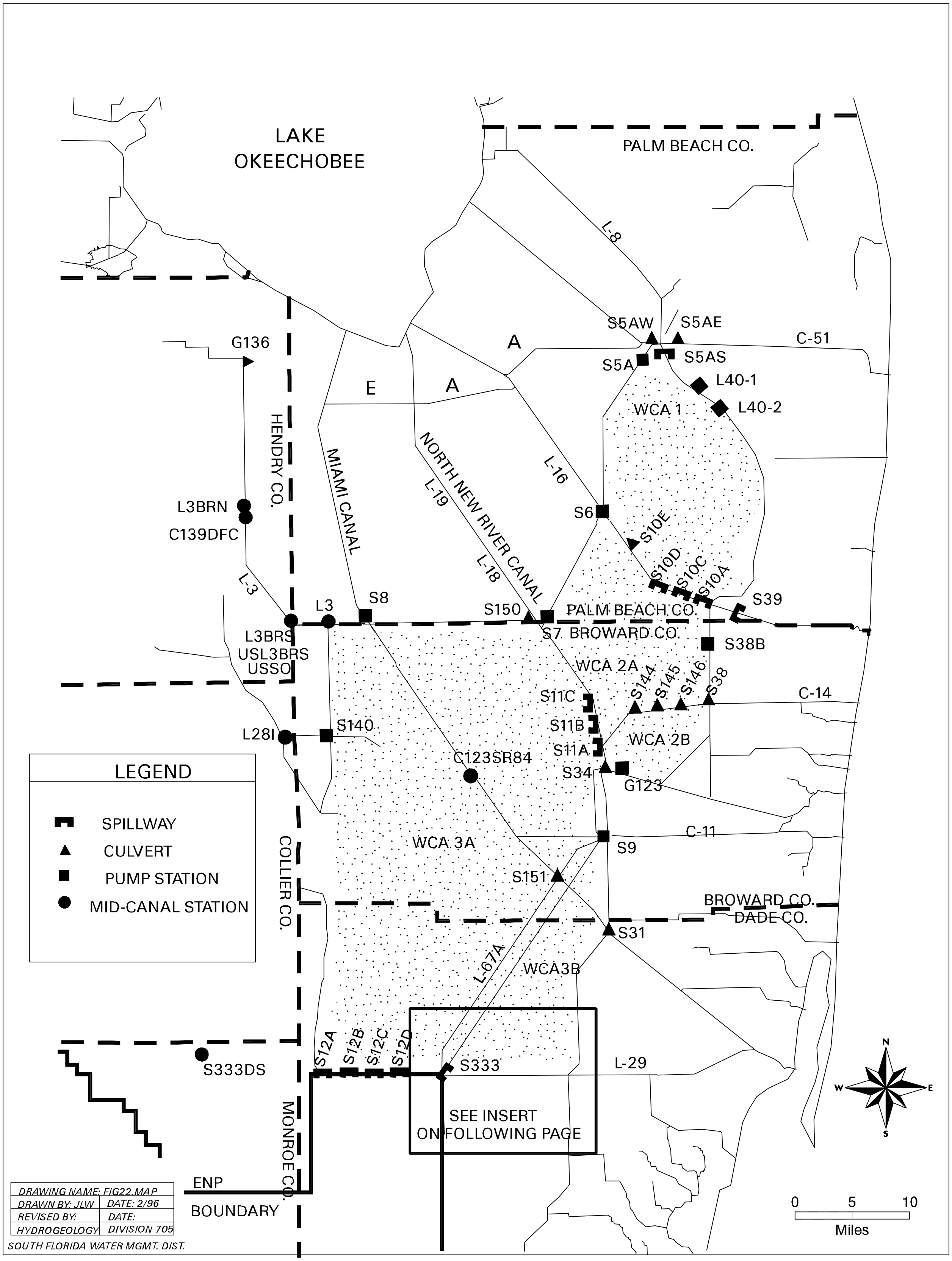
s Protection Area (WCA1)

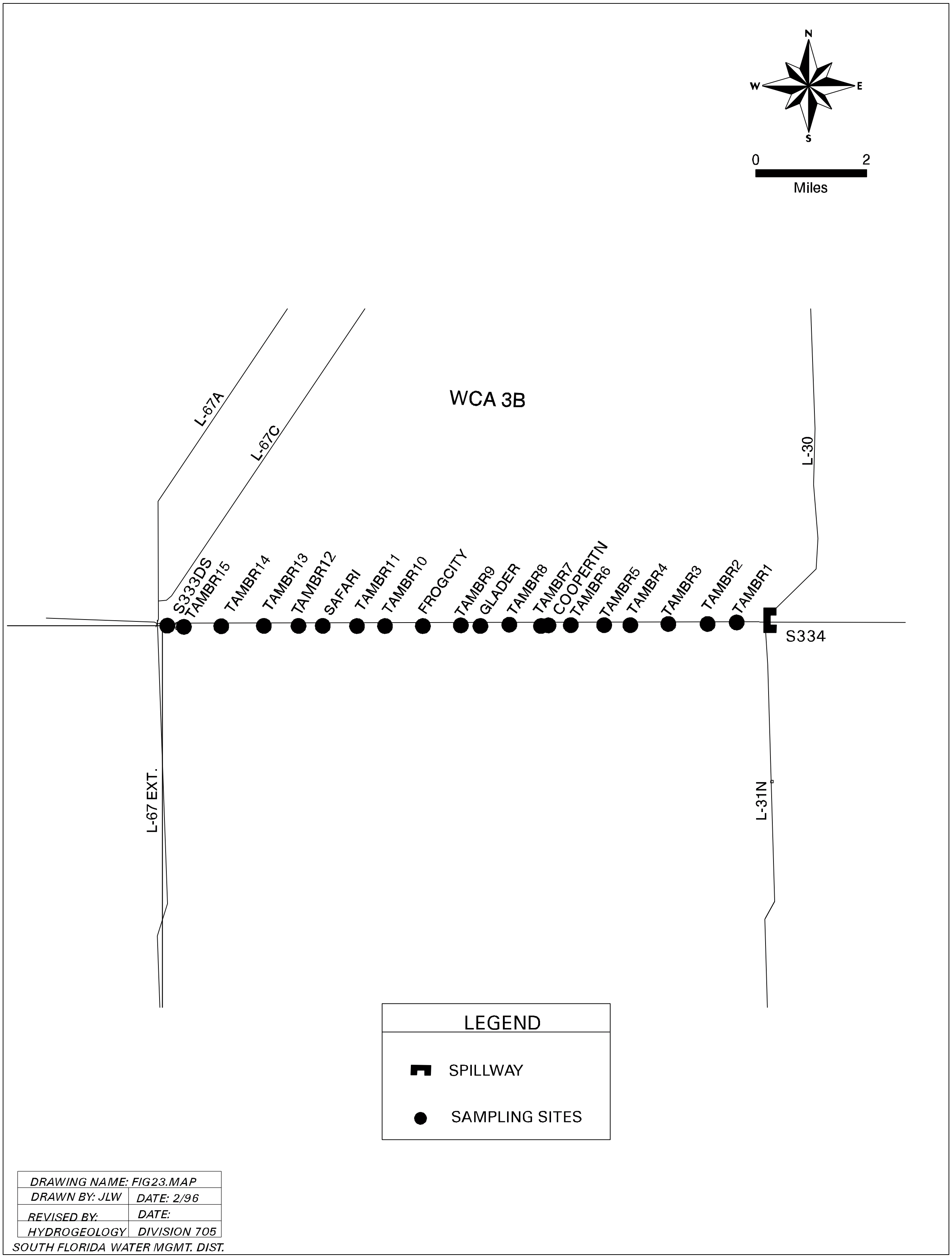


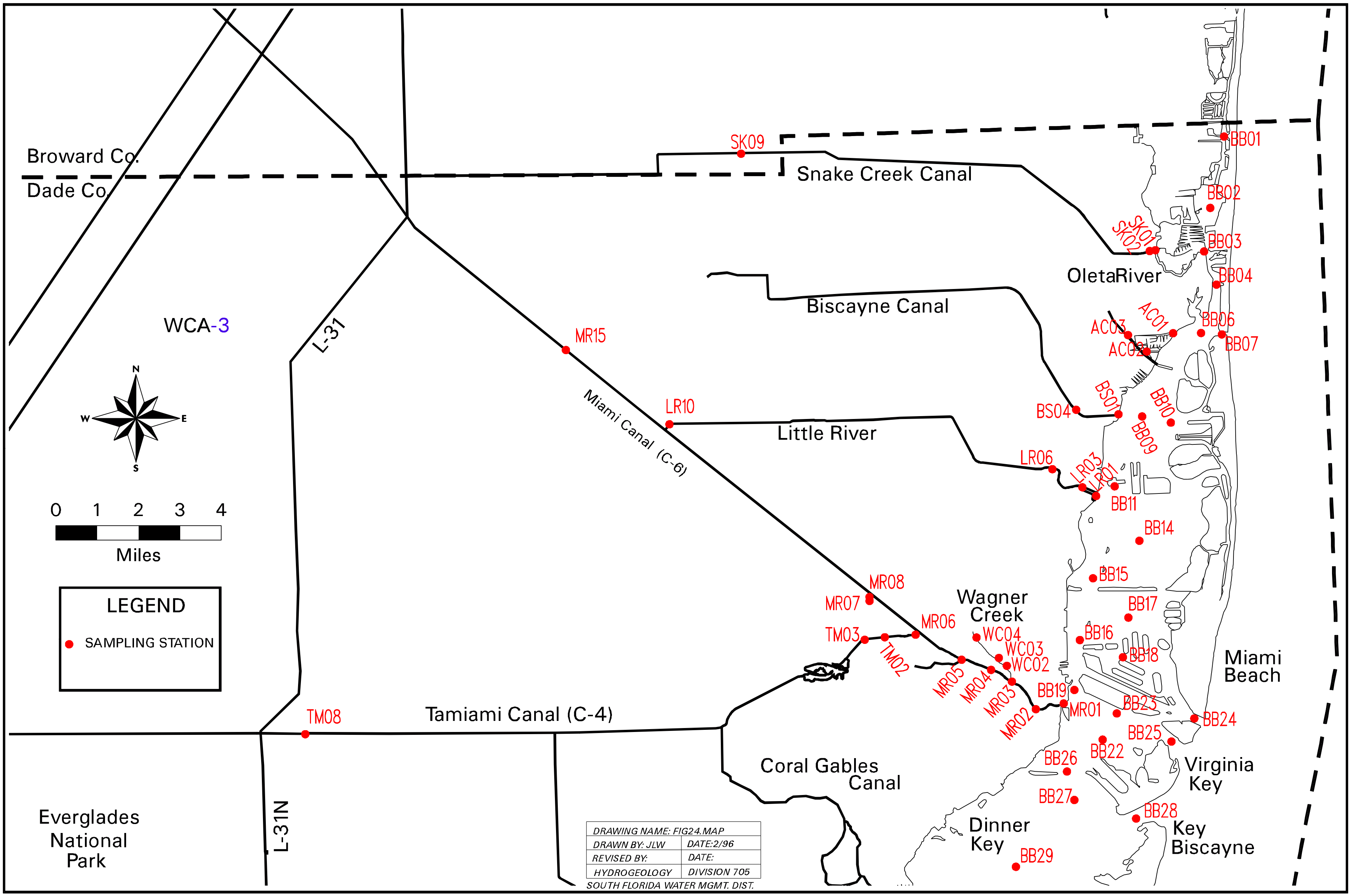
N
W
E
S
0
1
Miles
L-39
L-6
CA27
F1
F2
CA28
CA29
F4
L-38E
L-38W
WCA 2
L-36
CA215
L-35B
L-35A
C-42
NORTH NE
LEGEND
Sampling Stations
DRAWING NAME: FIG33.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.

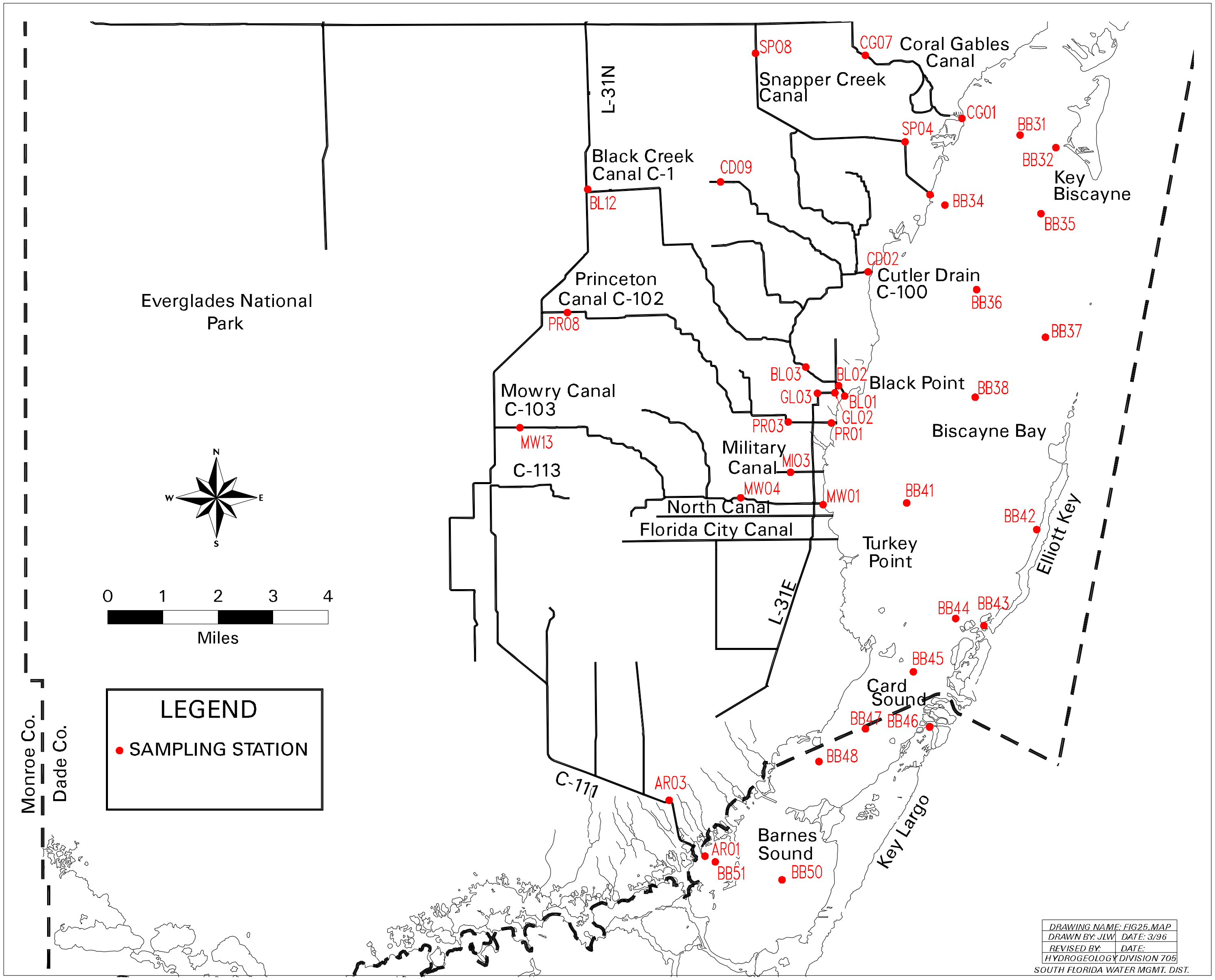

L-4
L-5
L-38E
L-38W
CA35
CA33
CA36
CA32
L-28
L-35B
CA38
CA34
CA311
L-68A
L-37
C-304
WCA 3
L-33
L28 TIEBACK
CA315
9
L-67A
L-67C
L-28
N
W
E
S
LEGEND
Sampling Stations
0
1
2
Miles
DRAWING NAME: FIG34.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.


BIG CYPRESS
NATIONAL PRESERVE
BCWQA1
BCWQA2
BCWQA3
BCWQA4
BCWQA5
BCWQA6
BCWQA7
BCWQA8
BCWQA9
BCWQA10
BCWQA11
BCWQA12
BCWQA13
BCWQA14
84
75
41
N
S
E
W
LEGEND
Monitoring Sites in Big Cypress National Preserve
Major Roads
County Lines
BCNP Boundary
0
5
10
Miles
DRAWING NAME:BCNP.MAP
DRAWN BY: JLW
DATE:8/97
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 7053
SOUTH FLORIDA WATER MGMT. DIST.

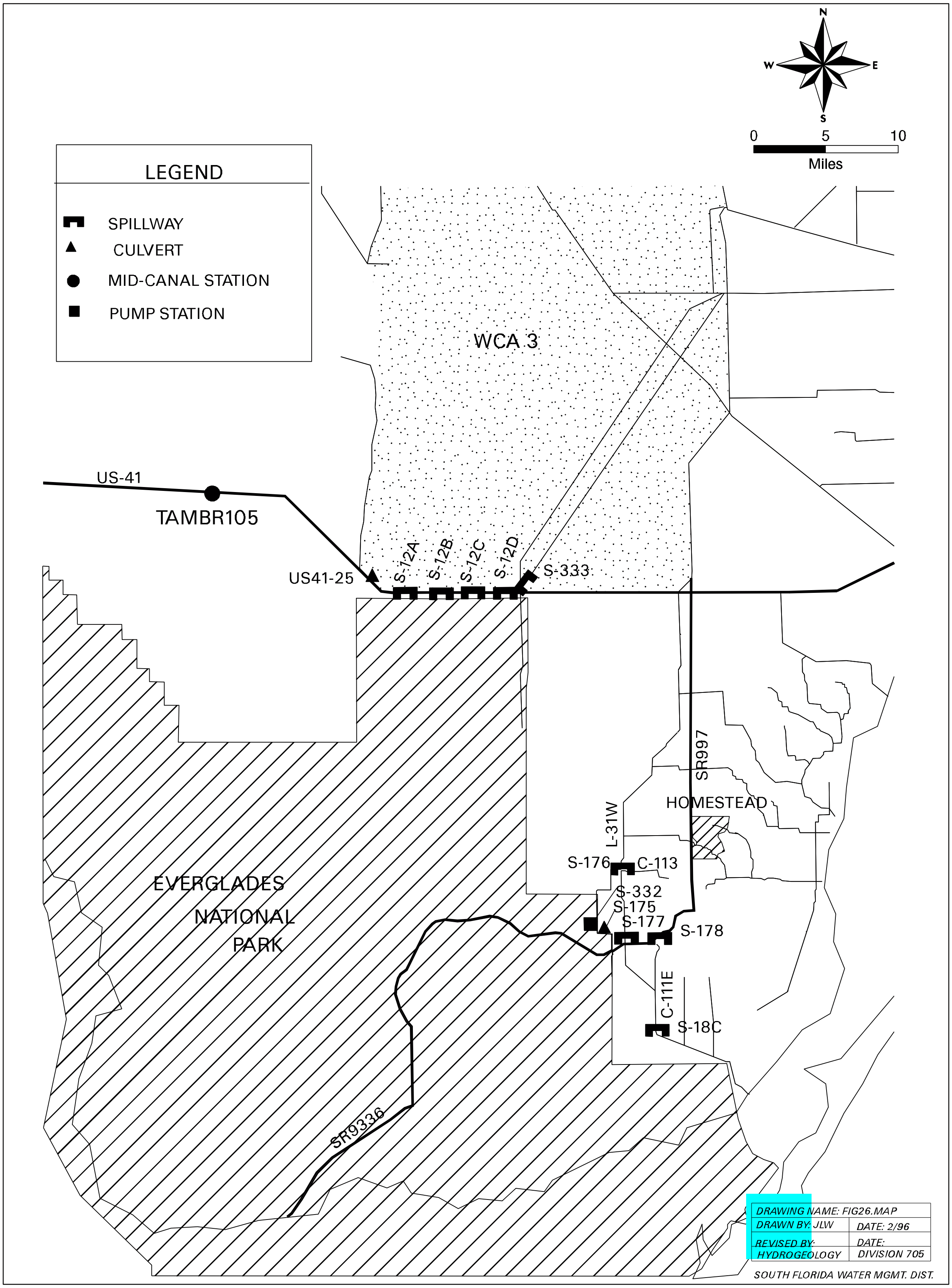

LAKE
OKEECHOBEE
PALM BEACH CO.
L-8
S5AW
S5AE
C-51
S5A
S5AS
L40-1
L40-2
WCA 1
E
A
A
G136
HENDRY CO.
MIAMI CANAL
NORTH NEW RIVER CANAL
L-19
L-16
L-18
S6
S10E
S10D
S10C
S10A
S39
L3BRN
C139DFC
L-3
L3
S8
S150
S7
PALM BEACH CO.
BROWARD CO.
L3BRS
USL3BRS
USSO
S38B
WCA 2A
S144
S145
S146
S38
C-14
S11C
S11B
S11A
S34
G123
WCA 2B
L28I
S140
C123SR84
LEGEND
SPILLWAY
CULVERT
PUMP STATION
MID-CANAL STATION
COLLIER CO.
WCA 3A
S9
C-11
S151
BROWARD CO.
DADE CO.
S31
L-67A
WCA3B
S12A
S12B
S12C
S12D
S333
L-29
S333DS
SEE INSERT
ON FOLLOWING PAGE
MONROE CO.
ENP
BOUNDARY
N
W
E
S
0
5
10
Miles
DRAWING NAME: FIG22.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.


N
W
E
S
0
2
Miles
WCA 3B
L-67A
L-67C
L-30
S333DS
TAMBR15
TAMBR14
TAMBR13
TAMBR12
SAFARI
TAMBR11
TAMBR10
FROGCITY
TAMBR9
GLADER
TAMBR8
TAMBR7
COOPERTN
TAMBR6
TAMBR5
TAMBR4
TAMBR3
TAMBR2
TAMBR1
S334
L-67 EXT.
L-31N
LEGEND
SPILLWAY
SAMPLING SITES
DRAWING NAME: FIG23.MAP
DRAWN BY: JLW
DATE: 2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.


Broward Co.
Dade Co.
WCA-3
N
W
E
S
0 1 2 3 4
Miles
LEGEND
SAMPLING STATION
Everglades National Park
L-31N
L-31
TM08
Tamiami Canal (C-4)
MR15
Miami Canal (C-6)
LR10
SK09
Snake Creek Canal
Biscayne Canal
Little River
OletaRiver
Coral Gables Canal
Wagner Creek
Dinner Key
Virginia Key
Key Biscayne
Miami Beach
MR08
MR07
MR06
TM03
TM02
MR05
MR04
MR03
MR02
MR01
WC04
WC03
WC02
LR06
LR03
LR01
BS04
BS01
AC03
AC02
AC01
SK01
SK02
BB01
BB02
BB03
BB04
BB06
BB07
BB09
BB10
BB11
BB14
BB15
BB16
BB17
BB18
BB19
BB22
BB23
BB24
BB25
BB26
BB27
BB28
BB29
DRAWING NAME: FIG24.MAP
DRAWN BY: JLW
DATE:2/96
REVISED BY:
DATE:
HYDROGEOLOGY
DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.



Coral Gables Canal
CG07
CG01
SP08
Snapper Creek Canal
SP04
L-31N
Black Creek Canal C-1
BL12
CD09
BB31
BB32
Key Biscayne
BB34
BB35
CD02
Cutler Drain C-100
BB36
BB37
Everglades National Park
Princeton Canal C-102
PR08
BL03
BL02
Black Point
BB38
GL03
BL01
GL02
Mowry Canal C-103
MW13
PR03
PR01
Biscayne Bay
Military Canal
MI03
C-113
MW04
North Canal
MW01
BB41
Florida City Canal
BB42
Elliott Key
Turkey Point
L-31E
BB44
BB43
BB45
Card Sound
BB47
BB46
BB48
C-111
AR03
Barnes Sound
AR01
BB51
BB50
Key Largo
N
E
S
W
0
1
2
3
4
Miles
LEGEND
SAMPLING STATION
Monroe Co.
Dade Co.
DRAWING NAME: FIG25.MAP
DRAWN BY: JLW
DATE: 3/96
REVISED BY:
DATE:
HYDROGEOLOGY DIVISION 705
SOUTH FLORIDA WATER MGMT. DIST.


N
W
E
S
0
5
10
Miles
LEGEND
SPILLWAY
CULVERT
MID-CANAL STATION
PUMP STATION
WCA 3
US-41
TAMBR105
US41-25
S-12A
S-12B
S-12C
S-12D
S-333
SR997
HOMESTEAD
L-31W
S-176
C-113
S-332
S-175
S-177
S-178
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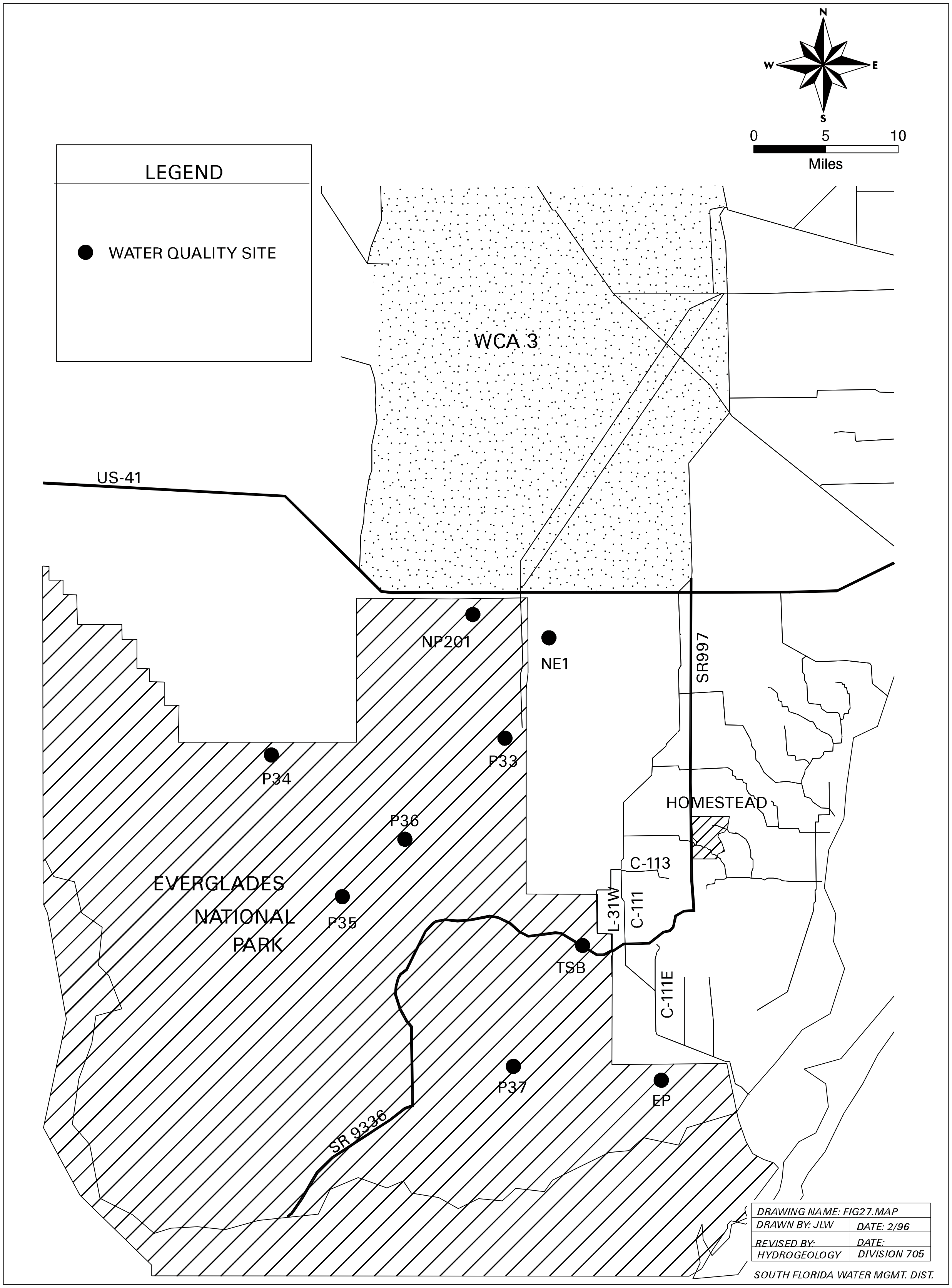

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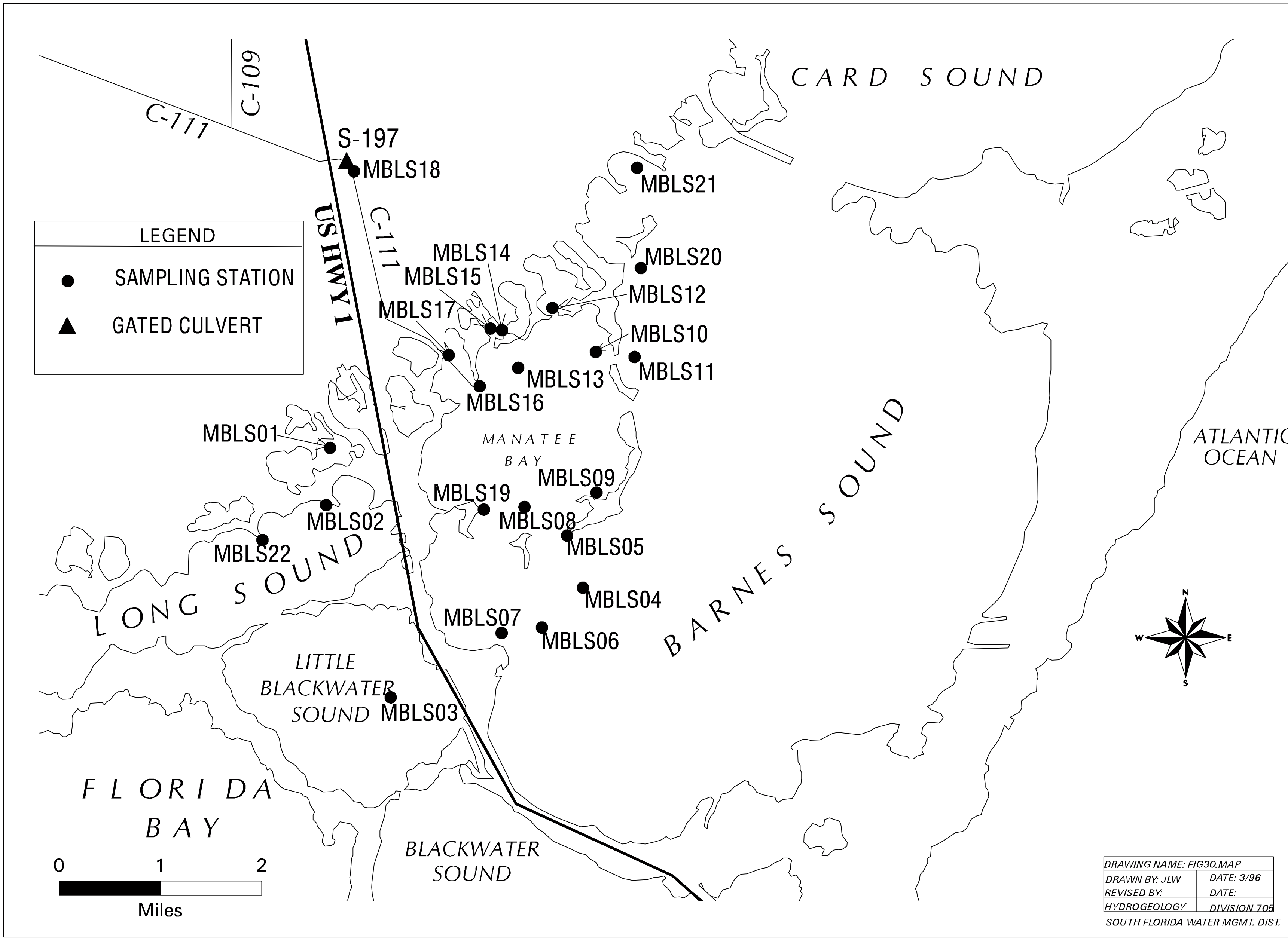
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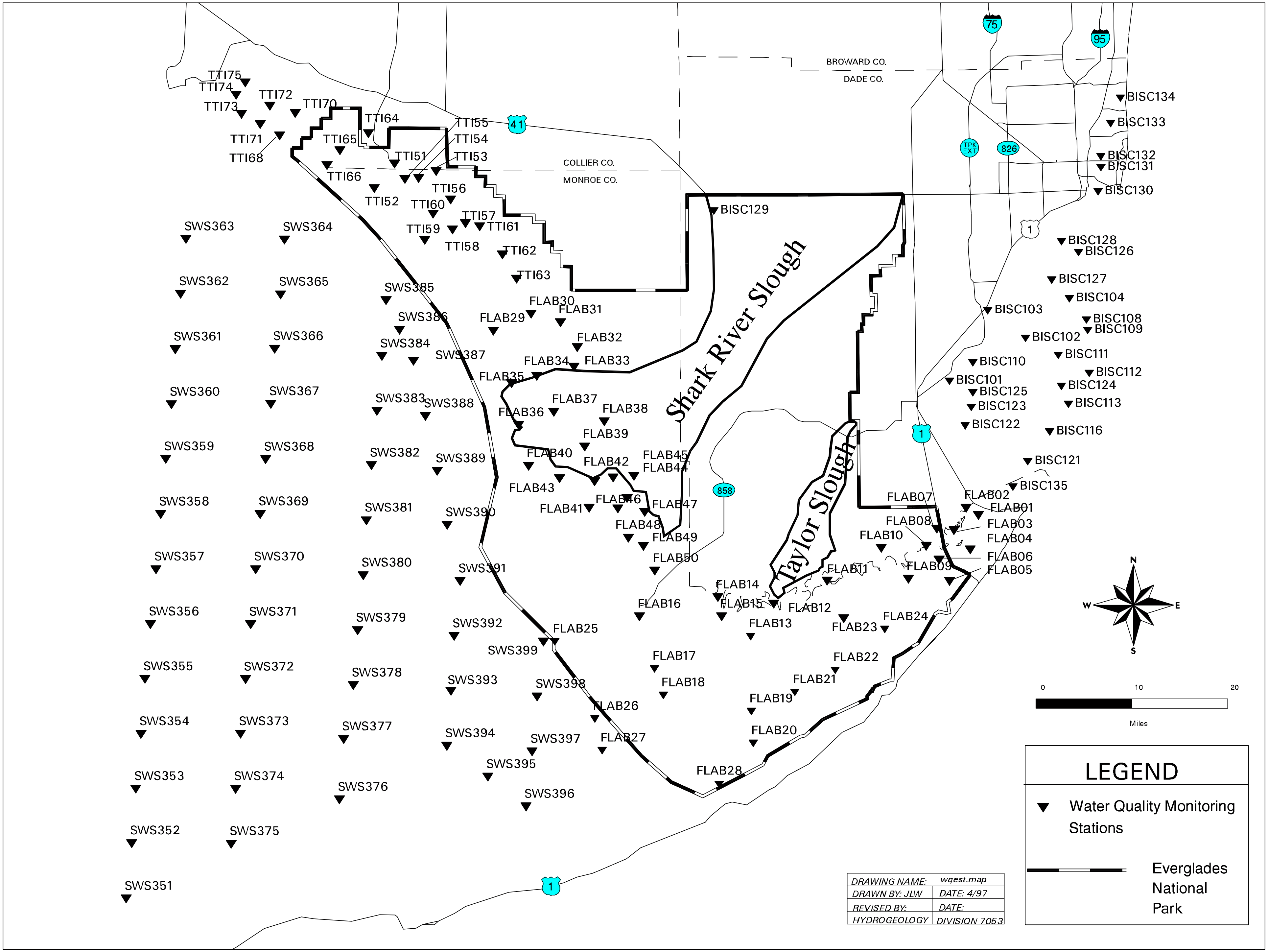

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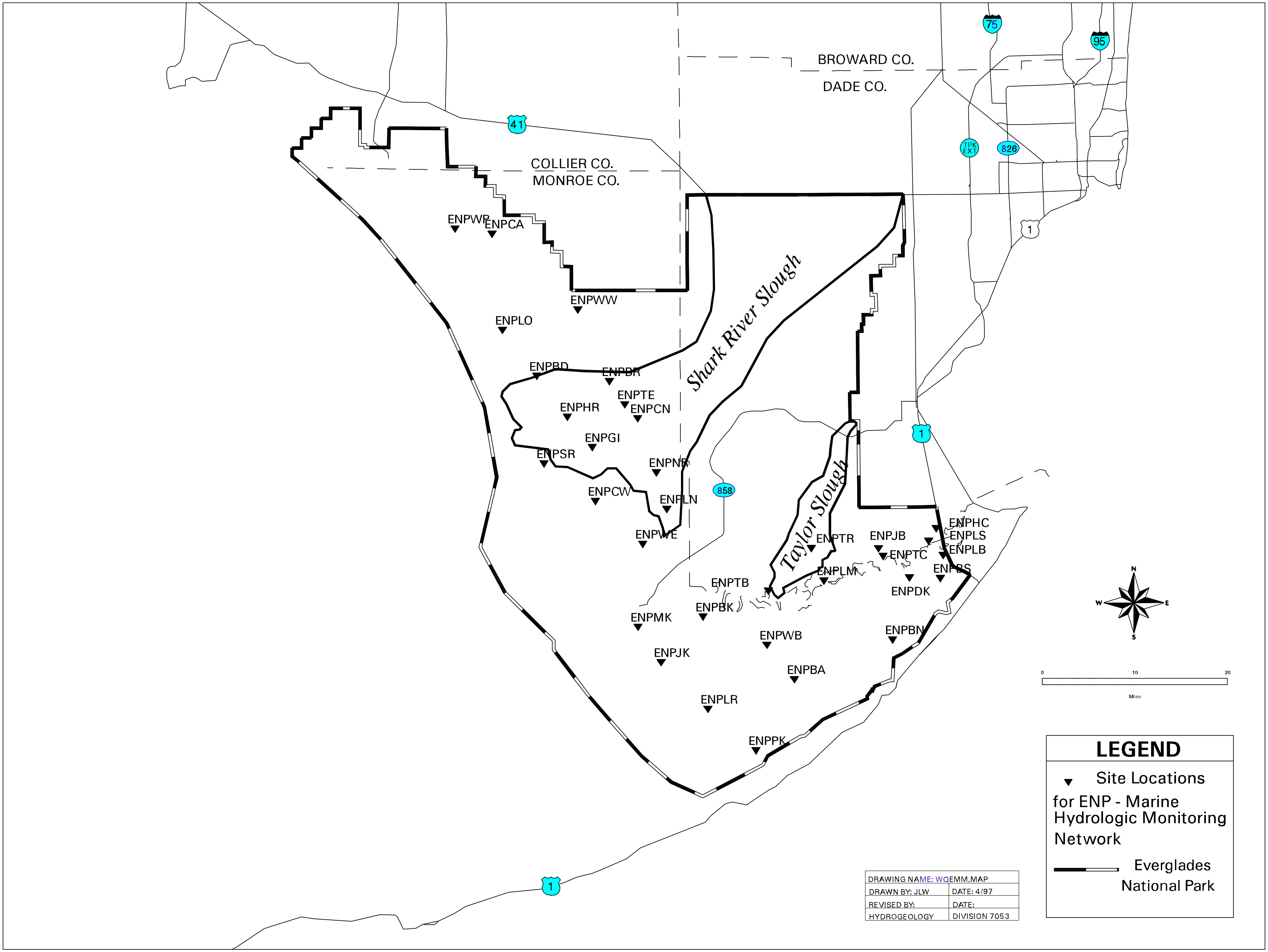
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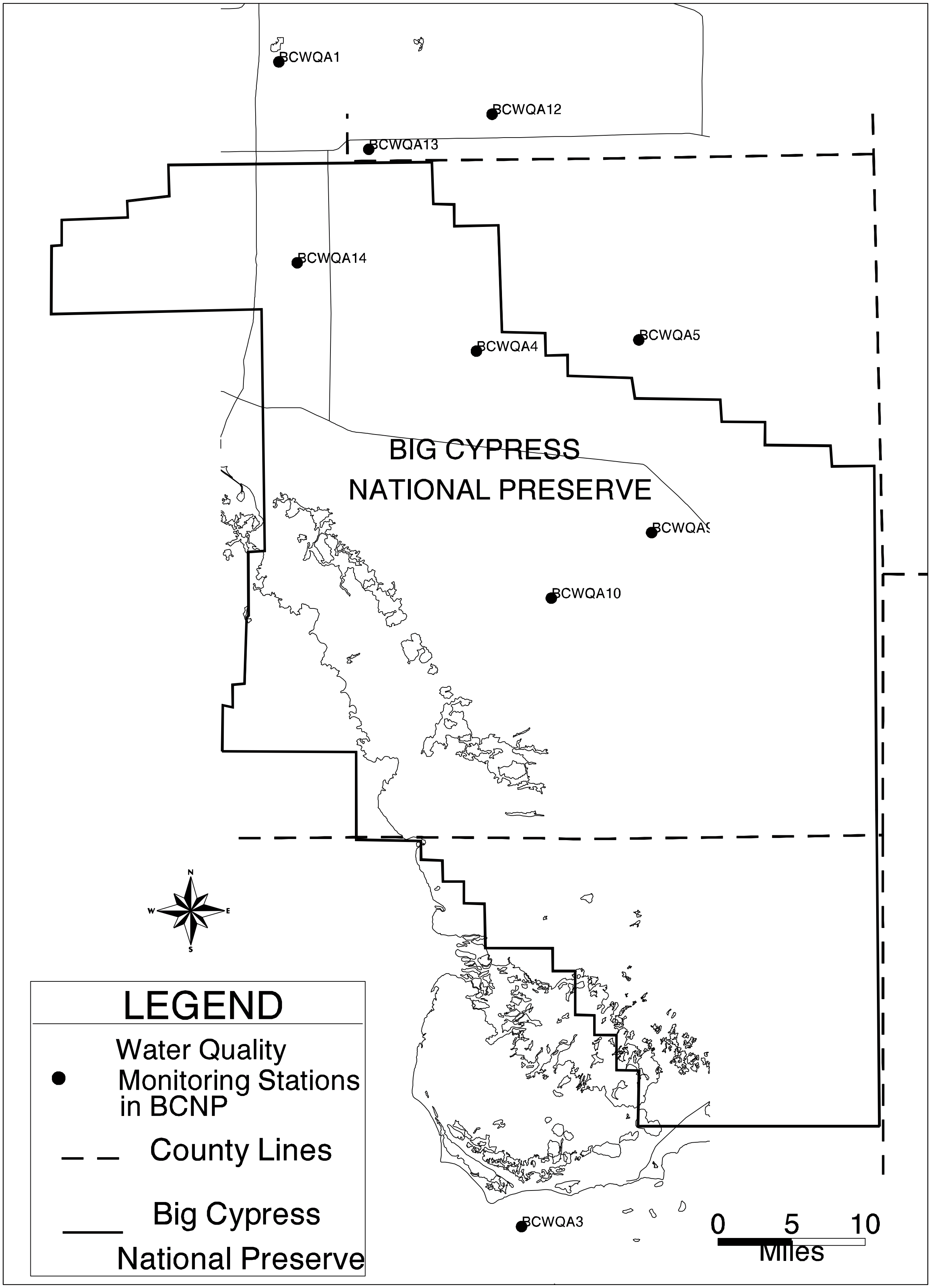

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County Lines
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ATTACHMENT E

WATER QUALITY
OVERVIEW OF HISTORIC CONDITION

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ATTACHMENT E
OVERVIEW OF HISTORIC CONDITION

H-E.1 OVERVIEW

Prior to efforts to drain portions of the Kissimmee River-Lake Okeechobee-Everglades (KOE) system in the early 1880's, water quality conditions in this 10,890 square mile wilderness watershed were unimpacted. The KOE watershed extended 310 miles north to south from its headwaters north of Lake Tohopekaliga to the coastal waters of Florida Bay and 62 miles east to west from the Atlantic Coastal Ridge to the eastern edge of the Big Cypress rise. Over the past 120 years efforts to drain, dike and convert wetlands and watercourses for urban and agricultural uses throughout the KOE watershed, have resulted in substantial degradation to water quality conditions across the fresh water lakes and marshes, estuaries and coastal marine environments of the area.

Due to the extent of the alteration to the natural systems by these activities over the past century, it is very difficult to estimate what the original undisturbed water quality conditions of the 1880's might have been. By characterizing the water quality of those few relatively unimpacted freshwater ecosystems remaining today, we can attempt to estimate what the original water quality in the ecosystem was prior to alteration. Graves *et al.*, 1997 has characterized freshwater water quality in the relatively unaltered Savannas Preserve as typified by low conductivity, hardness, pH and nutrient concentrations. These conditions may have been predominating in many other waterbodies in south Florida before anthropogenic alteration. In the estuarine regions of South Florida, it is unlikely that there are any ecosystems that have not been hydrologically altered with the subsequent alterations to water quality conditions. Therefore, there may be no estuaries systems in the immediate area suitable for use as a model of an undisturbed system.

For this discussion of historic water quality conditions, the study area of the C&SF Project was divided into six aggregate regions symbolic of historic conditions. The following subsections discuss the presumed early water quality conditions of these major historic regions in the study area.

H-E.2 KISSIMMEE RIVER BASIN

The 3,054-square-mile area of the Kissimmee River basin originates in the Shingle/Boggy/Reedy Creek area south of Orlando and flows approximately 110 miles south through Lake Tohopekaliga (Lake Toho), and Lake Kissimmee onto the northern shoreline of Lake Okeechobee. The drainage basin is about 27 miles wide at its maximum. Prior to installation of the drainage works in the Upper Kissimmee Chain of Lakes and Tributaries region in the 1850's, the headwater region of the Kissimmee River basin was Lake Kissimmee according to U.S. Army Corps of Engineers (USACE, 1975) navigability studies. Additional drainage works constructed after 1850 extended the Kissimmee drainage basin northward to the Bay/Clear/Conway Lakes area south of Orlando.

The Kissimmee River basin Chain of Lakes headwaters area contained hundreds of lakes, each contributing wet season flows to a series of creeks flowing across swampy terrain, south to Lake Toho. The general land elevation in this region is about 100 feet above mean sea level. Water flows across this region of the upper Kissimmee River basin were likely slow and seasonal with surface sheet flows highest during the annual summer/fall wet season. Due to the long residence time of surface and ground waters in contact with the moist sandy and organic soils, water quality conditions were likely low in dissolved nutrients, high in color and having a strong diel dissolved oxygen pattern. Many of the lakes in the region had extensive marsh littoral zones, which purified the lake waters, keeping turbidity low and light transmission high through the lake water column. Water level oscillations between dry and wet season in many of the lakes were likely substantial. It is likely that many of the lakes and creeks had extensive growth of rooted submerged aquatic vegetation, which purified the lake/creek waters.

South of Lake Toho, the tributaries of Canoe Creek and Reedy Creek significantly increased flows south through the Cypress Lake and Lake Hatchineha area, to the north shore of Lake Kissimmee. The Kissimmee River flowed south from Lake Kissimmee to Lake Okeechobee prior to navigation improves to the river. It was a 98-mile long, shallow, sluggish meandering river with water depths of only 1-2 feet in many locations. An extensive 50,000-acre wetland floodplain adjacent to the river moderated high water and wet season flows, and improved water quality in the river system. The Kissimmee River was channelized for flood control and navigation improvement purposes in the 1960's to become the 56-mile long, 300-foot wide, C-38 canal. This effectively isolated the wetland floodplain from river flows.

H-E.3 LAKE OKEECHOBEE

With an area of 730 square miles, Lake Okeechobee is the second largest freshwater lake in the southeastern U.S. and the central component of the KOE watershed. This broad, shallow lake with average depths of 9 feet was much less eutrophic than current conditions. Lake Okeechobee's major freshwater inflows come from direct rainfall (47%) and the Kissimmee River (25%) (Jones, 1987). Numerous other creeks providing significant inflows to the lake include Fisheating Creek, Taylor Creek/Nubbin Slough, and the Harney Pond and Indian Prairie basins. Prior to the drainage works of Hamilton Disston in the 1880's, the lake water surface oscillated between 18 to 22 feet Mean Sea Level (MSL), depending of the extent of the wet and dry season inflows and outflows as well as evaporation off the Lake's surface. When Disston excavated a drainage channel between Lake Okeechobee and nearby Lake Hicpochee along the lake's southwest shoreline, the average depth of Lake Okeechobee dropped 4 feet, sending massive volumes of water down the Caloosahatchee River. Historically, the oscillation between Lake Okeechobee's average wet season and dry season elevation (about 4 feet typically) was much less then the more drastic current wet and dry season lake surface oscillations which approach 9 feet.

Historically, Lake Okeechobee had a larger, more extensive wetland littoral zone then what exists today along the shoreline. Extensive adjacent wetland areas extended from the lake's northwestern and southern shorelines. Historic in-lake total phosphorus (TP) levels are estimated in the 40 ppb TP range (Joyner, 1974) as opposed to the current 100 ppb TP range. Due to the extensive littoral and shoreline wetland systems existing in the pre-drainage Lake Okeechobee, it is likely that in-lake turbidity was much lower then current conditions, that water column light transmission was much higher than current conditions, and that water quality in the lake was much better than the eutrophic conditions of today. In addition, it is also likely that extensive areas of rooted submerged aquatic vegetation, in addition to the extensive macrophytic littoral zone, purified the lake's waters.

H-E.4 UPPER EAST COAST (ST. LUCIE RIVER BASIN AND INDIAN RIVER LAGOON)

Prior to drainage activities, the St. Lucie River basin and southern Indian River Lagoon area was a low, flat coastal region with poorly drained sandy soil uplands intermixed with numerous scattered isolated freshwater wetlands grading to a broad, shallow coastal lagoon. Although inlets were periodically open in the southern portion of the Indian River Lagoon (IRL), in present-day St. Lucie and Martin Counties, the only dependable, natural connection between the IRL and the Atlantic Ocean occurred at the Jupiter Inlet at the extreme southern end of the lagoon. Thus, tidal flushing throughout the southern IRL was much more limited then current conditions (three inlets connecting IRL to the ocean) and the lagoon waters would have exhibited a much lower salinity than current conditions. Historic IRL substrates were dominated by freshwater plants rather then the current day seagrasses. Water depths in the southern IRL averaged only 3-4 feet and light transmission to bottom sediments would have enabled luxuriant growth of rooted aquatic plants. This dense assemblage of rooted aquatic vegetation efficiently trapped dissolved and suspended particles and nutrients, and helped to maintain low turbidity in lagoon waters.

Prior to the extensive drainage activities conducted in this region in the early 1900's, the major freshwater inflows to the southern IRL were dominated by wet season flows from the St. Lucie River and the Loxahatchee River systems. The St. Lucie Canal (C-44) was completed in 1924, connecting Lake Okeechobee to the southern IRL via the St. Lucie River. Extensive local agricultural drainage canal systems were constructed in the 1920-1930's, including channelization and drainage of the entire North Fork of the St. Lucie River basin. During the 1950-1970's, additional drainage canals (C-23, C-24 and C-25) were constructed. The drainage basin of the southern IRL was greatly expanded, resulting in massive additional episodic freshwater canal flows to the Lagoon, resulting in wide swings in salinity in the estuary, and introduction of stormwater-borne pollutants, excessive sediments and turbidity. These actions, together with construction of barrier island access causeways and navigational channel dredging, have resulted in the highly altered and ecologically degraded southern IRL ecosystem of the 1990's**.**

H-E.5 CENTRAL EVERGLADES BASIN

Prior to the initiation in 1906 of major drainage works (South and North New River Canals) from the southern shoreline of Lake Okeechobee southward through the Everglades to the Atlantic Ocean, the central Everglades ecosystem was one of the largest unaltered semi-tropical wetland systems in the world. Over the course of the next 70 years, the physical extent of this massive herbaceous wetland was diminished by 50% and water quality conditions in various locations in the Everglades were significantly degraded. In the early 1900's, the Everglades organic soils were categorized into three groups based on the overlying vegetation (Baldwin and Hawker, 1915). Within 3-5 miles of the southern shoreline of the lake, soils were classified as custard apple muck, based upon the dominance of the custard apple tree (McCormick *et al*., 1998(in-prep)). Further south from the lake, the wetland was dominated by soils derived from willow and alder trees. However, the predominant organic soil in the Everglades was sawgrass peat, with sawgrass as the dominant vegetation.

The Everglades ecosystem developed under extremely low rates of TP supply. Increased rates of TP loading from agricultural and urban sources over the past several decades have been associated with several changes in ecological conditions that are indicative of cultural eutrophication (McCormick *et al*., 1998(in-prep)). Historically, nutrient inputs to Everglades marsh waters were derived primarily from atmospheric deposition (rainfall and dry fallout). Median TP concentrations in historic rainfall to the Everglades marsh ranged between 4-7 ppb. Water column TP concentrations in the historic Everglades averaged 5-10 ppb throughout the northern and central Everglades and were lowest in the southern Everglades region (Taylor Slough area) (McCormick *et al*., 1998(in-prep)).

Periodic water flows during wet periods from Lake Okeechobee to the historic custard apple swamps and willow areas just south of Lake Okeechobee likely were somewhat enriched compared to the large expanse of Everglades sawgrass marsh further south. Nutrient inputs from surface water sheetflow from the lake to the custard apple and willow tree areas near Lake Okeechobee may have been in the 20-40 ppb TP range. However, these TP levels would be reduced quickly as waters traveled southward.

Relative to other key water chemistry features, the interior Everglades marsh (WCA-2A and 3A area and ENP) were slightly basic (pH) and highly mineralized containing bicarbonate, calcium and sodium as compared to the historic northeastern Everglades region (Loxahatchee NWR area). The northern region was slightly acidic and contained extremely low concentrations of major ions, a condition which reflects the rainfall-driven hydrology of the LNWR area (McCormick *et al.*, 1998(in-prep)). Concentrations of nitrogen and other macronutrients in interior Everglades surface waters were relatively high compared to TP. Concentrations of micronutrients in Everglades waters varied, but would not generally be considered limiting compared with the extremely low TP concentrations in the Everglades marsh. Dissolved oxygen (DO) in the predrainage Everglades marsh exhibited characteristic diel fluctuations in water column DO, with high daytime DO levels in open-water habitats such as sloughs and wet prairies which was a result of periphyton photosynthesis. The open water, slough habitats served as oxygen sources for adjacent sawgrass stands, where water-column photosynthesis is low (Belanger *et al.*, 1989).

H-E.6 LOWER EAST COAST (LAKE WORTH, NEW, HILLSBORO & MIAMI RIVERS & BISCAYNE BAY)

Prior to man's earliest colonization of the southeast Florida rock ridge stretching from modern-day Palm Beach south to Homestead in the mid-1800's, this subtropical area was densely vegetated with tropical hardwood hammocks, rockland pine forests, freshwater transverse glades connecting the interior Everglades to the coastal waters, and isolated freshwater wetlands on the ridge and brackish water wetlands along the shoreline. Water quality conditions in the diverse types of wetlands and watercourses in the southeast Florida Lower East Coast (LEC) would have varied considerably depending on salinity, substrate and nutrient input conditions; however, it can be inferred that water quality conditions were unimpacted simply because pollutant sources were non-existent.

Coastal rivers were likely highly stained and low in nutrients since they received mainly rainfall and inland surface water runoff from the interior oligotrophic Everglades (Pierce and Curl, 1970). Water quality conditions in the shallow freshwater coastal Lake Worth were likely nutrient poor with high color and low turbidity prior to inlet dredging activities that significantly modified salinity conditions in Lake Worth.

Historical accounts of Biscayne Bay (Thorhaug *et al.*, 1976; Parker *et al.*, 1955; SFWMD, 1995b) indicate that prior to inlet dredging and navigational channel dredging that the northern and central portion of the bay had much lower salinity conditions than present conditions. Prior to the excavation of the Miami Canal in 1911, the Miami River contained rapids, surficial aquifer flows to the bay and a number of springs in the bay producing freshwater boils. Prior to the excavation of the Miami Canal, wet season high water levels in the Everglades overflowed to the bay via coastal rivers and creeks, such as Arch and Snake Creek and the Miami River as well as through numerous transverse glades across the coastal limestone ridge. Biscayne Bay water quality in the late 1800's likely was low in nutrients, with low turbidity and high light transmittance to luxuriant seagrass meadows on the bay bottom. Hydrological and water quality conditions in the pre-drainage Biscayne Bay shallows were likely driven by surficial groundwater flows and wet season surface water flows.

With the major initiation of Everglades canal excavation projects in the 1905-1913 period, massive adverse impacts occurred not just to the interior glades but also to the coastal receiving waterbodies. Pre-construction water quality conditions in the coastal rivers, (such as the New and Hillsboro Rivers and Cypress Creek in Broward County and the Miami River), Snake and Arch Creeks and the Miami River in Dade County were significantly altered by substantial sedimentation resulting from canal construction and erosion. Alteration of the timing, quantity, and duration of freshwater flows to the coastal waterbodies, as well as drainage resulting in lower coastal ridge ground water table levels, resulted in sudden and significant water quality degradation in the receiving coastal water courses.

H-E.7 FLORIDA BAY AND THE FLORIDA KEYS

The 850-square-mile area of Florida Bay is bounded by the southern tip of the Florida peninsula and bounded to the east and south by the 110-mile-long string of islands called the Florida Keys. The landmass of the Florida Keys totals approximately 100 square miles. Keys soils consist of Miami oolite and Key Largo limestone and dominant vegetative communities consist of tropical hardwood hammocks, pine rocklands, brackish wetland transitional zones and tidal wetlands. Florida Bay is a subtropical estuary, averaging only 3 feet in depth. Historically, the estuarine waters of Florida Bay could be characterized as warm and very clear with lush seagrass beds growing on the expansive bay bottoms.

Freshwater flows to Florida Bay and the adjacent Florida Keys came mainly from rainfall, overland sheetflows from the Taylor Slough drainage in the southeastern Everglades and surficial ground-water flows from the Biscayne aquifer to the coastal bays along the northern shoreline of Florida Bay. Inflows of marine waters entered Florida Bay across its western margins from the Gulf of Mexico and through the Florida Keys passes separating the bay from the Atlantic Ocean.

Historically, both Florida Bay and Florida Keys estuarine and marine habitats evolved under very low nutrient conditions and were sensitive to increased levels of nutrients. The extensive seagrass meadows, low lying mangrove fringed islands, and submerged mud banks throughout the bay strongly influenced water circulation, wind fetch, and water turbidity conditions. Water quality in Florida Bay was highly variable with substantial variability in turbidity and salinity conditions relating to climatological events such as hurricanes, windy conditions with passage of cold fronts and large freshwater inflows from the southern everglades during annual wet seasons. In the deeper marine waters offshore of the Florida Keys, water clarity was excellent with visibility through the water column routinely exceeding 100 feet. The largest living coral reef in North America flourished in the marine waters offshore of the Florida Keys.

Significant man-induced impacts on water quality conditions throughout Florida Bay and the Keys began with the 1912 completion of Henry Flagler's Overseas railroad connecting the South Florida mainland with Key West. Construction of the approximate 113-mile-long railroad connecting numerous keys resulted in extensive filling and dredging of bay bottoms through a series of fill causeways and bridges. Alteration of historic water flow and salinity patterns in Florida Bay can be attributed to the construction of the Overseas Railroad and the subsequent 1938 completion of the Overseas Highway by the State of Florida. Railroad and highway alteration of water flow patterns between Florida Bay and the Atlantic Ocean, combined with major disruption and reduction of freshwater flows to the bay from the mainland as a result of mainland canal/levee construction and operation beginning in the 1920's, resulted in increased salinity occurring throughout Florida Bay. Degradation of historic Florida Bay water quality conditions is directly related to alteration of bay salinity patterns.

H-E.8 BIG CYPRESS BASIN

The 2,657 square-mile area (1.7-million acres) of the Big Cypress drainage basin was one of the last large natural areas in south Florida where water quality conditions were impacted by man's activities. This large area is very flat with maximum elevations of 17 feet above MSL in the northern region gradually grading 35 miles south to sea level in the coastal mangrove region of the Ten Thousand

Islands area, on the Gulf of Mexico (Duever *et al.*,1979). Prior to alteration by drainage works, the Big Cypress drainage area consisted generally of two watersheds, a smaller eastern area where surface drainage flowed southeasterly to the western region of Shark River Slough and a much larger central region characterized by north-to-south-oriented sloughs and Cypress strands flowing south to the Ten Thousand Islands coastal area.

Historic water quality conditions in the Big Cypress region were tied to the predominant carbonate marl soils of the area. Organic peats were found in the low lying north-south sloughs and strands as well as in the coastal mangrove areas; however, the organic peat areas covered a relatively small portion of the entire basin. Extensive areas of the Big Cypress coastal region are less then 2 feet above MSL and the water quality in this region was highly influenced by tidal fluctuations and salinity effects of the estuarine waters. The single largest physiographic region in the Big Cypress was the slightly elevated interior Pineland region, characterized by cypress domes and small circular depressions indicative of a juvenile karst terrain (Duever *et al.*, 1979). These topographic features suggest substantial vertical movement of rainfall derived surface waters downward to the surficial aquifer.

Drainage works and the associated effects on Big Cypress water quality conditions began in 1926 with the completion of the north-to-south-oriented Barron Collier Canal and associated State Road 29. In 1928, the east-to-west-oriented Tamiami Canal and associated Tamiami Trail was completed through the Big Cypress region. Although both of these canals were relatively shallow compared to other South Florida canal systems, the drainage effects of these canals was widespread in the Big Cypress, especially during the annual dry season. In addition, water flows were also affected by the constructed roadways.

Prior to the initiation of canal/road construction in the Big Cypress in the 1920's, water quality conditions could be described as high and unpolluted. Due to the topography, soils and vegetation of the area, water quality conditions had relatively high levels of dissolved constituents, such as calcium, chloride, sodium, potassium, hardness, specific conductance, and dissolved solids (Duever *et al.*, 1979). Dissolved oxygen, alkalinity, and pH were typical of unimpacted South Florida waters and likely exhibited strong diel fluctuations. Due to the extensive swamps and surface water contact times with vegetation, watercolor was highly stained with tannins and turbidity would have been relatively low. Historic nutrient concentrations in Big Cypress were relatively oligotrophic in phosphorus and nitrogen compounds (Odum, 1953; Klein *et al.*, 1970; Carter *et al.*, 1973**);** however, TP and nitrogen compound levels in Big Cypress surface waters would have been substantially higher than TP and TN concentrations in the central Everglades marshes due to differing soil conditions.

H-E.9 CALOOSAHATCHIE RIVER BASIN

As a result of Hamilton Disston's early drainage work in 1883 connecting Lake Okeechobee to Lake Hicpochee, the historic headwaters of the Caloosahatchee River and the drainage basin and water quality conditions of the Caloosahatchee River were drastically modified. Prior to Disston's drainage work (Leach *et al.*, 1972), the Caloosahatchee River was a shallow, meandering river. Water quality in the river prior to the 1880's was likely dominated by high color and high organics, exhibiting the highly stained tannic nature of many South Florida coastal rivers. Before dredging and channelization, the Caloosahatchee River meandered slowly from the headwater marshes on thick peat deposits west of Lake Okeechobee, spilling over falls and moving slowly through a series of oxbows before emptying into the Gulf of Mexico (Florida Gov. Commission Interim Report, 1998). Dissolved oxygen levels in the river likely fluctuated widely with a diel pattern. In the lower Caloosahatchee River near it's convergence with San Carlos Bay, the Caloosahatchee estuary likely exhibited luxuriant seagrass beds with high light transmittance to the substrate and low nutrient and suspended solids conditions.

ATTACHMENT F

ENVIRONMENTAL EFFECTS

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ATTACHMENT F

ENVIRONMENTAL EFFECTS

F.1 REGIONAL SYSTEM

F.1.1 Effects of the Recommended Plan

Viewed from a regional perspective, the recommended comprehensive plan is expected to greatly improve water quality conditions in the study area. The Recommended Plan creates approximately 181,250 acres of surface water storage area (WSA), totaling approximately 1.5 million-acre feet of additional storage volume compared to existing and future base conditions (***Table F.1***). This proposed increase in surface water storage volume is expected to result in a reduction in pollution loading into downstream receiving water bodies, through the attenuation of surface flows and settling of attendant sediment-bound pollution loads and through biological uptake processes in the WSAs prior to discharge. Aquifer Storage and Recovery (ASR) components in the Recommended Plan provide additional deep aquifer storage capacity totaling approximately 1,665 Million Gallons Per Day (MGD) (***Table F.2***). This additional storage capacity will also improve regional water quality conditions through aquifer storage of existing flood discharges.

Additionally, many components of the Recommended Plan include treatment features to assure that water quality conditions are improved or not degraded as a result of the operation of those components. Specifically, the Recommended Plan includes over 19 Stormwater Treatment Areas (STAs) totaling at least 35,550 acres, providing approximately 126,770 acre-feet of treatment volume (***Table F.3***). These STAs also represent additional storage volume beyond that provided by the designated water storage areas. Furthermore, those components of the Recommended Plan involving ASR and wastewater reuse include treatment facilities to meet applicable State of Florida water quality standards.

TABLE F.1 STORAGE AREAS/VOLUME

Component	Name of Component	Storage Area/Volume
A6	North of Lake Okeechobee	17,500, acres @ 11.5 feet (200,000 AF)
UU6_D13R	Upper East Coast C-23	8,400 acres @ 8 feet (67,200 AF)
UU6_D13R	Upper East Coast C-24	6,000 acres @ 8 feet (48,000 AF)
UU6_D13R	Upper East Coast C-25	12,800 acres @ 8 feet (102,400 AF)
UU6_D13R	Upper East Coast St. Lucie River, N. Fork	11,800 acres @ 8 feet (94,400 AF)
UU6_D13R	Upper East Coast St. Lucie River, S. Fork	9,350 acres @ 4 feet (37,400 AF)
B2	St Lucie (C-44)	10,000 acres @ 4 feet (40,000 AF)
D5	Caloosahatchee (C-43)	20,000 acres @ 8 feet (160,000 AF)
G6	EAA	60,000 acres @ 6 feet (360,000 AF)
W2	Taylor Creek/Nubbin Slough	5,000 acres @ 10 feet (50,000 AF)
GGG6	Southern L-8	1,200 acres @ 40 foot depth (48,000 AF)
VV6	Palm Beach County Ag Reserve	1,660 acres @ 12 feet (19,920 AF)
M6	Site 1	2,460 acres @ 6 feet (14,760 AF)
XX6	North Lake Belt	4,500 acres @ 20 foot depth (90,000 AF)
S6	Central Lake Belt	5,200 acres @ 36 foot depth (187,200 AF)
U6	Bird Drive Basin	2,900 acres @ 4 feet (11,600 AF)
OPE	Acme Basin B	620 acres @ 8 feet (4,950 AF)
OPE	Seminole Tribe Big Cypress	1,860 acres @ 4 feet (7,440 AF)
	TOTAL	***181,250 acres (1,543,270 AF)***

TABLE F.2
AQUIFER STORAGE AND RECOVERY FACILITIES

Component	Name of Component	Storage Capacity
D5	Caloosahatchee Storage Reservoir	220 MGD (44@5MGD)
M6	Site 1 Impoundment	150 MGD (30@ 5MGD
GG4	Lake Okeechobee	1,000 MGD (200@5 MGD)
LL6	C-51	170 MGD (34@5 MGD)
VV6	Palm Beach County Ag Reserve	75 MGD (15 @ 5 MGD)
GGG6	L-8	50 MGD (10 @ 5 MGD)
	TOTAL CAPACITY	***1,665 MGD***

TABLE F.3
STORMWATER TREATMENT AREAS/VOLUME

Component	Name of Component	Storage Area/Volume
DDD5	Caloosahatchee River (C-43)	5,000 acres @ 4 feet (20,000 AF)
A6	North of Lake Okeechobee	2,500 acres @ 4 feet (10,000 AF)
W2	Taylor Creek/Nubbin Slough	5,000 acres @ 4 feet (20,000 AF)
Q5	Western C-11	1,600 acres @ 4 feet (6,400 AF)
R4	C-9	2,500 acres @ 4 feet (10,000 AF)
S6	Central Lake Belt	640 acres @ 4 feet (2,560 AF)
CCC6	L-28I	1,100 acres @ 4 feet (4,400 AF)
CCC6	L-28I	800 acres @ 4 feet (3,200 AF)
X6	C-17 Backpumping	550 acres @ 4 feet (2,200 AF)
WW5	C-111 North	3,200 acres @ 4 feet (12,800 AF)
K6	L-8 Project	undetermined acreage
XX6	North Lake Belt	1,200 acres @ 4 feet (4,800 AF)
Y6	C-51 Backpumping	600 acres @ 4 feet (2,400 AF)
OPE	Miccosukee Tribe Water Management Plan	900 acres @ 4 feet (3,600 AF)
OPE	Acme Basin B	310 acres @ 4 feet (1,240 AF)
OPE	Seminole Tribe Big Cypress	5,270 acres @ 1 foot (5,270 AF)3,835 AF)
OPE	South Biscayne Bay Coastal Wetlands	undetermined acreage
OPE	S-154 Basin	1,775 acres @ 4 feet (7,100 AF)
OPE	S65-D Basin	2,600 acres @ 4 feet (10,400 AF)
	TOTAL	**35,550 + acres (126,370 + AF)**

The ad hoc Restudy Water Quality Team (WQT), which was created to evaluate the effect of Restudy alternatives on water quality conditions in the study area and co-chaired by the USEPA and FDEP, determined that the Recommended Plan was preferred over other alternatives and the future (2050) base condition from a water quality perspective (see Section 7.3.2.4.3). The WQT consisted of staff from the following agencies: USEPA, FDEP, USACE, SFWMD, ENP, LNWR, USFWS, BCNP, NOAA/NMFS, FDACS, Seminole Tribe, Palm Beach County, Broward County and Miami-Dade County. The WQT's evaluation was conducted iteratively, using water quality models, hydrologic data, and performance indicators. The WQT provided recommendations to the Alternatives Evaluation Team (AET) for optimizing the performance of the alternative plans to achieve water quality objectives. Many of these suggested modifications were subsequently included in the design of the components. A summary of the WQT's conclusions and recommendations is included below in ***Table F.4***. A detailed description of the work done by the WQT is located in the Water Quality Analysis section of Appendix D, Attachment D.

TABLE F.4 Restudy Water Quality Team's Combined *Ranking* Matrix

The Base Conditions and alternative plans were ranked on a scale of 1-7, with higher scores indicating a more preferred condition from a water quality perspective.

Subregion	95B	50B	A	B	C	D	D13R
1. Lake Okeechobee (see footnote 1)	2.5	2.5	2.5	6.5	4.5	6.5	4.5
2. EAA/ECP	1	3.5	7	6	3.5	2	5
3. WCAs 2 & 3 (see footnote 2)	1	6	7	2	3	4.5	4.5
4. St. Lucie Watershed	1	2	3.5	3.5	5	6	7
5. Caloosahatchee Watershed	1.5	1.5	3	4	5	6.5	6.5
6. LNWR	1	2	5	5	5	5	5
7. ENP	1.5	5	3.5	6.5	1.5	3.5	6.5
8. LEC (see footnote 3)	4.5	4.5	1	2	3	6.5	6.5
Cumulative Score	***14***	***27***	***32.5***	***35.5***	***30.5***	***40.5***	***45.5***

Restudy WQT Recommendations to Restudy Team

From a water quality perspective, Alternative D13R is preferred over Alternatives B, A, & C. The 95 Base and the 50 Base were not acceptable.

1. The WQT determined that the Base Conditions and alternative plans should not be ranked based upon the USEPA preliminary mercury model results (model needs further development). Atmospheric deposition is the dominant contributor of mercury in the Everglades Protection Area (EPA). Restudy alternative plans as evaluated by the USEPA preliminary mercury model are not expected to significantly affect mercury in the EPA.

2. Due to a lack of model results (particularly Everglades Landscape Model results), Restudy alternative plans could not be ranked based upon an empirical evaluation of water quality impacts or benefits in Big Cypress

National Preserve and the Holeyland and Rotenberger Wildlife Management Areas.

Footnotes

1. Ranking of alternatives for Lake Okeechobee is based on evaluation of selected performance indicators. Comparing alternatives, differences greater than one percent in relative performance calculated by the model were assigned different ranks. Although the differences between simulated conditions for the alternatives are within the uncertainty of the model, the WQT felt it was important to rank the plans for Lake Okeechobee from a water quality perspective.

2. WCAs 2 & 3 rankings were weighted to account for relative size (acreage).

3. Ranking of the alternatives based on an evaluation of potential water quality impacts/benefits in the LEC is primarily based upon salinity targets in Lake Worth and Biscayne Bay. The presumed water quality benefits resulting from an evaluation of the hydraulic performance of selected reservoirs were also evaluated. For those performance indicators, a score of zero was assigned to alternatives for which no hydraulic performance for the reservoirs was observed.

Implementation of the Comprehensive Plan consistent with the Implementation Plan (see ***Section 10***) will lead to improved water quality throughout the study area. However, achieving water quality objectives for ecological restoration in all water bodies within the study area depends on actions outside the scope of the Restudy. To fully achieve ecological restoration pollution loads must be identified and quantified within each of the study area regions, and load reduction and concentration targets for pollutants of concern must be established. Concurrent with or prior to the proposed operation of components of the Comprehensive Plan, water quality remediation programs for degraded and/or designated use-impaired water bodies must be implemented by the responsible agencies in order to fully achieve ecological restoration objectives.

The components of the Recommended Plan will be adaptively constructed and operated generally in accordance with the implementation plan. Adaptive implementation of the components may require incremental improvement of existing and projected future water quality conditions within the watersheds in which the components are implemented. Concurrent with or prior to the proposed operation of components of the Recommended Plan, water quality remediation programs for 303(d)-listed and other impaired water bodies must be implemented in order to fully achieve ecosystem restoration objectives.

Watershed water quality improvements are especially critical when the operation of a component or several components of the Recommended Plan would result in significant hydrologic changes within those watersheds. Many of the plan components will substantially affect the volume and timing of surface water deliveries in several of the Restudy area's watersheds. The SFWMD, FDEP, and other agencies have developed water quality improvement strategies for several of the impaired waterbodies within the Restudy area. The most notable example is the Everglades Forever Act (EFA), which focuses on achieving adequate water quality in the Everglades. The EFA provides an iterative process that is designed to insure that after implementation, compliance with all water quality standards will be achieved in the Everglades Protection Area (EPA).

However, the EFA is limited geographically to the defined Everglades Protection Area. Other examples include Surface Water Improvement and Management (SWIM) Act planning efforts for the Indian River Lagoon, Lake Okeechobee, and Biscayne Bay, and the Florida Keys National Marine Sanctuary Water Quality Protection Program.

There is not, presently, a comprehensive water quality strategy for the entire Restudy area, and the degree to which some of the existing water quality improvement plans have been implemented has been limited by lack of funding necessary to complete assessment and planning activities. Watershed assessments are necessary to develop pollutant source reduction programs and to design and construct water quality treatment facilities, if necessary. In some cases, future water quality certification in accordance with section 401 of the Federal Water Pollution Control Act (=Clean Water Act) for construction and operation of some of the components included in the Recommended Plan may be dependant upon the successful implementation of watershed water quality improvement projects or programs prior to or concurrent with construction of those Recommended Plan components. Accordingly, the implementation plan for the eventual Recommended Plan includes a framework for evaluating water quality conditions, data and monitoring needs, developing water quality criteria and pollution reduction targets, and watershed water quality improvement programs as part of the overall implementation of the Recommended Plan.

F.2 KISSIMMEE RIVER REGION

Water quality conditions in the Kissimmee River Region are expected to be improved compared to both the 1995 and 2050 base conditions through implementation of the Recommended Plan. Construction and operation of two water storage/treatment components in the Kissimmee River Region, Components A6 and W2, as well as two "Other Project Elements" (OPE), combined reservoir/STAs in the S-154 basin and the S65-D basin, will provide water quality benefits to both the lower Kissimmee River and Taylor Creek/Nubbin Slough (TCNS) basins as well as to downstream, Lake Okeechobee.

Construction and operation of Component A6 (north of Lake Okeechobee water storage reservoir and stormwater treatment area) would result in 17,500 acres of Water Storage Area (WSA) with a maximum depth of 11.5 feet and a 2,500-acre stormwater treatment area (STA). The conceptual design of Component A6 is described as either being operated as a:

1) WSA/STA near the Lake where Lake Okeechobee water will be backpumped to, or;
2) WSA/STA(s) located near the Kissimmee River in the S-65 E basin , north of the Lake, and used to attenuate high river flows and treat stormwater prior to passing into Lake Okeechobee.

From a water quality enhancement perspective, the second operation scenario would be preferred over the first, since the second operating scenario would maximize reduction in pollutant loading from the Kissimmee River to Lake Okeechobee. Total phosphorus (TP) loading data provided in the Lake Okeechobee SWIM Plan (SFWMD, 1997) indicates that average TP concentrations in the lower Kissimmee River, i.e., Pools S-65D and S-65E, during 1990-94, were 0.77mg/L and 0.36 mg/L respectively (see table 8.2.6-1 excerpted from SFWMD (1997)).

These average TP concentrations in the lower Kissimmee River are some of the highest TP average concentrations in the entire Kissimmee River drainage basin. The associated average TP loading from Pools S-65 D&E, during 1990-94, were 29.1 and 43.0 tons/year, respectively. These TP loading rates were some of the highest in the entire Kissimmee River basin with the exception of the TP loading to Lake Okeechobee coming from the TCNS area (90.4 tons/year).

The SFWMD 1997 Lake Okeechobee SWIM Plan (SFWMD, 1997) identifies four critical upstream drainage basins where TP loading to the Lake must be significantly reduced to enable long-term recovery and restoration of Lake Okeechobee water quality conditions and ecological health (Figure F.1, excerpted from SFWMD (1997))

Table F.5 Phosphorus Loading to Lake Okeechobee (excerpted from SFWMD, 1997a)

	Discharge	Area	Target	Target Load	1990-94	Average	Over/Under
Controllable Sources	**Acre-feet**	**(sq. mi)**	**Total P (mg/L)**	**Tons/yr.**	**Total P (mg/L)**	**Tons/yr.**	**Tons/yr.**
715 Farms (Cul 12A)	9,293	4	0.18	2.3	0.15	1.9	-0.4
C-40 Basin (S-72)	57,475	87	0.18	14.1	0.19	14.9	0.8
C-41 Basin (S-71)	131,786	176	0.18	32.3	0.19	34.0	1.7
S-84 Basin (C41A)	118,152	180	0.10	16.1	0.07	10.5	-5.6
S-308C (St. Lucie-C-44)	89,047	190	0.17	20.6	0.15	18.4	-2.2
East Beach DD (Cul 10)	7,973	10	0.18	2.0	0.56	6.1	4.1
East Shore DD (Cul12)	11,959	13	0.13	2.1	0.19	3.1	1.0
Fisheating Creek	178,682	462	0.18	43.8	0.16	39.0	-4.8
Industrial Canal	22,211	23	0.18	5.4	0.11	3.1	-2.3
L-48 Basin (S-127)	13,267	32	0.18	3.3	0.25	4.4	1.1
L-49 Basin (S-129)	8,595	19	0.18	2.1	0.13	1.6	-0.5
L-59E	6,017	15	0.16	1.3	0.23	1.8	0.5
L-59W	6,539	15	0.16	1.4	0.17	1.5	0.1
L-60E	1,452	6	0.10	0.2	0.17	0.4	0.2
L-60W	672	6	0.10	0.1	0.13	0.1	0.0
L-61E	6,248	22	0.09	0.8	0.14	1.2	0.5
L-61W	8,884	22	0.09	1.1	0.11	1.4	0.3
Taylor Creek/Nubbin Slough (S-	108,829	188	0.18	26.7	0.61	90.4	63.7
S-131 Basin	7,965	11	0.15	1.6	0.10	1.1	-0.5
S-133 Basin	24,249	40	0.18	5.9	0.25	8.4	2.4
S-135 Basin	21,558	28	0.16	4.7	0.10	2.8	-1.9
S-154 Basin	19,550	37	0.18	4.8	0.72	19.0	14.2
S-2	23,692	166	0.16	5.2	0.25	8.0	2.9
S-3	6,635	101	0.15	1.4	0.15	1.3	0.0
S-4	17,767	66	0.18	4.4	0.17	4.2	-0.2
S-65A	115,348	173	0.07	11.0	0.14	21.2	10.2
S-65B	(96,982)	222	0.06	-7.9	0.06	-7.6	0.3
S-65C	132,981	95	0.13	23.6	0.05	8.4	-15.1
S-65D	27,712	193	0.18	6.8	0.77	29.1	22.3
S-65E	87,447	66	0.18	21.4	0.36	43.0	21.5
South FL Conservancy DD (S-	3,407	15	0.09	0.4	0.12	0.5	0.1
South Shore/So. Bay DD	7,195	7	0.08	0.8	0.12	1.2	0.4
Nicodemus Slough (Cul5)	4,182	28	0.06	0.3	0.05	0.3	-0.1
Controllable Totals				**260**		**375**	
Uncontrollable							
Rainfall	1,893,356		-		0.03	72.0	
s65 (Lake Kissimmee)	732,227		-		0.04	37.8	
Lake Istokpoga (S-68)	183,879		-		0.03	7.1	
S-5A Basin (S-352-WPB Canal)	39		-		0.13		
East Caloosahatchee (S-77)	3,616		-		0.24	1.2	
L-8 Basin (culv10a)	6,634		-		0.27	2.4	
Uncontrollable Totals						**120.5**	
Total Loading						**495**	
Target Loading (conc. based)						**381**	
Vollenweider Target						**399**	
Over-target						**93-115**	

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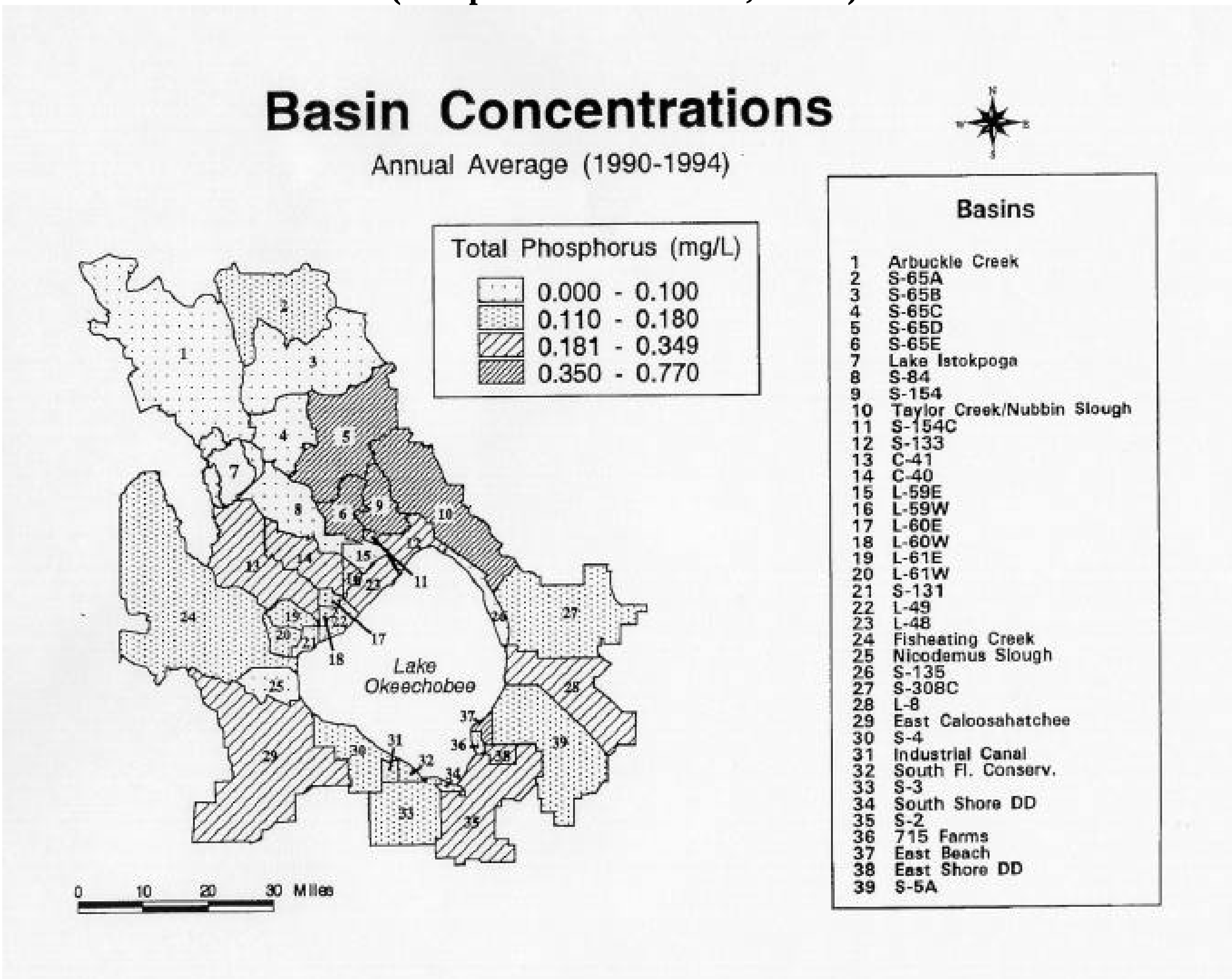
Figure F.1 Contributions of Phosphorus from Lake Okeechobee Basins (exerpted from SFWMD, 1997a)



Those four critical basins which produce high TP loads to the downstream Lake Okeechobee are: the S-65 D basin, the S-65-E basin, the TCNS basin, and the S-154 basin. Water quality degradation in the lower Kissimmee River region south of Lake Kissimmee is mainly attributable to agricultural nonpoint pollution consisting primarily of elevated nutrients and fecal bacteriological contamination and increased turbidity and sedimentation in watercourses of the region.

Construction of one or more WSA/STAs in the Kissimmee River region consistent with Component A6 would result in sequestration of particulate and dissolved nutrients and other pollutants in the WSA(s) through sedimentation and biological uptake processes. Maximizing the hydrologic retention time of surface runoff waters captured in the WSA(s) would increase the pollutant reduction benefits provided by the WSA/STA(s).

In addition to phosphorus loading, other key water quality parameters of concern in the Kissimmee River region are dissolved oxygen (DO) and nitrogen compounds (NOx). Construction of WSA/STAs north of Lake Okeechobee would also, based on similar water quality treatment processes, result in reduction on NOx loading to the surface waterbodies in the basin as well as to Lake Okeechobee.

In terms of maximizing future water quality benefits provided by WSA/STA construction and operation in the lower Kissimmee River area, it is likely that water quality benefits could be increased by siting multiple WSA/STAs totaling 20,000 acres at strategic locations, optimized for reducing nutrient loading to downstream surface waterbodies, as opposed to the construction of one large contiguous 20,000-acre WSA/STA in the basin. Existing and ongoing water quality monitoring in the Kissimmee river region being conducted by the SFWMD could be used to optimally site several WSA/STAs totaling 20,000 acres while realizing the primary hydrologic water storage purpose of the Kissimmee River basin WSA(s).

Construction and operation of Recommended Plan Component W2, a combined 5,000-acre WSA (maximum depth 10 feet) coupled with a 5,000-acre STA (maximum depth 4 feet) will result in substantial reduction of nutrient loads entering the Taylor Creek/Nubbin Slough watercourses and Lake Okeechobee. The purpose of this component is to provide flood protection, water quality treatment, water supply benefits and enhancement of the St. Lucie and Caloosahatchee River estuaries. This WSA combination is sized to capture and treat storm water runoff from the TCNS basin, which is the highest nutrient loading basin flowing to the eutrophic Lake Okeechobee. The design of the combination WSA/STA is intended to reduce TP concentrations in TCNS runoff to Lake Okeechobee by 80 percent from 0.528 mg/L down to 0.107 mg/L. This reduction in nutrient loading to the Lake would contribute toward the Lake Okeechobee SWIM Plan target for reducing TP loading to the Lake and ultimately restoring the ecological health of the Lake.

Two additional water-quality-related Recommended Plan components which will attenuate peak flows and improve water quality conditions in tributary basins flowing to Lake Okeechobee are described in the OPE entitled "Lake Okeechobee Watershed Water Quality Treatment Facilities". This OPE is a logical extension of the WRDA '96 Critical Project entitled "Lake Okeechobee Water Retention/Phosphorus Removal" which is not associated with the Recommended Plan. The Lake Okeechobee Watershed Water Quality Treatment Facilities OPE will result in construction and operation of a 1,775-acre combined reservoir/STA in the S-154 basin and a 2,600-acre reservoir/STA in the S65-D basin. Additionally this OPE project would entail re-isolation of approximately 3,500 acres of previously drained wetlands (ditch plugging) in the previously identified critical phosphorus loading basins north of Lake Okeechobee. The main purpose of this OPE would be nutrient load reduction within the basins and to the downstream Lake. There are potentially additional combined reservoir/STA stormwater treatment facilities needed in the Lake Okeechobee watershed that are not included in the Recommended Plan. The recommended Restudy Comprehensive Water Quality Plan will further evaluate the potential need for other water quality treatment facilities in the Region.

F.3 LAKE OKEECHOBEE

Water quality conditions in Lake Okeechobee are expected to be slightly improved relative to the 1995 base and the 2050 base conditions as a result of implementation of several components of the Recommended Plan. Water quality improvements in water inflows to the Lake will be more marked than immediate in-lake water quality improvements. The above discussed Recommended Plan-related water quality improvements in watersheds north of the Lake will result in reduction of agricultural nonpoint source pollutants (nutrients, bacteriological contamination, turbidity/sedimentation) entering Lake Okeechobee relative to the 1995 and 2050 base conditions.

The key water quality parameters of concern in Lake Okeechobee waters are TP, NOx, chlorophyll-a and turbidity. Currently, water quality can be characterized as eutrophic, with in-lake TP concentrations averaging 90-100 ppb TP. Pollutant loading, primarily nutrients, over the past several decades has significantly degraded Lake Okeechobee water quality and resulted in massive loading of nutrients to Lake sediments. Average in-lake TP concentrations have increased from 40 ppb in the early 1970's to current conditions in the 100 ppb range. Resuspension of nutrient laden lake sediments during strong wind events dominate pollutant loading within the lake (Reddy et. al., 1995).

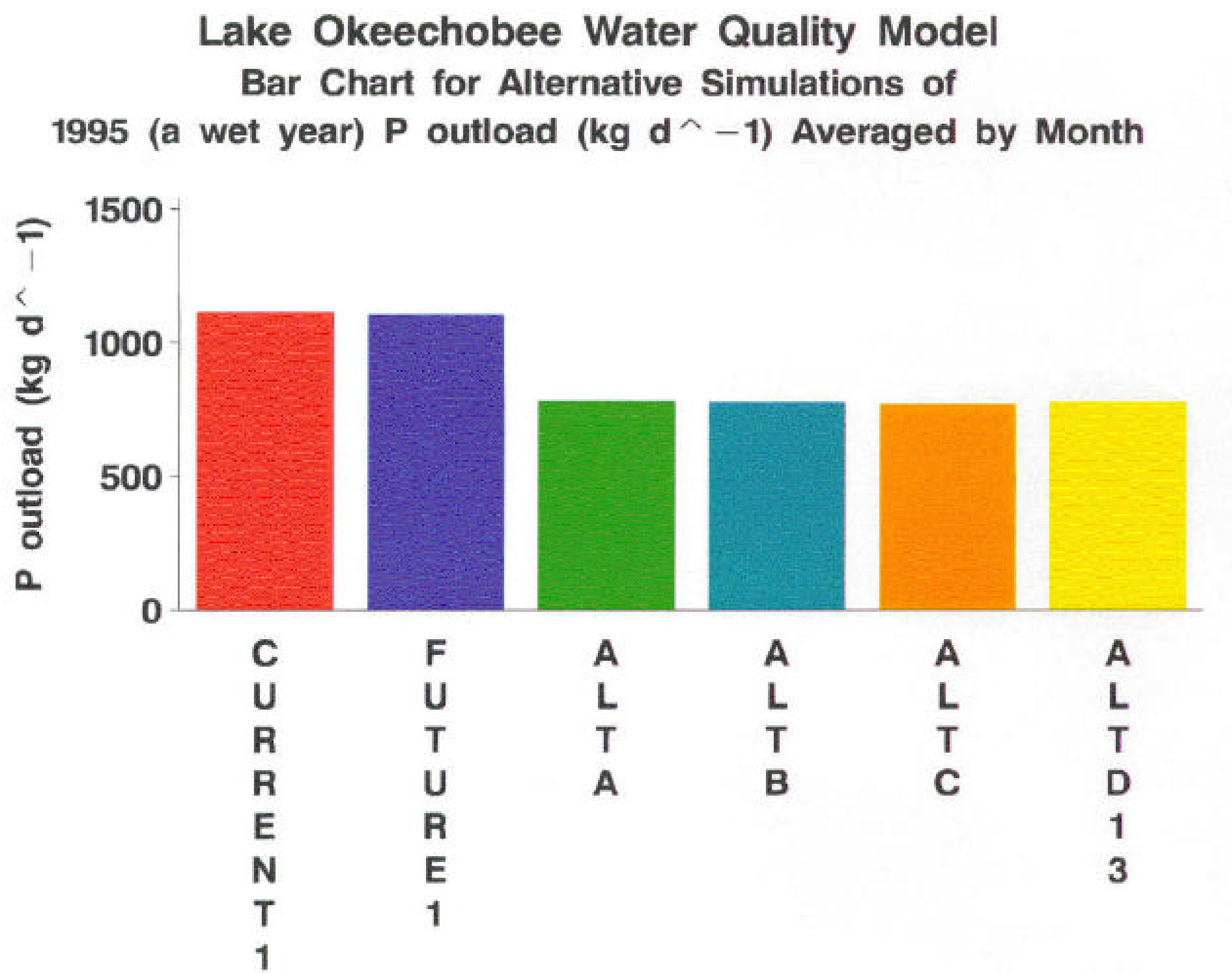
Recommended Plan components GG4 and DDD5 are expected to result in incremental improvement for in-lake water quality conditions. Component GG4 is the Recommended Plan Lake Okeechobee Aquifer Storage and Recovery (ASR) project. This component would result in the construction and operation of 200 ASR wells located on the Lake's peripheral levee (Hoover Dike) with each ASR pump having a maximum capacity of 5 million gallons per day (MGD), for a total Lake ASR maximum capacity of 1 billion gallons per day. The multiple purposes of Lake ASR include: 1) providing additional regional water storage while reducing evapotranspiration losses and minimizing the acreage of regional above-ground storage reservoirs; 2) improving the Lake's water supply capacity for downstream environmental/urban/ agricultural users; and 3) reducing harmful regulatory discharges to the St. Lucie and Caloosahatchee estuaries and maintaining existing flood protection.

Although implementation of ASR facilities on the scale proposed by Component GG4 is unprecedented, preliminary data (David Pyne, CH2M Hill, personal communication) indicates that nutrient levels in ASR waters stored and recovered from the upper Floridan aquifer may be significantly decreased from concentrations in well injectate. If future pilot project associated with Component GG4 prove this nutrient reduction feature of ASR to be present in large scale ASR projects, then some water quality benefits may be realized in Lake Okeechobee waters (at least localized) as a result of large scale ASR implementation. As required in the Clean Water Act, the COE and SFWMD will have to commit to the ASR regulating agencies (FDEP and USEPA) that all recovered ASR waters will be fully treated to met the Class I Water Quality Standards applicable to Lake Okeechobee waters. Regulatory issues involved with operating the raw water ASR facilities proposed in the Recommended Plan will need to be successfully resolved by the involved agencies. Operational data from several large ASR pilot projects will be needed to successfully resolve the regulatory issues involved with Restudy ASR components.

Recommended Plan Component DDD5 calls for the construction and operation of a 5,000-acre STA (maximum depth 4 feet) in the vicinity of structure S-77, where the Caloosahatchee River flows from Lake Okeechobee. The STA would be coupled with a backpumping facility to backpump excess Caloosahatchee basin water to the Lake. Backpumping would only occur when Lake water levels and storage capacity was appropriate. Based on the design of the 5,000-acre STA and the performance of the Everglades Nutrient Removal (ENR) Project, it is anticipated that backpumped water from the STA to the lake would be below 50 ppb TP. Since average TP concentrations in the Lake are 100 ppb, it is anticipated that the backpumped Component DDD5 waters would have a localized beneficial effect.

Although implementation of Lake Okeechobee watershed Recommended Plan components along with Components GG4 and DDD5 are anticipated to reduce nutrient and pollutant loading to Lake Okeechobee, the Restudy Water Quality Team's analysis of the overall effect of the Recommended Plan on Lake waters concluded that only minor improvements would result to Lake Okeechobee water quality. This conclusion was based on several analyses, including extensive water quality modeling of the 1995 and 2050 base conditions and all evaluated Restudy alternatives (A, B, C, and D13R) using the Lake Okeechobee Water Quality Model (LOWQM) (James et. al., 1997). The LOWQM analysis concluded that when comparing the Recommended Plan to the 1995 and 2050 base conditions using six Lake Okeeechobee water quality performance indicators (TP Inload; TP Outload; Median Lake TP; Median Lake chlorophyll; Maximum Lake TP and Maximum Lake chlorophyll-a, that the Recommended Plan would result in slightly better cumulative water quality conditions in Lake Okeechobee waters than either the 1995 or the 2050 base conditions (see Table F.2 excerpted from LOWQM web site, 1998: internet). However, the slight water quality benefits of Recommended Plan components GG4 and DDD5 on in-lake water quality conditions are overwhelmed by the effects of lake resuspension of nutrient rich sediments as well as by nutrient enriched inflows from the watersheds flowing into the Lake.

Figure F.2 Lake Okeechobee Water Quality Model. 1995 (a wet year) Phosphorus Outload (exerpted from Lake Okeechobee Water Quality Model web site, James



1998)

This general conclusion is supported by recent work (Havens, 1997). This recent work indicates that due to the dominant effect of Lake Okeechobee sediment resuspension with the associated release of nutrients into the lake water column, it would be several decades before lake-wide TP concentrations and other associated lake water column parameters would show significant improvement, even if all nutrient inflows to the lake were eliminated. Therefore, water quality improvements to Lake Okeechobee waters resulting from Recommended Plan implementation will be gradual and it will take several decades for these benefits to be fully realized.

F.4 UPPER EAST COAST AND INDIAN RIVER LAGOON

The Recommended Plan includes several components specifically addressing ecological conditions in the Upper East Coast and Indian River Lagoon region, including the St. Lucie River estuary. Furthermore, other regional storage features (e.g., Components A6, D5, G6, W2, and GG4: see below) are expected to improve water quality conditions in the region by contributing to the attenuation of flood discharges via the C & SF Project. Additionally, an OPE outside of the Restudy Recommended Plan involves attenuation of C-25 Canal flows to improve water quality in the Indian River Lagoon.

Water quality conditions in the St. Lucie River and Indian River Lagoon estuaries are expected to be significantly improved as a result of the implementation of the following components:

Component A6 – North Storage 17,500-acre reservoir (maximum depth 11.5 feet) with 2,500-acre stormwater treatment area, Kissimmee River watershed; regional system storage reduces flood discharges from Lake Okeechobee into St. Lucie (C-44) Canal;

Component B2 – C-44 (St. Lucie) Canal 10,000-acre reservoir (maximum depth 4 feet); attenuates C-44 basin runoff, reduces flood discharges into C-44 Canal;

Component C7 – Environmental water supplies to St. Lucie River estuary to achieve optimal salinity;

Component D5 – Caloosahatchee (C-43) Canal 20,000-acre regional system storage (maximum depth 8 feet) reduces flood discharges into St. Lucie and Caloosahatchee Canals;

Component F3 – modified regulation schedule for Lake Okeechobee to provide increased environmental deliveries to the WCAs/Everglades national Park (ENP) and reduce flood discharges to St. Lucie and Caloosahatchee estuaries;

Component G6 – Everglades Agricultural Area (EAA) 60,000-acre reservoir (maximum depth 6 feet); regional system storage reduces Lake Okeechobee flood discharges into C-44 Canal;

Component W2 – TCNS storage and treatment; regional system storage reduces flood discharges from Lake Okeechobee into C-44 Canal; long-term net improvement of Lake Okeechobee water quality discharged into C-44 Canal;

Component GG4 – Regional-scale aquifer storage of Lake Okeechobee water reduces flood discharges into C-44 Canal; water supply to St. Lucie River estuary upon recovery;

Component UU7 – Surface water storage reservoirs totaling 27,200 acres in C-23 and C-24 Canal basins and 21,150 acres of storage in North Fork and South Fork basins of the St. Lucie River. The reservoirs provide regional storage volume totaling 349,400 acre-feet and are designed to prevent undesirable flood discharges to the St. Lucie River estuary.

Key water quality parameters of concern in this region include nutrients, mercury and other heavy metals, dissolved oxygen, pesticides, salinity, turbidity, and coliform bacteria. A substantial amount of the surface water storage area in the Recommended Plan (Components B2 and UU7, see Table F.6) was developed specifically to prevent freshwater inundation of the St. Lucie River estuary consistent with salinity targets. It is expected that these surface water storage areas can be optimized to reduce nutrient and heavy metal concentrations and turbidity levels in inflows to the estuary. Nutrient reductions may also improve dissolved oxygen conditions by reducing Biochemical Oxygen Demand (BOD). Attenuation of runoff should also reduce coliform bacteria concentrations in the estuary. Certain pesticide concentrations may also be reduced, depending upon pesticide forms (dissolved or particulate) and pesticide application practices in the watershed. It is not expected that increased surface water storage will affect mercury concentrations.

F.5 EVERGLADES AGRICULTURAL AREA

F.5.1 Water Quality in the EAA

The Recommended Plan is expected to improve water quality conditions in the Everglades Agricultural Area (EAA). Phosphorus is the primary pollutant of concern in the EAA, particularly as it affects ecological conditions in the downstream WCAs.

The principle water quality benefit to the EAA resulting from the Recommended Plan is the conversion of approximately 60,000 acres (Component G6) of farmland and concomitant elimination of attendant nonpoint source pollution loads to surface water storage.

The phosphorus load reduction estimate for the EFA BMP regulatory program in the EAA is 25 percent. The three-year average (for the period ending April 30, 1997) in total phosphorus loads originating from EAA farms indicates a 51 percent reduction compared to the 1979–1988 baseline period (SFWMD, 1997). Other pollutants of concern in the EAA include mercury, NOx, dissolved oxygen, and pesticides. Water column mercury concentrations in the EAA are not expected to be affected by construction and operation of G6.

Combined, the existing EAA regulatory program and the increase in storage volume on former farmland in the EAA will result in a net reduction of phosphorus and other non-point source pollutants in surface waters of the EAA compared to existing and future base conditions.

F.5.2 Effects of Recommended Plan on the Everglades Construction Project

The water quality performance of the ECP is expected to be somewhat improved over the 2050 base condition. Increasing hydraulic and phosphorus loads are predicted to affect the performance efficacy of the Everglades Construction project (ECP). The ECP and BMPs in the EAA comprise the primary water quality improvement strategy for the downstream WCAs.

For purposes of evaluating the future (2050) base condition and alternative plans, the so-called “Phase 2” treatment technologies necessary to meet water quality criteria adopted pursuant to the EFA were assumed to be implemented. The EFA requires that, by December 31, 2006, the ECP treat EAA stormwater runoff delivered to the EPA to either the adopted criterion or to the default numeric water quality criteria of 10 parts per billion (ppb) total water column phosphorus concentration (TP).

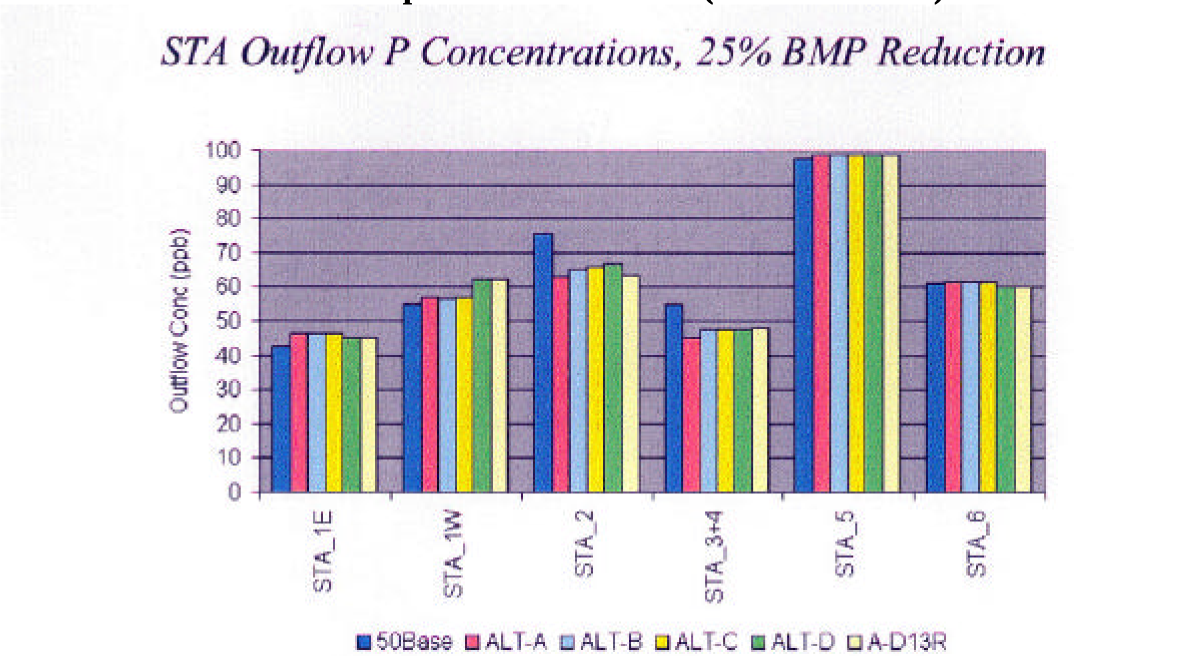
However, since the numeric treatment targets are not yet known, nor has the most appropriate supplemental treatment technology been selected, the Restudy Water Quality team (WQT) determined that the potential impact of the future base and Restudy alternatives on the design and operation of the ECP could best be evaluated in the context of the interim treatment targets defined in the conceptual plan for the ECP (Burns & McDonnell, 1994) and current design criteria for the ECP.

An evaluation of the effect of the future base condition and Restudy alternatives on the interim operation of the ECP was conducted by William W. Walker, Jr. (Walker, 1998). Walker's evaluation indicates that, utilizing existing water quality data and the phosphorus settling rate constant and EAA BMP phosphorus load reduction assumptions used in the conceptual design for the ECP (Burns & McDonnell, 1994), the 31-year average hydraulic and phosphorus loads in the Recommended Plan would cause the interim phosphorus concentration target (50 ppb) to not be met at STAs 1W, 2, 5, and 6. This potential problem also exists for all of the STAs except STA 1E in the 2050 base condition.

On the other hand, using the 51% observed average phosphorus reduction rate from 1995 to 1997 for the EAA BMP significantly changes the outcome. Walker observes that all STAs with the exception of STA 5, meet or exceed the interim phosphorus concentration target. STA 5 is the sole exception due to the hydrologic model not including the nearly 2,000 acre treatment area of STA 6 Section 2. Changing other criteria such as the settling rate constant to that observed in the Everglades Nutrient Removal project over the 1995 to 1997 period would also significantly improve the STA performance models.

It is important to note that when compared to projected 2050 base conditions, the Recommended Plan is not predicted to exacerbate performance deficiencies predicted for the ECP. Significantly, the Recommended Plan improves the predicted performance at STA 3\4. STA 3\4 benefits from the proposed 60,000-acre EAA reservoir (Component G6), acting as a net sink for phosphorus. STA 1E is not predicted to be adversely affected by the future base or Recommended Plan flows, as shown in Figure F.3 (excerpted from Walker, (1998: Internet)).

Figure F.3 STA Outflow Phosphorus Concentrations, 25% BMP Reduction Excerpted from Walker (1998:internet)



This chart shows the flow-weighted-mean concentration in the combined discharge from each STA for 1965-1995. Results assume a BMP load reduction of 25% (ECP Design Basis). The combined discharge consists of the treatment area outflow plus bypasses (excluding urban water-supply deliveries).

As noted above, the predicted performance deficiency at STA 5 is caused by not including STA 6 Section 2 as a future base condition or in any of the Restudy alternatives. For modeling purposes, STA 6 Section 2 was not included in the SFWMM simulations because this element was not included in the conceptual design. The construction schedule for the ECP indicates that construction of STA 6 Section 2 is to be completed by October, 2004. Elimination of STA 6 Section 2 from the SFWMM simulations requires all of the C-139 basin runoff to be routed through STA 5, thereby increasing the average hydraulic and phosphorus loads above the amounts for which it was designed.

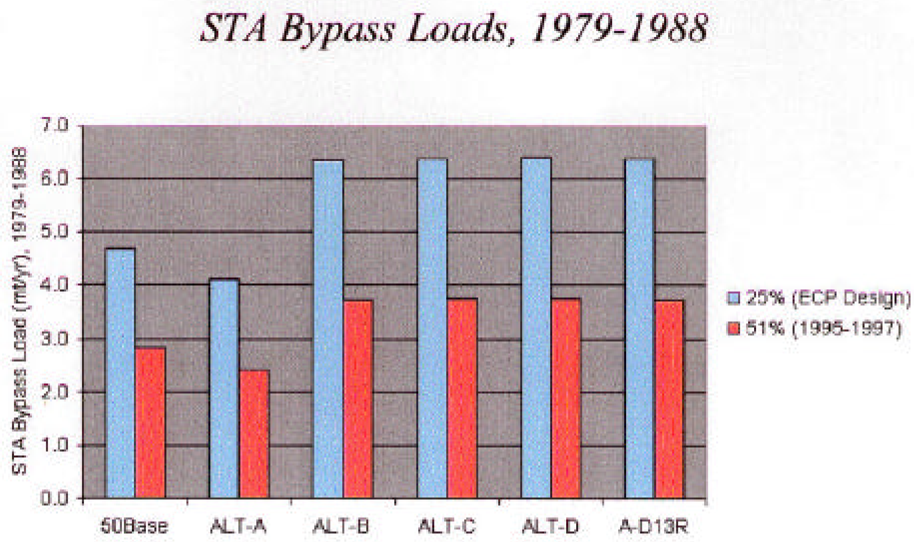
The ECP is designed to treat one hundred percent of the runoff originating within the EAA for the 1979-1988 baseline period to an interim phosphorus concentration target of 50 ppb. The conceptual design for the ECP does not provide for any bypasses of 1979-1988 flows. It is important to note that the period of record utilized for evaluating alternatives during the Restudy was 1965-1995, a much longer and, on average, wetter period than the baseline period utilized to design the ECP. In addition, different operational rules (Rain-Driven Operational Rules, Component H7) were used to evaluate the effects of Restudy alternatives, including the Recommended Plan, on the ECP.

Nevertheless, using 1979-1988 hydrologic conditions, Walker's evaluation indicates that bypasses of the STAs are predicted to occur in the 2050 base condition. Furthermore, the amount of bypassing is predicted to increase over the 2050 base with implementation of the IDP. Bypass phosphorus loads to the WCAs are further increased when considering 1965-1995 average hydrologic conditions. (See Figures F.4 and F.5 from Walker (1998: internet)). Bypasses of the STAs induced by high-flow events may cause water quality criteria to not be met in the WCAs and create an ecological impact through increased phosphorus loading.

Since the ECP is designed to treat all of the EAA runoff volume for the 1979-1988 baseline years, it is assumed that the ECP will be modified to handle bypass volumes which are inherent in the 2050 base operations. Bypass volumes created by the IDP which are greater than those in 2050 base conditions may necessitate further design or operational changes to assure that downstream water quality criteria continue to be achieved.

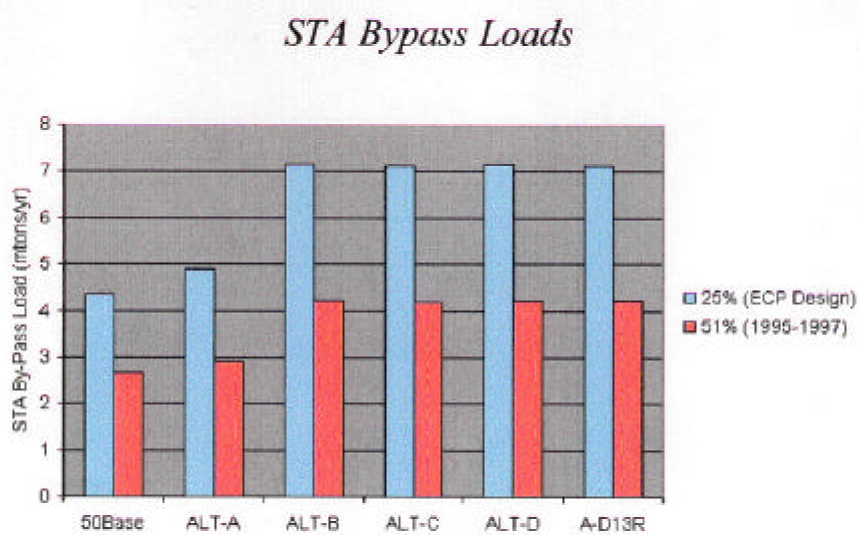
One of the main objectives of the Restudy is to create additional regional water storage to increase the volume and optimize the timing of water delivered to the EPA. This objective is consistent with the 28 percent average increase to the WCAs requirement contained in Section 373.4592(4)(b)2 of the EFA. According to Walker, the IDP resulted in a 19 percent increase in flow from the ECP to the WCAs compared to the baseline period (1979-1988). This was an improvement over the projected 12 percent increase predicted for the 2050 base condition. It should be noted that the 19 percent increase predicted for the IDP is to be achieved concurrent with other measures to be undertaken to achieve optimal hydrologic conditions in the Everglades. Therefore, increasing average volumes delivered from the ECP to the WCAs beyond that predicted for the IDP may create, under certain conditions, adverse ecological effects (e.g. prolonged hydroperiods, inundation of tree islands) in the WCAs. No alternative plan delivered more than 23 percent (Alternative B) greater flows via the ECP to the WCAs.

Figure F.4 STA Bypass Loads, 1979-1988
Excerpted from Walker (1998:internet)



This chart shows average annual STA bypass loads for Water Years 1979-1988 and for two BMP performance assumptions (25% & 51%). Bypass occurs when basin outflow (required for flood control) exceeds STA hydraulic capacity. This 10-year period was used as a hydrologic basis for designing the Stormwater Treatment Areas. Both the Everglades Forever Act and Settlement Agreement require that treatment facilities be sized to treat all flows during this period(excluding urban water-supply deliveries) without hydraulic bypass.

Figure F.5 STA Bypass Loads, 1965-1995
Excerpted from Walker (1998: internet)



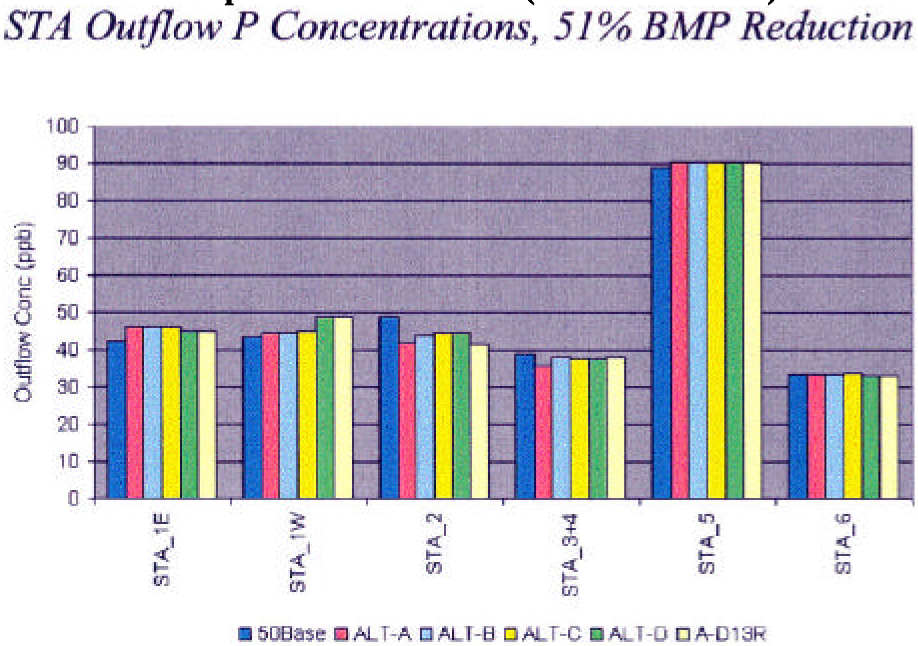
This chart shows average annual STA bypass loads for 1965-1995 and for two BMP performance assumptions (25% & 51%). Bypass occurs when basin outflow (required for flood control) exceeds STA hydraulic capacity. Click here to view bypass volumes & loads for each STA & 25% BMP performance assumption.

One preliminary conclusion which can be drawn from this evaluation is that if the EAA reservoir (Component G5) is constructed and operated as modeled in the Recommended Plan, the size of STA 3\4 could either be reduced and still achieve the interim phosphorus concentration target or the water quality benefits of the 60,000 acres of EAA storage could be expanded to benefit other ECP STAs. The beneficial effect of Component G5 on STA function illustrated by Walker's evaluation suggests that splitting the 60,000 acres of storage area into other basins or delivering water from other basins would similarly benefit other STAs.

Supplemental treatment technologies designed to achieve low phosphorus concentrations (Phase 2) in discharges from the STAs consistent with the requirements of the EFA should be designed consistent with the average hydraulic and phosphorus loads inherent in the Recommended Plan. It should be noted that this conclusion is based on Walker's modeling results utilizing existing water quality data, operational rules (lake regulation schedule, etc.) for the 2050 base condition and the Recommended Plan, and the phosphorus settling rate (10.2 m/yr.) and the BMP load reduction (25 percent) assumptions used to develop the conceptual plan for the ECP (Burns & McDonnell, 1994).

The observed three-year average in actual phosphorus load reduction resulting from implementation of BMPs in the EAA is 51 percent (SFWMD, 1997b), not the 25 percent assumed for the conceptual design of the ECP. Walker's evaluation further indicates that a 51 percent load reduction resulting from BMPs enhances the performance of the STAs (see Figure F.6, excerpted from Walker (1998: Internet)). Furthermore, observed performance at the ENR STA demonstration project indicates the cumulative three average settling rate constant and outflow concentrations of phosphorus were significantly better than the 10.2 meters per year settling rate constant used for ECP design and interim concentration target of 50 ppb (SFWMD, 1998). Increased phosphorus load reduction and an increased settling rate consistent with that observed at the ENR Project may negate the need to modify the size and/or operation of the STAs if attained over the long-term. The underlying assumption remains that Phase 2 water quality treatment technologies will achieve EFA required default numeric TP criterion of 10 PPB or an alternative approved numeric TP criterion.

Figure F.6 STA Outflow P Concentrations, 51% BMP Reduction
Excerpted from Walker (1998: Internet)



This chart shows the flow-weighted-mean concentration in the combined discharge from each STA for 1965-1995. Results assume a BMP load reduction of 51% (1995-1997 average). The combined discharge consists of the treatment area outflow plus bypasses (excluding urban water-supply deliveries).

F.6 WATER CONSERVATION AREAS (INCLUDING ROTENBERGER AND HOLEY LAND WMAS)

The primary pollutant of concern in the WCAs and Rotenberger and Holeyland WMAs is phosphorus. A principle assumption for purposes of evaluating the effect of the Recommended Plan on water quality in the WCAs is that the EFA is fully implemented, and that all discharges into the EPA comply with all water quality criteria, including the yet-to-be-established phosphorus criterion. Accordingly, the evaluation focused upon projected increases and decreases of structural flows into the WCAs.

Other parameters/pollutants of concern in the WCAs and Rotenberger and Holeyland WMAs include NOx, dissolved oxygen, conductivity, and mercury.

Many of the components of the Recommended Plan are designed to achieve hydrologic targets in Loxahatchee National Wildlife Refuge (WCA 1) and WCAs 2 and 3 and downstream in ENP and Florida Bay. Generally, these components are to be operated to increase the volume of water delivered into and retained in the WCAs and to optimize the timing of those deliveries. The following components are expected to affect hydrologic and water quality conditions in the WCAs and downstream in Everglades National Park and Florida Bay:

Component F3 - modified regulation schedule for Lake Okeechobee to provide increased environmental deliveries to the WCAs and ENP;

Component H6 - Rain-driven operations in WCAs 2 and 3 to improve hydropatterns and hydroperiods in the WCAs and ENP;

Component 04 - WCA 3A/3B levee seepage management;

Component Q5 - Western C-11 basin diversion (eliminates discharges of urban runoff to eastern WCA-3A via S-9 pump station);

Component S6 - Central Lake Belt Storage Area, operated to improve hydropatterns and hydroperiods in WCA 3B;

Component AA3 - Additional water control structures between WCA3A & 3B;

Component GG4 - Lake Okeechobee ASR to increase storage of lake water for environmental and water supply deliveries;

Component II3 - Increased capacity of ECP pump station G-404 to improve hydropatterns and hydroperiods in WCA 3A;

Component KK4 - Internal L-7 and L-40 canal structures to improve hydropatterns and hydroperiods in WCA1 (Loxahatchee National Wildlife Refuge: LNWR);

Component QQ6 - Partial decompartmentalization of WCA 3 to reestablish ecological and hydrologic connection between WCA 3A and 3B and Northeast Shark River Slough;

Component RR4 - Relocation and increase in capacity of pump station S-140 to improve hydropatterns and hydroperiods in central WCA 3A;

Component SS4 - Increasing capacity of S-150 to discharge LEC water supply deliveries to US 27 borrow canal (potential adverse impact in WCA 3A associated with Component SS4);

Component ZZ5 - Storage of excess flows in WCA 3A and 3B in Central Lake Belt storage area, to be returned to WCA 3A to achieve preferred hydropatterns and hydroperiods;

Component AAA6 - Conservation of water use in LEC; expected to benefit WCAs through reducing water supply demand from WCAs/regional system;

Component CCC6 - L-28I levee modifications;

Component EEE5 - Storage of excess flows from WCA 2A & 2B in Central Lake Belt storage area, to be returned to WCA 3B to achieve preferred hydropatterns and hydroperiods.

Seminole Tribe Water Conservation Plan OPE - Detention and treatment of stormwater runoff from Tribal Big Cypress reservation lands.

Miccosukee Tribe Water Conservation Plan OPE - Detention and treatment of stormwater runoff from Miccosukee Tribal lands.

Collectively, these components will result in an increase in the average annual volume of water (and phosphorus and nitrogen loads) delivered to the WCAs compared to current (1995) and future (2050) base conditions. Utilizing the water budget data generated from the SFWMM simulations of the base conditions and the alternatives, 31-year average structural flows into the EPA are projected to increase from approximately 2,092.0 thousand acre-feet (k ac. ft.) per year (2050 base condition) to 2,181.9 k ac. ft. per year in Alternative D13R (SFWMD, 1998).

The projected increase in average annual volume is not, however, simply an accumulated incremental increase for all of the existing and proposed water control structures discharging into the EPA. For example, the volume of water delivered by some of the structures contained in the Recommended Plan discharging water into the WCAs is predicted to increase greatly (e.g., S-140 pump station, 31-year average increase in volume is approximately 285.0 k ac. ft.; S-150 pump station, 31-year average increase in volume is approximately 32.2 k ac. ft), whereas other structures will be significantly decreased (e.g., S-9 pump station, 31-year average decrease in volume is 185.8 k ac. ft.; S-190 water control structure, 31-year average decrease in volume is 89.3 k ac. ft., 2050 flows from S-190 eliminated;(see Table F.6).

Decreases in average annual structural flows containing significant pollution loads (e.g., S-9, S-190) would be expected to improve water quality conditions in those areas within the water conservation areas impacted by those discharges. Conversely, increases in structural discharges (e.g., S-140, S-150) could create potential water quality problems except where treatment facilities are provided. Treatment facilities are provided in nearly every instance where increases occur. For modified pump station S-140 (Component RR4), the majority of the projected increase in volume is flow out of STA 3\4 directed west along the L-5 and L-4 borrow canals via modified pump station G-404 (Component II3). However, a portion of the water discharged via S-140 would include runoff from cattle pastures on the Seminole (see Seminole Tribe Big Cypress OPE) and Miccosukee tribal reservation lands (see Miccosukee Tribe WCP OPE) adjacent to northwest WCA 3A. The Seminole Tribe and Miccosukee Tribe have identified stormwater runoff treatment facilities for discharges from their respective reservations.

The affect of flows and attendant pollution loads into the WCAs resulting from the implementation of Recommended Plan components will be evaluated in future detailed design studies and may affect the final design of treatment facilities. Implementation of the Recommended Plan is not expected to alter mercury concentrations (which is primarily atmospheric in origin), or conductivity within the canals and marsh areas. Similarly, dissolved oxygen levels are not expected to be affected by Recommended Plan components.

It is also important to note that even with such modifications in place, the net phosphorus load delivered into the EPA is projected to increase (compared to projected 2050 base conditions) as a result of increasing the quantity of water provided by the Recommended Plan to the EPA; however, any increase in the net phosphorus load delivered to the WCAs and ENP would be delivered at a concentration which would not cause the numeric phosphorus criterion to be exceeded.

The Seminole Tribe Big Cypress OPE project would result in construction and operation of approximately 5,270 acres of Wetland Resource Areas WRA), that would be operated much like STAs, treating agricultural stormwater runoff in wetland cells impounded to no deeper then one foot in depth. Additionally, approximately 1,860 acres of Irrigation Storage Areas (maximum depth of 4 feet) would be constructed to attenuate peak flows and be operate in conjunction with the WRAs. These OPE project features would sequester particulate and dissolved nutrients and others pollutants, reducing pollutant loads to the downstream S-140 pump, adjacent to WCA 3A. The Seminole Tribe Big Cypress OPE is consistent with the Non-ECP permit provisions of the EFA.

The Miccosukee Tribe Water Conservation Plan would result in the construction and operation of approximately 900 acres of wetland stormwater treatment areas, treating agricultural stormwater runoff in wetland cells impounded to no deeper then four feet in depth. This OPE project feature would sequester particulate and dissolved nutrients and others pollutants, reducing pollutant loads to the downstream S-140 pump, adjacent to WCA 3A. The Miccosukee Tribe Water Conservation Plan OPE is consistent with the Non-ECP permit provisions of the EFA.

The IDP results in increased average annual flows to the Rotenberger and Holey Land WMAs consistent with preferred regulation schedules for those areas. The average annual volume of water discharged from STA 5 to the Rotenberger WMA is projected to increase from 128.5 k ac. ft. (2050 base condition, 31-year average) to 156.0 k ac. ft. as a result of IDP implementation. Most of this increase in volume comes from STA 5. For the Holey Land WMA, the average annual volume increases from 11.0 k ac. ft. to 42.8 k ac. ft. (SFWMD, 1998).

Prior to implementing the canals and water control structures necessary to implement the proposed regulation schedules (Components DD5 and EE5), water budget data indicate that if will be necessary to construct STA 6 Section 2 or modify STA 5 to assure that water quality criteria (including Florida's antidegradation requirement for OFWs) for the Rotenberger and Holey Land WMAs are achieved. Further evaluation of the IDP water budget and routing mechanisms for those areas will also be necessary to ascertain whether additional design or operational modifications are necessary to meet EFA requirements for discharges into the Rotenberger and Holey Land WMAs created by the IDP.

TABLE F.6
EPA STRUCTURES TABLE
31-YEAR AVERAGES

Structure	Description	95B	50B	D13R	D13R –50B
S5A2SO	S5AS to WCA1	263.7	0	0	*0*
S6	EAA to WCA1 or STA2	239.9	0	0	*0*
L8TCA1	L8 to WCA1 via S5AS	27.3	0	0	*0*
S7	EAA to WCA2A	287.3	49.4	95.5	*+46.1*
S8	EAA to WCA3A	359.0	382.4	168.3	*-214.1*
S150	EAA to WCA3A	31.8	10.2	42.4	*+32.2*
S9	C11W to WCA3A	177.9	193.6	7.8	*-185.8*
ACMERF	ACME to WCA1	31.2	39.0	39.6	*+0.6*
L28WQ	L28 (S-190) to WCA3A	106.7	89.3	0	*-89.3*
S140A	L28 to WCA3A	93.8	174.9	459.9	*+285.0*
G155	L4 to WCA3A	95.2	0	0	*0*
G204	Holeyland to WCA3A	0.4	0	0	*0*
G205	Holeyland to WCA3A	0.6	0	0	*0*
G206	Holeyland to WCA3A	0.5	0	0	*0*
G123	NNRC to WCA3A	1.2	0	0	*0*
S174	L31 to L31W (S3332)	135.9	0	0	*0*
S5AWC1	LEC WS from Lake O		18.9	2.3	*-16.6*
ST1WQ1	STA1W to WCA1		162.2	179.6	*+17.4*
ST1EQ1	STA1E to WCA1		122.4	127.8	*+5.4*
S6LCWS	LEC WS from Lake O		4.2	0.3	*-3.9*
ST2OT1	STA2 to WCA2		232.7	201.8	*-30.9*
ST2BYP	EAA/Lake O to WCA2		21.1	7.8	*-13.3*
ST6WCA	STA6 to WCA3A		21.3	12.9	*-8.4*
RTTWCA	Rotenberger to WCA3A		37.4	13.7	*-23.7*

HLYNW	Holeyland to WCA3A		0.7	7.5	*+6.8*
HLYDS	Holey. Flood to WCA3A	0	0	24.1	*+24.1*
ST3NEA	STA3\4 to WCA3A		188.2	132.2	*-56.0*
ST3TNW	STA3\4 to WCA3A		113.1	104.5	*-8.6*
S142W	S142 to WCA3A via G123	1.2	0.9	0	*-0.9*
S332D	L31N to ENP		141.0	121.0	*-20.0*
S332B	L31N to ENP		24.8	96.8	*+72.0*
S332A	L31N to ENP		18.6	72.6	*+54.0*
S356	L31N to ENP		45.6	0	*-45.6*
S356A	L31N to ENP		0	131.8	*+131.8*
S356B	L31N to ENP		0	131.8	*+131.8*
S18C	C111 to ENP		0	0	*0*
CULV	C111 to L31W		0.1	0	*0*

1) Structures and water budget numbers from SFWMM water budget files.
2) Amounts are in k ac. ft. (1,000 acre-feet)

F.7 LOWER EAST COAST AND BISCAYNE BAY

Water quality conditions in portions of the Lower East Coast (LEC) and Biscayne Bay are currently degraded. FDEP listed approximately 90 water bodies or segments of water bodies within the LEC sub-region as not presently meeting water quality standards (FDEP, 1998:draft). Parameters and pollutants of concern include phosphorus, NOx, dissolved oxygen, mercury, coliform bacteria, volatile organic compounds, heavy metals, pesticides, tri-butyl tin (TBT), and salinity.

There are several components in the Recommended Plan designed to achieve public water supply, salinity control and water quality objectives in the LEC region (Palm Beach, Broward, and Miami-Dade Counties), and to meet environmental targets in Lake Worth Lagoon and Biscayne Bay. The following components are expected to affect hydrologic conditions in the LEC:

Component K6 – Southern L-8 basin improvements to enhance water supply function in Palm Beach County Water Catchment Area;

Component L3 – Relocate coastal wellfield operations to minimize threat of saltwater intrusion;

Component M6 – Site 1 reservoir adjacent to Hillsboro Canal; supplemental storage for LEC water supply;

Component R4 – C-9 Canal impoundment/diversion canal for treatment of water supply deliveries from North Lake Belt Storage Area (Component XX6);

Component S6 – Central Lakebelt storage area; provides regional storage for public and environmental water supply, and salinity control, includes 640-acre STA;

Component T6 – C-4 Canal divide structures for seepage control and coastal wellfield recharge;

Component U6 – Bird Drive basin reservoir; seepage control, flood attenuation, and water supply deliveries to South Dade Conveyance System;

Components X6 & Y6 – Backpumping of urban runoff from C-17 Canal and C-51 Canal watersheds to supplement water storage/supply in West Palm Beach Water Catchment Area;

Component BB5 – Improvements to Dade-Broward Levee to reduce seepage losses, enhancing Miami-Dade County Northwest Wellfield;

Component CC6 – Improve Broward County secondary canal system to enhance wellfield recharge and salinity control functions;

Component LL6 – C-51 Canal aquifer storage and recovery water supply and salinity control;

Component VV6 – Palm Beach County Agricultural Reserve reservoir to increase water supply storage in central and southern Palm Beach County;

Component WW5 – C-111N Spreader Canal, improve flows to Model Lands/southern Biscayne Bay, 3,200-acre STA:

Component XX6 – North Lake Belt storage area to provide public water supply, canal stage (salinity) control, and to achieve salinity targets in Biscayne Bay, STA of undetermined acreage;

Component ZZ5 – Diversion of excess flows out of WCA 3A & 3B to enhance function of Central Lakebelt storage area (Component S6);

Component AAA6 – Increased conservation of regional system water delivered to LEC public water supply/distribution systems;

Component BBB6 – Reuse of treated wastewater to meet salinity targets in Biscayne Bay;

Component FFF5 – Higher stages in C-102 and C-103 Canals for urban and environmental (Biscayne Bay) water supply;

Component GGG6 – C-51 Canal/Southern L-8 basin reservoir to achieve salinity targets in Lake Worth Lagoon, control flooding, and provide additional water supply to Lake Worth Drainage District, 1,100 acre STA;

Component HHH6 – West Miami-Dade County wastewater reuse to enhance ground water recharge and provide additional water supply for salinity control and to meet environmental targets in the ENP;

Acme Basin B OPE - Combination reservoir/STA adjacent to the Loxahatchee National Wildlife Refuge in Palm Beach County to provide water quality treatment and stormwater attenuation;

Biscayne Bay Coastal Wetlands OPE - rehydrate coastal wetlands and reduce point source discharges to southern Biscayne Bay, STA of undetermined acreage.

Construction and operation of these components is expected to result in a net improvement in water quality conditions in the LEC. Water quality improvements are expected simply through the attenuation function (and attendant pollutant load reduction, particularly nutrients and heavy metals) of the storage components for those surface waters presently discharged to coastal canals and estuaries. Storage and attenuation facilities may also improve bacteriological quality through attenuation of surface waters containing coliform bacteria and will improve dissolved oxygen conditions where existing conditions have been adversely affected by increases in BOD loading. Salinity regimes are also expected to be improved consistent with ecological targets.

Additionally, water quality conditions are expected to be improved as a result of the incorporation of treatment features into the design and operation of several components. Where the design and operation of a component could increase pollution loads in ground water or downstream receiving waters through aquifer injection or diversion of surface waters, treatment facilities necessary to meet water quality standards have been included in the design and cost estimates for those components (e.g., chlorination treatment prior to aquifer injection, STAs associated with diverting runoff into reservoirs/storage areas, treatment works at wastewater reuse facilities to produce effluent meeting water quality standards). These facilities, depending upon location and further detailed design (volumes, attenuation times, discharge points), could result in a net reduction of pollutants in receiving water bodies compared to existing and future base conditions.

The beneficial effect of such facilities is not quantifiable at the feasibility investigation stage, for several reasons. First, exact locations of the components and volumes of water added to downstream receiving waters have not been determined. This information will be determined at the detailed design stage of project implementation.

Second, and most importantly, existing and projected pollution loads and TMDLs in receiving waters affected by the operation of the components of the Recommended Plan necessary to achieve ecologically sustainable conditions have not been determined, particularly for nutrients. According to FDEP's draft 1998 303(d) list (FDEP, 1998:draft), 90 of the 169 listed water bodies and/or segments of water bodies designated by FDEP as not meeting water quality standards criteria in the Restudy area are within the LEC (FDEP, 1998). TMDLs have not been established for any of these waterbodies.

While it is expected that components of the Initial Draft Plan would improve water quality for Lake Worth Lagoon and Biscayne Bay compared to existing and projected future conditions additional analysis is needed to fully quantify the water quality objectives for these areas. Construction and operation of those components of the Recommended Plan affecting hydrologic conditions in the LEC are not expected to affect total mercury concentrations and loads, the primary source of which is atmospheric deposition.

F.8 EVERGLADES NATIONAL PARK AND FLORIDA BAY

Water quality conditions in freshwater regions of Everglades National Park (ENP) are not expected to be significantly changed by implementation of the Recommended Plan compared to the 1995 and 2050 base conditions as the water quality meets the default phosphorus criterion now. Water quality conditions in the estuarine portion of ENP and in Florida Bay are expected to be improved by the Recommended Plan relative to the 1995 and 2050 base conditions. The key water quality parameters of concern in the ENP and Florida Bay are TP, mercury and salinity.

Currently ENP freshwater marshes are oligotrophic (low nutrient levels) with TP concentrations in the ENP marsh routinely below 10 ppb TP (McCormick et. al., 1998). A primary evaluation tool used by the Restudy Water Quality Team (WQT) to evaluate the relative water quality effects of the various Restudy alternatives reviewed during the Restudy Plan Formulation and Evaluation Phase (October 1997 - June 1998: also see Section 7) was the Everglades Water Quality Model (EWQM) (SFWMD, 1998). The EWQM simulates phosphorus transport in the EPA (ENP and WCAs) and links to hydrologic output from the South Florida Water Management Model (SFWMM). Relative ranking of the various Restudy Alternatives as well as the 1995 and 2050 base cases are shown in Table F.4. The EWQM evaluation of the Restudy alternatives and the 1995 and 2050 base conditions indicated that Alternatives B and D-13R were the preferred alternatives from a water quality perspective. This conclusion is tied closely to the decompartmentalization aspects of the Recommended Plan and Alternative B, which reduce structural flows into ENP and increase surface water sheetflow of waters entering ENP. The EWQM results suggest and the Restudy WQT concluded that maximizing surface water sheetflow of hydrologic flows entering ENP would reduce the net nutrient load within ENP.

The following Recommended Plan components are of particular interest relative to potential effects they may have on water quality conditions in ENP:

Component Q5 - Western C-11 basin diversion (eliminates discharges of urban runoff to eastern WCA 3A and ENP via S-9 pump station);

Component FF4 - Relocation of a portion of L-31 North canal with new water control structures (S-356 A&B) to increase flows to NE Shark River Slough (ENP);

Component OO4 - Modify operation of S332- A/B/D structures in ENP Taylor Slough area to increase flows delivered to ENP and Florida Bay;

Component RR4 - Relocation and increase in capacity of pump station S-140 to improve hydropatterns and hydroperiods in WCA 3A, ENP and Florida Bay;

Component CCC6 - L-28I Canal modifications and STAs: convert existing canal flow discharge into western WCA 3A to surface water sheetflows through Everglades marsh and add two STAs to clean water prior to sheetflow;

Recommended Plan Components Q5 and CCC6 will have beneficial effects on water quality conditions in ENP. Table F.6 provided water flow information from the SFWMM showing increases and reductions of flows resulting from implementation of the Recommended Plan compared to 2050 base conditions. Component Q5 will relocate the discharge of C-11 west basin stormwater runoff at the S-9 pump structure which discharges to WCA 3A south to the North Lake Belt storage area with eventual routing of these flows to Biscayne Bay. Table F.6 shows that the Recommended Plan will result in 185,800 acre-feet/year (SFWMM 31-year average) less water being discharged from S-9 into WCA 3A than the 2050 base condition. Component Q5 will therefore result in a significant reduction of pollutant loading into WCA 3A and downstream ENP. Component CCC6 will result in a reduction of pollutant loading to the western portion of WCA 3A and the downstream ENP. This is demonstrated in Table F.6 under structure L28WQ, that shows that average flows (SFWMM 31 year average) from the L-28 I canal will be reduced from 89,300 acre-feet/year in the 2050 base condition to zero. Component CCC6 will replace L-28 I canal flow with overland sheetflow, resulting in significant reduction of pollutant loading to the downstream waterbodies (WCA 3A and ENP).

Recommended Plan Components FF4, OO4 and RR4 will result in increased flows entering ENP as a result of Recommended Plan hydrological restoration actions (Table F.6). This table shows that Components FF4, OO4 and RR4 will result in 263,600 acre-feet/year, 106,000 acre- feet/year and 285,000 acre-feet/year (SFWMM 31 year average) greater water discharges into WCA 3A and ENP than the 2050 base condition. Although these increased flows are important to future restoration of the WCAs, ENP and Florida Bay, it is important to note that the implementation of the Recommended Plan will have to ensure that all additional flows greater than 2050 base condition flows will have to be adequately treated in order to meet all State/Tribal water quality standards in the receiving waterbodies. If not adequately treated these additional flows to WCA 3A and ENP could have negative water quality effects. For Recommended Plan components FF4, OO4 and RR4, it is assumed that additional waters delivered to the EPA by these structures will be adequately treated consistent with the water quality requirements of the EFA.

The focus of the Restudy water quality evaluation for Florida Bay relates to restoring ecologically desirable freshwater flows to the Bay, thereby restoring seasonal salinity conditions across the Bay to as close to historic conditions as possible.

The following Recommended Plan components are expected to operate synergistically in a manner which will improve estuarine water quality conditions in the ENP/Florida Bay region:

Component F3 - Modified regulation schedule for Lake Okeechobee to provide increased environmental water delivers to the WCAs, ENP and Florida Bay;

Component G6 - EAA reservoir - 60,000 acres at a maximum of 6 feet depth; regional storage that results in increased environmental water delivers to the WCAs, ENP and Florida Bay;

Component H7 - Everglades rain-driven operations in WCAs 2 and 3 to improve hydropatterns and hydroperiods in the WCAs and ENP;

Component S6 - Central Lake Belt Storage Area, operated to improve hydropatterns and hydroperiods in WCA 3B and ENP;

Component U6 - Bird Drive Basin reservoir; seepage control, flood attenuation, and water supply deliveries to the South Dade Conveyance System;

Component V4 - L 31 North seepage management, reducing seepage to the east from NE Shark River Slough and maintain higher water stages and longer water duration in NE Shark River Slough;

Component AA7 - Additional water control structures between WCA 3A and 3B to increase flows to ENP;

Component FF4 - Relocate a portion of L-31 North canal with new water control structures (S-356 A&B) to increase flows to NE Shark River Slough (ENP);

Component GG4 - Regional-scale Lake Okeechobee ASR (1,000 MGD); improve water flows to WCAs and ENP;

Component OO4 - Modify operation of S332- A/B/D structures in ENP Taylor Slough area to increase flows delivered to ENP and Florida Bay;

Component QQ7 - Partial decompartmentalization of WCA 3A, backfill Miami Canal, reestablish historic hydrologic sheetflows between WCA 3 and ENP;

Component RR4 - Relocation and increase in capacity of pump station S-140 to improve hydropatterns and hydroperiods in WCA 3A, ENP and Florida Bay;

Component WW5 - C-111N Spreader Canal; backfill C-110/lower C-111 canal systems, remove S-197/S-18C structures, extend C111N east to create a water spreader: improved water management for ENP panhandle area and NE FL Bay;

Component YY4 - Diversion of excess WCA 2B water to NE Shark River Slough or Central Lake Belt storage area, enhance hydropatterns/hydroperiods in NE Shark River Slough (ENP) and Florida Bay;

Component EEE5 - Storage of excess flows from WCA 2A/B & WCA 3A in Central Lake Belt storage area, to be returned to WCA 3B, and ENP to acheive preferred hydropatterns and hydroperiods, benefits to downstream FL Bay also;

Component HHH6 - West Miami-Dade Reuse; enhance groundwater recharge in bird Drive basin and provide additional water supplies to the South Dade Conveyance System to enhance seepage control in eastern ENP.

From a cumulative water quality benefits to Florida Bay perspective, several Hydrological Performance Measures (HPM) developed by the Restudy Project, relating to improved freshwater flows to Florida Bay and improved salinity conditions in Florida Bay, demonstrate the positive synergistic effect of the above listed 16 Recommended Plan components. The HPM entitled "Average Annual Flows toward FL Bay across Taylor Slough for the 31 yr. simulation" period indicates that Recommended Plan freshwater flows from Taylor Slough to Florida Bay are closer to the Natural System Model (NSM) target than either the 1995 or 2050 base condition flows. Another relevant HPM in the Florida Bay area entitled "Average Annual Overland Flows toward Whitewater Bay and Florida Bay for the 31 year simulation period" indicates that: 1) Recommended Plan flows from the

Shark River Slough (SRS) are closer to the NSM target than either the 1995 or the 2050 base condition SRS flows (SRS freshwater flows enter the western portion of Florida Bay) and 2) total southward flows to the northeastern portion of Florida Bay from three ENP basins indicate that the Recommended Plan freshwater flows are much closer to the NSM target then the 1995 base condition flows and are generally equal to 2050 base condition freshwater flows.

Relative to HPM that relate to restoration of ecologically beneficial salinity conditions in eastern Florida Bay, which receives flows from the Taylor Slough/River, the HPM entitled "Number of Months high/low Salinity Criteria Exceeded for Little Madeira Bay" is especially important. Little Madeira Bay receives freshwater from Taylor Slough/River in a portion of northeastern Florida Bay where ecologically damaging hypersaline conditions have been documented in the past decade. This HPM clearly indicated that the Recommended Plan salinity characteristics in Little Madeira Bay are much closer to the NSM salinity targets than either the 1995 or 2050 base conditions.

In summary, the above discussed HPM indicate that improved hydroperiods and hydropatterns of Recommended Plan (synergistic effect of above referenced 16 Recommended Plan components) freshwater flows to Florida Bay, relative to both the 1995 and 2050 base conditions, will result in improved water quality conditions in Florida Bay.

F.9 FLORIDA KEYS

Water quality conditions in the Florida Keys are not expected to be significantly affected by the Recommended Plan relative to the 1995 and 2050 base conditions. Major water quality parameters of concern in waters of the Florida Keys are: DO; TP; NOx; turbidity; chlorophyll-a and coliforms. For the purposes of this study, the waters of the Florida Keys are evaluated as those waters within the boundaries of the Florida Keys National Marine Sanctuary (FKNMS). The waters of Florida Bay are contiguous with Florida Keys waters on the northern side of the Keys. Salinity conditions in Florida Keys waters are dominated by marine influences, although in the area of northeast Florida Bay, freshwater runoff from the southern Everglades to the north seasonally influences Florida Keys water quality conditions.

Although Recommended Plan Components OO4 and WW5 will alter freshwater flows to coastal waters near Key Largo, no evidence exists that these Restudy water management effects will significantly modify Florida Keys water quality relative to the 2050 base condition. Component OO4 will increase freshwaters flows to the Taylor Slough/Florida Bay coastal region. Component WW5 will eliminate C-111 canal flows and increase surface water sheet flows from the southern Everglades to coastal portions of northeast Florida Bay and, Blackwater Sound.

Further development of the Florida Bay hydrodynamic and water quality models currently under development should provide more information relative to the potential effects of Restudy components on water quality conditions in the Florida Keys. Also, if a Florida Bay Feasibility Study is initiated, it is likely that future evaluations of potential removal/culverting of portions of Florida Keys highway causeways, currently restricting upper Florida Keys hydrological flushing, would be conducted. Future potential removal/culverting of highway causeways in the upper Florida Keys could have significant beneficial effects on water quality conditions in Florida Keys waters.

F.10 BIG CYPRESS REGION

Water quality conditions in the Big Cypress Region are expected to be improved compared to both the 1995 and 2050 base conditions through implementation of the Recommended Plan. The key water quality parameters of concern in the Big Cypress region are: TP, NOx and DO. The largest beneficial effect of the Recommended Plan on Big Cypress water quality conditions will result from implementation of Recommended Plan component CCC6 (modifications to the L-28 Interceptor Canal). Improvement to Big Cypress water quality conditions is expected to result from implementation of Recommended Plan component QQ7 - partial decompartmentalization of WCA 3A, although to a lesser extent than from CCC6 implementation.

Implementation of Recommended Plan component CCC6 would result in the backfilling of the southern portion of the L-28 Interceptor canal south of existing Structure S-190 (approximately 12 miles) and degrading the existing levee on the southwest side of the L-28 I canal. Current canal water flows in the west feeder and north feeder canals upstream from structure S-190 will be modified to be surface water sheetflows south across the Big Cypress National Preserve (BCNP), downstream from the Seminole Tribe's Big Cypress Reservation, using several pump stations and a spreader canal system. Additionally, S-190 would be converted from a gated structure to a pump station to maintain upstream flood protection. Two new STAs would be constructed adjacent to the west and north feeder canals to treat storm water runoff from upstream basins prior to entering the Seminole Tribe's Big Cypress Reservation. The two STAs, a 1,100-acre STA adjacent to the north feeder canal and a 800-acre STA adjacent to the west feeder canal are sized to reduce TP and other pollutant loads entering the downstream waters of the Seminole Tribe, the BCNP, the Miccosukee Tribe Reservation and ultimately WCA 3A, so as to assure compliance with Tribal and State water quality standards in the receiving waterbodies. Modification of the existing west and north feeder canal flows and L-28 I canal flows to Recommended Plan surface water sheetflows across the BCNP is also anticipated to provide beneficial water quality treatment for the downstream nutrient-sensitive waterbodies.

Recommended Plan component QQ7 would result in the partial decompartmentalization of WCA 3A. Of particular relevance to Big Cypress region water quality conditions is the degradation of the L-28 and L-28 Tieback levees with backfilling of the adjacent borrow canals and removal of the S-343A and S-344 structures in the L-28 levee. Removal of the L-28 and L-28 Tieback levees/canals and S-343A/344 will enable wet season surface water sheetflows in the western region of WCA 3A to flow in a southwesterly direction across the eastern region of BCNP. Therefore, existing pollutant loading being delivered to the southeastern region of BCNP and the westernmost region of ENP through the S-343A/S-344 structures will be spread out across an approximate 15-mile long front in the eastern area of BCNP. Replacing the existing structural point source wet season flows from WCA 3A with broad dispersed surface water sheetflows will result in pollutant uptake and sequestration by the native vegetation in the area and generally improve water quality conditions in the eastern BCNP.

F.11 CALOOSAHATCHEE RIVER REGION

Water quality conditions in the Caloosahatchee River Region are expected to be improved compared to both the 1995 and 2050 base conditions through implementation of the Recommended Plan. The key water quality parameters of concern in the Caloosahatchee River region are: TP, NOx, DO, conductivity, coliforms and pesticides. The following Recommended Plan components are expected to operate synergistically in a manner which will improve freshwater and estuarine water quality conditions in the Caloosahatchee River basin:

Component A6 - North of Lake Okeechobee storage - 20,000 acres at a maximum of 10 feet depth, Kissimmee River watershed; regional storage reduces flood discharges from Lake Okeechobee to the Caloosahatchee River;

Component B2 - C-44 (St. Lucie) Canal reservoir - 10,000 acres at a maximum of 4 feet depth, increases C-44 basin and regional storage capacity and reduces need to release Lake Okeechobee flood discharges to the Caloosahatchee River basin;

Component D5 - Caloosahatchee (C-43) Canal reservoir with aquifer storage and recovery (ASR) wells - 20,000 acres of reservoir at a maximum of 8 feet depth, 44 five MGD ASR wells (220 MGD maximum capacity) increases Caloosahatchee River basin storage and reduces Lake Okeechobee flood releases to the Caloosahatchee estuary;

Component E5 - Environmental water supply deliveries to the Caloosahatchee estuary to achieve optimal salinity;

Component F3 - Modified regulation schedule for Lake Okeechobee to provide increased environmental deliveries to the WCAs/ENP and reduce flood discharges to the Caloosahatchee estuary;

Component G6 - EAA reservoir - 60,000 acres at a maximum of 6 feet depth; regional system storage that reduces Lake Okeechobee flood releases to the Caloosahatchee estuary;

Component GG4 - Regional-scale aquifer storage (ASR) of Lake Okeechobee water - 1000 MGD maximum capacity, reduces Lake Okeechobee flood discharges to the Calooashatchee estuary and improves low flow augmentation from Lake Okeechobee to the Caloosahatchee River/estuary during dry periods;

Component DDD5 - Caloosahatchee River (C-43) backpumping to Lake Okeechobee with STA - increases regional water storage by capturing C-43 excess storm water runoff, and after water quality treatment via a 5,000-acre STA, diverts storm water flows to Lake Okeechobee when Lake Okeechobee is at appropriate water level.

Major benefits of the Recommended Plan components to Caloosahatchee River and estuary water quality conditions result from substantially reducing the levels of non-point source pollutant loading to basin waters during the annual wet season rain events and Lake Okeechobee flood control discharges by capturing these runoff waters in the regional water storage facilities. Of particular importance to water quality improvement in the C-43 basin are the 20,000-acre reservoir in the basin (Component D5) and the 60,000 acre reservoir in the EAA (Component G6). By retaining wet season stormwater runoff in the regional water storage facilities, sedimentation processes will sequester sediment-bound pollutants and biological uptake processes in the water storage facilities will sequester dissolved pollutants. Operation of the water storage facilities will reduce loading of TP, NOx, coliforms and pesticides to C-43 basin waters. Additionally, operation of the ASR facilities in the C-43 basin and around Lake Okeechobee (Components D5 and GG4), implementation of the modified Lake regulation schedule (Component F3) and operation of the C-43 backpump with STA facility (Component DDD5) will reduce wet season peak flows to the Caloosahatchee River and estuary and thereby reduce nonpoint source pollutant loading to the river and estuary.

Conversely, during the dry season when maintenance of adequate low flows to the river and estuary dominants water quality concerns in the region, implementation of the Recommended Plan components that increase flows to the river/estuary are important. The Recommended Plan components that improve dry season river/estuary water quality conditions are: the C-43 and Lake Okeechobee ASR facilities (Components D5 and GG4) and improved environmental flows from Lake Okeechobee (Component E5). These components are expected to specifically improve DO and conductivity conditions in the river/estuary identified as key water quality parameters in the basin.

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LIST OF ACRONYMS AND ABBREVIATIONS

AIRS - Aerometric Information Retrieval System (a USEPA Database)
AIRS-AFS - Aerometric Information Retrieval System - Air Quality Subsystem
AIRS-AQS - Aerometric Information Retrieval System - Air Facility Subsystem
AIRSWeb - USEPA Website for AIRS Database
CAA - Clean Air Act
CO - Carbon Monoxide
FAMS - Florida Atmospheric Mercury Study
HAPs - Hazardous Air Pollutants
MACT - Maximum Achievable Control Technology
MDN - National Mercury Deposition Network
NAAQS - National Ambient Air Quality Standards
NO_2 - Nitrogen Dioxide
NO_x - Nitrogen Oxides
O_3 - Ozone
Pb - Lead
$PM_{2.5}$ - Particulate Matter (Less Than 2.5-Micron Diameter)
PM_{10} - Particulate Matter (Less Than 10-Micron Diameter)
SIP - State Implementation Plan
SOFAMMS - South Florida Mercury Monitoring Study
SO_2 - Sulfur Dioxide
Title IV - Section in CAA Addressing Acid Rain
VOCs - Volatile Organic Compounds

APPENDIX I

AIR QUALITY

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APPENDIX I
AIR QUALITY

To supplement Section 3.1.3, the existing air quality in the region covered by this C&SF Restudy PEIS is discussed in detail in this Appendix I and its Attachments A-C. Overall, the air quality for the region is considered good, or to be in attainment with all National Ambient Air Quality Standards (NAAQS), as established by the Clean Air Act (CAA). Within south Florida however, a concern exists regarding the deposition of mercury into the Everglades through the atmosphere. This issue, along with the status of attainment of the NAAQS, location of ambient air monitoring stations, identification of emission sources, emission restrictions, and other special concerns are discussed.

I.1 ATTAINMENT STATUS OF CRITERIA POLLUTANTS

This region, along with the entire State of Florida, is currently in attainment for the six criteria pollutants. These six pollutants have limits on the amount that may be present in the atmosphere, as established by the CAA. ***Table I.1-1*** identifies the six criteria pollutants and their associated NAAQS, based upon the mechanism of measurement.

The 8-hour ozone and $PM_{2.5}$ standards were promulgated by the U.S. Environmental Protection Agency (USEPA) in July of 1997. The attainment determinations for these new standards will not be made until the years 2000 and 2003-2004, respectively. A concern exists as to the ability of the PEIS study area, particularly the southeast portion, to maintain NAAQS compliance in the future, considering the expected growth rate. Below is a brief discussion of each criteria pollutant, and concerns related to that pollutant that may affect future activities within the PEIS study area.

I.1.1 Carbon Monoxide (CO)

CO is a colorless, odorless, gas formed when carbon in fuels is not completely burned. Emissions of this pollutant are primarily attributed to motor vehicles, which account for about 60% of the CO nationwide. In urban areas, motor vehicles are responsible for as much as 95% of the CO in the atmosphere. While motor vehicle emissions are a concern in the southeastern region of Florida as the population in this area is expected to continue to grow, sub-tropical climates such as those found in the PEIS study area, generally do not have problems in maintaining the CO NAAQS. Currently, the entire PEIS study area is in attainment for this criteria pollutant.

Table I.1-1. The Six Criteria Pollutants and Their Associated NAAQS.

Criteria Pollutant	Common Abbreviation	Measurement Period	Standard
Carbon Monoxide	CO	8-hour average	9ppm[1] 10 mg/m^3
		1-hour average	35ppm 40 mg/m^3
Lead	Pb	quarterly average	1.5$\mu g/m^3$
Sulfur Dioxide	SO_2	annual arithmetic mean	0.03ppm 80 $\mu g/m^3$
		24-hour average	0.14ppm 365$\mu g/m^3$
		3-hour average	0.50ppm 1300$\mu g/m^3$
Nitrogen Dioxide	NO_2	annual arithmetic mean	0.053ppm 100$\mu g/m^3$
Ozone	O_3	1-hour average[2] 8-hour average	0.12ppm 235$\mu g/m^3$ 0.08ppm 157$\mu g/m^3$
Particulate Matter < 10 microns Particulate Matter <2.5 microns	PM_{10} $PM_{2.5}$	annual average 24-hour average	50$\mu g/m^3$ 150$\mu g/m^3$
		annual arithmetic mean 24-hour average	15 $\mu g/m^3$ 65$\mu g/m^3$

[1] ppm = parts per million

[2] the 1-hour standard for areas demonstrating attainment has been revoked. As such, the PEIS study area is now only subject to the 8-hour ozone standard.

Attainment for this pollutant is defined as no more than one exceedence of the NAAQS in a calendar year. Carbon monoxide data for 1996-97 are presented in Table A-1 (see Attachment A), and demonstrate this region's compliance with the CO Standard.

I.1.2 Lead (Pb)

Since the ban on leaded gasoline, dramatic decreases in atmospheric lead concentrations have occurred, and industrial processes are now responsible for most violations of the Pb standard. The PEIS study area is no exception to this trend. Lead levels in this area are typically attributed to waste incineration. Currently, the study area is in attainment for the lead NAAQS, even though lead emission sources exist within the region. Concentrations of lead in the study area are well below the Pb NAAQS. Pb monitoring data for 1995-97 are presented in Table A-2 (see Attachment A), along with Pb emission values within the region.

I.1.3 Sulfur Dioxide (SO_2)

SO_2 forms when fuels such as coal and oil are burned, and during certain industrial processes such as smelting. Like many of the other criteria pollutants, SO_2 can bring about respiratory illnesses in humans and can also damage foliage on trees and agricultural crops. SO_2 and nitrogen oxides are the major precursors of acid rain. SO_2 emissions in Florida are primarily attributed to electric power generation. While the State is currently in attainment for this pollutant, occasional excursions above the standard have been reported. Air monitoring results from monitors within the study area are presented in Table A-3 (see Attachment A), for the years 1995-97. Title IV of the CAA requires that total annual SO_2 emissions be reduced by 40% from 1980 levels by the year 2010.

I.1.4 Nitrogen Dioxide (NO_2)

NO_2 is one of a category of compounds entitled nitrogen oxides (NO_x). NO_x is formed when fuel is burned at high temperatures. The NAAQS focuses on NO_2, the primary source of which is exhaust from motor vehicles and emissions from stationary sources, such as electrical utilities and industrial boilers. In addition to its effects on the respiratory system, this pollutant is a concern because it reacts in the atmosphere to form nitric acid, a component of acid rain. Nitrogen oxides also play a role in the formation of ozone, particulate matter, and regional haze and can contribute to eutrophication of water bodies through deposition and global warming (when in the form of nitrous oxide). At this time, the entire study area is in attainment for this criteria pollutant. Because NO_x emissions in the region are primarily generated by motor vehicles, the projected growth in Florida could impact the levels of this pollutant in the atmosphere within the PEIS region. Title IV of the CAA requires that by the year 2010, emissions of this pollutant will have been reduced by 10% from 1980 levels. Currently available data on levels of this pollutant throughout the study area for the years 1995-97 are presented in Table A-4 (see Attachment A).

I.1.5 Ozone (O_3)

Ground-level ozone is considered the most pervasive of the six criteria pollutants, and the hardest of the pollutants to control. Unlike the other criteria pollutants, ozone is not directly emitted to the atmosphere. Ozone forms through a series of photochemical reactions between NO_x and Volatile Organic Compounds (VOCs). Some of the more common sources of VOCs and NO_x are gasoline vapor, chemical solvents, and combustion of fuels. Often these precursors of ozone are emitted in one area, but travel to another before the ozone forming reactions take place. Ozone formation is influenced by prevailing meteorological conditions, population growth, and VOC to NO_x ratios in the atmosphere. While ozone in the upper atmosphere is beneficial, at ground level it can damage lung tissue, reduce lung function, and sensitize the lungs to other irritants. Ground level ozone also damages the foliage on trees and interferes with the ability of plants to produce and store food. Although the southeastern Florida and Tampa Bay areas (located just outside the northwestern edge of the PEIS study area) were originally listed as nonattainment areas for the 1-hour ozone NAAQS, they have recently been redesignated as "maintenance" areas, indicating their attainment status. The southeastern region of Florida, originally designated as a "moderate" nonattainment area for this pollutant, includes the counties of Dade, Broward, and Palm Beach. Currently covered by a maintenance plan for ozone, the southeastern region is expected to also meet the 8-hour ozone standard recently promulgated by the USEPA. Ozone monitoring data are presented in Table A-5 (Attachment A).

I.1.6 Particulate Matter (< 10 Microns (PM_{10}) and < 2.5 Microns ($PM_{2.5}$)

Particulate matter (PM) is the general term for solid, liquid or gaseous particles found in the atmosphere. This criteria pollutant is both emitted to (primary PM), and formed in (secondary PM) the atmosphere. Primary PM is typically emitted from industrial facilities, power plants, and open burning, and as fugitive dust from road work, construction projects, phosphate mining, and agricultural activities (e.g., plowing of fields). The recently promulgated $PM_{2.5}$ standard was imposed because smaller particles have been determined to cause adverse health effects, due to their ability to reach the lower regions of the respiratory tract. The ambient monitoring network for $PM_{2.5}$ will not be fully established and operational until 2000. At present, no violation of the PM_{10} standard has been recorded in Florida. Air monitoring results for PM_{10} for 1995-97 are presented in Table A-6 (Attachment A).

I.2 HAZARDOUS AIR POLLUTANTS

In addition to criteria pollutants, the CAA also regulates 188 Hazardous Air Pollutants (HAPs). These pollutants may present significant ecological threats and cancer and non-cancer health risks to urban populations. Many HAPs can be transported through the atmosphere over long distances and are persistent in the environment.

The Urban Air Toxics Monitoring Program (UATMP) was initiated in 1987 and provided an opportunity for State and local air agencies to obtain air toxic monitoring data. Normally, only one monitoring location is located in each city; however, some larger urban areas have two monitors. Under the UATMP, monitoring data were obtained for Fort Lauderdale (1989), Miami (1988, 1989), and Orlando (1990). Data from the UATMP indicate there is an increased probability for persons residing in these areas to contract cancer due to inhalation of the HAPs monitored. The respective increases in probability are 2.7 in 10,000 (primarily due to butadiene), 4.3

in 10,000 (primarily due to chloroform) and 3.3 in 10,000 (primarily due to butadiene), for the carcinogenic HAPs that were monitored. These numbers indicate the number of persons, in excess of what would be expected for that area, that are likely to develop cancer based upon typical exposures in the area. Additionally, all three areas demonstrated increased levels of concern for certain non-carcinogenic HAPs. Xylene was a concern in all three cities. Acrolein concentrations also presented a concern in Miami.

I.3 AMBIENT AIR MONITORING SITES

Ambient air monitoring sites for criteria pollutants throughout the United States are typically located in urban and suburban areas, and to a lesser extent in rural areas. The majority of monitoring sites are operated by state and local government agencies, with a few being operated by federal agencies and tribes. Data from monitoring stations are typically reported by the operating entity through a computer database operated and maintained by the USEPA. While most of the monitoring sites are located in urban and suburban areas, not all monitoring locations are selected based upon the same criteria. For instance, CO monitoring sites are located primarily to measure mobile source emissions, lead monitoring sites are placed to measure point source emissions, and SO_2 monitoring sites are almost always placed in populous locations. Generally, the selective placement, or the strategy behind how the monitoring sites are located, is based upon the premise of measuring ambient concentrations where the suspected sources are expected to have the greatest impact.

Within the counties of the study area, there are 57 criteria air pollutant monitoring sites spanning 10 of the 16 counties within the study area. These monitoring sites measure the concentrations of a variety of the six criteria pollutants in the atmosphere at a given time. Figure I.3-1 depicts the general locations of these 57 monitors. The list of analytes for each monitoring site is included in Attachment B. Of the 57 monitoring sites currently operational, 16 are located in Broward County, the largest number in any single county, and 12 are located in Dade County. Polk, which ties with Dade County for the largest number of criteria pollutant emitting sources, has only four monitoring sites. The 16 counties and the number of monitoring sites in each county are provided in ***Table I.3-1***.

While there have been special UATMP studies to measure ambient levels of hazardous air pollutants, there are no permanent HAP monitors in the PEIS area at this time, nor are any planned.

Table I.3-1. The Number of Air Quality Monitors in the 16 Counties of the Study Area.

County	Number of Monitors
Broward	16
Collier	1
Dade	12
Glades	0
Hendry	0
Highlands	0
Lee	3
Martin	1
Monroe	0
Okeechobee	0
Orange	7
Osceola	1
Palm Beach	10
Polk	4
St Lucie	2
Charlotte	0

I.3.1 Emission Sources

Approximately 73 "large" (see Attachment C) criteria air pollutant or pollutant precursor emission sources are present within the counties of the PEIS study area. Specifically**,** these sources are located within a majority of the 16 counties comprising the study area, and emit between one and four of the criteria pollutants per facility. The distribution of the large air emission sources within the study area is presented in ***Figure I.3.1-1***. As is depicted in this figure, almost one-half (40%) of the large sources are located in just two counties, Dade and Polk. Of the 73 large sources reporting criteria pollutant emissions, a approximately 65% are required to report NO_2 releases, approximately 45% of the reporting facilities emit SO_2, and approximately 35% are required to report VOC emissions.

Hazardous air pollutant sources in the study area are less well identified. Within Dade, Broward, and Palm Beach Counties, sources currently regulated by any of the twenty-two (22) existing Maximum Achievable Control Technology (MACT) standards have been identified. Dade County reports 329 HAP sources, Broward County reports 95 HAP sources and Palm Beach reports 400 HAP sources.

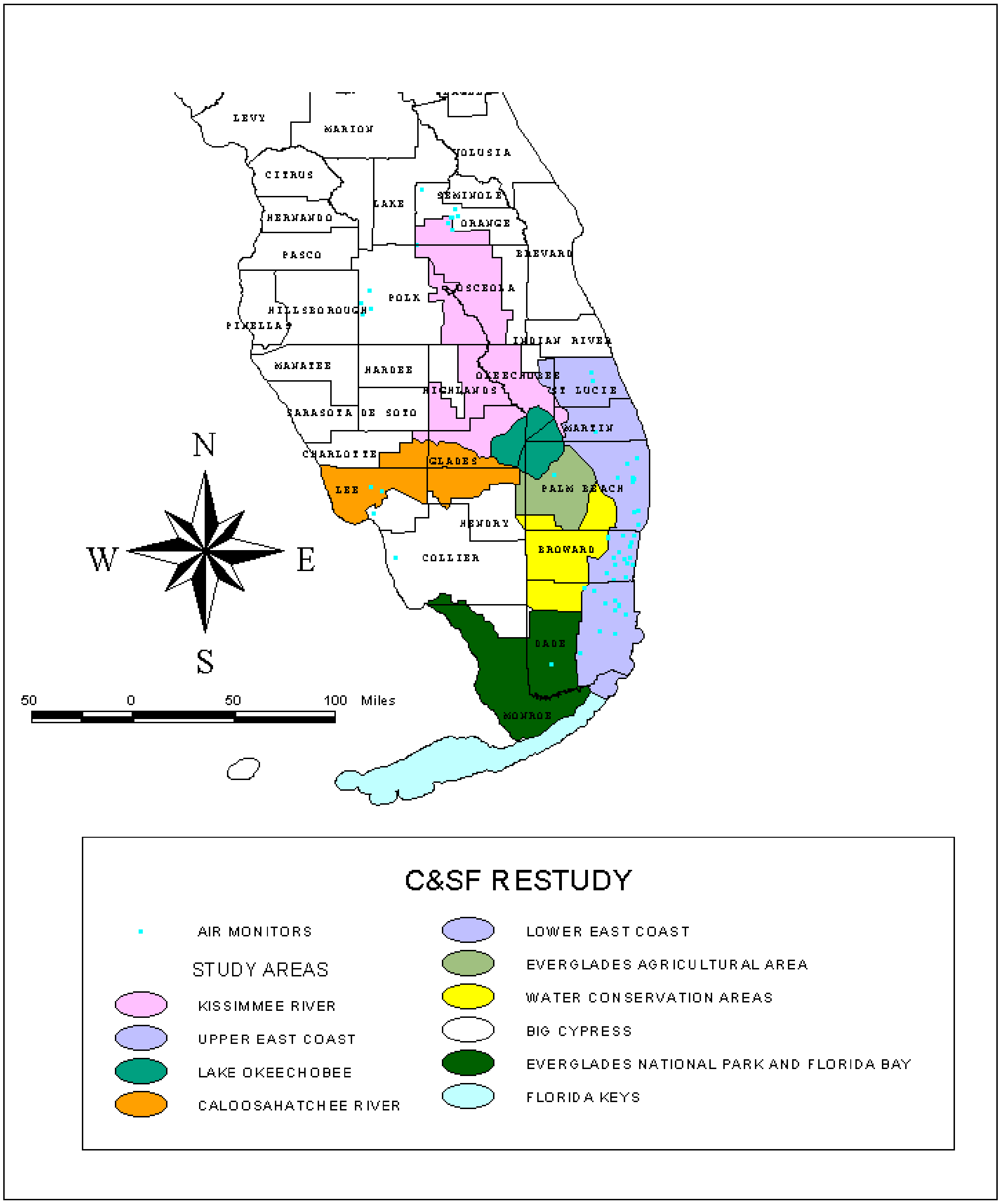

Figure I.3-1. General locations of the 57 criteria air pollutant monitoring sites within 10 of the 16 counties of the study area.

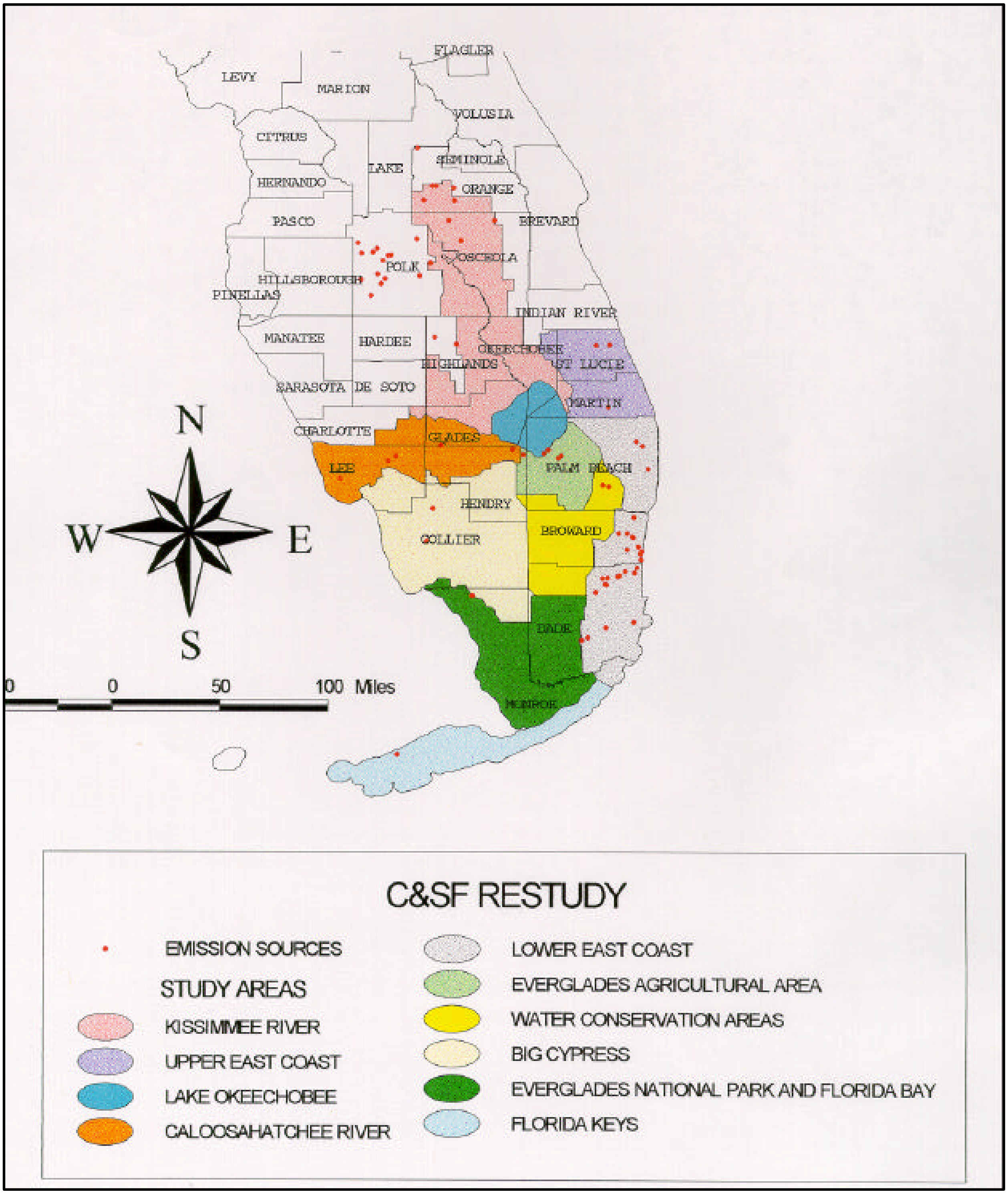

Figure I.3.1-1. The distribution of large air emission sources within the 16 counties of the study area.

I.3.2 Emission Restrictions

Because the southeastern portion of the study area is classified as an "Ozone Maintenance Area" under the CAA, it is required to have a Maintenance Plan to maintain attainment of the 1-hour ozone standard. The maintenance plan is an addendum to the State Implementation Plan (SIP) that requires the affected area to continue implementing the emission reduction measures that brought the area into attainment. This SIP also contains a contingency plan that will require additional emission reduction measures, should emission increases above target levels occur. As mentioned above, the existing Maintenance Plan was developed to comply with the 1-hour ozone standard which has now been revoked for this area, and only the 8-hour standard now applies. As a result, the State of Florida will be allowed to remove any contingency measures from the maintenance plan that are linked to the 1-hour ozone air quality standard; however, contingency measures related to controlling increases in emissions will remain.

Emission restrictions, or limits, exist for specified categories of industrial sources emitting hazardous air pollutants. These limits are outlined within the promulgated MACT standards. The specific HAP emissions controlled by any given MACT are dependent upon the industry subcategory and the HAP(s) that subcategory is expected to emit. MACT standards have been promulgated in three phases, with all but the final phase having been completed.

I.4 SPECIAL CONCERNS

Within the study area, work has been ongoing to address the issue of elevated levels of mercury in the Everglades. Mercury is a concern because it can be transformed in the environment to methylmercury, a persistent, bioaccumulative, toxic compound. Mercury, a HAP, can cause nerve damage in humans and wildlife that consume aquatic organisms, such as plankton and fish. Effects on Everglades wildlife resulting from mercury ingestion may include irregularities in the wading bird population and the death of at least one Florida Panther. The elevated mercury level in the Everglades, and its effects throughout the food chain, has resulted in fish consumption advisories and bans within the PEIS study area

Two of the major studies being conducted to determine the extent and nature of the atmospheric deposition of mercury into the Florida Everglades, the Florida Atmospheric Mercury Study (FAMS) and the South Florida Mercury Monitoring Study (SOFAMMS) have been completed. EPA funded part of each of these studies through grants to the State of Florida. The FAMS monitoring network has been dismantled, with the exception of three sites that are going to be maintained for the National Mercury Deposition Network (MDN), under the National Atmospheric Deposition Program. Although all field work is completed for SOFAMMS, data analysis still needs to be performed for some samples. Preliminary results of the FAMS indicate that the current primary source of mercury to the Everglades system is atmospheric; however, it is not known whether the mercury deposition to the Everglades is from local sources such as incinerators, or if it results from enhanced deposition of the global pool of mercury due to the unique climate of the area. Preliminary results of the SOFAMMS suggest that the form of mercury emitted by several incinerators may have a very short atmospheric half life. Annual average mercury emissions from South Florida are three times higher than the State average. MACT regulations for medical and municipal waste incinerators will reduce mercury emissions; however, it is unknown whether these emission reductions will adequately protect the South Florida ecosystem from the impacts of mercury deposition.

The estimation of mercury evasion from natural and anthropogenic sources, an assessment of trends in sediment mercury accumulation in South Florida, and the development of a method to measure reactive gaseous mercury in source gasses and at ambient levels are all underway by the State of Florida and the USEPA. USEPA Region 4 is currently surveying policies and regulations that are being used nationally and internationally to limit or ban mercury emissions. The Region is also working with the Office of Air and Radiation to insure that the South Florida research is integrated into national efforts on mercury under Section 112 of the CAA. The Office of Research and Development has been approached regarding additional South Florida mercury research needs. These needs include a determination of the acceptable mercury loading to the system, the relative contribution of local versus global sources of atmospheric mercury deposition, models and data required to establish mercury emission limits based on the protection of water quality and additional technologies to reduce mercury emissions. Specifically, future research is needed to identify and characterize emissions from key mercury emitting sources within the study area from Hillsborough, Dade, Broward, and Palm Beach Counties, including inputs from non-traditional sources such as sewage sludge aeration and landfill off-gassing. The vertical profile of mercury and reactive gaseous mercury within the atmosphere and the amount of dry deposition of mercury to the ecosystem must also be determined. Ultimately, modeling will be used to determine the atmospheric background and how mercury gets into the rainfall in South Florida.

Another issue of interest is the atmospheric deposition of NO_x . The deposition of nitrogen compounds through the atmosphere is a growing concern in South Florida. This concern has been drawing increased attention with the plans to lower anthropogenic phosphorous levels in the Everglades. These lower phosphorous levels may result in nitrogen becoming the driving factor in eutrophication.

I.5 REFERENCES

Several publications and internet web sites were consulted in order to develop Appendix I. These references were the Code of Federal Register (40 CFR 53); the State of Florida Administrative Code (F.A.C. 62-296) and statutes (Chapter 403); the website for the Broward County Department of Natural Resources Protection (1998: internet) Air Division; the website for the Florida Department of Environmental Protection (FDEP, 1998: internet) Division of Air Resources; the FDEP 1997 Earth Day Report (FDEP, 1997); and various USEPA publications, websites, and databases (USEPA, 1994a; 1994b; 1998: internet-a; 1998:internet-b; 1998: draft). The latter includes the USEPA AIRS database which incorporates AIRS-AFS (facilities emissions data) and AIRS-AQS (ambient air quality data). It also includes the USEPA web page (internet address: http://www.epa.gov/oar/aqtrnd96/) and the USEPA website known as "AIRSWeb" (USEPA, 1998: internet-a; internet address: http://www.epa.gov/airsweb) which provides portions of the AIRS database (see Attachment C).

ATTACHMENT A

ATTACHMENT A

AIR QUALITY MONITORING DATA

TABLE A-1. Carbon Monoxide Monitoring Data.

CARBON MONOXIDE, 3rd Highest 1 hr and 8 hr Maxima over 2-Year Period (in ppm)			
COUNTY	MONITOR LOCATION	1996 - 1997	
		1 hr	8 hr
Broward	Sunrise Blvd, Ft Laud	6.0	4.4
	Lincoln Park Elem.	7.1	4.8
	University Dr., Hollywood	5.5	3.8
	Pompano Beach	4.7	3.1
	Plunkett St, Hollywood	4.4	3.1
	State Road 207	4.3	2.9
Dade	16000 S. Dixie Hwy	3.3	2.2
	2201 SW 4 Street	8.7	4.4
	Metro Annex	6.8	3.6
Orange	Orange Ave, Orlando	8.7	4.3
	Morris Blvd, Winter Park	3.9	2.5
Palm Beach	Belvedere Road	3.7	2.5
	Cross County Mall	5.9	3.6

TABLE A-2. Lead Monitoring Data.

Lead, Quarterly and 24 hr Maxima (in µg/m^3)				
COUNTY	MONITOR LOCATION	1995	1996	1997
		Quart'ly	Quart'ly	Quart'ly
Broward	48 St, Pompano Bch.	.02	.05	.04
	Hollywood Blvd[a]	.05[b]	--	--
	Winston Park Blvd[c]	--	.05[d]	.04
Palm Beach	Jog Rd & Beeline Hwy	.00	.00	.00

(a) only 1995 data available
(b) data from 3rd and 4th quarters missing
(c) 1995 data unavailable
(d) data from 1st quarter missing

TABLE A-3. Sulfur Dioxide Monitoring Data.

SULFUR DIOXIDE, Maxima and Annual Mean (in ppm)										
COUNTY	MONITOR LOCATION	1995			1996			1997		
		24 hr	3 hr	Annual	24 hr	3 hr	Annual	24 hr	3 hr	Annual
Broward	Lincoln Park Elem	.009	.032	.002	.011	.039	.002	.014	.065	.002
Dade	FHP Depot, US 27	.006	.011	.002	.005	.010	.002	.004	.009	.001
Orange	Morris Blvd, Winter Pk.	.008	.025	.002	.011	.048	.002	.007	.023	.002
Palm Beach	15 Street, Riviera Beach	.026	.103	.002	.017	.069	.002	.016	.059	.002
Polk	Anderson & Pinecrest	.016	.070	.005	.027	.162	.006	.018	.051	.007
	4th Circle, Mulberry	.012	.042	.003	.021	.047	.004	.015	.064	.004

TABLE A-4. Nitrogen Dioxide Monitoring Data.

NITROGEN DIOXIDE, 1 hr Maximum and Annual Mean (in ppm)				
COUNTY	MONITOR LOCATION			
		Annual 1	Annual 1	Annual 1
Broward	NW 41 Str, Coral Springs	.009	.008	.009
	7000 N Ocean Dr, Dania	.011	.010	.010
Dade	Rosenstiel School	.008	.007	.007
	Metro Annex, 3rd Street	.015	.016	.017
Orange	Morris Blvd, Winter Park	.010	.013	.013
Palm Beach	Belvedere Road	.012	.012	.012

[1]This value is the annual average of all data collected

TABLE A-5. Ozone Monitoring Data.

OZONE, 4th Highest 1 hr Maximum over 3 Year Period (in ppm)		
COUNTY	MONITOR LOCATION	1995-97
Broward	NW 41 Str, Coral Springs	.087
	NE 48 Str, Pompano	.098
	Ocean Drive, Dania	.103
Dade	Krome Ave	.099
	Rosenstiel School	.099
	Old Cutler Rd	.103
	Everglades Nat'l Park	.086
Lee	SE 6 Ct, Cape Coral	.078
	School St & Bay St	.082
Orange	Winegard Rd, Orlando	.106
	Morris Blvd, Winter Park	.096
Osceola	West 192, Kissimmee	.096
Palm Beach	Okeechobee Blvd	.085
	NW 1 Ave, Delray	.089
Polk	James W. Sikes Elem	.097
	Sikes Blvd, Lakeland	.099
St Lucie	Rock Road, Ft Pierce	.082
Broward	NW 41 Str, Coral Springs	.067
	NE 48 Str, Pompano	.069
	Ocean Drive, Dania	.073
Dade	Krome Ave	.071
	Rosenstiel School	.074
	Old Cutler Rd	.075
	Everglades Nat'l Park	.066
Lee	SE 6 Ct, Cape Coral	.067
	School St & Bay St	.072
Orange	Winegard Rd, Orlando	.079
	Morris Blvd, Winter Park	.078
Osceola	West 192, Kissimmee	.075
Palm Beach	Okeechobee Blvd	.060
	NW 1 Ave, Delray	.068
Polk	James W. Sikes Elem	.079
	Sikes Blvd, Lakeland	.077
St Lucie	Rock Road, Ft Pierce	.067

TABLE A-6. Particulate Matter Monitoring Data.

PM$_{10}$, 24 hr Maximum and Annual Mean (in μg/m^3)							
COUNTY	MONITOR LOCATION	1995		1996		1997	
		24 hr	Annual	24 hr	Annual	24 hr	Annual
Broward	1000 E Sunrise Blvd	26	18	31	19	28	18
	Lincoln Park Elem	31	20	35	20	31	20
	SW 4th Ave, Ft Laud	--	--	--	--	26	19
	SW 70th Ave, Davie	21	15	28	17	23	16
	Plunkett Str, Hollywood	24	15	29	17	26	17
	Taft Str, Pembroke Pines	22	15	28	16	24	16
	Winston Park Blvd	--	--	25	15	21	15
	NW 72 Ave, Plantation	22	15	23	15	24	15
	NE 12 Str, Pompano	27	17	34	17	26	18
Collier	East Naples Fire Dept	25	16	29	16	28	18
Dade	7100 NW 36th Street	33	24	49	25	35	23
	NW 20 St & 12 Ave	36	25	49	28	37	26
	6400 NW 27 Ave, Miami	32	22	47	23	29	22
	NW 2 Str, Fire Station	41	29	47	27	41	22
Lee	Princeton Str, Ft Myers	24	16	32	17	29	18
Martin	16550 SW Warfield Blvd	--	--	33	19	31	18
Orange	Washington Str, Zellwood	29	17	28	17	36	19
	33 Str, Sheriff's Dept	38	25	41	25	44	26
	W Central & Parramore	33	21	35	21	40	23
	N Primrose Ave, Orlando	33	20	33	21	36	21
	Morris Blvd, Winter Park	28	18	51	22	35	20
Palm Beach	State Rd 80, Belle Glade	30	19	47	23	35	20
	Belvedere Rd	26	18	31	19	30	20
	3188 PGA Blvd	29	17	31	18	30	19
	S Congress Ave, Delray	26	18	29	19	29	21
Polk	Anderson & Pinecrest Rd	33	21	38	22	33	20
St. Lucie	SW Glades Cutoff	--	--	--	--	28	17

ATTACHMENT B

AIR MONITORING SITES AND CRITERIA POLLUTANTS MONITORED

ATTACHMENT B

AIR MONITORING SITES AND CRITERIA POLLUTANTS MONITORED

TABLE B-1. Air Monitoring Sites and Criteria Pollutants Monitored

MONITOR TABLE							
COUNTY	MONITOR LOCATION	CRITERIA POLLUTANT					
		CO	NO_2	O_3	Pb	PM_{10}	SO_2
Broward	12300 NW 41 Str		X	X			
	Coral Springs			X			
	12600 W Sample Rd		X				
	1000 E Sunrise Blvd	X				X	
	SW 4th Ave, Ft Laud					X	
	Lincoln Park Elementary	X				X	X
	SW 70th Ave, Davie					X	
	2900 S. University Drive	X					
	1951 NE 48th Str, Pomp.			X	X		
	851 SW 3 Ave, Pompano	X					
	Plunkett Str, Hollywood	X				X	
	3701 N. State Rd 207	X					
	Taft Str, Pembroke Pines					X	
	Winston Park Blvd				X	X	
	NW 72 Ave, Plantation					X	
	NE 12 Str, Pompano					X	
	7000 N Ocean Dr, Dania		X	X			
Collier	East Naples Fire Dept					X	
Dade	FHP, Route 27, Miami						X
	7100 NW 36th Street					X	
	Krome Ave, Thompson Pk			X			
	Rosenstiel School		X	X			
	Old Cutler Rd			X			
	Everglades Nat'l Park			X			
Dade (Cont.)	16000 South Dixie, Miami	X					
	NW 20 St & 12 Ave					X	
	2201 SW 4th Str	X					
	6400 NW 27 Ave, Miami					X	
	Metro Annex, NW 3rd Str	X	X				
	NW 2 Str, Fire Station					X	
Lee	Princeton Str, Ft Myers					X	
	SE 6th Ct, Cape Coral			X			
	School St & Bay St			X			
Martin	16550 SW Warfield Blvd					X	

COUNTY	MONITOR LOCATION	CRITERIA POLLUTANT					
		CO	NO_2	O_3	Pb	PM_{10}	SO_2
Orange	Washington Str, Zellwood					X	
	33 Str, Sheriff's Dept					X	
	7055 Winegard Rd			X			
	W Central & Parramore					X	
	N Primrose Ave, Orlando					X	
	No 1 Orange Ave, Orlando	X					
	Morris Blvd, Winter Park	X	X	X		X	X
Osceola	8706 W 192, Kissimmee			X			
Palm Beach	10999 Okeechobee Blvd			X			
	50 S Military Trail	X					
	State Rd 80, Belle Glade					X	
	Jog Rd & Beeline Hwy				X		
	3700 Belvedere Rd	X	X			X	
	4356 Okeechobee Blvd	X					
	3188 PGA Blvd					X	
	S Congress Ave, Delray					X	
	210 NW 1st Ave, Delray			X			
	1050 15th Str, West						X
Polk	Anderson & Pinecrest Rd					X	X
	NW 4th Circle, Mulberry						X
	James W Sikes Elem			X			
	1015 Sikes Blvd, Lakeland			X			
St Lucie	101 N Rock Road			X			
	SW Glades Cutoff					X	

ATTACHMENT C

CRITERIA USED IN SELECTING EMISSION SOURCES AND MONITORING DATA USED IN APPENDIX I

ATTACHMENT C
CRITERIA USED IN SELECTING EMISSION SOURCES AND MONITORING DATA USED IN APPENDIX I

The USEPA's web site AIRSWeb (http://www.epa.gov/airsweb) was used in gathering the data used in this report. Monitor Reports were used to gather information on all currently active ambient air criteria pollutant monitoring sites within the study area. The tables in Attachments A and B were developed using these reports. Source Reports were used to find information on the facilities within the study area. Source Reports include facilities that emit criteria pollutants in amounts sufficient to be designated "large" sources. Criteria pollutants are those for which the USEPA has set health-based standards. Based on AIRSWeb, ***Table C-1*** below lists criteria pollutants and the threshold amounts for designation as large sources (excerpted):

TABLE C-1. Criteria Pollutant Emission Thresholds (Tons/Year)

CO	Carbon Monoxide gas	1000
NO_2	Nitrogen Dioxide gas	100
SO_2	Sulfur Dioxide gas	100
VOC	Volatile Organic Compounds *	100
PT	Particulate Matter (total)	100
PM_{10}	Particulate Matter (<10 µm)	100
Pb	Lead particles	5

** VOCs are not criteria pollutants, but they are precursors of criteria pollutant ozone (smog).*

Disclaimer (excerpted from AIRSWeb):

AIRSWeb reports are produced from a monthly extract of the USEPA's air pollution database, AIRS. The Source Report data for this report were extracted on July 31, 1998. They represent the best information available to the USEPA from state agencies on that date. However, some values may be absent due to incomplete reporting, and some values subsequently may be changed due to quality assurance activities. The AIRS database is updated daily by state and local organizations who own and submit the data. Please contact the pertinent state agency to report errors.

Readers are cautioned not to infer a qualitative ranking order of geographic areas based on AIRSWeb reports. Air pollution levels measured in the vicinity of a particular monitoring site may not be *representative of the prevailing air quality of a county or urban area. Pollutants emitted from a particular source may have little impact on the immediate geographic area, and the amount of pollutants emitted does not indicate whether the source is complying with applicable regulations.*

ATTACHMENT D

ENVIRONMENTAL EFFECTS

ATTACHMENT D

ENVIRONMENTAL EFFECTS

EXECUTIVE SUMMARY

Air Quality: In general, the Recommended Plan (Alt. D13R) and the other action alternatives (Alt. A, B, C) are not expected to significantly impact the air quality of the South Florida project area of the C&SF Restudy. While some short-term impacts are predicted, the overall long-term direct air quality impacts due to the project would either be negligible (no effects) in southern regions or be slightly positive (beneficial effects) in northern regions. No regions are expected to experience negative long-term air quality impacts due directly to the project.

Air Quality

This section discusses the air quality impacts of the four alternatives considered in the C&SF Restudy PEIS. These four alternatives consist of three action alternatives, Alternatives A, B, and C, and the Initial Draft Plan (IDP), Alternative D13R. The IDP (= PEIS Preferred Alternative or Preferred Plan) will eventually evolve into the Recommended Plan through further study design. In addition to air quality impacts, mitigative measures that can be used to lessen impacts will be identified and explored where short-term impacts have the potential to be detectable. Overall, it is expected that none of the proposed alternatives will have a long-term detrimental impact on air quality in the study region. In fact, some activities may have a slight, net positive impact on air quality. These positive impacts would mostly be associated with changes in land use. Negative impacts resulting from the implementation of the IDP or any of the other alternatives will be of limited duration, and solely related to dredging, excavation, and/or construction activities.

Table D-1 provides a summary of the activities expected to have an impact on air quality. The regions identified within the “Locations” column correspond to the regions identified within the Component Summaries on the South Florida Water Management District’s [SFWMD] Central and Southern Florida Restudy Web Page. This web page is located at the following address: http://www.sfwmd.gov/org/pld/restudy (SFWMD, 1998: internet).

Impacts on Attainment Status of Criteria Pollutants

It is not expected that implementation of the IDP or any of the action alternatives will negatively impact the long-term attainment status of the PEIS study area. Some short-term impacts are expected, however. Of the pollutants for which National Ambient Air Quality Standards (NAAQS) exist, the standard for particulate matter less than ten microns in diameter (PM_{10}) is the most likely to be measurably impacted on a short-term basis. Particulate matter levels in the Lake Okeechobee, Everglades Agricultural Area, Water Conservation Areas/Everglades National Park, and the Water Preserve Areas are likely to increase over the short-term as a result of any of the four alternatives being selected. This short-term increase will be associated with earth-moving activities required to accomplish the proposed construction activities. Alternatives C and D13R will result in a short-term increase in particulate matter in the Lower East Coast region. No measurable negative impact on the NAAQS attainment status or existing air quality is expected as a result of these activities.

Slight long-term improvements in air quality are likely. These improvements will occur due to changes in land use from agricultural to uses such as water storage and impoundments. This change in land use may result in slight improvements in carbon monoxide, nitrogen dioxide, ozone, particulate matter, and hazardous air pollutant levels. Table D-2 below provides a summary of impacts over the long and short term for each pollutant evaluated for the C&SF Restudy**.**

Table D-1. Comparison of Action Alternative

LOCATION	ALTERNATIVE A	ALTERNATIVE B	ALTERNATIVE C	ALTERNATIVE D13R
Lake Okeechobee	- construct storage reservoirs N, E, and W of the Lake	No Change From A	No Change From A	No Change From A
Everglades Agricultural Area	- construct storage reservoirs	No Change From A	in addition to A: - operate second reservoir as "dry storage" and subdivide it into 2 - 20,000 acre compartments	No Change From C
Water Conservation Areas / Everglades National Park	- relocate S-345 structures	-relocate and increase capacities of S-356 pumps -decompartmentalize the WCA-3 - eliminate additional S-345 structures in L-67A - relocate S-140 pump station -relocate L-31N levee	in addition to A & B: - dredge L-29 south of WCA-3B - maintain L-28 & L-29 levees - replace S-345 structures	in addition to A, B, & C: - remove L-28 tie back levee - increase S-140 pump station capacity - remove S-344, S-343 A & B, and S-12 structures -backfill L-67A canal south of S-345 structures - backfill Miami canal
Other Natural Areas	NO ACTIVITY	NO ACTIVITY	-modify west feeder canal structure S-190 of the L-28 interceptor canal	No Change From C
Water Preserve Areas	- construct water preserve areas for site 1, C-9, and C-11 STAs/impoundments, Central Lake Belt im-ground storage area, and Bird Drive recharge area	- add water preserve areas for North Lake Belt Storage area and Palm beach County Agricultural Reserve Reservoir	in addition to A & B: - modify North Lake Belt storage area - modify Palm Beach County Agricultural Reserve reservoir	in addition to A, B, & C: - increase size of Site 1 impoundment -increase storage in southern L-8 basin by 1,200 acres
Lower East Coast	- construction of canal improvements to Broward County secondary canals - construct pump facilities	NO ACTIVITY	- extend C-111N spreader canal east of Card Sound Road	in addition to C: - construct storage reservoir as part of L-8 project - increase pump capacities of Broward secondary canals - improve Dade/Broward levee - add 2 control structures to C-4 canal

Table D-2. Anticipated Direct Short- and Long-Term Impacts on Levels of Each Criteria Air Pollutant.

POLLUTANT		**CO**	**Pb**	**SO_2**	**NO_2**	**O_3**	**PM_{10}**	**$PM_{2.5}$**	**HAP**	**Overall**
IMPACTS	Short-term	0	-	0	0	0	-	0	0	slight -
	Long-term	+	0	0	+	+	+	+	+	+

NOTE: "+" indicates a positive impact (i.e. lower levels), "0" indicates no impact and "-" indicates a negative impact (i.e. increasing levels) on emissions of that pollutant or its precursors.

Carbon Monoxide (CO)

Evaluation of the IDP and the other action alternatives reveals that there may be only a negligible impact on CO emissions within the study area. CO emissions are typically associated with motor vehicle use, and the proposed alternatives primarily alter water flow and storage within the Everglades. Any short-term impacts will be associated with the operation of heavy equipment used to excavate and create reservoirs, impoundments, water preserve areas, etc. These impacts will not only be short term, but will also be intermittent in nature and likely offset by the cessation in use of agricultural equipment. Thus, CO levels in the study area will not be measurably impacted by any of the proposed alternatives in the short term. Over the long term, a slight positive impact on air quality may be attained. This positive impact can be attributed to the removal of land from agricultural use, resulting in a decrease in emissions from farm equipment.

Lead (Pb)

Existing lead emission levels and atmospheric concentrations will not likely be significantly affected by the IDP or the other action alternatives on a long-term basis. Recent lead emissions in the study area are associated with waste incineration. However, there is the possibility that historic lead deposits attributable to atmospheric deposition could be re-suspended by excavation and earthmoving activity. This lead would have been atmospherically deposited as a result of leaded gasoline usage prior to the 1980's. Because activities being undertaken as part of the C&SF Restudy are construction/excavation related activities, and do not involve burning or incineration, it is likely there will only be a negligible short-term negative impact on air quality in the study region. Regardless of this short-term impact, there is a high probability there will be no detectable long-term impact on lead levels in the atmosphere.

Sulfur Dioxide (SO_2)

None of the four proposed alternatives will affect existing sulfur dioxide emission levels. Within the study area, emissions of sulfur dioxides are normally associated with the burning of coal and oil by electric utilities. Because none of the four alternatives are likely to cause an appreciable increase in electric power consumption in the region, no impacts on existing SO_2 levels in the atmosphere are expected.

Nitrogen Dioxide (NO_2)

Emissions of nitrogen dioxide within the study area are typically associated with exhaust emissions from motor vehicles and emissions from stationary sources such as industrial boilers and electric utilities. All four of the proposed alternatives involve some construction activity. Normally, construction activities involve the use of heavy equipment which emit similar pollutants to motor vehicles. Considering the planned construction activities of all four alternatives, it can be deduced that some NO_2 emissions will occur as a result of implementing any of the proposed alternatives. However, such emissions will be negligible when considered in conjunction with emission levels expected from routine motor vehicle and stationary source operation within the region. In fact, no net change in NO_2 emissions will likely occur over the region as a whole due to a deceased level of agricultural equipment use in some portions of the study area. Thus, implementation of any of the proposed alternatives will not appreciably affect short term attainment of the air quality standard for NO_2 within the region, and may even reduce NO_2 levels slightly in the long term.

Ozone (O_3)

Although the study area is currently designated as a “maintenance” area for this air quality standard, it is not expected that implementation of any of the four proposed alternatives will have a significant impact on ozone levels in the short term. Ozone levels in the atmosphere are influenced by the levels of volatile organic compounds (VOCs) and nitrogen oxides (NO_x), as well as by meteorological conditions. Negligible amounts of additional NO_x emissions are expected to be generated over the short-term, regardless of which alternative is implemented, due to emissions from construction equipment, as mentioned previously (Section 8.1.3.1.4: *Nitrogen Dioxide*). Nevertheless, these will be offset by a reduction in use of agricultural equipment within the region. Therefore, it is unlikely there will be any increase in ozone levels within the study area as a result of the IDP or any of the other action alternatives being implemented. Over the long term, a slight positive impact on air quality may be attained. This positive impact can be attributed to the removal of land from agricultural use, resulting in a decrease in ozone precursor emissions from farm equipment.

Particulate Matter Less Than 10 Microns in Diameter (PM_{10})

As stated earlier in the Existing Conditions Section (3.1.3: *Air Quality*), particulate matter is the general term for solid, liquid, or gaseous particles found in the atmosphere. PM_{10} refers to coarse particles associated with open burning and fugative dust emissions from road work, construction projects, mining, and plowing of agricultural fields. As noted earlier in this section, all four alternatives proposed involve either construction activities, excavation, or earth moving. Additionally, it is conceivable that some open burning of vegetated land may be performed as part of the clearing process to prepare for construction, excavation, or earth moving activities. Although a significant increase in coarse particulate matter is expected during implementation of the IDP or any of the other action alternatives, it is unlikely that the air quality standard for particulate matter will be exceeded.

On a long-term basis, the Everglades Agricultural Area (EAA) dry storage reservoir planned under Alternatives C and D13R, will increase particulate matter levels in the air if dust suppression techniques are not employed while the area is dry. However, the removal of lands from agricultural use through the construction of storage reservoirs will provide a net positive impact on particulate matter levels. This positive impact will be achieved through the reduction of particulate matter associated with plowing and sugar cane harvesting. If either action Alternative A or B is implemented, a net overall improvement in particulate matter levels will be realized.

Some mitigative measures that can be undertaken to reduce particulate emissions include wetting down of un-vegetated areas with water for dust control, and completely covering excavated materials with tarps or other impervious materials. These actions will prevent particulates from becoming airborne prior to the materials being spread or transported off site. By timing activities according to favorable meteorological conditions, emissions of coarse particulate from open burning can also be minimized. These activities will keep the suspension of particulate matter to a minimum during associated Restudy operations.

Considering the goal of the C&SF Restudy is to hydrologically restore South Florida and increase the acreage of wetted areas (e.g., additional surface water storage reservoirs and increased hydroperiods for existing wetlands), the chance of natural (lightning) peat and other fires in South Florida may decrease. As such, the Restudy could reduce the amount of PM_{10} emissions associated with natural open burning as well.

Particulate Matter Less Than 2.5 Microns in Diameter ($PM_{2.5}$)

Particulate matter less than 2.5 microns in diameter, also called fine particulates, is associated with emissions from industrial facilities, power plants, and combustion processes. As noted earlier, all four proposed alternatives will result in short-term emissions from construction equipment involved in excavation and earth moving. Any increase in $PM_{2.5}$ emissions associated with the IDP or the other action alternatives may be offset in the short-term by an associated reduction in agricultural equipment emissions and associated agricultural activities. The long-term reduction in agricultural activity associated emissions will lead to a net decrease in $PM_{2.5}$ levels.

Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs) are typically released by identifiable air pollution sources, such as chemical plants, industrial operations, dry cleaners, printing plants, and motor vehicles. The Clean Air Act lists 188 HAPs for regulation based upon their potential for adverse health and/or environmental impact. Regulation of these 188 HAPs occurs through Maximum Achievable Control Technology (MACT) regulations directed at controlling HAP emission sources. The activities proposed under the IDP and the other action alternatives involve redirecting water flow and construction of levees, pump stations, and water impoundment areas. Because the associated activities do not involve any of the regulated industries under the MACT standards, no additional industrial-related emissions of hazardous air pollutants are expected regardless of which alternative is implemented. However, it must be noted that HAP emissions are also attributed to emissions from motor vehicles such as cars, buses, and trucks. Consequently, it is expected that some additional emissions of HAPS, such as formaldehyde and benzene, will be generated on a short-term basis as a result of construction equipment operation. Nevertheless, these emissions will be negligible when compared to routine emissions from automobiles and other mobile sources in the study area. Therefore, no significant short-term or long-term increases in HAP emissions are expected. In fact, a slight long-term decrease in HAP emissions associated with reduced agricultural activities may occur as a result of implementing any of the proposed alternatives.

Emission Sources and Restrictions

No permanent new emission sources will be created as a result of implementation of the IDP or any of the other action alternatives. Although a short-term increase in mobile source emissions may occur through the introduction of construction vehicles, it is expected that on a net basis, no increase will be realized. The no net increase in mobile source assumption is based upon the presumption that local contractors will be used to perform construction related activities, thus simply repositioning the sources from one location within the project area to another. In the long term, no change in the number or type of regulated emission sources is expected as a result of this project.

No new emission restrictions beyond those identified within the Ozone Maintenance Plan for this area. However, should any criteria pollutant standard be violated, provisions exists within the Clean Air Act and the Florida State Implementation Plan (SIP) to impose additional restrictions.

Special Concerns

Special concerns previously mentioned in the Existing Conditions Section (3.1.3: *Air Quality)* relate to mercury. Regarding mercury emissions, although no new emission sources will be created, nor will the emissions of existing sources be affected, activities are planned within areas of the Everglades where mercury in fish, soil and sediments is a concern. Mitigative measures to prevent volatilization of mercury from dredged/excavated sediments and soils should be implemented in these areas. Areas with a potential for the presence of mercury in dredged sediment or excavated soil are Water Conservation Areas 1, 2 and 3, and the Everglades National Park.

Indirect Air Quality Impacts

In addition to the discussed direct air quality impacts of the Restudy, consideration should also be given to indirect impacts. From an indirect impact perspective, the levels of several air quality pollutants associated with development (e.g., ozone) may increase over the project horizon (2050). Given that the Restudy proposes new water supplies and water reuse projects for public drinking water consumption, the potential for continued development and population growth in South Florida is enhanced beyond what is currently projected. If so, additional infrastructure development attendant with increasing populations (e.g., power plants with associated emissions) can also be expected. Although continued development in South Florida is projected even without implementation of the Restudy, the construction of water supplies at relatively inexpensive consumer cost and the increased availability of power, increases this likelihood of development and the associated air quality emissions as well as other sources of pollution, beyond what is currently projected for the region. Therefore, based upon the preceding scenario, air pollution in the study area could measurably increase over what is currently projected for this region. This increase could ultimately be offset by further promulgation of MACT and implementation of projected Clean Air Act air pollution controls, such as the Residual Risk provisions of Section 112(k).

Summary

Table D-3 provides a summary of expected direct air quality impacts by the action alternatives, including the IDP. Impacts are presented for several geographic areas within the study region. The “Locations” within the table correlate with the components identified in the Component Summaries found on the South Florida Water Management District Central and Southern Florida Restudy Web page (SFWMD, 1998: internet).

Table D-3. Summary of Direct Air Quality Environmental Effects.

Location	Alternative A		Alternative B		Alternative C		Alternative D13R	
	short-term	long-term	short-term	long-term	short-term	long-term	Short-Term	long-term
Lake Okeechobee	-	+	-	+	-	+	-	+
Everglades Agricultural Area	-	+	-	+	-	+	-	+
Water Conservation Areas/ Everglades National Park	-	0	-	0	-	0	-	0
Other Natural Area	0	0	0	0	-	0	-	0
Water Preserve Areas	-	0	-	0	-	0	-	0
Lower East Coast	-	0	0	0	-	0	-	0

NOTE: "+" means beneficial effects, "0" means no effects, and "-" indicates negative effects. Further explanation of each alternatives affect on air quality is provided within this section.

ATTACHMENT E

REFERENCES CITED
LIST OF ACRONYMS AND ABBREVIATIONS

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APPENDIX J

EXISTING CONDITIONS

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APPENDIX J

EXISTING CONDITIONS

The area covered by this study involves a significant portion of the State of Florida. This appendix describes the existing physical, ecological, and socio-economic conditions within this large study area. The study area has been arranged, purely for organization purposes for the NEPA document, into ten physiographic regions as depicted in ***Figure J.1-1***. Within ***Appendices J and K***, a regional overview of the study area is discussed first, followed by each of the ten physiographic regions, individually and in greater detail. The physiographic regions are: Kissimmee River, Lake Okeechobee, Upper East Coast (Martin and St. Lucie Counties), Caloosahatchee River, Everglades Agriculture Area, Lower East Coast (Palm Beach, Broward, and Miami-Dade Counties, including Biscayne Bay), Water Conservation Area (including the WCAs and Holey Land and Rotenberger Wildlife Management Areas), Everglades National Park (including Florida Bay, Whitewater Bay, and the Ten Thousand Islands), Big Cypress (the entire Big Cypress Basin, including the southwest coast from Estero Bay to Everglades City, and the Big Cypress National Preserve), and the Florida Keys.

J.1 REGIONAL OVERVIEW

The following section provides a comprehensive regional overview of the existing physical, ecological, and socio-economic conditions within the study area described above.

J.1.1 Geology and Soils

The following section is a discussion of the geology and soils of central and south Florida, resources that determine, in conjunction with rainfall, evapotranspiration and other factors, the hydrologic framework and ultimately the ecological framework for this study. This section does not strictly adhere to the regional organization described above due to geologic formations which extend beyond hydrologic and other boundaries used to define the physiographic regions.

J.1.1.1 Geology of Project Area

Geologic units exposed at land surface in southern Florida have been mapped by Puri and Vernon (1964) and Brooks (1981), and have been presented in detailed county maps by the Florida Geological Survey. The surficial geology is extremely important to environmental issues such as land use, waste disposal, surface- and

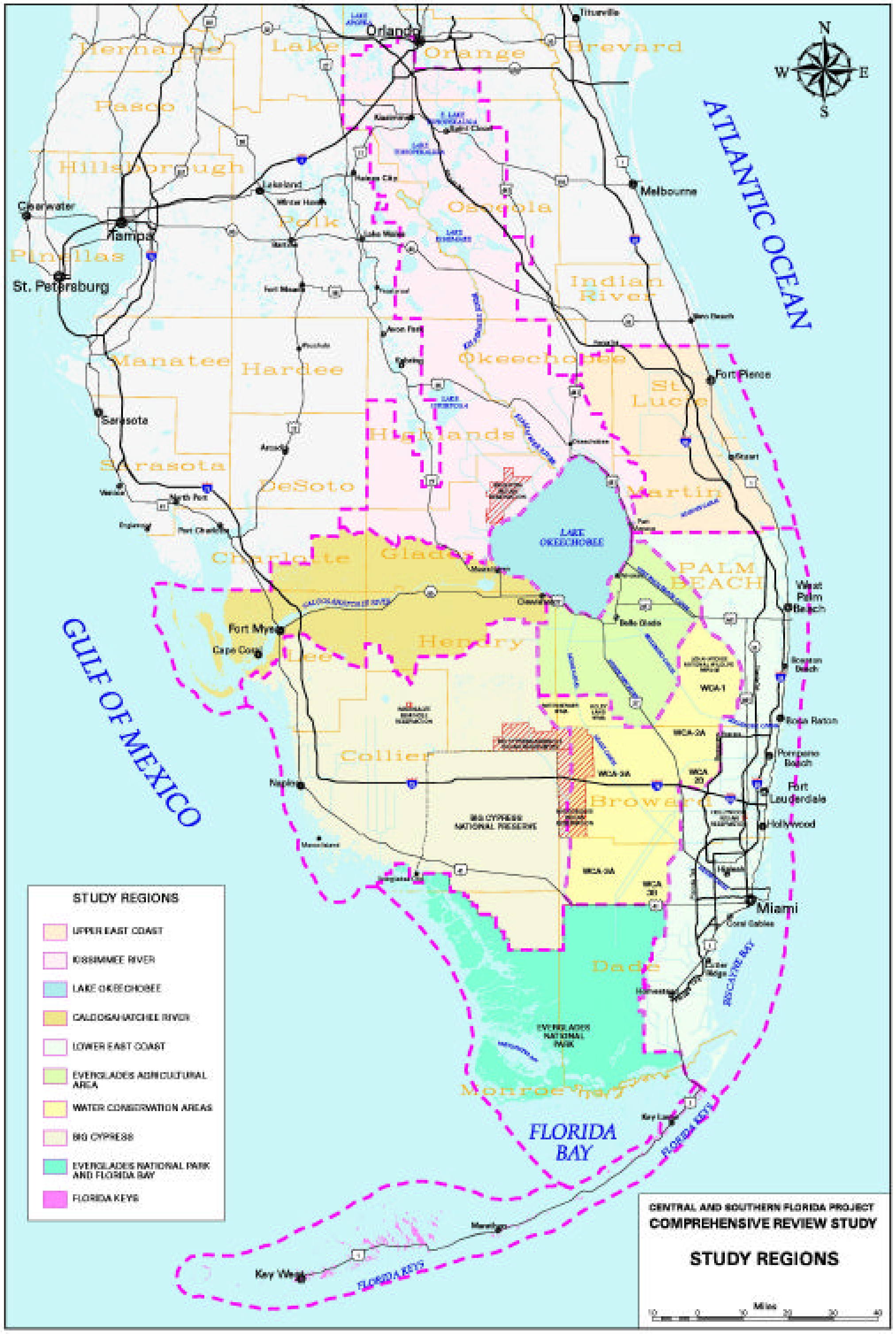


Figure J.1-1 Study Regions

groundwater quality, drainage, ground water recharge, physiographic characteristics, and ecological zonation.

The surficial geology described by Puri and Vernon (1964) generally corresponds to the distinct regions that have been identified for discussion within the draft PEIS. The lithology of geologic units that are at or near land surface plays a major role in determining the physiography by controlling drainage, elevation, soil development, recharge and runoff, and the dominant ecological environment.

The Kissimmee River region is underlain by marine and estuarine terrace deposits of Pleistocene to Holocene age, including fine- to medium-grained Pamlico sands. The Kissimmee River basin is poorly drained due to the low permeability of these siliciclastic sediments. To the south these insoluble sediments thin and become more carbonate. The higher elevations at the southern end of the Lake Wales Ridge and the Eastern and Southwestern Flatwoods provinces are underlain by the Hawthorn Group and a thin fine-grained sand veneer. The Caloosahatchee Formation, a highly variable lithologic unit, underlies the northern perimeter of Lake Okeechobee and extends to the southwest, north, and east of the Big Cypress Swamp basin.

Upper East Coast and Caloosahatchee River regions - Drainage within the Upper East Coast and the Caloosahatchee River basin formed on top of the Anastasia Formation, a variably shelly, sandy limestone. In the southwestern region, the higher elevation associated with the Immokalee Rise is an accumulation of sands overlying the Caloosahatchee Formation.

Lake Okeechobee, Everglades Agriculture Area, the Water Conservation Area regions - These areas developed primarily on top of the Fort Thompson Formation (Pleistocene age), a formation comprised of interbedded sand, shell and limestone and to the south, the Tamiami Formation of Pliocene age. The quartz sand content within the Fort Thompson Formation and the Miami Limestone decreases southward and the ridges change from quartz dominated coastal ridges to wider oolite shoals.

Lower East Coast - Thin sand and the Miami Limestone underlie most of the Lower East Coast and form the highest elevations in the area corresponding to the Atlantic Coastal Ridge. These units are highly permeable and higher elevations are well drained. The oolitic facies of the Miami Limestone is breached by numerous shallow sloughs, further enhancing drainage. Coastal marshes form at lower elevations and within the breaches created by the sloughs. The higher elevations of the Lower East Coast and Atlantic Coastal Ridge are due to the cemented deposits of the Anastasia Formation to the north and the Miami Limestone to the south.

Florida Keys - The shape, size, and hydrologic characteristics of these islands are based on geologic differences (White, 1970). The Upper Florida Keys are narrow islands oriented northeast/southwest and are made up of exposed Pleistocene age coral reefs known as the Key Largo Limestone (Perkins, 1977). The Key Largo Limestone is highly permeable and has non-uniform porosity development due to the highly variable texture of the reef deposits. The Lower Florida Keys are underlain by the Miami Oolite which was originally formed as oolitic shoals like those to the north in the southern part of the Atlantic Coastal Ridge. The permeability of the Miami Limestone (oolite facies) is an order of magnitude less than that of the Key Largo Limestone. These islands are generally larger than those in the Upper Keys and are oriented in a northwest/southeast direction. The areal expanse of these islands and the homogenous texture and lower permeability of the limestones cause freshwater lenses (up to 20 feet thick) and ponds to accumulate more readily (Vacher and others, 1992).

The Big Cypress region - This area developed on top of the sandy, marly, fossiliferous limestone and sand of the Tamiami Formation of Pliocene age.

Lower West Coast, Ten Thousand Islands, Whitewater Bay - The variation observed in these 3 regions is related to the change from a sand covered limestone to an exposed limestone surface. In the Lower West Coast, from the Caloosahatchee River basin to Naples, there is significant sand cover that has been modified by coastal processes, with oyster bars scattered throughout. Ten Thousand Islands is a transitional region where some sand is available to create barrier islands, but is underlain primarily by the Tamiami Formation. Because of the low relief, numerous marshy backbays or lagoons, such as Whitewater Bay, occupy exposed limestone surfaces behind the slightly higher sand buildup of Cape Sable. Drainage east of Whitewater Bay, along the sloughs of the Everglades, is primarily across exposed Tamiami Formation and the bryozoan facies of the Miami Limestone between Cape Sable and the Lower East Coast (Hoffmeister and others, 1967).

Florida Bay - Florida Bay consists of open water and isolated islands. It is underlain by the burrowed bryozoan facies of the Miami Limestone. Sediment cover is highly variable consisting of open sand, exposed bedrock, and mudbanks (Prager, 1997).

J.1.1.2 Hydrostratigraphy

Much of the work in identifying, mapping and describing the geologic units within southern Florida has been done in an effort to understand the hydrologic resources of the area. The relation between the carbonate units and the interfingering siliciclastic sediments (quartz rich sand) controls numerous environmental aspects of the south Florida ecosystem mainly due to the profound influence these units have on the movement of water. Along with stratigraphic names, these units also are delineated as hydrologic units based on their hydraulic properties.

In general, the southern part of the Florida carbonate contains three major aquifer systems: the surficial aquifer system, the intermediate aquifer system/ intermediate confining unit, and the Floridan aquifer system (Klein, et al. 1975; Causarus, 1985; Fernald and Patton, 1986; Southeastern Geological Society, 1986; Miller, 1986; Causarus, 1987; Johnston and Miller, 1988; Fish and Stewart, 1991; McPherson and Halley, 1997; Miller 1997).

J.1.1.3 Surficial Aquifer System

In southern Florida, because the Floridan and intermediate aquifer systems are saline or have low yield, practically all municipal and irrigation water is obtained from the surficial aquifer system. The surficial aquifer system comprises all the rocks and sediments from land surface to the top of the intermediate confining unit. The discontinuous and locally productive nature of the shallow water bearing units reflect the complex interfingering of lithologic units throughout southern Florida (Causarus, 1985, 1987; Fish and Stewart, 1991; Weedman and others, 1997). Surficial aquifers of southern Florida include: the Biscayne aquifer, the undifferentiated surficial aquifer, the coastal aquifer of Palm Beach and Martin Counties and the shallow aquifer of southwest Florida. As more mapping and hydrologic investigations are completed, it is likely that additional surficial aquifers will be delineated within this system.

The Biscayne aquifer is a highly productive unconfined aquifer that underlies parts of Miami-Dade, Broward, and southern Palm Beach Counties. It is wedge shaped, highly permeable, and is more than 200 feet thick in the Atlantic Coastal Ridge and thins to a feather edge about 35 to 40 miles west in the Everglades.

Several unconfined surficial aquifers have been identified within the surficial deposits of quartz sand, shelly beds of the Anastasia Formation, shelly limestone of the Tamiami Formation, and limestone units of the upper Hawthorn Group. Although these local, discontinuous, unconfined, shallow aquifers are not as productive as the Biscayne aquifer, they are an important source of water for Martin, Palm Beach, Hendry, Lee, Collier, St. Lucie, Glades and Charlotte Counties (Hyde, 1975).

The coastal aquifer of Palm Beach and Martin Counties occurs within the Anastasia Formation, which is composed of discontinuous permeable limestone interbedded with thick sand sections. This aquifer is about 250 feet thick near the coast and thins inland, becoming more mineralized. Maximum yield has been determined to be 1,000 gallons per minute.

The shallow aquifer of southwest Florida provides an important source of potable water to the municipal communities of southwestern Florida. This aquifer is wedge shaped; ranging from 130 feet thick near Naples to between 60 and 80 feet in the central part of Collier County, thinning to a feather edge near the east edge of the county. The permeability decreases to the west and the aquifer is thickest and most productive in the solution-riddled limestone of the Tamiami Formation in central and west-central Collier County. Maximum yield is 2,500 gallons per minute.

In the Florida Keys, the lack of freshwater resources requires that potable water supplies are piped in from wellfields near Homestead. The Miami Limestone (oolite and Key Largo facies) is highly permeable. In some areas, particularly in the larger islands of the lower oolite Keys, freshwater or brackish water lenses may occur. Although ground waters generally have salinities equal to or greater than sea water, sewage effluent and waste disposal within these units may contribute to a decrease in salinity and an influx of nutrients (Shinn and et al. 1994).

J.1.1.4 The Intermediate Aquifer System / Intermediate Confining Unit

The intermediate aquifer system consists of beds of sand, sandy limestone, limestone, and dolostone of Oligocene to Pliocene age that dip and thicken to the south and southwest. It includes the Tampa Member, the undifferentiated Arcadia Formation, and the Peace River Formation, all of the Hawthorn Group, and the Tamiami Formation. In southwestern Florida (Lee and Collier Counties), the intermediate aquifer system is under confined conditions and is used as a source of potable water. The transmissivity values reported for the aquifer system are 10,000 ft^2/d or less and yields are highly variable (Miller, 1997). To the south and east the clay content increases and the aquifer system becomes predominantly a low permeability clay forming the intermediate confining unit (SEGS, 1986). In much of southern Florida, the intermediate confining unit effectively separates the surficial aquifer system from the Floridan aquifer system. Although the extent of the intermediate aquifer system is limited to southwestern Florida, local water-yielding zones in the Hawthorn Group exist along the east coast of Florida, but are not considered part of the intermediate aquifer system (Miller, 1997).

J.1.1.5 The Floridan Aquifer System

The Floridan aquifer system is a thick sequence of carbonate units, including the Avon Park Formation of Eocene age, the Ocala Limestone of Eocene age, the Suwannee Limestone of Oligocene age, and the Arcadia Formation of the Hawthorn Group of Oligocene to Miocene age (Miller, 1986, 1997). Less permeable carbonate units, referred to as the middle confining unit, separate the system into two major aquifers called the Upper and Lower Floridan aquifers. North of Lake Okeechobee, the Floridan aquifer system yields freshwater although it is more mineralized (total dissolved solids are greater than 1,000 mg/L) along coastal areas and in southern

Florida (Sprinkle 1989). In southern Florida, more than 600 feet of low permeability siliciclastic sediments confine this aquifer and create artesian conditions. Although the head gradient is upward, the low permeability units prevent significant upward migration of saline waters into the shallower aquifers. Depth to the Floridan aquifer is approximately 400 feet near Naples and 900 feet in coastal Miami-Dade County (Klein and others, 1975). The transmissivity is generally less that 250,000 ft^2/d, generally decreasing to the south due to the presence of low permeability limestones. In the Upper East Coast, the Upper Floridan aquifer is used for drinking water supply. In the Lower East Coast, from Jupiter to south Miami, the Upper Floridan aquifer is being considered for storage of potable water within an aquifer storage and retrieval program. In the Lower Floridan aquifer, there are zones of cavernous limestones and dolostones with transmissivities in excess of 3,000,000 ft^2/d. However, because these zones produce saline water, they are not used for drinking water supply. Because of their depth and salinity, these deeper zones of the Lower Floridan aquifer are used primarily for injection of treated effluent wastewater.

J.1.1.6 Soils

Soils of the south Florida ecosystem range from excessively drained on the ridges to very poorly drained in wet depressions. Many of the soils of the Everglades are underlain by limestone. Most soil differences are related to organic matter, geologic substrate and hydrology. Soil classification is controlled by three major factors: 1) the sand and clay content of the substrate which influence the chemical and hydrologic properties of the soil; 2) the depth from the soil surface to the water table which controls the wetness of the soil; and 3) the available water capacity, or the amount of water retained by a soil after a thorough wetting and subsequent drainage, which is highly important in sustaining plant life.

Soils are highly variable across the landscape and often are mapped at varying scales based on the need for detailed information. Detailed soil mapping for each county of Florida has been done by the Soil Conservation Service (now called the National Resources Conservation Service) of the U.S. Department of Agriculture, and is available for detailed site investigations. There are approximately 31 general soil associations in the south Florida ecosystem generally corresponding to major physiographic regions (Caldwell and Johnson, 1982; Brown, Stone and Carlisle, 1990). Soil associations consist of soil series and soil map units. Identifying and describing soil associations, series and map units is beyond the scope of this report. The general soil map prepared by Caldwell and Johnson (1982) was used to describe the general soil orders found in the south Florida ecosystem.

Soil orders are related to the physiographic provinces and substrate origin. Four major soil orders found within the south Florida ecosystem are: Histosols, Spodosols, Entisols, and Alfisols. In areas where rock outcrops occur, weathering of the limestone forms caliche or calcrete. Caliche is not a soil but can influence physiography, drainage and vegetation.

Histosols are soils that are dominantly organic, consisting of peat and muck deposits of varying thickness over sand, marl, or limestone. These soils usually are found in swamps, mangroves, and fresh and saltwater marsh environments. They are less frequently found in rockland areas.

Spodosols are soils characterized by a spodic horizon, a zone where organic matter combined with aluminum and/or iron has accumulated due to downward leaching. These soils usually are associated with flatwoods and dry prairies, sandhill and sand pine scrub, mixed hardwood forests, swamps, marshes, and infrequently in salt marsh and mangrove ecosystems.

Entisols are soils that have a minor or undeveloped soil profile. Entisols are found in nearly all of the physiographic provinces in the south Florida ecosystem.

Alfisols are soils that have light colored surface horizons, low organic matter content and loamy subsoil horizons with moderate to high base saturation. They occur throughout the physiographic provinces in the south Florida ecosystem.

Caliche is not a soil, but a weathering surface formed by the intensive dissolution of original limestone and rapid reprecipitation of calcite. The reprecipitation of calcite results in significantly reduced porosity and creates a relatively impervious, hard surface or calcrete on exposed limestone rocks or beneath thin organic soils. The hard, protective surfaces, also known as cap rock, are often red-brown in appearance and range from less than an inch to more than a foot in thickness. Where successive caliche weathering surfaces occur in limestone deposits, their impervious nature can create vertical divisions of porous zones (Hoffmeister and others, 1967; Moore, 1989).

The general characteristics of soils within the south Florida ecosystem are discussed below:

The Kissimmee River region is underlain by poorly drained sandy and sandy-over-loamy soils or muck (spodosols, alfisols, and some histosols). To the west in the Lake Wales Ridge soils are excessively drained thick sands (entisols).

The Upper East Coast is characterized by sandy and sandy-over-loamy soils with moderate natural drainage (spodosols and alfisols). In coastal areas, soils are predominantly sandy although some organic soils may be scattered throughout (entisols, histosols, and some alfisols).

Lake Okeechobee is underlain by peat and muck (histosols of organic origin and entisols) although much of the peat has been altered to muck by oxidation processes. In surrounding drainage areas, soils range from fine sand and loamy material having poor natural drainage (predominantly alfisols and entisols with some histosols) to sandy and sandy-over-loamy soils with moderate natural drainage (spodosols and alfisols).

The Everglades Agriculture Area is primarily underlain by peat and muck (histosols of organic origin and entisols) although much of the peat has been altered to muck by oxidation processes.

The Water Conservation Areas are primarily underlain by peat and muck (histosols of organic origin and entisols) although much of the peat has been altered to muck by oxidation processes. Other soils in these areas include fine sand and loamy material that have poor natural drainage (predominantly alfisols and entisols with histosols).

The Lower East Coast has several predominant soil characteristics, including sandy and sandy-over-loamy soils with moderate natural drainage (spodosols and alfisols). To the west of the Atlantic Coastal Ridge, soils contain fine sand and loamy material and have poor natural drainage (predominantly alfisols and entisols with some histosols). In coastal areas the soils are predominantly sandy although some organic soils are scattered throughout (entisols, histosols, and some alfisols). There are also areas where rock outcrops sometimes referred to as 'rockland' or a weathered rock surface (caliche and entisols of recent limestone origin) occurs. Rock outcrops are characterized by karst features such as solution pits, caves and sinkholes. Commonly the rock surface is extremely rugged and pitted. Pits in the rock surface range from several inches to several feet in diameter and depth. Where soils occur on these rock surfaces, they are primarily entisols, but may also include alfisols and histosols.

The Everglades National Park is underlain by peat and muck (histosols of organic origin and entisols) although much of the peat has been altered to muck by oxidation processes. There are also areas where rock outcrops or a weathered rock surface (caliche and entisols of recent limestone origin) occurs. Rock outcrops are characterized by karst features such as solution pits, caves and sinkholes. Commonly the rock surface is extremely rugged and pitted. Pits in the rock surface range from several inches to several feet in diameter and depth. Where soil development has occurred on these surfaces, soils are primarily entisols but may also include alfisols and histosols.

Florida Bay, Whitewater Bay, and the Ten Thousand Islands are underlain by exposed rock surfaces and modern sediment. On islands and in coastal areas, soils are predominantly sandy although some organic soils are scattered throughout (entisols, histosols, and some alfisols). Exposed rock surfaces also occur and are characterized by karst features such as solution pits, caves and sinkholes. Commonly the rock surface is extremely rugged and pitted. Pits in the rock surface range from several inches to several feet in diameter and depth. Where soil development has occurred, soils are primarily entisols but may also include alfisols and histosols.

The Florida Keys are underlain primarily by exposed rock outcrops with caliche crusts. Rock outcrops are characterized by karst features such as solution pits, caves and sinkholes. Commonly the rock surface is extremely rugged and pitted. Pits in the rock surface range from several inches to several feet in diameter and depth. Where soil development has occurred in the rock surface, soils are primarily entisols but may also include alfisols and histosols.

Big Cypress Swamp basin is underlain by soils containing fine sand and loamy material that have poor natural drainage and scattered areas of rock outcrop. Rock outcrops are characterized by karst features such as solution pits, caves and sinkholes.

Caloosahatchee River basin and Lower West Coast soils are characterized by sandy and sandy-over-loamy soils with moderate natural drainage (spodosols and alfisols). In coastal areas, the soils are predominantly sandy although some organic soils are scattered throughout (entisols, histosols, and some alfisols).

J.1.2 Climate

The south Florida ecosystem has a generally subtropical climate, characterized by long, hot, humid and wet summers followed by mild, dry winters. The wet season extends from May to October, while the dry season occurs from November to April (Thomas, 1974). The wet season is characterized by high humidity, intense solar radiation, and unstable atmospheric conditions that result in frequent local thunderstorms, often accompanied by intense rainfall of short duration. Severe tropical storms can also occur during the wet season. Large amounts of rain can fall over localized areas in a short period of time and can result in extended periods of flooding.

The fall-winter dry season is characterized by mild, dry weather. Frontal storms dominate the weather during the dry season often bringing cool, sometimes freezing temperatures, and rainfall of moderate amount and low intensity. Severe weather can accompany some fronts, bringing thunderstorms, tornadoes, and large amounts of rainfall. Thunderstorms that are not associated with fronts are possible in the dry season, but are relatively infrequent compared to the wet season.

Mean annual temperature for the south Florida ecosystem ranges from 72°F (22°C) in the northern Everglades to 76°F (24°C) in the south (Thomas, 1974). Mean monthly air temperatures range from a low of 63°F (17°C) in January to a high of 85°F (29°C) (Thomas, 1974). Infrequently, freezing temperatures and frost occur when arctic air masses follow winter cold fronts into the area.

J.1.2.1 Rainfall

On the average, south Florida receives about 53 inches (135 cm) of rain annually, 75 percent of which falls in the wet season (Shih, 1983). During the dry season, precipitation is governed by large-scale (synoptic) winter weather fronts which pass through the region roughly every seven days (Bradley, 1972). Rainfall from these fronts exhibits a more uniform distribution across the south Florida ecosystem as compared to rainfall derived from the highly variable convection-type thundershowers that occur during the wet season.

Rainfall distributions over the south Florida ecosystem follows a bimodal pattern with one peak occurring in May or June and the other in September or October (Thomas, 1974). Annual rainfall for the entire period of record throughout the south Florida ecosystem has ranged from a low of 37 inches (94 cm) in 1961 to a high of 106 inches (269 cm) in 1947. Typically annual values vary from 40 to 65 inches (102 to 165 cm) with a mean annual rainfall over the Everglades of 51 inches (130 cm) (MacVicar and Lin, 1984). Within the Everglades the greatest average annual rainfalls occurs in the Everglades Agriculture Area and in Everglades National Park. The lowest average annual rainfall occurs in WCA-3A (MacVicar, 1983; Sculley, 1986).

During the wet season, convective showers (thunderstorms) occur almost daily, and their distribution across the study area is largely dependent on sea breeze circulation. Short-duration, high intensity thundershowers are related to cyclic land-breeze convection patterns resulting in midday to late afternoon shower activity. Convective storms exhibit larger differences in precipitation from station to station as compared to winter frontal (synoptic) storms (Bradley, 1972; Woodley *et al*, 1974). Woodley (1970) estimates that, due to natural variability, rainfall generated from a single cumulonimbus cloud in south Florida can range from 200 to 2,000 acre-ft (244,000 to 2,440,000 m^3).

J.1.2.2 Wind

Wind direction and patterns are determined by the easterly tradewinds and land-sea convection patterns during the wet season and by synoptic weather fronts during the dry season (Schomer and Drew, 1982). Southern Florida shows a dominant easterly influence, which varies from east southeast in the spring-summer to due east in the fall (Schomer and Drew, 1982). During the winter dry season, cold fronts pass over the basin approximately once a week (Schomer and Drew, 1982). Prevailing wind patterns are affected during the summer wet season by convective heating and during the dry season by regional scale weather systems (Schomer and Drew, 1982).

J.1.2.3 Tropical Cyclones

Strong winds associated with hurricanes and other storm events are an important physical process shaping the Everglades and Florida Bay (Craighead and Gilbert, 1962). The natural communities of the south Florida ecosystem are, to a large extent, hurricane adapted and respond quickly with few long-term effects (Deuver et al., 1994). High winds and associated wave action can redistribute such physical features as barrier islands, inlets, channels and sand shoals, and change established plant and animal communities. South Florida has been struck by more hurricanes and tropical storms than any other equally sized area in the United States (Gentry, 1974). This area was close enough to the paths of 138 tropical storms between the period 1871-1981 to have been potentially affected by them (Duever et al., 1994). The south Florida ecosystemis exposed to Atlantic, Gulf, and Caribbean generated hurricanes. Hurricanes strike most frequently during August, September and October with a return frequency of about every three years (Gentry, 1984). Destruction occurs from storm surges, wind, tornadoes, and rainfall (flooding). The hurricanes of 1926, 1928, 1935, 1947, 1960, 1962, and 1965 caused loss of life and/or major damage to the region that led to additional water management and drainage efforts in the Everglades.

J.1.2.4 Evapotranspiration

Evapotranspiration is the combined process of evaporation from land and water surfaces and transpiration from plants. It is the method by which the bulk of the rainfall in the area is returned to the atmosphere and plays a major role in the climate of the south Florida ecosystem. This process is estimated to remove between 70-90 percent of the rainfall in undisturbed south Florida wetlands (Duever et al., 1994). Evaporation from open water surfaces peaks annually in the late spring when temperatures and wind speeds are high and relative humidities are low. Evaporation is lowest during the winter when the temperatures and wind speeds are low (Duever et al., 1994). The depth to the water table and type of vegetative cover are also important in determining the amount of evapotranspiration losses. Where the water table is close to the land surface, evaporation from the soil is increased by capillary rise of moisture, and is about the same as evaporation from an open body of water. Lake evaporation in south Florida ranges from about 50 to 54 inches per year (in/yr).

Jackson and Maurrasse (1976) made water budget studies of selected quarry lakes. In one lake in northern Miami-Dade County, 49 feet deep, with a surface area of 6,741,000 square feet, they determined a storage volume of approximately 2.5

billion gallons of water, compared with about 0.5 billion gallons in the original rocks. This represented a gain in storage of about 2.0 billion gallons for the lake. For an assumed annual lake evaporation of 51 inches, total evaporation losses were only about 210 million gallons. The authors also indicated that over the long term, average rainfall should largely compensate for lake evaporation losses. Even for short term annual rainfall deficits (periods of drought) of 5 to 6 inches, the gain in net storage would still be approximately 1.8 billion gallons or more than 5 times the original storage in the rock.

The 1994 landcover map (***Figure J-1.1.2.5-1***) of the Lakebelt area shows that this portion of the Lower East Coast study area consists of large patches of the invasive non-native melaleuca (*Melaleuca quinquenervia*) and limestone quarry lakes. Unfortunately, there is presently very little information available regarding the evapotranspiration rates of melaleuca. The recent report on evapotranspiration rates of melaleuca (Chin,1996) was used to select appropriate parameters for modeling melaleuca evapotranspiration in both the regional model and the MODFLOW model. The method includes two factors for determining melaleuca losses in the lakebelt region. First, Chin (1996) calculated the actual evapotranspiration rates for melaleuca utilizing the Penman-Monteith method. In addition to the Penman-Monteith evapotranspiration rates calculated for melaleuca, Chin (1996) suggests that a second component be added which accounts for evaporative losses due to interception of rainfall within the melaleuca canopy. It is assumed that these interception losses are removed from the system during heavy rainfall events and not available as recharge to the aquifer or for utilization by the vegetation. In order to determine the interception losses, Chin (1996) utilized Woodall’s (1984) empirical equation for estimating interception losses. The result is that Chin (1996) determined that the maximum evapotranspiration rate for melaleuca is approximately 51 in/yr plus an interception loss of approximately 12 in/yr resulting in a total loss of 63 in/yr.

J.1.3 Air Quality

The existing air quality within the region is currently considered good and the region is in attainment for all National Ambient Air Quality Standards (NAAQS). In 1995, southeastern Florida was redesignated to "attainment" for the one-hour ozone standard and is now a “maintenance” area for ozone. Ozone is the primary regulated pollutant of concern in this region. Another air quality concern within the region is the atmospheric deposition of mercury, although no NAAQS for this pollutant currently exists. For additional specific and detailed information on air quality within the project area, refer to ***Appendix I.***

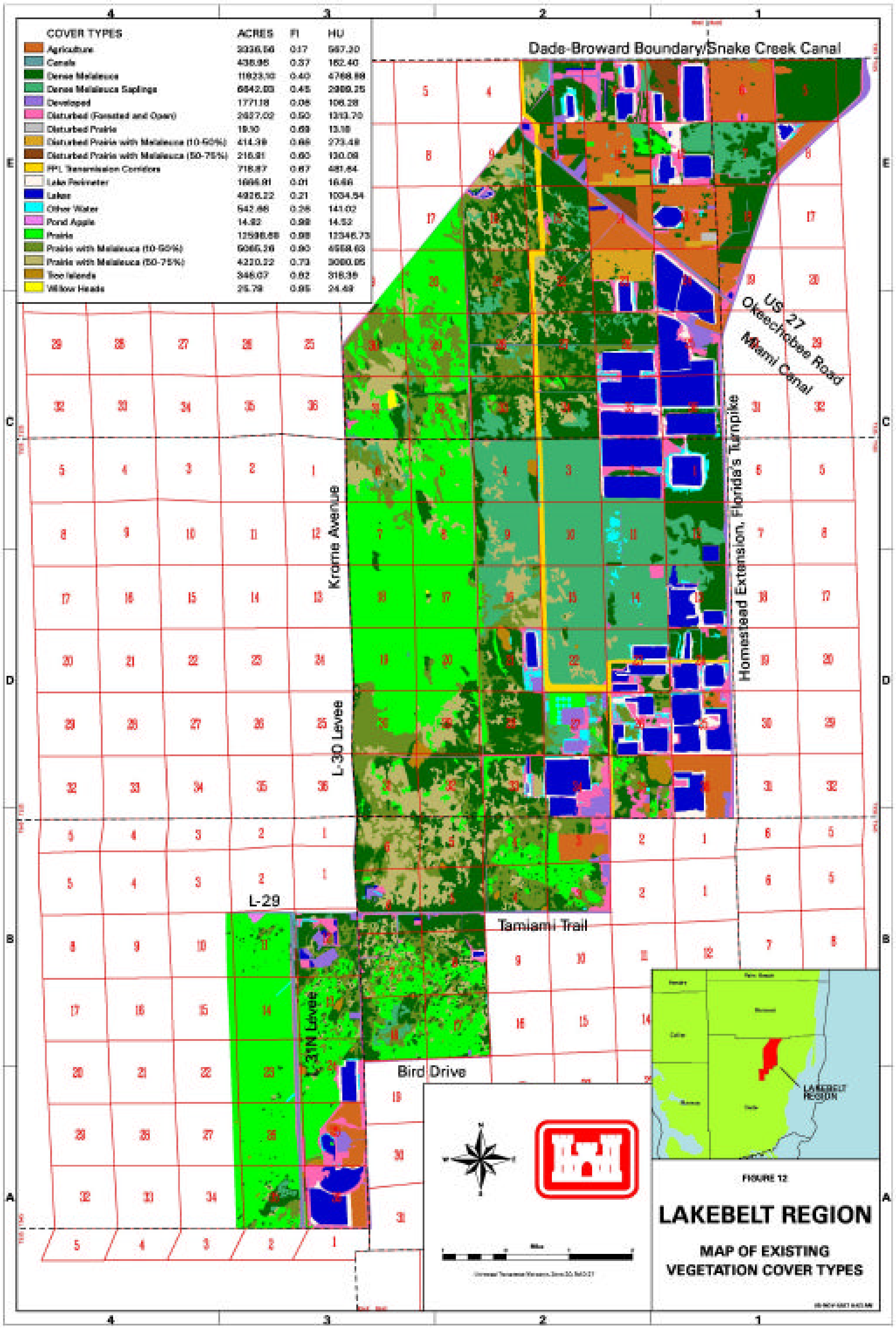


Figure J-1.1.2.5-1 Lakebelt Vegetation Map

J.1.4 Noise

Within the natural areas of the proposed project, including the Everglades Protection Area, Everglades National Park, Big Cypress National Preserve, Florida Bay, Lake Okeechobee and other peripheral natural areas, the wilderness character of the area is such that external sources of noise are limited and of low occurrence. Existing sources of noise are limited to vehicles that travel on transportation arteries that are often miles distant, and airplanes. Other sources of noise, more voluminous, but less frequent, and which may occur within these natural areas, are that of air boats, off road vehicles, swamp buggies, motor boats, and airplanes.

Rural, undeveloped sites have typical noise levels in the range of 35-55 dB. Levels along transportation arteries are typically about 70 decibels (dB). Additional sources of noise, in rural, agricultural areas such as within the Kissimmee region, the Everglades Agricultural Area, Caloosahatchee and St. Lucie basins, and in south Miami-Dade County, include noise associated with agricultural production, processing and transportation of agricultural produce. Specifically, the use of farm equipment, transport trucks, heavy equipment, tractors, plows, irrigation equipment, agricultural processing facilities, railroad and other transportation facilities, would be expected to provide dominant background noise to the otherwise relative quiet natural soundscape.

Within the rural municipalities, and urban areas along the Upper and Lower East Coast, as well as the West Coast, sound levels would be expected to be of greater intensity, frequency, and duration. Noise associated with transportation arteries, such as highways, railroads, primary and secondary roads, airports etc., inherent in areas of higher population would be significant and probably override those sounds associated with natural emissions. Other sources of noise might be expected to include noise from everyday social and human communication and activity, operation of construction and landscaping equipment, and operations at commercial and industrial facilities. In general, urban emissions would not be expected to exceed about 60 dB, but may attain 90 dB or greater in busier urban areas or near to frequently used, high volume transportation arteries.

J.1.5 Vegetation

The C&SF region consists of a complex system of hydrologically interrelated landscapes. Because the Everglades is located on a peninsula that extends from a temperate to a subtropical climate, the associated flora consists of tropical, temperate, and endemic species (Gunderson 1994). Descriptions of historical communities for the south Florida ecosystem are provided by Davis (1943). Gunderson (1994) grouped Everglades communities into upland and wetland vegetative components based on hydro-edaphic conditions, water chemistry, and vegetative growth form. Everglades uplands are composed of rockland communities, which include rockland pine forests and tropical hardwood hammocks.

Everglades freshwater wetland communities are categorized as forested wetlands, marshes, prairies, and ponds and sloughs. The periphyton community, composed of many taxa of microalgae, occurs in many of the freshwater communities in the Everglades, and is an important element of the base of the food chain.

J.1.5.1 Uplands/Pine Rocklands

South Florida upland forest types can be classed as either pine forests or hardwood hammocks. They occur on the Atlantic Coastal Ridge, which extends south a distance of 65 miles from north Miami, along the east coast, and then turns inland in a long curve, terminating at the end of Long Pine Key in Everglades National Park. This outcropping was formed from mid-pleistocene marine limestone (Snyder et al. 1990) and decreases in elevation from north to south, starting at 20 feet near Miami, decreasing to 5 feet at the entrance to Everglades National Park, and terminating at 1.5 feet on Long Pine Key (Craighead 1974; Gunderson 1994). The distribution of pine forests and hardwood hammocks on the ridge is largely affected by fire frequency and substrate (Gunderson 1994). The soils of pine forests and hammocks are very different from soils found elsewhere in Florida. They are largely organic in matter and have good drainage; they remain saturated only when flooded by high water levels. Due to the high proportion of organic matter, the soils burn easily during drought conditions (Snyder et al. 1990). The relative cover of pine forests and hardwood hammock on rockland is the direct result of the fire history; pine forests burn more frequently. The hydroperiod for the pine forest is 0 to 60 days (Duever et al., 1986; USACE, 1990).

J.1.5.2 Pine Flatwoods

Pine flatwoods, unlike rockland pine communities, usually develop in flat areas where the soil is sandy and fairly deep, often mineral-poor and poorly drained, and showing a spodic (organic matter) horizon (spodosols). Some flatwoods soils also have a clay hardpan. Pines up to 60 feet tall, with a shrubby or grassy understory dominate the forest canopy. In the central and south Florida landscape, pine flatwoods are important in the Kissimmee, Upper East Coast, Lake Okeechobee and Caloosahatchee regions. They cover a much smaller percentage of the landscape in the northern Lower East Coast and Big Cypress regions, and are nearly absent south of a line extending roughly between Marco Island, on the west coast, to Fort Lauderdale in the east. Flatwoods are open, pine dominated woodlands with an understory and scattered shrub layer of hardwoods, and often a grassy or herbaceous ground cover layer. Fire is a natural controlling factor in flatwoods communities. By periodically setting back invading hardwood plant species, lightning-set fire maintains a mosaic of plant communities in flatwoods areas, and generally the density and height of the hardwood understory in pine stands is an indicator of fire history. All of the tree, shrub and grass species in flatwoods are drought tolerant, and many are fire-resistant. Flatwoods soils characteristically suffer strong seasonal fluctuations in the amount of water available for plant growth. During the rainy season, they drain slowly, and water may pond at or over the surface. In contrast, during the annual dry season, tree evapotranspiration may exhaust all available soil water, limiting conditions for many herbaceous and shrubby plants. Plants adapted to this association must tolerate soil saturation or flooding as well as drought. Although four species of pine can be found in Florida flatwoods, in the south Florida region only one, south Florida slash pine (*Pinus elliottii* var. *densa*), is widespread. Typical understory tree species include live oak (*Quercus viriginiana*), wax myrtle (*Myrica cerifera*), gallberry (*Ilex glabra*), saw palmetto (*Serenoa repens*), and others. Pine flatwoods provide important habitat for large resident mammals, including white-tailed deer, bobcat, grey fox, opossum, Florida panther and black bear. They also support many species of reptiles, including the gopher tortoise and the eastern indigo snake. They are nesting habitat for the endangered red-cockaded woodpecker.

J.1.5.3 Rockland Pine Forests

The dominant species in rockland pine forests is the Florida slash pine *(Pinus elliotti var. densa*) (Gunderson 1994; Lodge 1994; Snyder et al. 1990). They occur in areas that have slightly higher elevations of bedrock limestone than the surrounding wet prairies or mangroves (Snyder et al. 1990). A sub-canopy of rockland pine forests rarely occurs but may consist of wild tamarind (*Lysiloma latisiliqua*) and live oak (*Quercus virginiana*) (Snyder et al. 1990). Pine forests have been categorized based on their understories; some pine forests have a low stature understory and some have a well-developed hardwood understory (Gunderson 1994). Those rockland pine forests with a low-stature understory burn more regularly. The understories in pine forests are species rich (Gunderson 1994); Loope et al. (1979) reported 186 species in the understory of the pine forests on Long Pine Key in Everglades National Park. This made it the most species rich community in Everglades National Park.

The dominant understory hardwoods that occur in pine rocklands include rough velvetseed (*Guettarda scabra*), indigo berry (*Randra aculeata*), varnish leaf (*Dodonea viscosa*), myrsine (*Myrsine floridana*), and willow bustic (*Bumelia salicifolia*). The palm species that most often occur in rockland pine forests are cabbage palm (*Sabal palmetto*) and saw palmetto (*Serenoa repens*) (Gunderson 1994). The herbaceous layer of rockland pine forests is species diverse and contains a mixture of tropical and temparate species, many which are endemic. The temparate species are more common in the Big Cypress and northern Miami (Biscayne pinelands) rockridge regions. Snyder et al. (1990) listed herbaceous species restricted to rockland pine forest; they include *Angadenia sagrae*, *Melanthera parvifolia*, *Jacquemontia curtissii*, *Crossopetalum ilicifolium*, *Acalypha charmaedrifolia*, *Cassia deeringiana*, *Crotalaria pumila*, *Andropogon cabanisii*, and *Anemia adiantifolia*.

Rockland pine forests are fire "climax" communities (Lodge 1994). Slash pine communities are highly resistant to fire and are actually maintained by fire. Fire affects rockland pine forests by controlling the dominant upland species. Rockland pine forests that have experienced recent fire (3-4 years) have an open understory. Those forests that have not experienced fire for over five years begin to support dense hardwood species in their understory. If the understory succeeds to support a dense understory and fire occurs, the results can be devastating; the dense understory provides a large fuel load and causes the fire to become so hot that it burns and kills the pine overstory (Lodge 1994).

J.1.5.4 Tropical Hardwood Hammocks

Tropical hardwood hammocks are composed of broad-leafed evergreen species of Antillean-West Indian origin (Gunderson 1994; Snyder et al. 1990). Similar to the rockland pine forests, many of the taxa are endemic. Inundation may occur only during extremely high water periods (Duever et al., 1986; Gunderson et al., 1982; Olmstead et al., 1980), although forests have been observed with hydroperiods of 10 to 45 days (Duever et al., 1986). Tropical hardwood hammocks occur on regions of higher elevation and, unlike pine forests, rarely experience fire. Although influenced by fire, there are many other environmental components that influence the structure and composition of tropical hardwood hammocks; these include rainfall, temperature, hurricanes, type of adjacent vegetation, elevation, and substrate. The primary overstory species include live oak, mastic (*Mastichodendron foetidissimun*), willow bustic (*Bumelia salicifolia*), strangler fig (*Ficus aurea*), wild tamarind (*Lysiloma latisiliqum*), cabbage palm (*Sabal palmetto*), and gumbo limbo (*Bursera simaruba*) (Gunderson 1994, Snyder et al. 1990). Other species include sugarberry (*Celtis laevigata*) and mahogany (*Swietenia mahogani*). Smaller trees include lancewood *(Nectandra coriacea),* stoppers *(Eugenia spp.),* pigeon plum *(Cocoloba diversifolia*) and marlberry (*Ardisia escalloniordes*). They tend to be depauparate in terrestrial herbaceous species as a result of the lack of light that penetrates the canopy. Most of the herbaceous species found in hammocks are epiphytes, including vines, orchids and ferns.

The largest number (59 taxa) of rare and threatened plants are supported by hardwood hammocks. Gunderson (1994) lists the rarest of these taxa as follows: hand fern (*Ophioglossum palmatum*), Floridian royal palm (*Roystonea elata*), bromeliads (*Catopsis floribunda, Gusmania monostachia, Encyclia, Brassia cuadata, Oncidium floridanum, Macradenia lutescens*), and myrtle-of-the-river (*Calyptranthes zuzygium*).

J.1.5.5 Forested Wetlands (Swamp)

The woody wetland communities in south Florida consist of bay heads, willow heads, and cypress heads (Gunderson 1994; Lodge 1994; SFWMD 1992); they are found dispersed throughout the freshwater marshes at sites with the highest elevation (SFWMD 1992). Depending on the type of vegetation they support, they are sometimes called tree islands (Lodge 1994). Tree islands that support tropical hardwood hammock species have higher elevations and are more correctly referred to as hammocks (Lodge 1994). Tree islands add functional diversity to the surrounding freshwater marsh by adding habitat with variable structure that can be utilized by numerous species during portions of their life cycles. Wading birds often use tree islands for nesting and many rookeries are found on tree islands.

The dominant type of tree composing the overstory distinguishes the type of tree island (Lodge 1992). The understories of tree islands are often composed of a dense shrub layer composed primarily of cocoplum (*Chrysobalanus icaco*), buttonbush (*Cephalanthus danaeifolium*), leatherleaf fern (*Acrostichum danaeifolium*), cinnamon fern (*Osmunda cinnamonea*), royal fern (*O. regalis*), chain fern (*Anchistea virginica*), bracken fern (*pteridium aguilinum*) and lizards tail (*Saururus cenvus*) (SFWMD 1992).

Tree island communities are maintained by a combination of fire and hydrology. When fire is either too frequent or too infrequent and/or the natural hydroperiod is altered, the vegetative components of tree islands become stressed. Alligators may also have an influential role on the health of tree islands; alligator holes are usually associated with some type of tree island.

Bay heads

Bay heads are dominated by bay trees (Davis 1943; Craighead 1971) and are the most common type of tree island (Lodge 1992). They are found in the sloughs of the Loxahatchee National Wildlife Refuge and all of Shark River Slough. In the northeast portion of the Everglades, two types of bay heads have been described (Gleason and Stone 1994) and are distinguished by their shape, size, topography and vegetation; tree islands dominated by red bay (*Persea borbonia*) are usually round in shape and tree islands that are larger and elongated in shape are often dominated by dahoon holly (*Ilex cassine*). Some tree islands are dominated by swamp bay *(Magnolia virginiana*). Species present in addition to the dominant canopy species include dahoon holly, pond apple (*Annona glabra*), and wax myrtle (*Myrica cerigera*). On tree islands with higher elevations, tropical hardwoods, such as strangler fig (*Ficus aurea*), may be present. Age dating of peat forests suggests that tree islands formed only 1200 years ago and therefore, are a relatively new component of the landscape (Gleason and Stone 1994).

Willow heads

Willow heads are composed of generally monotypic stands of willow *(Salix caroliniana*) and often grow on sites with disturbed soils. Disturbance may include physical alteration by man through forestry practices, agricultural activities, or by natural disturbance, such as alligators creating alligator holes (Gunderson 1994).

Other species common to willow heads include phragmites (*Phragmites australis*), sawgrass (*Cladium jamaicense*), alligator flag (*Thalia geniculata*), whitevine (*Sarcostemma clausum*), climbing hempweed (*Mikania scandens*), and Everglades morning glory (*Ipomoea sagittata*). Willows are important community components in that they serve as roosting and nesting sites for many wading birds.

Cypress Forests

Cypress forests are found in south Florida in depressions, when the hydroperiod is longer than the surrounding marsh (Lodge 1994). Two types of cypress communities exist in the south Florida ecosystem, cypress domes and cypress prairies. Cypress domes are distinguished from cypress prairies by their structure and support tall, dense pond cypress (*Taxodium ascendens*) (Gunderson 1994). The understories of cypress domes are dependant on soil elevations; those cypress domes with higher elevations may consist of species also found in bay heads (woody species) and those with lower elevations, aquatic species. The centers of cypress domes tend to favor more optimal growth conditions and the result is taller trees towards the centers or the “dome-like” appearance. Cypress "strands", differ from domes only in their general physical shape, strands being more elongate and tending to orient in the direction of predominant overland flow. Cypress strands are common in the Big Cypress region and elsewhere. Cypress trees in the south Florida ecosystem rarely reach heights greater than 50 feet.

Cypress prairies, also called dwarf or hatrack cypress (Gunderson 1994; Lodge 1994), support stunted cypress trees that are widely distributed with understories that consist of wet prairie species (Gunderson 1994) and are more marsh-like in their appearance than swamps (Lodge 1994).

Cypress trees, similar to pine trees, have a high resistance to fire, except during times of drought. If drought conditions prevail and the surrounding wetlands soils are dry, fire will burn the upper peat layer and cause root damage that often kills the trees (Lodge 1994).

J.1.5.6 Pond Apple Forests

Pond apple stands occur throughout south Florida. These trees exist at localities that have long hydroperiods. Pond apple trees have large trunks and buttresses roots and grow to heights of 35 feet or less (Lodge 1994). Many epiphytes use pond apples as sites of attachment; during the dry season, pond apple trees drop their leaves, creating an environment suitable for epiphyte attachment. Wading birds use pond apple trees for nesting; the configuration of the branches and usual location near open water make them a good nesting substrate (Lodge 1994).

Historically, a dense forest of pond apple trees existed at the southern end of Lake Okeechobee. Some believe that this forest used to help to “regulate” flows that occurred out of Lake Okeechobee during periods of high water. Today, no forest exists, having been replaced years ago by agricultural crops (Gunderson 1994; Lodge 1994).

J.1.5.7 Freshwater Marsh

Freshwater marsh communities include sawgrass marshes, which grow in peat soils; wet prairies, which grow in either peat or marl soils, and ponds and sloughs. Wet prairies growing in marl soils have shorter hydroperiods and are restricted to the southern part of the Everglades system. The composition of freshwater marshes is affected by prevailing water conditions (Loveless 1959). The abundance and density of the vegetative components of wetlands is partly determined by the water depth, duration of inundation, and the rate of a rise or decline in water levels.

Sawgrass Marsh

Sawgrass (*Cladium jamaicense*) is one of several dominant vegetative community types found throughout the freshwater Everglades marsh. Sawgrass can survive in low-nutrient environments; this is one characteristic that made it suitable for the oligotrophic conditions of the historic Everglades. It typically occurs on land elevations slightly higher than aquatic sloughs but lower than bayhead tree islands (SFWMD 1992). Estimates of the extent of sawgrass range from 65 to 70 percent of the remaining Everglades marsh (Dineen 1972; Kushlan 1987; Loveless 1959; Schomer and Drew 1982). In the northern Everglades, sawgrass that grows where peat soils are deep is tall and dense, reaching heights of up to 3 m (Gunderson 1994; Kushlan 1990). Dense sawgrass communities limit the growth of other species and few species co-exist, with the exception of some woody plants which establish in openings in or on the border of dense marshes. In the southern portion of the Everglades, where soil depths are less, sawgrass is less dense and attains heights of 80-150 cm. Sawgrass is most often the dominant plant but occurs with a number of other sedges, grasses, herbs, and attached emergent or floating-leafed aquatic plants (Loveless 1959).

Sawgrass tolerates a wide range of hydroperiods, from 6 months to nearly continuous flooding, but the average hydroperiod is around 10 months (Lodge 1994); extended periods of high water will kill sawgrass (Davis 1990). Water depth works in concert with hydroperiod to create optimal conditions for sawgrass. Sawgrass regrowth is rapid after a burn (SFWMD 1992). However, if following a burn, sawgrass in inundated with water for an extended period of time, it will die.

Wet Prairie

Wet prairies are seasonally inundated wetland communities with intermediate hydroperiod and depth requirements; they require shorter hydroperiods (6-10 months) and depths than do sawgrass marsh. Seasonal drying of these communities is required for seed germination and the establishment of new seedlings. Common aquatic emergent plants in wet prairies include spikerush (*Eleocharis cellulosa*), beak rush *(Rhynchospora tracyi*), maidencane (*Panicum hemitomon*), arrowhead (*Sagittaria latifolia*), and pickerel weed (*Pontederia lanceolata*) (SFWMD 1992).

An important distinction must be made between wet prairies supported by peat soils and those supported by marl soils; each soil type supports vegetation distinct from the other (SFWMD 1992). Wet prairies growing over peat soils have longer hydroperiods than do marl prairies, support vegetation distinct to peat soils, and are often a transition between sawgrass marsh and the deeper sloughs in the Everglades. These peat-based prairies occur in the northern and central Everglades. Marl prairies are restricted to the southern end of the Everglades system and occur on the east and west margins of Shark River Slough and Taylor Slough (Gunderson 1994). Marl prairies require the shortest hydroperiod of all the marsh communities in the Everglades, averaging between three and seven months (Lodge 1994). The majority of the marl prairies in Everglades National Park are dominated by muhly grass (*Muhlenbergia filipes*) and sawgrass (Gunderson 1994). Plant diversity is high with over 100 species occurring; other species that co-occur include blackrush (*Schoenus nigricans*), arrowfeather (*Aristida purpurascens*), Florida bluestem (*Schizachyrium rhizomatum*), and Elliot's lovegrass (*Eragrostis elliotti*).

Many wading birds use marl prairies as important short-hydroperiod feeding grounds. Early in the dry season, when the sawgrass marshes are inundated with higher water levels, these transitional areas become accessible for foraging (Lodge 1994). The endangered Cape Sable seaside sparrow is dependant on the short-hydroperiod marl prairies to successfully breed.

Sloughs

Sloughs occur in the northern Everglades in what is now known as the Loxahatchee National Wildlife Refuge and the Hillsborough Lake area, as well as in the central and southern Everglades. They are typically the deepest wetland community, with hydroperiods of about 11 months (Lodge 1994). Sloughs, such as Shark River Slough, may obtain a depth of 3 feet or greater and may be inundated for several years continuously. Therefore they provide valuable habitat for a variety of fishes and aquatic invertebrates, and provide refugia for other animals during drought. Sloughs occur over peat soils and are often characterized by a vast number of tree islands, which provide a type of upland habitat within the deeper aquatic ecosystem. The dominant vegetation occurring within the sloughs include submerged and floating aquatic plants such as water lily, pond lily, spatterdock, bladerwort, and maidencane. Normally sawgrass is absent or comprises a modest amount of the total biomass.

J.1.5.8 Mangrove Swamps

Historically, mangrove swamps occurred along much of the coastal areas of the periphery of central and south Florida (Davis 1943). Today, while reduced in abundance through development and naturally occurring events such as hurricanes and freeze events, mangrove swamps still occupy over 500 square miles along the perimeter of Florida Bay, within the Florida Keys, and particularly in the coastal areas of Whitewater Bay northward into the Ten Thousand Islands. Acting as a buffer between the saline, marine environment and the freshwater marsh, wet prairie, and slough environment, mangroves can be one of the most productive ecosystems of all within the study area.

Mangrove forests are the most extensive habitat type in the Lower Everglades and Florida Keys areas (Schomer and Drew, 1982; Minerals Management Service, 1990). Mangrove communities are composed of an association of unrelated tropical hardwood tree species adapted to grow in saline soils under conditions of intermittent flooding. Mangrove species are not generally frost hardy, and are found throughout the tropical world along low energy coasts. In the Keys and coastal Florida, the red mangrove (*Rhizophora mangle)* dominates the intertidal zone of outer fringes and mangrove cays, while black mangrove (*Avicennia germinans)* occupies the inner side of fringing stands, as well as lower-energy hypersaline flats and deeply flooding basins. White mangrove (*Laguncularia racemosa)* is found in lower salinity areas, as well as forming extensive “dwarfed” stands over rocky flat areas of the lower Keys. Mangrove stands and cays are important wildlife habitat. Most mangrove stands export particulate and dissolved organic matter to surrounding waters, supporting a diverse food web (Odum, 1982). Red mangrove prop roots provide vital nursery and grow-out habitat for many species of commercial fish and such invertebrates as lobsters and crabs, and many species of wading birds utilize mangrove canopies and islets for roosting and nesting.

J.1.5.9 Periphyton

The periphyton community is an assemblage of many different species of green, and blue-green algae and diatoms. They are key components of the Everglades ecosystem in that they act as primary producers, producing O_2 through photosynthesis, serve as a food source to many invertebrates, and herbivorous fish, and through their decay, build a calcitic mud sediment. Periphyton are generally attached to floating or emergent vegetation or grow along the substrate where they are referred to as an algal mat. Periphyton act as important indicator organisms, as they are very sensitive to changes in water chemistry, nutrients, and other ions such as calcium. There are generally two kinds of periphyton. In areas with high concentrations of calcium, periphyton species are dominated by blue-green algae, and often are encrusted calcium carbonate crystals, which give a spongy texture. These periphyton communities often occur over marl soil, in wet prairie communities with relatively short hydroperiods. In areas of relatively low calcium concentration, in sloughs and deeper wet prairie communities, the periphyton is dominated by green algal species which are more nutritious for primary consumers.

J.1.5.10 Marine and Coastal Resources

The following are not so much vegetation types as habitats that are important in the overall system, in terms of their productivity and fragility. These key habitats, or ecosystems, are threatened by current water management practices and merit recognition and mention here as they may be affected by the Restudy Initial Draft Plan.

Estuaries

Estuaries are critically important as nursery, breeding, staging, and resting areas for fish, shellfish, reptiles, birds, and mammals. The south Florida ecosystem contains numerous coastal resources, some of which are found nowhere else in North America. The south Florida ecosystem includes several major estuarine ecosystems: southern Indian River Lagoon, Lake Worth Lagoon and Biscayne Bay on the east coast; Florida Bay on the southern coast; and the Ten Thousand Islands region, Rookery Bay, Estero Bay, Caloosahatchee River, Charlotte Harbor, and Sarasota Bay on the Gulf Coast.

Seagrasses

Of the 3,860 square miles of seagrasses in the United States portion of the Gulf of Mexico, more than 85 percent occur in Florida waters (Iverson and Bittaker 1986). More than 2,124 square miles of seagrass beds occur in the shallow waters of Florida Bay and the adjacent reef tract alone; seagrasses cover 80 percent of the submerged lands between Cape Sable, north Biscayne Bay, and the Dry Tortugas (Jaap and Hallock 1990). Seagrass meadows improve water quality by removing nutrients, by dissipating the effects of waves and currents, and by stabilizing bottom habitats thereby reducing suspended solids. Seagrass beds support some of the most abundant fish populations in the Indian River Lagoon, with a large species diversity. Pinfish and several species of mojarra are very abundant in the seagrass habitat. These species are known to feed on seagrasses and on the epiphytes and epifauna of the seagrasses, providing a critical link in the food chain between the primary producers and the higher level consumers such as the common snook and spotted seatrout.

The seagrass habitat is also a critical resource for the Florida manatee *(Trichechus manatus latirastris).* This marine mammal depends on seagrasses for a major part of its food supply (Lain, 1978; Van Meter, 1989; Provancha and Hall, 1992). It has been reported that manatee grazing may result in up to a 68 percent decrease in seagrass biomass (Virnstein, 1987; Provancha and Hall, 1991a), illustrating the importance of seagrasses as manatee forage. Juvenile sea turtles have also been documented as foraging on turtle grass (*Thalassia testudinum*) and other seagrasses in the Indian River Lagoon (Mendonca, 1981; Mendonca and Ehrhart, 1982). Turtlegrass is the predominant species in waters deeper than 1-2 feet. Associated with the turtlegrass is manatee grass (*Cymodocea manatorum*). Shallower areas may have a thin cover of shoal grass (*Halodule wrightii*). Seagrass beds are essential habitat for juvenile fish and invertebrates. Calcareous algae often occur interspersed with seagrasses in mixed assemblages.

The seagrass communities of south Florida have experienced substantial declines in acreage and quality in recent years. An estimated 30 percent of the seagrass communities have been destroyed in Florida’s estuaries since the 1940's. Indian River Lagoon and Charlotte Harbor have each lost about 30 percent of their seagrass beds. Since 1987, more than 59,306 acres of seagrasses have been affected by several factors including degraded water quality, dredging from boat propellers, freshwater management of the Everglades flow, severe temperature variability, and others; resulting in a massive die-off (Haddad and Sargent 1994). Seagrass beds in Monroe, Lee, Miami-Dade, and Charlotte Counties have experienced the heaviest damages from propellers.

Coral Reefs

Coral reefs are a prominent coastal resource in the south Florida ecosystem, which contain several different kinds of coastal reef assemblages: ivory tree coral reefs, worm reefs, vermetid reefs, and the coral reef of the Florida Keys. The Keys coral reef complex consists of a tract of semi-continuous offshore bank reefs that make up the third largest barrier reef in the world and more than 6,000 inshore patch reefs. As such, the Keys’ reef constitutes the only coral assemblages of any significance in the continental United States. In addition, coral reefs hold unparalleled marine diversity and are likened to the tropical rainforests of the sea. The Florida Keys coral reef is the most visited and heavily used reef in the world, hosting millions of users annually. Coral reefs also exist in the nearshore and offshore waters of the Lower East Coast, which may be affected by freshwater discharges from C&SF canals and inland rivers and streams.

J.1.6 Fish and Wildlife

The following discussion is an overview of common, keystone, and/or indicator fish and wildlife species that inhabit the central and south Florida study area.

J.1.6.1 Invertebrates

Macroinvertebrates represent an important component of the Everglades food web. Kolpinsky and Higer (1969), working in the marshes of Everglades National Park, first reported the importance of crustaceans to the Everglades food web. Such species as crayfish (*Procambarus alleni*), and the freshwater shrimp (*Palaemonetes paludosus*) as well as small forage fish represent a major component of the Everglades food web providing prey for larger fish, amphibians, reptiles and wading birds. Most freshwater invertebrates are temperate species. The Everglades do not have a great diversity of freshwater invertebrates due to its limited type of habitat and nearly tropical climate, which many temperate species cannot tolerate (Lodge 1994). Important invertebrates include: the Florida apple snail (*Pomacea paludosa*), Seminole rams-horn (*Planorbella duryi*), riverine grass shrimp (*Palaemonetes paludosus*), Florida spiny lobster (*Panulirus argus*), blue crab (*Callinectes sapidus*), pink shrimp (*Penaeus duorarum*), crayfish (*Procambarus alleni*). The importance of the Florida apple snail to the diet of the snail kite *(Rostrhamus sociabilis)* is widely documented in the literature. There are also dozens of species of aquatic and terrestrial insects and spiders, many that are important in the food chain in the juvenile or adult phase of their life cycle.

J.1.6.2 Fishery Resources

Within the study area there are a large number of fish species, residing in the inland freshwater lakes, canals, sloughs, and borrow pits. Some of the important commercial and freshwater sport fish found in south Florida include: largemouth bass (*Micropterus salmoides*), redear sunfish (*Lepomis microlophus*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), Florida gar (*Lepisosteus platyrhincus*), threadfin shad (*Dorosoma petenense*), gizzard shad (*Dorosoma cepedianum*), white catfish (*Ameirus catus*), yellow bullhead (*Ameiurus natalis*), and Tilapia (*Tilapia* spp.). These fish are not only sought after by fisherman, but are critically important in the diets of predators including wading birds, alligators, otters, racoons, mink, and other animals.

Numerous forage species, including the Cyprinodontids such as the golden topminnow (*Fundulus chrysotus*), the least killifish (*Heterandria formosa*), and the Florida flagfish (*Jordanella floridae*) are commonly found and are known to be important food resources for wading birds, amphibians, and reptiles. Other important forage fish include: golden shiners (*Notemigonus crysoleucas*), marsh killifish (*Fundulus chrysotus*), sailfin molly (*Poecilia latipinna*), bluefin killifish (*Lucania goodei*), oscars (*Astronotus ocellatus*), and eastern mosquitofish (*Gambusia holbrooki*). These fish are important in the processing of food in the form of plankton, macroinvertebrates, and algae and plant material, which is then available to first order predators.

Within the study area, fish inhabit the open water aquatic sloughs and wet prairie communities, as well as the deep-water canal environments. While canals and many sloughs contain water throughout the year and from year to year, many areas of the interior marsh experience seasonal drydowns. As a result, fish populations within the marsh fluctuate widely, moving from shallower areas into the sloughs, alligator holes, and canals during dry periods. The gradual recession in water levels, during the dry season, concentrates fish in shallow water and renders them more susceptible to predators such as wading birds. This is a key component in the ecology of the south Florida ecosystem. ***Table J-1.6.2-1*** lists some of the common species found in the study area.

The extensive canal system supports fish species that normally would not be common inhabitants of the Everglades marshes, but are typically found in lakes. These fish include black crappie *(Pomoxis nigromaculatus)*, catfish (*Ictalurus* spp.), and shad (*Dorosoma* spp.). Oscars *(Astronotus* spp,), spotted tilapia (*Tilapia mariae*), walking catfish (*Clarias batrachus*), and the black acara (*Cichlasoma bimaculatum*) are examples of exotic fish species that have become established within south Florida. The origin of these exotics is assumed to be from tropical fish farms in Florida. The extensive canal system offers refuge for fish during drought conditions allowing for rapid repopulation of the marsh when water levels rise. Generally, sport fish are harvested from the borrow canals that surround Everglades marsh. As water levels in the canal and marsh rise, fish populations disperse into the interior marsh and reproduce with minimum competition and predation. As water levels recede, fish concentrate into the deeper waters of the surrounding canals where they become available as prey for wildlife and fishermen. In some instances, the canal fishery has experienced major fish kills due to overcrowding and oxygen depletion.

Estuarine and Marine Fisheries

Anglers spend millions of dollars annually in Florida, fishing for such species as red drum, spotted seatrout, tarpon, snook, jacks, snappers, groupers, sharks, spiny lobsters, and stone crabs. In 1991, anglers landed more than 23.3 million pounds of fish and 9.9 million pounds of shellfish. Some 217 fish species have been collected from various marine and estuarine mangrove communities of south Florida, including sport and commercial fish and invertebrates such as the spiny lobster, pink shrimp, mullet, tarpon, and mangrove snapper (Lewis et al. 1985). Over 600 species of fish have been noted from the Indian River Lagoon region (IRLNEP 1996). A total of 246 fish species have been reported from the estuarine ecosystem of Charlotte Harbor, including 18 commercially important species and 5 species that are important for recreational fisheries (Taylor 1974). Also, Charlotte Harbor is the southern range of the threatened Gulf sturgeon.

Table J-1.6.2-1
Common Everglades Fresh Water Fish Species
(After Gunderson And Loftus, 1993)

Common Name	Scientific Name
Florida Gar	*Lepisosteus platyrhincus*
Bowfin	*Amia calva*
Golden shiner	*Notemigonus crysoleucas*
Tailight shiner	*Notropis maculatus*
Coastal shiner	*Notropis petersoni*
Lake chubsucker	*Erionyzon sucetta*
Yellow bullhead	*Ictalurus natalis*
Brown bullhead	*Ictalurus nebulosus*
Tadpole madtom	*Noturus gyrinus*
Diamond killifish	*Adinia xenica*
Sheepshead minnow	*Cyprinodon variegatus*
Golden topminnow	*Fundulus chrysotus*
Marsh killifish	*Fundulus confluentus*
Seminole killifish	*Fundulus seminolis*
Flagfish	*Jordanella floridae*
Bluefin killifish	*Lucania goodei*
Rainwater killifish	*Lucania parva*
Mosquitofish	*Gambusia affinis*
Least killifish	*Heterandria formosa*
Sailfin molly	*Poecilia latipinna*
Brook silverside	*Labidesthes sicculus*
Everglades pygmy sunfish	*Elassoma evergladei*
Bluespotted sunfish	*Enneacanthus gloriosus*
Warmouth	*Lepomis gulosus*
Bluegill	*Lepomis macrochirus*
Dollar sunfish	*Lepomis marginatus*
Redear sunfish	*Lepomis microlophus*
Spotted sunfish	*Lepomis punctatus*
Largemouth bass	*Micropterus salmoides*
Swampdarter	*Etheostoma fusiforme*

An estimated 96 percent (98 percent Gulf of Mexico and 94 percent southeast Atlantic) by weight of commercially and recreationally important marine fish species in south Florida are dependent upon estuarine habitats for critical life processes (Chambers 1991). The coastal, estuarine, and nearshore ecosystems of south Florida provide a nursery for a wide variety of fish and shellfish species supporting offshore fisheries in the south Atlantic and Gulf of Mexico. However, the habitats that historically supported south Florida fish populations have declined significantly in area and quality over the past 50 years. The alteration of freshwater flows to the estuaries along the southern and southwestern coasts of Florida has reduced water quality of the estuarine habitats of the region. Florida Bay is a key nursery area for various marine species including spotted seatrout, bonefish, red drum, tarpon, pink shrimp, and spiny lobster. However, a 90 percent reduction in freshwater inflow and increased levels of nutrient and pesticides have contributed to an increase of algal blooms, lost seagrass beds, sponge mortality, and salinity increases. These changes have caused increased incidences of fish kills and serious losses of mangroves, all of which are directly linked to land use or land misuse in areas surrounding the Everglades, as well as to south Florida's water management regime.

J.1.6.3 Reptiles and Amphibians

Important reptile species commonly encountered within the study area include the American alligator (*Alligator mississippiensis*), American crocodile (*Crocodylus acutus*), turtles, lizards, and snakes. The American alligator, more than any other species, is most often identified with the Everglades and it's unique wetland ecosystem. Turtles include the five species of sea turtles, including the loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), and the green turtle (*Chelonia mydas*). Freshwater species include snapping turtle (*Chelydra serpentina*), striped mud turtle (*Kinosternon bauri*), mud turtle (*K. subruburm*), cooter (*Chrysemys floridana*), Florida chicken turtle (*Deirochelys reticularia*), and Florida softshell turtle (*Trionys ferox*). Lizards such as the green anole (*Anolis carolinensis*), are found in the central Everglades, and several species of skinks occur more commonly in terrestrial habitats. Numerous snakes inhabit the wetland and terrestrial environment of the south Florida ecosystem. Drier habitats support such species as the Florida brown snake (*Storeria dekayi*), southern ringneck snake (*Diadophis punctatus*), southern black racer (*Coluber constrictor*), scarlet snake (*Cemophora coccinea*), and two rattlesnakes (*Sistrurus miliarius* and *Crotalus adamanteus*). The eastern indigo snake (*Drymarchon corais*), a Federally listed endangered species, and the Florida pine *snake (Pituophis melanoleucus mugitus*), a state species of special concern, may also exist in drier areas of the study area. Wetter habitats support more aquatic species such as the water snake (*Natrix sipedon*), the green water snake (*N. cyclopion*), mud snake (*Francia abacura*), eastern garter snake (*Thamnophis sirtalis*), ribbon snake (*T. sauritus*), rat snake (*Elaphe obsoleta*), and the Florida cottonmouth (*Agkistrodon piscivorus*) (McDiarmid and Pritchard, 1978).

Important amphibians, known to occur in south Florida, include the Everglades bullfrog, or pig frog (*Rana grylio*), which occurs primarily within wet prairie and aquatic slough habitats throughout the Everglades (Ligas, 1960). This amphibian is considered an important economic species and provides recreation for sportsmen and some supplemental income for a few commercial froggers who market these animals through wholesalers, hotels and restaurants. Other important frog species, including the Florida cricket frog (*Acris gryllus*) and southern leopard frog (*Rana sphenocephala*), are common in marshes and wet prairies, while such species as the southern chorus frog (*Pseudacris nigrita*) and various tree frogs (squirrel tree frog, *Hyla squirela*; green tree frog, *H. cinerea*) are common to tree islands and cypress forests. Salamanders inhabit the densely vegetated, still or slow-moving waters of the sawgrass marshes and wet prairies. They include the greater siren (*Siren lancertina*) and the Everglades dwarf siren (*Pseudobranchus striatus*). Toads such the eastern narrow-mouth toad (*Gastrophryne carolinensis*) also occur within the study area.

J.1.6.4 Avifauna

Robertson and Kushlan (1984) indicate that even though nearly 400 species of birds have been recorded in southern Florida, the regional avifauna is characterized by about 300 taxa. Of these species listed, approximately 60 percent are wintering and migrant birds, while about 116 species comprise the native breeding avifauna. South Florida's wetland habitats have historically supported a great diversity and abundance of wading birds (Kushlan and White, 1977). Despite the 95 percent reduction in wading bird population in the state reported since the 1800s, all fourteen species of wading birds found in the eastern United States were reported nesting in Florida in 1977 (Custer and Osborn, 1977).

Colonial wading birds (Order Ciconiformes) commonly observed within the the study area include eleven species of herons and egrets, two species of ibis, the wood stork, and the roseate spoonbill (Robertson and Kushlan, 1984). Important species include white ibis (*Eudocimus albus*), glossy ibis (*Plegadis falcinellus*), the great egret (*Casmerodius albus*), great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), tricolored heron (*E. tricolor*), green-backed heron (*Butorides striatus*), snowy egret (*E. thula*), cattle egret (*Bubulcus ibis*), black-crowned night heron (*Nycticorax nycticorax*), and yellow-crowned night heron (*N. violacea*). The roseate spoonbill (*Ajaia ajaja*), a state species of special concern, and the wood stork (*Mycteria americana*), a Federally listed endangered species, both occur within the study area. Most wading bird species exhibit a seasonal pattern of abundance, being more abundant during the dry season than during the wet season. The majority of species nest in late winter or early spring, although a few, such as the great egret, are reported to nest at different times throughout the year (Kushlan and White, 1977a).

The reproductive cycle of most wading birds is tightly linked with seasonal water level fluctuations within the marsh. During the rainy season, when water levels are high, fish and invertebrate prey species repopulate the newly flooded marsh and begin to increase in abundance. As water levels recede during the dry season, the density of these prey species (topminnows, mosquitofish, killifish, crayfish, freshwater prawns and insect larvae) increase as they concentrate in remnant pools and along the edge of the drying marsh.

Diving birds commonly found in the south Florida ecosystem include the pied-billed grebe (*Podilymbus podiceps*), anhinga (*Anhinga anhinga*), double-crested cormorant (*Phalacrocorax auritus*), common merganser (*Mergus merganser*), and red-breasted merganser (*Mergus serrator*).

Just over 70 species of land birds breed in southern Florida, half of which are songbirds, or passerine types (Lodge 1994). Birds of prey include: the Federally listed (threatened) bald eagle (*Haliaeetus leucocephalus*), Federally listed (endangered) snail kite (*Rostrhamus sociabilis*), and osprey (*Pandion haliaetus*).

Migratory Birds

The south Florida ecosystem is located along one of the primary migratory routes for bird species that breed in temperate North America and winter in the tropics of the Caribbean and South America. More than 116 species of neotropical migrants have been recorded in the south Florida ecosystem. Large numbers of species like the bobolink migrate through the south Florida ecosystem, as they fly from their breeding grounds in southern Canada and the northern Great Plains to the marshes of Argentina and Brazil. Virtually the entire North American population of blackpoll warblers migrates to South America along a route that passes through Florida to the West Indies. Other migratory species like the tanagers, chimney swifts, tree swallows, nighthawks, royal terns, and blue-winged teal also have major migratory pathways through the south Florida ecosystem.

More than 129 bird species migrate to the south Florida ecosystem to overwinter. Another 132 bird species breed in the south Florida ecosystem. Because the south Florida ecosystem lies near Cuba and the West Indies, it draws Caribbean species that rarely appear elsewhere in North America. Examples of these species include the smooth-billed ani, mangrove cuckoo, bananaquit, white-crowned pigeon, and black-whiskered vireo. The south Florida ecosystem has an endemic race of the yellow warbler and contains the majority of the nesting locations for the great white heron, reddish egret, roseate spoonbill, swallow-tailed kite, and short-tailed hawk in the United States.

The coastal area of the south Florida ecosystem like the rest of Florida provides important breeding and wintering areas for shorebirds. The beaches provide nesting habitat for 13 species of shorebirds and support one of the two largest concentrations of wintering shorebirds in Florida. A list of resident and migrant species observed during a recent avian survey on Lake Okeechobee (USACE 1998), and indicative of species found throughout the study area are presented in ***Table J-1.6.4-1.*** For a more complete listing of Florida bird life reference USFWS Draft Multi-Species Recovery Plan.

Table J-1.6.4-1
List Of Common Resident And Migratory Avifauna Of South Florida (After USACE Wildlife Survey Of Lake Okeechobee 1998).

Common/Scientific Name	**Status**
Arboreal Birds [a]	
Blue-gray gnatcatcher (*Polioptila caerulea)*	Resident
Boat-tailed grackle (*Quiscalus major*)	Resident
Common yellowthroat (*Geothlypis trichas*)	Resident
Downey woodpecker (*Picoides pubescens*)	Resident
Eastern meadowlark (*Sturnella magna*)	Resident
Fish crow (*Corvus ossifragus*)	Resident
Killdeer (*Charadrius vociferus*)	Resident
Northern cardinal (*Cardinalis cardinalis*)	Resident
Red-bellied woodpecker (*Melanerpes carolinus*)	Resident
Red-winged blackbird (*Agelaius phoeniceus*)	Resident
Eastern phoebe (*Sayornis phoebe*)	Migrant
Marsh wren (*Cistothorus palustris*)	Migrant
Northern rough-winged swallow (*Stelgidopteryx serripennis*)	Migrant
Palm warbler (*Dendroica palmarum*)	Migrant
Savannah sparrow (*Passerculus sandwichensis*)	Migrant
Sedge wren (*Cistothorus platensis*)	Migrant
Swamp sparrow (*Melospiza georgiana*)	Migrant
Yellow-rumped warbler (*Dendroica coronata*)	Migrant
Aerial Feeding Birds [b]	
Barn swallow (*Hirundo rustica*)	Migrant
Chimney swift (*Chaetura pelagica*)	Migrant
Tree swallow (*Tachycineta bicolor*)	Migrant
Aerial Searching Birds [a]	
Belted kingfisher (*Ceryle alcyon*)	Resident
Caspian tern (*Sterna caspia*)	Resident
Laughing gull (*Larus atricilla*)	Resident
Ringed-billed gull (*Larus delawarensis*)	Resident
Ruddy duck (*Oxyura jamaicensis*)	Resident

Table J-1.6.4-1 List Of Common Resident And Migratory Avifauna Of South Florida (After USACE Wildlife Survey Of Lake Okeechobee 1998).	
Common/Scientific Name	**Status**
Black tern (*Chlidonias niger*)	Migrant
Forster's tern (*Sterna forsteri*)	Migrant
Floating and Diving Birds [a]	
American white pelican (*Pelicanus erythrorhyncus*)	Resident
Brown pelican (*Pelicanus occidentalis*)	Resident
Common gallinule (*Gallinula chloropus*)	Resident
Double-crested cormorant(*Phalacrocorax auritas*)	Resident
Pied-billed grebe (*Podilymbus podiceps*)	Resident
Purple gallinule (*Porphyrula martinica*)	Resident
American coot (*Fulica americana*)	Migrant
Raptors and Vultures [b]	
American kestrel (*Falco sparverius*)	Resident
Bald eagle (*Haliaeetus leucocephalus*)	Resident
Osprey (*Pandion haliaetus*)	Resident
Red-shouldered hawk (*Buteo lineatus*)	Resident
Snail kite (*Rostrhamus sociabilis*)	Resident
Turkey vulture (*Cathartes aura*)	Resident
American swallow-tailed kite (*Elanoides forficatus*)	Migrant
Northern harrier (*Circus cyaneus*)	Migrant
Peregrine falcon (*Falco peregrinus*)	Migrant
Shorebirds [a]	
Black-necked stilt (*Himantopus mexicanus*)	Migrant
Dunlin (*Calidris alpina*)	Migrant
Greater yellowlegs (*Tringa melanoleuca*)	Migrant
Least sandpiper (*Calidris minulilla*)	Migrant
Lesser yellowlegs (*Tringa flavipes*)	Migrant
Stilt sandpiper (*Calidris himantopus*)	Migrant
Surface Feeding Ducks [b]	
Fulvous whistling duck (*Dendrocygna bicolor*)	Resident
Mottled duck (*Anas fulvigula*)	Resident
Blue-winged teal (*Anas discors*)	Migrant
Ringed-necked duck (*Aythya collaris*)	Migrant
Wading Birds a Long Legged [b]	
Great blue heron (*Ardea herodias*)	Resident
Great egret (*Casmerodius albus*)	Resident

Table J-1.6.4-1 List Of Common Resident And Migratory Avifauna Of South Florida (After USACE Wildlife Survey Of Lake Okeechobee 1998).	
Common/Scientific Name	**Status**
Sandhill crane (*Grus canadensis*)	Resident
Wading Birds a Short Legged [b]	
Glossy ibis (*Plegadis falcinellus*)	Resident
Green-backed heron (*Butorides striatus*)	Resident
King rail (*Rallus elagans*)	Resident
Least bittern (*Ixobrychus exilis*)	Resident
Limpkin (*Aramus guarauna*)	Resident
Little blue heron (*Egretta caerulea*)	Resident
Snowy egret (*Egretta thula*)	Resident
Tricolored heron (*Egretta tricolor*)	Resident
White ibis (*Eudocimus albus*)	Resident
Sora rail (*Porzana carolina*)	Migrant

a Avifaunal Groups taken from Drew and Schomer (1984)
b Supplemental Avifaunal Groups

J.1.6.5 Mammals

North America is the origin of all of Florida's native mammalian species, none of the native species had their origin in the tropics (Lodge 1994). Layne (1984) lists up to 30 species, which have been seen or collected in Everglades National Park. The most diverse group of mammals is the carnivores, while the most abundant group is the rodents. A noted feature of the mammal fauna is the near absence of bats (Layne, 1984). ***Table J-1.6.5-1***, below lists the most common mammals of the Everglades region.

South Florida is also home to three species of exotic mammal, which are widespread in natural habitats. In sandy upland areas of the Big Cypress, but less common in other wetland areas of the system, is found the nine-banded armadillo (*Dasypus novemcinctus*). Feral populations of domestic hogs (*Sus scrofa*) are distributed around fringe wetlands in the Big Cypress and elsewhere. Finally, the black rat (*Rattus rattus*) is found around garbage dumps, and buildings, but also in coastal areas including mangrove swamps (Davis and Ogden 1994).

Table J-1.6.5-1 Common Mammals Of The Everglades Region (After Lodge 1994)	
Common name	**Scientific name**
terrestrial and terrestrial/aquatic species	
opossum	*Didelphis virginiana*
marsh rabbit	*Sylvilagus palustris*
gray squirrel	*Sciurus carolinensis*
hispid cotton rat	*Sigmodon hispidus*
round-tailed muskrat	*Neofiber alleni*
gray fox	*Urocyon cinereoargenteus*
raccoon	*Procyon lotor*
Everglades mink	*Mustela vison evergladensis*
striped skunk	*Mephitis mephitis*
river otter	*Lutra concolor*
Florida panther	*Felis concolor*
bobcat	*Lynx rufus*
white-tailed deer	*Odocoileus virginianus*
marine/estuarine species	
Atlantic bottlenose dolphin	*Tursiops truncatus*
West Indian manatee	*Trichechus* manatus

J.1.7 Threatened and Endangered Species

The U.S. Fish and Wildlife Service (USFWS) identified the following eighteen Federally listed plant and animal species that would likely be affected by Restudy alternatives within the study area. For a complete species description, taxonomy, distribution, habitat requirements, management objectives, and current recovery status, reference the Draft Multi-Species Recovery Plan for the Threatened and Endangered Species of south Florida, Volume I (USFWS 1998) or the USFWS endangered species web site at *http://www.fws.gov/~r9endspp.* For a complete listing of all the Federally listed threatened and endangered plant and animal species occurring or thought to occur within the study area, reference the above web site. The Florida Game and Fresh Water Fish Commission (GFC) in a letter dated February 23, 1998, provided information on state listed species. This information is incorporated below. These species and their designation are listed in ***Table J-1.7-1***.

Table J-1.7-1 Threatened, Endangered & SSC Plant And Animal Species Likely To Be Affected By The C&Sf Restudy			
Scientific Name	**Common Name**	**USFWS**	**GFC**
Trichechus manatus	West Indian Manatee	E	E
Felis concolor	Florida panther	E	E
Rostrhamus sociabilis plumbeus	snail kite	E	E
Mycteria americana	wood stork	E	E
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	E	E
Crocodylus acutus	American crocodile	E	E
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E	E
Picoides borealis	red-cockaded woodpecker	E	T
Haliaeetus leucocephalus	bald eagle	T	T
Polyborus plancus	Audubon's crested caracara	T	T
Drymarchon corais couperi	Eastern indigo snake	T	T
Aphelocoma coerulescens	Florida scrub-jay	T	T
Cucurbita okeechobeensis	Okeechobee gourd	E	
Amorpha crenulata	crenulate lead-plant	E	
Euphorbia deltoidea	deltoid spurge	E	
Galactia smallii	Small's milkpea	E	
Polygala smallii	tiny polygala	E	
Euphorbia garberi	Garber's spurge	T	
Falco sparverius paulus	American kestrel(SE subsp.)		T
Grus canadensis pratensis	Florida sandhill crane		T
Mustela vison evergladensis	Everglades mink		T
Sciurus niger avicennia	Big Cypress fox squirrel		T
Ursus americanus floridanus	Florida black bear		T
Rana capito	gopher frog		SSC
Gopherus polyphemus	gopher tortoise		SSC
Pituophis melanoleucus mugitus	Florida pine snake		SSC
Aramus guarauna	limpkin		SSC
Egretta caerulea	little blue heron		SSC
Egretta thula	snowy egret		SSC
Egretta tricolor	tricolored heron		SSC
Eudocimus alba	white ibis		SSC
Speotyto cunicularia	burrowing owl		SSC

Table J-1.7-1 Threatened, Endangered & SSC Plant And Animal Species Likely To Be Affected By The C&Sf Restudy			
Blarina carolinensis shermani	Shermans short-tailed shrew		SSC
Podomys floridanus	Florida mouse		SSC
Sciurus niger shermani	Sherman's fox squirrel		SSC
Liguus fasciatus	Florida tree snail		SSC

E Endangered
T Threatened
SSC State listed Species of Special Concern

J.1.7.1 Animal Species

The following is an overview of the listed animal species identified by the USFWS as likely to be affected by Restudy alternatives, including two mammals, eight birds, and one reptile.

West Indian manatee

The West Indian manatee (*Trichechus manatus*) has been recognized as an endangered species since 1967. Both the USFWS and GFC list it as an endangered species. Manatees are also protected under the provisions of the Marine Mammal Protection Act of 1972, as well as by Florida law. Manatees occur in both fresh and salt water habitats, and are believed to show preference to waters with salinity levels < 25ppt. Waters colder than 20^0C increase the manatee's susceptibility to cold-stress and cold-induced mortality. Manatees therefore generally seek out warm water refuges in quiet areas in canals, creeks, lagoons or rivers. Manatees are also found throughout the waterways in south Florida, Lake Okeechobee and occasionally in the Florida Keys. In south Florida, manatees are most prominent year round in the Indian River, Biscayne Bay, Everglades and Ten Thousand Islands area, Estero Bay and Caloosahatchee River area and Charlotte Harbor area. Manatees feed on a variety of submergent, emergent and floating vegetation and usually forage in shallow grass beds adjacent to deeper channels. The primary threats to manatees today are due to collisions with watercraft, degradation of seagrasses and accidents occurring at water control structures.

Florida panther

The Florida panther (*Felis concolor*), Florida's state animal, is one of the most endangered large mammals in the world. Although it is listed as endangered by the USFWS and GFC, no critical habitat has been designated. Population estimates in south Florida range between 30 to 80 total animals. The only known, remaining panther population is centered in and around the Big Cypress Swamp/Everglades physiographic region of south Florida. About half of the known panther range is situated on private lands north of Interstate 75, the remainder being located on key public lands. In general, panthers prefer lands of higher elevation, better drained, with a high percentage of hardwood hammocks and pine flatwoods. These lands are most productive for important prey species, white-tailed deer, feral hogs, raccoon and 9-banded armadillo. Environmental factors affecting the Florida panther include habitat loss and fragmentation, environmental contaminants, prey availability, human-related disturbance and mortality, disease, and genetic erosion (Dunbar 1994).

Snail kite

The snail kite (*Rostrhamus sociabilis plumbeus*) is wide ranging raptor, listed as endangered by the USFWS and GFC. Within the study area, critical habitat includes portions of the Water Conservation Areas (WCAs), portions of Everglades National Park and western portions of Lake Okeechobee. Lake Okeechobee and surrounding wetlands are major nesting and foraging habitats, particularly the large marsh in the southwestern portion of the lake. The snail kite has a highly specific diet composed almost exclusively of apple snails (*Pomacea paludosa*), which makes the kite directly dependent on hydrology and water quality within these watersheds. Preferred habitat for the snail kite includes long hydroperiod wetlands, flooded for $\geq$ 1 year, with marsh vegetation dominated by spike rush, beak rush, maidencane, sawgrass and/or cattails, and relatively clear and open areas in order to visually search for apple snails. Nesting almost always occurs over water, near suitable foraging habitat, but may occur in herbaceous vegetation during periods of low water when dry conditions prevail beneath willow stands. The principal threats to snail kites are related directly to the water management of the C&SF Project, which may contribute to the loss or degradation of wetlands, as well as degradation of water quality from agricultural and urban sources.

Wood stork

The wood stork (*Mycteria americana*) is listed as an endangered species by the USFWS and the GFC. In a USFWS coordinated survey of wood stork colonies, conducted from 1991-1995, between 1,339 (1991) and 2,639 (1995) wood stork nests were surveyed in south Florida, approximately 35 percent of the total nesting effort in the southeast United States. In south Florida, breeding colonies of the wood stork occur throughout the study area, with particularly important colonies occurring at Corkscrew Wildlife Sanctuary, Cuthbert Lake, East River and Sadie Cypress. Wood storks forage in freshwater marshes, seasonally flooded roadside or agricultural ditches, narrow tidal creeks, shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Wood storks feed almost entirely on fish between 2 and 25 cm in length (Kahl 1964, Ogden *et al.* 1976, Coulter 1987), and depend on prey species being concentrated in receding waters as they use a tactile feeding technique, using their stout beak as a probe. A key environmental concern is that of nesting failure due to water management practices currently in place. During wet years, fish are not sufficiently concentrated in shallow pools for the storks to forage effectively. In dry years, freshwater sloughs are overdrained, and thus unable to produce the fish on which storks feed.

Cape Sable seaside sparrow

Cape Sable seaside sparrows (*Ammodramus maritimus mirabilis*) are listed as endangered by the USFWS and the GFC. Critical habitat for the Cape Sable seaside sparrow was designated in 1977. They have the most restricted range of any of the seaside sparrows, and occur only in the Everglades region of Miami-Dade and Monroe Counties in south Florida. Presently, the known distribution of the sparrow is restricted to two areas on the east and west sides of Shark River Slough and Taylor Slough in Everglades National Park. The preferred habitat of the sparrow are short-hydroperiod marl prairies, dominated by muhly grass (*Muhlenbergia filipes)* with open space for ground movement. Nesting occurs from late February through early August, with the majority of nesting occurring in the spring when the marl prairies are usually dry. Sparrows build nests of grassy materials about 14 cm above the ground (Werner 1975, Lockwood *et al*. 1997). Currently the greatest threat to the Cape Sable seaside sparrow appears to be loss of its nesting habitat due to changes in historical hydropatterns within the sparrow range as a result of the C&SF Project, its associated operational schedules, and flood control regulatory releases.

American crocodile

The American crocodile (*Crocodylus acutus*) is designated as endangered by the USFWS and the GFC. Critical habitat was designated in 1979, and is described in the Multi-Species Recovery Plan for south Florida (USFWS 1998). The American crocodile inhabits coastal habitats of extreme south Florida, including coastal areas of Miami-Dade, Monroe, Collier, and Lee counties. Crocodiles are regularly observed in Florida and Biscayne Bays, found primarily in mangrove swamps, along low energy mangrove lined bays, creeks, and inland swamps (Kushlan and Mazzotti 1989). The crocodile population in Florida, although small, appears stable. Recent changes in nesting effort, from survey data collected from the late 1970's, indicate population levels be on the rise. Crocodiles are susceptible to poaching for their hides and for meat. Habitat loss and fragmentation due to increases in urbanization and agricultural land uses, natural catastrophes e.g. hurricanes, changes in the distribution, timing, quantity, and quality of freshwater flows, and direct human disturbance to animals and their nests, also affect crocodiles.

Florida grasshopper sparrow

The USFWS listed the Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) as endangered in 1986 because of habitat loss and degradation resulting from conversion of native vegetation to improved pasture (USFWS 1998). It is also listed as endangered by the GFC. No critical habitat has been designated for this sub-species. The Florida grasshopper sparrow is non-migratory, and is limited to the prairie region of south-central Florida. Within the study area, it is known to inhabit Glades, Highlands, Okeechobee, Osceola, and Polk Counties, in habitat consisting primarily of tree-less, relatively poorly drained grasslands that have a history of frequent fires (USFWS 1988, Delany 1996a). Less than 600 Florida grasshopper sparrows are thought to exist as of the 1997 breeding season. The Florida grasshopper sparrow is currently protected on three large tracts of land, including Avon Park Air Force Reserve (Highlands and Polk Counties), Three Lakes Wildlife Management Area (Osceola County), and the National Audubon Society's Ordway-Whittell Kissimmee Prairie Sanctuary. Threats to the Florida grasshopper sparrows include habitat loss, overgrazing, unfavorable hydrologic conditions which prevent nesting. If unfavorable conditions continue for extended periods, they alter the vegetation composition, predation and nest parasitism.

Red-cockaded woodpecker

The USFWS has listed the Red-cockaded woodpecker (*Picoides borealis*) as endangered, due largely to destruction of its habitat, and fragmentation of its historic home range. It is listed as threatened by the GFC. The estimated Florida breeding population of the red-cockaded woodpecker is about 1,500 pairs, with about 75 percent of that total occurring in the panhandle (Cox *et al.* 1995). Active colonies of red-cockaded woodpeckers are interspersed throughout the study area, most notably in Osceola, Highlands, St. Lucie, Palm Beach, Glades, Charlotte, Lee, and Monroe Counties. Pine stands, or pine-dominated hardwood stands, with a low or sparse understory and ample old-growth pines, constitute primary red-cockaded woodpecker nesting and roosting habitat (USFWS 1998). Longleaf pine provide important nesting habitat where available, however cavities are also constructed in other pines, and in southwest Florida, the hydric slash pine is preferred. Throughout its range, the red-cockaded woodpecker is threatened by habitat loss and fragmentation, lack of fire or infrequent fire which maintains habitat quality, and invasion by exotic vegetation.

Bald eagle

The bald eagle (*Haliaeetus leucocephalus*) is listed as threatened by both the USFWS and the GFC. Bald eagles are known throughout the study area, where they typically are found near estuaries, large lakes, reservoirs, major rivers and particularly along the southwest coast and in the Kissimmee River region. Eagle numbers have responded positively to the banning of DDT and other organochlorines and the listing of the bald eagle as an endangered species (since re-classified to threatened). Eagles feed primarily on fish, water dependent birds, and mammals. Eagles are opportunistic feeders and will also eat carrion. Current threats to the bald eagle include habitat loss and fragmentation, collisions with cars and powerlines, and shooting (USFWS 1998).

Audubon's crested caracara

The Florida population of this resident, non-migratory raptor is listed as threatened by the USFWS and GFC. The caracara (*Polyborus plancus)* commonly occurs in dry or wet prairie areas, as well as improved or semi-improved pasture. The region of greatest abundance is a five county area north and west of Lake Okeechobee, including Glades, DeSoto, Highlands, Okeechobee, and Osceola counties (Kissimmee River and Caloosahatchee River regions). Caracara have also been observed nesting in the Big Cypress region, west of the Big Cypress Seminole Indian Reservation. Caracaras are highly opportunistic feeders, eating carrion and a large variety of live prey. Their numbers continue to decline throughout their range due largely to loss of habitat. In particular, the caracara has suffered because its preferred dry prairie habitat has been destroyed or modified for agriculture or residential development. Direct human mortality, e.g. vehicular accidents and illegal trapping, also pose a significant threat to caracara.

Eastern indigo snake

The eastern indigo snake (*Drymarchon corais couperi*) is a large, black, non-venomous snake and occurs within every major physiographic region within the study area. The USFWS and GFC list it as a threatened species. The eastern indigo snake, generally an upland species, occupies a wide variety of habit, including pine flatwoods, scrubby flatwoods, dry prairie, tropical hardwood hammocks, along the margins of freshwater marshes, agricultural fields, coastal dunes, and human altered habitats. They are usually not found in abundance in the wetland complexes of the central Everglades region. In wetter habitats, eastern indigo snakes may take shelter in hollowed root channels, hollow logs, or the burrows of rodents, armadillo, or crabs (Lawler, 1977, Moler 1985b, Layne and Steiner 1996). Currently the greatest impact to the eastern indigo snake has been by the loss, degradation, and fragmentation of their habitat due to residential and commercial construction, agriculture and timbering. Pesticides, mortality from vehicles, and illegal trapping also pose a threat to recovery efforts of this species.

Florida scrub-jay

The Florida scrub-jay (*Aphelocoma coerulescens*) is a medium sized song bird, which occurs in relict oak dominated scrub or xeric oak scrub, on well drained, sandy soils. Optimal habitat for scrub-jays is one in which oaks are one to three meters high, interspersed with 10 to 50 percent of unvegetated, sandy openings, and with a sand pine (*Pinus clausa*) cover of less than 20 percent (Woolfenden and Fitzpatrick 1990). One of three, "core populations", which comprises a significant portion of the remaining scrub-jay population, is found in the Lake Wales Ridge region (Fitzpatrick et al. 1994). This region encompasses parts of Polk, Osceola, Highlands, and Glades Counties. Scrub-jays are extremely territorial, habitat-specific, and sedentary and the species has declined by an estimated 25 to 50 percent in the past ten to twelve years (USFWS 1998). Currently the greatest impact to this state (threatened) and Federally (threatened) listed species is from habitat fragmentation, degradation and loss of scrub habitat. This is thought to be due to widespread fire suppression, conversion of rural lands to citrus production and residential development (Fernald 1989, Fitzpatrick et al. 1991).

J.1.7.2 Plant Species

The following is an overview of the listed plant species identified by the USFWS as likely to be affected by Restudy alternatives. The Okeechobee gourd resides within the Herbert Hoover Dike along Lake Okeechobee, while the other plant species identified mostly inhabit the pine rocklands, along the Atlantic Coastal Ridge.

Okeechobee gourd

The Okeechobee gourd (*Cucurbita okeechobeensis*) is listed as endangered by the USFWS. There are several localized sites along the southeastern shore of Lake Okeechobee, where this vine is found within the study area, including: Torry Island, Ritta Island, Kreamer Island, Bay Bottom Dynamite Hole Island, South Shore Dynamite Hole Island, and the southern shore of the Lake Okeechobee Rim Canal (Walters et al. 1992; Walters and Deckers-Walters 1993). Fluctuating lake levels are necessary for the continued survival and recovery of the gourd within and around Lake Okeechobee. High lake levels facilitate seed dispersal and inhibit proliferation of aggressive weeds and exotic plants in local habitats. As lake levels decrease, the cleared open habitats allow gourds to germinate and quickly climb onto adjacent trees. Prolonged high or low lake stages are detrimental to the gourd as well, affecting seed germination, plant survival, and encroachment by woody vegetation, eg. Melaleuca.

Crenulate Lead-plant

The crenulate lead-plant (*Amorpha crenulata*) is an endangered shrub endemic to Miami-Dade County. It occurs on marl prairies and wet pinelands. It was Federally listed as endangered species by the USFWS in 1985. The crenulate lead-plant has a restricted range, and is known from only nine sites from Coral Gables to Kendall. Vegetative communities within the historic range of the crenulate lead-plant have been almost entirely destroyed, and its habitat remains threatened by expanding development and agriculture. Fire suppression, invasion by exotic vegetation, and drainage further threatens its habitat.

Deltoid Spurge

Designated by USFWS as endangered in 1985, the deltoid spurge (*Euphorbia deltoidea*) is endemic to Miami-Dade County and occurs from south Miami to the Homestead area. It occurs in the pine rocklands, in areas with an open shrub canopy, on exposed limestone, or along the edges of sand pockets. Ninety-eight percent of its historic range has been destroyed as a result of urban expansion. Periodic fires, necessary to maintain spurge habitat, are routinely suppressed, and exotic plant invasions of spurge habitat threaten the recovery of this plant.

Small's Milkpea

Small's milkpea (*Galactia smallii*) is endemic to the pine rocklands of Miami-Dade County. As with the deltoid spurge, it has been designated by USFWS as endangered since 1985. Due to the nearly total destruction of pine rocklands in Miami-Dade County, habitat is limited and fragmented and difficult to manage. Periodic fires, necessary to maintain appropriate habitat, are routinely suppressed, and exotic plants, most notably *Schinus* and *Neyraudia*, further degrade milkpea habitat.

Tiny Polygala

Tiny polygala (*Polygala smallii*) is listed as an endangered plant species by the USFWS. This short-lived herb occurs along the Atlantic coast, within the Lower East Coast and Martin and St. Lucie Counties. The tiny polygala inhabits the remaining pine rocklands, open sand pine scrub, sandhill, and well drained coastal spoil habitats (Bradley and Gann 1995). The USFWS (1998) Multi-Species Recovery Plan for south Florida, may be referenced for a complete description of tiny polygala habitat occurring in counties within the study area. Tiny polygala populations are estimated to contain roughly 2,000-2,500 individual plants, although tiny polygala is known to exhibit annual fluctuations as much as several hundred percent, season to season (Bradley and Gann 1995, DERM 1993). Environmental factors affecting tiny polygala are similar to those for the deltoid spurge and Small's milkpea.

Garber's Spurge

Garber's spurge (*Euphorbia garberi*) is a short-lived perennial herb known to inhabit pine rocklands, coastal flats, coastal grasslands, and beach ridges in Miami-Dade and Monroe counties, including the Florida Keys. Garber's spurge was listed by the USFWS as an endangered species in 1985 because of habitat loss from residential and commercial development (50 CFR 29349). Cape Sable, Long Pine Key and Big Pine Key all contain populations of Garber's spurge, which typically grow at low elevations, on thin sandy soils, or directly on limestone. As with the other pine rockland herb species above, development, fire suppression and invasive exotics continue to contribute to the overall decline in spurge populations and habitat quality.

Presently twenty-three species of animals occur within the study area that are designated as threatened or endangered by the USFWS. An additional twenty-two species are under review to determine their status. The GFC has identified thirty-two species designated as threatened or endangered which occur within the Everglades. An additional eighteen species are classified as species of special concern. These species and their designation are listed in ***Tables J-1.7-2*** and ***J-1.7-3***.

Table J-1.7-2
Protected Wildlife Species Present And Potentially Present Within The Project Area

Scientific Name	Common Name	GFC[1]	USFWS[2]
Amphibians And Reptiles			
Alligator mississippiensis	American alligator	SSC	T-S/A
Caretta caretta caretta	Atlantic loggerhead turtle	T	T
Chelonia mydas mydas	Atlantic green turtle	E	E
Crocodylus acutus	American crocodile	E	E
Dermochelys coriacea	Leatherback turtle	E	E
Drymarchon corais couperi	Eastern indigo snake	T	T
Eretmochelys imbricata imbricata	Atlantic hawksbill turtle	E	E
Gopherus polyphemus	Gopher tortoise	SSC	C2
Heterodon simus	Southern hognose snake	---	C2
Lepidochelys kempii	Atlantic ridley turtle	E	E
Nerodia clarkii	Gulf salt marsh snake	---	C2
Ophisaurus compressus	Island glass lizard	---	C2
Pituophis melanoleucus mugitus	Florida pine snake	SSC	C2
Pseudobranchus striatus lustricolus	Gulf hammock dwarf siren	---	C2
Rana capito aesopus	Florida crawfish frog	SSC	C2
Sceloporus woodi	Florida scrub lizard	---	C2
Kinosternon bauri	Striped mud turtle	E	
Diadophis punctatus acricus	Big Pine Key ringneck snake	T	
Storeria dekayi victa	Florida brown snake	T	
Thamnophis sauritus sackeni	Florida ribbon snake	T	
Eumeces egregius egregius	Florida Keys mole skink	SSC	
Elaphe guttata guttata	Red rat snake	SSC	

Table J-1.7-2 Protected Wildlife Species Present And Potentially Present Within The Project Area			
Scientific Name	**Common Name**	**GFC[1]**	**USFWS[2]**
Tantilla oolitica	Miami black-headed snake	T	C2
Birds			
Ajaia ajaja	Roseate spoonbill	SSC	---
Ammodramus maritima	Cape Sable seaside sparrow	E	E
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E	E
Aphelocoma coerulescens coerulescens	Florida scrub jay	T	T
Aramus guarauna	Limpkin	SSC	---
Charadrius melodus	Piping plover	T	T
Columba leucocephala	White-crowned pigeon	T	C2
Dendroica kirtlandii	Kirtland's warbler	E	E
Egretta caerulea	Little blue heron	SSC	---
Egretta rufescens	Reddish egret	SSC	C2
Egretta thula	Snowy egret	SSC	---
Egretta tricolor	Tricolored heron	SSC	---
Eudocimus albus	White ibis	SSC	---
Falco peregrinus tundrius	Arctic peregrine falcon	E	T
Falco sparverius paulus	Southeastern American kestrel	T	C2
Grus canadensis pratensis	Florida sandhill crane	T	---
Haematopus palliatus	American oystercatcher	SSC	---
Haliaeetus leucocephalus	Bald eagle	T	T
Lanius ludovicianus migrans	Migrant loggerhead shrike	---	C2
Mycteria americana	Wood stork	E	E
Pandion haliaetus	Osprey	SSC*	---
Pelecanus occidentalis	Brown pelican	SSC	---
Picoides borealis	Red-cockaded woodpecker	T	E
Polyborus plancus audubonii	Audubon's crested caracara	T	T
Rostrhamus sociabilis plumbeus	Snail kite	E	E
Speotyto cunicularia	Burrowing owl	SSC	---
Sterna albifrons	Least tern	T	---
Sterna dougallii	Roseate tern	T	T

Table J-1.7-2 Protected Wildlife Species Present And Potentially Present Within The Project Area			
Scientific Name	**Common Name**	**GFC[1]**	**USFWS[2]**
Charadrius alexandrinus tenuirostris	Southeastern snowy plover	T	
Rhynchops niger	Black skimmer	SSC	
Grus americana	Whooping crane	SSC	
Mammals			
Blarina carolinensis (=brevicauda) shermani	Sherman's short-tailed shrew	SSC	C2
Eumops glaucinus floridanus	Florida mastiff bat	E	C1
Felis concolor coryi	Florida panther	E	E
Mustela vison evergladensis	Everglades mink	T	---
Neofiber alleni	Round-tailed muskrat	---	C2
Peromyscus (= Podomys) floridanus	Florida mouse	SSC	C2
Plecotus rafinesquii	Southeastern big-eared bat	---	C2
Scalopus aquaticus bassi	Englewood mole	---	C2
Sciurus niger avicennia	Mangrove fox squirrel	T	C2
Trichechus manatus latirostris	West Indian manatee	E	E
Neotoma floridana smalli	Key Largo woodrat	E	E
Odocoileus virginianus clavium	Key deer	E	E
Oryzomys argentatus	Silver rice rat	E	E
Oryzomys palustris sanibeli	Sanibel rice rat	E	
Peromyscus gossypinus allapaticola	Key Largo cotton mouse	E	E
Sylvilagus palustris hefneri	Lower Keys marsh rabbit	E	E
Sciurus niger shermani	Sherman's fox squirrel	SSC	
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	T
Ursus americanus floridanus	Florida black bear	T	C2
Invertebrates			
Liguus fasciatus	Florida tree snail	SSC	---
Heraclides aristodemus ponceanus	Schaus' swallowtail butterfly	E	E
Dendrogyra cylindrus	Pillar coral	E	
Orthalicus reses	Stock Island tree snail	E	T
Strymon acis bartrami	Bartram's hairstreak butterfly	---	C-2

Table J-1.7-2 Protected Wildlife Species Present And Potentially Present Within The Project Area			
Scientific Name	**Common Name**	**GFC[1]**	**USFWS[2]**
Fish			
Centropomas undecimalis	Common snook	SSC	
Rivulus marmoratus	Mangrove rivulus	SSC	
Starksia starcki	Key blenny	SSC	

Notes
1 Florida Game and Fresh Water Fish Commission, June, 1994
E Endangered
T Threatened
SSC Species of Special Concern
2 U.S. Fish and Wildlife Service, June, 1994
E Endangered
T Threatened
C1 A candidate for Federal listing, with enough substantial information on biological vulnerability and threats to support proposals for listing.
C2 A candidate for listing, with some evidence of vulnerability, but for which not enough data exist to support listing.
T-S/A Threatened due to Similarity of Appearance
* Monroe County only

Table J-1.7-3 Federally Protected Plant Species Present And Potentially Present Within The Project Area			
Scientific Name	**Common Name**	**FDA[1]**	**USFWS[2]**
Plants			
Amorpha crenulata	Crenulate lead plant	E	E
Asimina tetramera	Four-petal pawpaw	E	E
Bonamia grandiflora	Florida bonamia	E	T
Chamaesyce deltoidea	Wedge spurge	E	E
Chamaesyce garberi	Garber's spurge	E	T
Cucurbita okeechobeensis	Okeechobee gourd	E	E
Eriogonum longifolium var. gnaphalifolium	Scrub wild buckwheat	T	T
Eryngium cunneifolium	Wedge-leaved button snakeroot	E	E
Galactia smallii	Small's milkpea	E	E
Jacquemontia reclinata	Beach jacquemontia	E	E
Polygala smallii	Tiny polygala	E	E
Roystonea elata	Florida royal palm	E	---
Tillandsia pruinosa	Hoary airplant	E	---

Notes
1 Florida Department of Agriculture, June, 1994
E Endangered
T Threatened
CE Commercially Exploited
2 U.S. Fish and Wildlife Service, June, 1994
E Endangered
T Threatened
C1 A candidate for Federal listing, with enough substantial information on biological vulnerability and threats to support proposals for listing.
C2 A candidate for listing, with some evidence of vulnerability, but for which not enough data exist to support listing.

J.1.7.3 Critical Habitat

Critical Habitat is a Federal term used to formally designate a specific area of habitat to the survival of that species. Of the listed species, Critical Habitat has been designated for the West Indian manatee, snail kite, Cape Sable seaside sparrow and American crocodile. For specific descriptions of these critical habitat geographic designations, refer to the draft Multi-Species Recovery Plan for the Threatened and Endangered Species of south Florida, Volume I (USFWS 1998).

J.1.8 Water Management

The Central and Southern Florida (C&SF) Project has been broken down into four hydrologically related geographical areas consisting of: 1) the Kissimmee River – Istokpoga Basin; 2) the Lake Okeechobee and Everglades Agricultural Area; 3) the Water Conservation Areas, Everglades National Park, and Everglades National Park - South Miami-Dade Conveyance Canals; and 4) the East Coast Canals.

J.1.8.1 Kissimmee River – Istokpoga Basin

The Kissimmee River – Lake Istokpoga Basin portion of the project includes most of Osceola and Okeechobee and parts of Orange, Polk, Highlands, and Glades Counties. It is bounded on the north by the lakes of the Orlando area, on the west by the Peace River watershed, on the south by Lake Okeechobee and on the east by the Upper St. Johns River Basin and the Taylor Creek-Nubbin Slough Basin. The project purposes include flood control, water supply, navigation, and the preservation of fish and wildlife. The project protects the lands adjacent to the lakes and along the Kissimmee River from frequent and prolonged flooding. It provides water supply for agricultural uses in the area in and around the lakes and the Kissimmee River. It also provides for navigation on the Kissimmee River and all lakes in the middle and upper Kissimmee River Basin. Locks are provided at control structures on the main watercourse between East Lake Tohopekaliga and Lake Okeechobee. Boatlifts are provided at all other structures. Maintaining lake stages at a desirable level for fish and wildlife and for recreational purposes is also important.

The Kissimmee Basin is an integrated system of lake storage capabilities and structure outlet capacities. The Upper Kissimmee Basin structures are operated according to regulation schedules. The regulation schedule essentially represents the seasonal and monthly limits of storage that guide the regulation of the project for the planned purposes. The regulation schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. The lakes are drawn down in the spring to provide flood control storage and for fish and wildlife enhancement. The minimum levels are set to provide for sufficient flood control storage and navigation depths. The amount of seasonal fluctuation was derived by determining the effect of various water levels on the flood control, low water regulation, groundwater, fish and wildlife, and recreation. Runoff during the wet season is stored for use in the dry season. The regulation schedules take into account these varying, and often, conflicting purposes.

The Lake Istokpoga Project works were primarily designed to protect lands adjacent to the lake from flooding by lake waters and provide water supply for agricultural use in areas around the lake and in the Indian Prairie area. At the same time, project works maintain the lake at a desirable level for fish and wildlife, navigation, and for recreational purposes.

The project has resulted in the reduction of areas inundated by major floods with floodwaters being passed for storage in Lake Okeechobee, and prevention of longer duration of low to no-flow water conditions during prolonged periods of drought in the lower basin. This is accomplished by conserving or storing waters within both the controlled pools behind the existing structures and in the channelways for drought protection. Other effects include year-round small boat navigation of the system from Lake Tohopekaliga to Lake Okeechobee with boat access to the Kissimmee River for fishing and recreation. The C-38 pools add to the total volume of water available for aquatic species support.

J.1.8.2 Lake Okeechobee and Everglades Agricultural Area

Lake water levels in Lake Okeechobee are regulated by a complex system of pumps and locks. The regulation schedule attempts to achieve the multiple-use purposes as well as provide seasonal lake level fluctuations. The schedule maintains a low lake stage to provide both storage capacity and flood protection for surrounding areas during the wet season. During the winter, lake levels may be increased to store water for the upcoming dry season. The general plan of operation for Lake Okeechobee is based on the following: 1) flood protection from lake waters and hurricane-driven wind tides for lands adjacent to the lake; 2) maintenance of an 8-foot navigation channel across Lake Okeechobee, as part of the Okeechobee Waterway and; 3) storage of water to meet the requirements of the agricultural area south and east of the lake.

Flood control works on Lake Okeechobee consist of a system of about 1,000 miles of encircling levees, designed to withstand a severe combination of flood stage and hurricane occurrence, plus the regulatory outlets of St. Lucie Canal and the Caloosahatchee River. The design discharge of Moore Haven Spillway is 9,300 cfs; that of St. Lucie spillway is about 16,000 cfs. Following removal of local runoff from the agricultural areas south of the lake, an additional regulatory capability of several thousand cfs is available through the Miami, North New River, Hillsboro, and West Palm Beach canals by pumping into the three Water Conservation Areas (WCAs). The crest elevation of the levee system surrounding the lake ranges from 32 to 45 ft., NGVD. The likelihood of overtopping the levees from having excess storage is almost non-existent. Possible flooding due to overtopping of levees within the Herbert Hoover Dike system is limited to short duration events involving wave runup in addition to hurricane-induced storm surge. The likelihood of such events is remote and the expected extent of flooding is minimal.

J.1.8.3 Water Conservation Areas (WCAs)

The primary purposes for the WCAs and their appurtenant levees, canals, structures, and pump stations include flood control, water conservation, prevention of salt-water intrusion, recreation, preservation of fish and wildlife, and water supply for Everglades National Park. The WCAs are completely contained by levees, except for about 7 miles on the west side of WCA-3A, which has a tieback levee. There are also levees on the east side of the East Everglades, which protect the agricultural and industrial areas, which otherwise would have been short hydroperiod wetlands, from inundation. This whole region is managed with a system of canals, multiple pump stations, and control structures. The main canals are West Palm Beach Canal, Miami Canal, Bolles and Cross Canals, North New River Canal, South New River Canal, Hillsboro Canal, and Tamiami Canal.

The WCAs provide a detention reservoir for excess water from the agricultural area and parts of the east coast region, and for flood discharge from Lake Okeechobee to the sea. The WCAs provide levees to prevent Everglades floodwaters from inundating the east coast urban areas; provide a water supply for east coast areas and Everglades National Park; improve the water supply for east coast communities by recharging underground freshwater reservoirs; reduce seepage; ameliorate salt-water intrusion in coastal wellfields; and benefit fish and wildlife in the Everglades. The South Miami-Dade Conveyance System provides a way to deliver water to areas of south Miami-Dade County. This canal system was overlaid on top of the existing flood control system. Many of these canals are used to remove water from interior areas to tidewater.

The regulation schedules contain instructions and guidance on how project spillways are to be operated to maintain water levels in the WCAs. The regulation schedule essentially represents the seasonal and monthly limits of storage which guides project regulation for the planned purposes. The schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. This seasonal range permits the storage of runoff during the wet season for use during the dry season. In addition, it serves to maintain and preserve the vegetative regimen in the WCAs, which is essential to fish and wildlife and the prevention of wind tides. Regulation schedules must take into account various, and often conflicting, purposes. Conceptually, reservoir storage is commonly divided into the inactive zone, the water supply (conservation) zone, and the flood control zone. The distribution of water between the flood control and water supply zones varies seasonally in the WCAs. The regulation schedules for WCA-1, WCA-2A, and WCA-3A include a minimum water level, as measured in the borrow canals, below which water releases are not permitted unless water is supplied from another source. Note that this does not mean that a minimum stage is maintained in the WCAs. When water levels fall below the minimum levels, transfers from Lake Okeechobee or the WCAs are made to meet water supply demands.

J.1.8.4 East Coast Canals

The East Coast Canals (ECC) are the flood control and outlet works that extend from St. Lucie County southward through Martin, Palm Beach and Broward

Counties to Miami-Dade County, a distance along the Atlantic Coast of about 170 miles. The ECC encompasses the majority of the canals and water control structures located along the lower east coast of Florida. The main design functions of the project canals and structures in the ECC area are to protect the adjacent coastal areas of the east coast of Florida against floods; store water in conservation areas west of the general alignment of the levees; control water elevations in adjacent areas; and provide water for conservation and utilization purposes. There are 40 operating canals, one levee, and 50 operating structures, consisting of 35 spillways, 14 culverts, and 1 pump station. The project works prevent major flood damages. However, due to urbanization, the existing surface water management system now has to handle greater peak flows than in the past.

Areas become flooded during heavy rainfall events due to antecedent conditions that cause saturation and high runoff from both developed and undeveloped areas. The automatic controls installed on some of the water control structures allow them to be placed on low range, which provides limited extra storage in the lakes and canals, increasing the gradient and capacity of the secondary systems. The automatic controls also allow for frequent gate changes that keep the water levels in the safe range. Saltwater intrusion has declined considerably at coastal structures since the installation of salinity dams downstream and the placement of salinity monitoring sensors near the structures. Damage to agriculture, citrus, and pasturelands has been reduced due to the effective drainage capabilities of the canals.

The project works maintain optimum stages for the purposes of flood control, water supply, groundwater recharge, and prevention of salt water intrusion. The coastal canals and control structures between St. Lucie and Miami-Dade Counties are designed to permit rapid removal of floodwaters from their immediately adjacent drainage area. The degree of flood protection provided by outlet capacity is dependent on whether the protected area is urban or agricultural. Maximum rates of removal vary from 40 percent to 100 percent SPF. Many of these coastal area structures have gates that open and close automatically to maintain optimum water levels upstream, with the exception of hurricane or tropical storm regulation. The canals and structures will be regulated automatically or manually, as designed, in accordance with the optimum water control and design elevations.

The network of canals and control structures provides for water and salinity control in the area. Wellfields, which are the source of municipal water supplies, are significantly recharged by conservation area water. Water stored in the WCAs can be used to maintain groundwater levels in the coastal area for public water supply, to irrigate the vast agricultural areas interspersed within the project area, and to maintain a freshwater head along the lower east for salinity control.

J.1.9 Water Quality

This baseline water quality section, together with ***Appendix H***, provides an overview of the existing conditions of the ten regions of the C&SF Restudy study area. Specifically, it identifies water quality parameters potentially affected by the current conditions in the region, selects “key” and additional “other” water quality parameters by region, highlights and discusses three major parameters of regional concern, provides water quality references used for baseline data compilations, and presents narrative on the overall water quality of the region. Surface water conditions are emphasized with some ground water information also being provided.

Because there currently are water quality concerns for several of these parameters, the U.S. Environmental Protection Agency (USEPA) and Florida Department Environmental Protection join the U.S. Army Corps of Engineer’s concerns about the water quality of south Florida. As National Environmental Policy Act Cooperating Agencies to the U.S. Army Corps of Engineers (USACE) for this PEIS, the U.S. Environmental Protection Agency and Florida Department of Environmental Protection encourage the U.S. Army Corps of Engineers to fully consider both water quantity and water quality actions in their hydrologic restoration of south Florida via the Restudy PEIS.

Study Area Regions - As previously indicated in this PEIS, the project area of the C&SF Restudy project area is divided into ten designated regions. These regions are as follows: Kissimmee River Region, Lake Okeechobee, Upper East Coast and Indian River Lagoon (including the St. Lucie River and the Indian River Lagoon), Everglades Agricultural Area, Water Conservation Areas, (including the Loxahatchee National Wildlife Refuge, WCA 2A/2B, WCA 3A/3B, and Holey Land and Rotenberger Wildlife Management Areas), Lower East Coast and Biscayne Bay (including the Loxahatchee River Aquatic Preserve, Lake Worth, and Biscayne Bay), Everglades National Park and Florida Bay (including the Shark River Slough/Taylor Slough, Florida Bay, Whitewater Bay, and Ten Thousand Islands), the Florida Keys, Big Cypress Region, and Caloosahatchee River Region.

Water Quality Parameters and Data - Numerous water quality parameters are potentially affected by the current conditions in the C&SF Restudy project area. This suite of water quality parameters of potential concern consists of metals, pesticides, nutrients, biologicals, physical parameters, and other parameters. These are listed below in ***Table J-1.9-1*** and are further addressed in ***Appendix H*** and its Attachment A. Of these parameters, several “key” parameters of concern were selected for each region. These key parameters were selected (see Table J-1.9.5-1) based on the perceived relevance to the regions and study area and the reasonable availability and accessibility of published data.

Table J-1.9-1
Suite Of Water Quality Parameters Potentially Affected By The Current Conditions Of The C&SF Restudy Project Area

Category	Water Quality Parameter
METALS:	Mercury, Copper, Cadmium, Lead, Zinc, Arsenic, and Tributyltin (TBT)
PESTICIDES:	DDT and Derivatives, Atrazine, Simazine, Ametryn, Endosulfan Compounds, Ethion, Bromacil, 2,4-D, Aldecarb, and Fenamiphos
NUTRIENTS:	Phosphorus, Nitrite/Nitrate, and Ammonia/Unionized Ammonia
BIOLOGICALS:	Fecal Coliforms and Pathogens, and Chlorophyll-a
PHYSICAL:	pH, Dissolved Oxygen, Conductivity, Turbidity, Oil & Grease, Temperature, and Salinity
OTHER	Polycyclic Aromatic Hydrocarbons (PAHs), Dioxins and Furans, Sulfate, Chloride, Polychlorinated Biphenyls (PCBs), and Volatile Organic Carbons (VOCs)

Water Quality Data - Data are compiled by region for those parameters considered "key" for individual regions (see ***Appendix H***), and by region for additional "other" parameters (see Attachment B of ***Appendix H***).

General Regional Conditions - The following overview description of the baseline water quality conditions of the C&SF Restudy project area is primarily based on the Florida Department of Environmental Protection (FDEP) Water Quality Assessment for the State of Florida also known as the 1996 Florida Department of Environmental Protection 305(b) report (FDEP, 1996), the 1997 Everglades Annual Report (Boyer and Jones, 1998), and the U.S. Geological Survey (USGS) Water Quality Assessment of south Florida (USGS, 1996).

The existing water quality conditions in the C&SF Restudy study area are significantly influenced by development related activities throughout the region. Hydrologic alterations have led to significant changes in the landscape by opening large land tracts for urban development and agricultural practices, and by the construction of extensive drainage networks. Natural drainage patterns in the region have been disrupted by the extensive array of levees and canals such that nonpoint runoff (agricultural and urban) is now part of the normal hydrological regime in many areas. Lake Okeechobee is at the center of the south Florida drainage system, receiving flow from the Kissimmee River basin, and to a lesser extent from Everglades Agriculture Area pumps back, and discharges water south and east through five major canals, and to the west through the Caloosahatchee River.

Lake Okeechobee may be considered a naturally eutrophic water body that is tending to become hypereutrophic, due primarily to nutrient inputs from the Kissimmee River and the Taylor Creek basins. Water quality conditions in the upper Kissimmee River appear to be improving, primarily due to rerouting of wastewater flows from the river to reuse and ground-water discharge sites. However, large quantities of nutrients are still discharged from Lake Toho to Lake Kissimmee and other downstream areas. Water quality improves from Lake Kissimmee to near Lake Okeechobee, where the channel flows mostly through unimproved rangeland; however, pollutant loadings increase as cattle and dairies grow more numerous near the lake. The lake's Total Phosphorous levels have doubled in the last decade, due in large part to agricultural runoff. This same runoff also has contributed to frequent and widespread algal blooms and at least one major fish kill. Because the lake's phosphorus is internally recycled and a vast reservoir of the nutrient is stored in ground water as well as wetland and canal sediments, phosphorus may not reach acceptable levels for many decades or even a century.

The Caloosahatchee River forms the major basin to the west of the lake, and exemplifies the water quality patterns throughout the remainder of the C&SF region. Water quality conditions are degraded in the upper and lower areas of the basin, due to agricultural and urban runoff, respectively. The channelized section of the river also shows degraded water quality conditions, due to agricultural inputs, as compared to tributaries lying in less developed areas of the basin. Problems associated with the degraded areas of the basin are typified by low dissolved oxygen levels, elevated conductivity, and decreased biodiversity. Conditions in the urbanized sections of the basin are influenced by nonpoint storm water flows, and are manifested in the river by elevated chlorophyll levels, algal blooms, periodic fish kills, and low dissolved oxygen levels.

Agricultural Best Management Practices (BMPs) have been implemented in the Everglades Agriculture Area however, this area remains a primary source of pollutants for the WCAs. The WCAs form the remnant wetland communities for the northern section of the Everglades system. These areas have been isolated from contiguous lands by a series of levees and pump stations. Water moving south from the lake and Everglades Agriculture Area is pumped through the WCAs, thereby making these areas nutrient filters for downstream basins. The highly altered hydroperiod, resulting from the levees and pump schedules, may exacerbate water quality conditions in the WCAs, as evidence by a general degradation of quality in the areas along the canals and pump stations, as compared to conditions in the central portions of the basins. Construction of the Stormwater Treatment Areas upstream of the WCAs will serve to improve water quality conditions in the latter through time; however, other problems may persist. No consumption advisories for largemouth bass have been issued for portions of the WCAs due to mercury contamination.

Water quality conditions along the Upper East Coast are rated as good in less developed areas of the basin. However, conditions are degraded in urbanized areas and along the extensive network of canals that drain this area. The worst water quality conditions in the Upper East Coast basin are reported in the St. Lucie River and the canals leading from the Everglades Agriculture Area. Other major problem areas are found in Five Mile and Ten Mile creeks (in the areas near Port St. Lucie), the main channel of North Fork in Port St. Lucie, and Manatee Pocket, a small port on the St. Lucie Estuary. Although the Savannas State Preserve, a 15 mile long freshwater marsh between Ft. Pierce and Stuart, has fairly good water quality, mercury concentrations in fish tissue were high enough to warrant a no consumption advisory for Largemouth bass. As described above, the major sources of pollution in this basin are urban runoff, agriculture, rangeland runoff, boat discharge, and sewage overflows.

Water bodies in the Lower East Coast basin are seriously degraded in the heavily urbanized areas, included the numerous man-made canals associated with the coast and drainage canals. This trend becomes obvious in Lake Worth, which has good water quality near the inlet and fair to good water quality north of the inlet, but poorer water quality to the south, especially in the area around the inlet to the West Palm Beach Canal. Water quality improves again at the South Lake Worth Inlet and near Boca Raton Inlet. A small section of the North Fork of the Loxahatchee River has low dissolved oxygen levels, and waters in Jonathan Dickinson State Park have high coliform bacteria counts. In the last decade, seagrass beds in the estuarine portion of the Loxahatchee River have declined dramatically. Canals and water bodies in and around Ft. Lauderdale are particularly degraded by urban runoff and historical wastewater treatment discharges, and in the westernmost areas on the canals by agricultural runoff. Problems associated with these pollutants are manifested in the canals dense growth of weeds, low biological diversity, and the occurrence of exotic plants and animals. The New and Miami Rivers run through highly urbanized areas of Ft. Lauderdale and Miami, respectively. Both are polluted by improperly functioning septic tanks, illegal discharges from vessels, industrial activities, illegal sewer connections, and storm water runoff. These discharges result in high nutrient pollution, high coliform bacteria counts, and heavy metals such as tin, copper, zinc, and chromium in sediments at all marina sites. Biscayne Bay has good water quality in the open water areas of the bay, and degraded conditions associated with the canals and their discharge points.

The phosphorus concentrations entering the Everglades National Park were lower in 1997 than the interim and long term limits established by the 1992 Settlement Agreement. While no significant trends in annual average mercury concentrations in water, sediment, or fish have been observed for the past five years, mercury concentrations in fish tissue were high enough to warrant a no-consumption advisory for Largemouth bass throughout most of the eastern two thirds of the Everglades National Park, and a recommendation of limited consumption for the southeast east corner of Everglades National Park. The best water quality conditions in the Everglades National Park were found along the coastal regions of the basin. Some parts of Florida Bay have experienced a massive seagrass and mangrove die-off, that likely stems from a lack of flushing from hurricanes, high water temperatures, and high levels of salinity. Water diverted into canals has reduced freshwater flows, and the salinity of bay water has been recorded as high as 70 ppt. The 1997 Everglades Annual Report states that for 1997, the highest observed salinity levels occurred in Whipray Bay, and ranged from 40.6 ppt to 42.3 ppt (water conditions in the bay are considered hypersaline when salinity exceeds 35 ppt). Hypersaline conditions were observed throughout most of the western portion of the bay during the dry season; however, they decreased below hypersaline levels once freshwater inputs increased in June 1997.

Water quality conditions in the Keys are generally good in areas open to the Atlantic or Gulf of Mexico. However, many manmade canals and marinas have water quality problems that are exacerbated by decreased flushing. Most of these problems are localized and generally can be attributed to wastewater plants and small "package plants" discharging to poorly flushed canals, septic tanks and cesspools, marinas lacking facilities to pump out waste from boats, fish processors, and storm water runoff, especially into the canals.

J.1.9.1 Water Quality Regulations and Standards Applicable to Region

Several Federal, State and Tribal regulations and standards are relevant to water quality maintenance in the C&SF Restudy region. These include the Federal Clean Water Act (CWA) and the Federal Safe Drinking Water Act; the State of Florida Everglades Forever Act, State Water Quality Regulations (i.e., Florida Statutes section 373 (Water Resources) and Florida statutes section 403 (Environmental Control), Surface Water Standards, Beneficial Use Classifications (Classes I-V), Ground Water Quality Standards, and Drinking Water Standards; and the Tribal Codes (Seminole Tribe of Florida Water Code and the Miccosukee Tribe of Indians of Florida Environmental Protection Code). Summaries of these regulations and standards are provided in ***Appendix H*** and its Attachment C. A related litigative action, the 1992 Settlement Agreement, is also relevant to the region and is summarized in ***Appendix H.***

In addition, U.S. Environmental Protection Agency or State of Florida aquatic life criteria (if established) and U.S. Environmental Protection Agency human health criteria (if established) are presented in (see Table H.1.4.1-1 in ***Appendix H***) for the suite of water quality parameters introduced previously in Section 1.9.1. In the absence of U.S. Environmental Protection Agency aquatic criterion or if the State of Florida criterion was more stringent than the U.S. Environmental Protection Agency criterion, the State of Florida criterion is listed. The table was developed from updates of U.S. Environmental Protection Agency (1986) and also references the State of Florida F.A.C. 62-302 for State pesticide criteria.

J.1.9.2 Regional Water Quality Monitoring

The following discussion summarizes current State and Federal Water Quality monitoring efforts within the existing study area.

Federal Monitoring

The U.S. Geological Survey, U.S. Environmental Protection Agency, and U.S. Army Corps of Engineers are conducting Federal water quality monitoring in south Florida.

The U.S. Geological Survey has conducted extensive long-term monitoring of surface water and groundwater quality at hundreds of locations throughout the south Florida ecosystem. This monitoring has included water physical parameters, nutrients, ions, metals, pesticides and other organic compounds. The U.S. Geological Survey (1996) has provided an overview of available information on surface water and ground water quality for waterbodies throughout the ecosystem. In 1993, the U.S. Environmental Protection Agency initiated the Regional Environmental Monitoring and Assessment Program (REMAP), which is the only system wide monitoring of the freshwater Everglades ecosystem (USEPA, 1996). This program monitors nutrient, phosphorus, mercury, water management, and habitat indicators. Such information is important for assessing ecosystem health and tracking the effectiveness of the Project Restudy and other efforts directed at ecosystem protection or restoration. The U.S. Army Corps of Engineers has also conducted water quality monitoring at key locations throughout south Florida.

The U.S. Army Corps of Engineers has historically conducted water quality monitoring at key locations throughout south Florida. Monitoring efforts have been undertaken around Lake Okeechoobee, the Loxahatchee NWR, Water Conservation Areas 1-3, and the Upper St. Johns portion of the C&SF project. Water quality data including field parameters, nutrients, metals, pesticides, and inorganic constituents are available from those programs. Funding and manpower considerations have changed the scope of this program several times in the last several years from long-term operation and maintenance efforts to more short-term synoptic studies associated with specific events or projects. As part of a long term effort the U.S. Army Corps of Engineers continues to maintain several water quality monitoring stations at 1) inflows to Everglades National Park, 2) stations required for operation of some of the features of the Modified Water Deliveries to Everglades National Park project, and 3) in the Upper St. Johns Project.

Because of the historical impacts and the difficulty in finding a concise, yet comprehensive, water quality data set addressing the entire system, phosphorus has been the Restudy's primary focus. Understanding is incomplete about the types, concentrations and loads of pollutants that are causing ecological problems and likely to create future ecological problems at critical locations. This lack of understanding exists in spite of a significant collective monitoring effort. A number of different agencies routinely collect large quantities of water quality data in the region, yet this data is seldom collected in conjunction with important events such as agricultural pesticide and fertilizer applications, major stormwater discharges or pumping activities. Many monitoring programs are localized efforts collecting data at fixed locations at scheduled times, which are then stored in databases and seldom used. When pollution impacts do become evident, existing monitoring efforts are often unable to identify the source or cause of the impacts. A detailed water quality monitoring program that is well coordinated among the collecting agencies is necessary to adequately ensure that water quality considerations are included in the stages of the design process for project features."

State of Florida Monitoring

The Florida Department of Environmental Protection and the South Florida Water Management District (SFWMD) conduct State of Florida water quality monitoring. Monitoring includes surface water, ground water and atmospheric deposition. Key references for these monitoring programs are South Florida Water Management District (1998a) and the Florida Department of Environmental Protection website (FDEP, 1998: internet). Florida counties also have various monitoring programs.

The Florida Department of Environmental Protection has developed an integrated ambient monitoring network to address point and nonpoint sources of pollution, BMPs, pesticides, habitat area, atmospheric deposition, land use/land cover, and the interactions of surface and ground waters. The South Florida Water Management District has grouped its 40 individual monitoring programs together under 24 main networks, where 22 are geographic areas and the other two (pesticide and atmospheric deposition) monitoring programs are District wide (SFWMD, 1998a).

J.1.9.3 Regional Water Quality Parameters and Pollutants of Concern

The suite of water quality parameters potentially affected by the existing conditions of the C&SF Restudy region were introduced in Section H.1.1. These water quality parameters were grouped as metals, nutrients, biologicals, physical parameters, and other parameters. Of this list, mercury, phosphorus and pesticides are considered three of the most important water quality parameters of the region. These three are described below.

Mercury

Mercury is a toxic heavy metal. Levels of mercury in south Florida water, animal tissue, sediment, periphyton, air, and soil have been shown by U.S. Environmental Protection Agency (1998) and other State and Federal agencies and other entities such as universities to be elevated in certain areas of south Florida. However, the sources, distribution, magnitude, transport, transformations and pathways of mercury through the south Florida ecosystem are poorly understood. Among the possible mercury sources in south Florida are natural mineral and peat deposits (Rood et al., 1995), and atmospheric deposition from global, regional and local (e.g., fossil fuel fired electrical generating plants, municipal waste incinerators, medical waste incinerators, paint operations, and agricultural operations) sources. Sources of mercury are now believed to primarily be from atmospheric deposition. Once elemental mercury is methylated by microbial action, it becomes biologically available for bioaccumulation at various levels of the food chain and for biomagnification up the food chain to top carnivores such as the Florida panther. Mercury is generally analyzed as total mercury (HgT) or methylmercury (HgMe) and measured in parts per trillion (ppt) or parts per billion (ppb).

Phosphorus

Phosphorus is a nutrient that often controls primary productivity in aquatic systems. Excess phosphorus entering natural systems is a result of many human activities, with urban runoff, agriculture, construction, development, sewage, and sewage treatment effluents, chief among them. The ecological significance of phosphorus loading in water bodies is increased primary productivity, loss of water column dissolved oxygen, algal blooms and changes in biodiversity. These may ultimately result in the loss of a waterbody's usefulness for recreation or as habitat for wildlife. In south Florida, agricultural practices in the Everglades Agriculture Area and other agricultural areas surrounding Lake Okeechobee have been a major source of phosphorus due to fertilizer applications and field runoff and southward migration through the Everglades. Phosphorus is considered a key water quality parameter of concern in this section for all ten regions considered in this PEIS for the study area (see Table J-1.9.4-1). Water concentrations of phosphorus are often analyzed as Total Phosphorus (TP) and measured in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Pesticides

An extensive array of pesticides is applied to (or persists in) south Florida waters, sediments and/or soils. The south Florida region is unique in that a very large and sensitive ecosystem exists in the midst of an evergrowing urban population and an extensive and intensive agricultural production area. A variety of pesticides are used in this area for a number of different reasons. Major uses are ground and/or aerial applications related to agricultural production, mosquito control, and aquatic plant growth in local waterways, golf course maintenace, and homeowner lawn and vegetation maintenance. Pesticides used in these ways are effective in controlling the pest of concern; however, the use of pesticides may also pose possible threats to the sensitive ecosystems in Florida due to the intense year round agriculture, coupled with the shallow water tables and the ever increasing urban sprawl that demands an increasing supply of quality water.

J.1.9.4 General Overview of Current Regional Water Quality Conditions

Presented below is an overview of regional water quality concerns for ground water and surface water within the study area.

Groundwater Conditions

Groundwater in south Florida consists of the surficial Biscayne aquifer and the Floridan aquifer. Both are critical to south Florida inhabitants and industry. The Biscayne aquifer has been classified as a Sole Source Aquifer under the Safe Drinking Water Act based on the aquifer's susceptibility to contamination and the fact that it is a principal source of drinking water. The Floridan aquifer system is one of the most productive aquifers in the world and is a multiple use aquifer system. Where it contains freshwater, it is the principal source of water supply. In several places where the aquifer contains saltwater, such as along the southeastern coast of Florida, treated sewage and industrial wastes are injected into it.

Because the Biscayne aquifer is highly permeable and is at or near the land surface practically everywhere, it is readily susceptible to groundwater contamination. Major sources of contamination are saltwater encroachment and infiltration of contaminants carried in canal water. Additional sources include direct infiltration of contaminants, such as chemicals or pesticides applied to or spilled on the land, or fertilizer carried in surface runoff, landfills, septic tanks, sewage plant treatment ponds, and wells used to dispose of storm water runoff or industrial waste. Numerous hazardous waste sites (e.g., Superfund and Resource Conservation and Recovery Act (RCRA) sites) have been identified in the area underlain by the Biscayne aquifer. Remedial action to cleanup existing contamination is underway at many of these sites, and waste management practices are generally monitored to prevent further contamination. Additional information on groundwater conditions and contamination in south Florida is presented in ***Appendix H***, including specific Superfund (National Priority List: NPL) and RCRA hazardous waste sites in south Florida. Trichloroethylene (TCE) and vinyl chloride are examples of groundwater contaminants of concern.

Surface Water Conditions

As previously suggested, perhaps the three most important water quality parameters of concern in the C&SF Restudy region are mercury, phosphorus, and pesticides. These are discussed below from a regional perspective. A more detailed discussion can be found in ***Appendix H*** and its Attachment E (mercury).

Mercury

Prior to the turn of the century, most of the mercury in the Everglades peat probably came from natural sources. Mercury deposition rates have increased about five fold since then. Some of this historically accumulated mercury is being recycled by the south Florida ecosystem; however, a mercury cycling model developed by Ambrose et al. (1998) indicates that this historical mercury can be buried beneath the recycling zone by accumulating peat if new sources are shut off, and that this process occurs in a timeframe of a decade, not a century. Potential sources of new mercury to the south Florida ecosystem include Lake Okeechobee releases, Everglades Agriculture Area runoff, and atmospheric deposition. It is now believed that atmospheric deposition may contribute more than 95 percent of the new mercury load to south Florida annually. Further study is required to quantify the relative contributions of local and global sources to the new mercury entering the study area. If local mercury sources, like municipal and medical waste incinerators, are making a significant contribution, rules limiting mercury in feed stocks and air emissions should result in a substantial benefit to the system.

The central Everglades is a wide, shallow, slow moving river. It has a large surface area for atmospheric deposition and methylation of mercury ions with little dilution other than rain. In order to further synthesize and integrate the interactions of the water quality and biota, the central Everglades flowway was parsed by latitude into seven units averaging approximately 27 km in length (north-south) over a total distance of 189 km (USEPA, 1998). Latitudinal parsing of the data aggregated the subtle patterns in plant and floating periphyton responses relative to TP concentrations in the system. These data indicated that TP affects the spatial distributions of emergent plant communities, floating periphyton presence, aquatic habitat and food web complexity, which in turn affect mosquitofish growth, biodilution and bioaccumulation of methylmercury (HgMe) in the system.

The canal data indicated that mercury interactions with Total Organic Carbon (TOC) and Sulfate (SO4), and biodilution of mercury in mosquitofish where TP concentrations were high, resulted in lower mosquitofish mercury concentrations north of Alligator Alley. However, South of Alligator Alley where TP, TOC, and SO4 concentrations declined, there was increased bioaccumulation of mercury in mosquitofish and periphyton, until TP declined to a median of 13.9 ug/L, when both biodilution and bioaccumulation of mercury declined. These data suggest that high methylmercury concentrations in water in the northern Everglades did not lead to high Total Mercury (HgT) in mosquitofish (HgT in mosquitofish = 95 percent HgMe) due to interactions with other constituents, biodilution, and associated changes in the food chain (USEPA, 1998).

The marsh data were more definitive, indicating mercury biodilution north of Alligator Alley and mercury interactions with TOC and SO4. As median TP declined from 16 to 12 µg/L, however, the median mercury concentration in mosquitofish nearly doubled to 208 µg/L and remained high south through the northern portion of the Everglades National Park. However, the mercury concentration in mosquitofish declined to 156 µg/kg in the southern portion of the Everglades National Park where median TP in water declined to 8.6 µg/L, indicating the absence of an inverse relationship between TP in water and mercury in mosquitofish in the southern Everglades. Median methylmercury concentrations in water declined north-to-south in both canal (i.e., 0.3 to 0.06 ng/L) and marsh (i.e., 0.54 to 0.15 ng/L) habitats indicating higher methylation occurred in the marsh. The marsh median mosquitofish Bioaccumulation Factor (BAF) for mercury increased from 0.6 x 105 in the north to 8.5 x 105 in southern Everglades National Park, indicating an increasing bioaccumulation efficiency in the food chain from northern-to-southern areas. Total mercury in periphyton, great egrets, and mosquitofish was spatially correlated with a mercury "hot spot' between Alligator Alley and Tamiami Trail. The stimulatory effects of TP on the plant communities and the methylating microbes appears to be a key component in mercury contamination.

Nearly all of the methylmercury in the south Florida ecosystem is produced internally. Only a fraction of the new and old mercury cycling is in a form that can be readily transformed into methylmercury. Numerous hypotheses have evolved over the last several years to explain the role of water quality in mercury methylation and bioaccumulation. While there is no single hypothesis that will explain the governance of methylmercury in this system, the effects of anthropogenic phosphorus exerts the most pervasive impact on this ultra-oligotrophic system. Even slight increases of phosphorus can act directly to increase the activity of both producers and decomposers in this system which can result in both increased biological production of green plant matter, diluting the bioconcentration of mercury, as well as an increased activity of the decomposing bacteria which can indirectly result in increased areas devoid of oxygen, further favoring the activities of methylating bacteria. Extreme increases in phosphorus, which occur in the northern Everglades, can maximize the production of methylmercury in the water while simultaneously altering the plant communities to pollution tolerant types (e.g., filamentous and bluegreen algae; cattails) and changing the food web sufficiently to severely reduce the bioaccumulation efficiency of methylmercury in fish. The complexity increases with the introduction of large amounts of sulfate into WCA-2 north of Alligator Alley which is rapidly reduced to sulfides providing an additional stimulatory effect on the methylating sulfur reducing bacteria in the marsh. The declining north-south gradients of TP, TOC, and HgMe in water are similar, while large amounts of sulfate only impact WCA-2. In contrast, total mercury in mosquitofish is lowest where phosphorus and sulfate are highest, and mercury is highest in mosquitofish where phosphorus moderates and sulfate is near background.

The lowest mercury in fish occurs in the southern Everglades National Park where phosphorus is lowest and the least methylmercury occurs in water. The rapid increase in the bioaccumulation factor from north-to south indicates a recovery in the structure and efficiency of the food web, where phosphorus concentrations decline to near background. These complex interactions cannot be explained by a single hypothesis but by several interacting together. Simultaneous controls of local atmospheric mercury emissions in concert with the phosphorus control strategies underway and the associated control of carbon, oxygen and sulfur, should result in the reduction of available inorganic and organic mercury in this system during the next several decades.

Based on the system-wide spatial data collected to date, it is apparent that the problems facing the south Florida ecosystem are highly interdependent. Approaches to restoring the ecosystem should follow a system wide methodology to address the interactive nature of the system. Additional technical findings are presented in a draft U.S. Environmental Protection Agency technical report (USEPA, 1998).

Phosphorus

Historically, south Florida waters were low nutrient waters (i.e., an oligotrophic system). Due to anthropogenic activities including the ditching and draining of wetlands and the expansion of agricultural practices applying fertilizers, waterbodies from the Kissimmee River southward have become nutrient ladened to various degrees. This is due to water body receipt of agricultural runoff from such land uses as pastures truck farming, and sugar cane fields. The Everglades Agriculture Area is one such area of farming, although the farming areas surrounding Lake Okeechobee in general have contributed to elevated nutrients in the Kissimmee River, Lake Okeechobee, the Caloosahatchee River, and the

Everglades. In addition, urban storm water runoff is another potential source of phosphorus to the natural areas and coastal systems of south Florida. Elevated phosphorus loading of waterbodies and the resulting increased water phosphorus concentrations (eutrophication) may have various ecological effects. These effects may include increased primary productivity, loss of water column dissolved oxygen, algal blooms, and changes in vegetation and biodiversity. The significance of such phosphorus loading may be the reduction or loss of a waterbody's habitat and/or recreational value.

The most significantly elevated nutrient in south Florida is phosphorus. In general, the trend for phosphorus concentrations is a decrease from north (Kissimmee River and Everglades Agriculture Area) to south (Everglades National Park) since the major anthropogenic sources are in the agricultural areas. Nutrient removal from marsh water is due to the natural water quality treatment processes associated with south Florida wetlands, notably the Everglades. Phosphorus levels in water bodies throughout south Florida have been summarized by the U.S. Geological Survey (1996). The highest concentrations (about 100 to 200 ppb) are in water discharged from the Kissimmee River, Lake Okeechobee, the Everglades Agriculture Area, the Caloosahatchee River, and the St. Lucie Canal. The lowest concentrations (about 10 ppb) are reported for marsh stations within the Everglades National Park. The Florida Everglades Forever Act (EFA) specifies that a yet to be established numeric phosphorus criterion is to be established for the Everglades by the State of Florida and then approved by the U.S. Environmental Protection Agency, or a default level of 10 ppb will be implemented. Currently, stormwater treatment areas (STAs) established by the EFA and being implemented by the approved U.S. Army Corps of Engineers, Everglades Construction Project would reduce phosphorus levels in agricultural runoff (in addition to the agricultural BMPs being implemented). A pilot STA, i.e., the Everglades Nutrient Removal (ENR) Project, is currently functioning and reducing phosphorus levels to less than 30 ppb. Additional STA treatment (Phase II) would be needed to reduce concentrations to levels in the range of the 10 ppb default level.

Pesticides

Three major areas of agricultural production are present in south Florida: 1) Miami-Dade County (which, relevant to agriculture, is located in the region designated in this PEIS as the Lower East Coast and Biscayne Bay); 2) the agricultural areas surrounding Lake Okeechobee (consisting of Palm Beach, Hendry, Glades and Martin Counties, which, relevant to agriculture, are located in the regions designated in this PEIS as the Kissimmee River Region, Upper East Coast and Indian River Lagoon, Lower East Coast and Biscayne Bay, Everglades Agricultural Area, Big Cypress Region, and Caloosahatchee River Region); and 3) Collier County (which is located in the regions designated in this PEIS as the Big Cypress Region and the Caloosahatchee River Region). Miami-Dade County ranks among the top counties in winter vegetable production in the U.S. and is number one in tropical fruit production. Agriculture in the four Everglades Agriculture Area counties includes sugar cane and truck farming. Collier County has approximately one third of its land utilized for agricultural purposes. Pesticide transport to the Everglades National Park from these three major agricultural areas can occur through hydrological connection to Everglades National Park from all three areas. Field studies have detected the presence of endosulfan and other pesticides in Florida Bay, especially near the C-111 basin (Scott et al. 1994; Scott et al. 1995). NOAA is continuing work on an ecotoxicological assessment of endosulfin and other potential endocrine-disrupting chemicals on living marine resources in Florida Bay.

The only long term pesticide monitoring in the C&SF Restudy project area is being conducted by the South Florida Water Management District (R. Pfeuffer: SFWMD, 1998 personal communication). The District has maintained a pesticide monitoring program in south Florida since 1984. The pesticide monitoring network includes sites designated in the Everglades National Park Memorandum of Agreement, the Miccosukee Tribe Memorandum of Agreement, the Lake Okeechobee Operating Permit and the Non-Everglades Construction Project Structure Permit. The monitoring provides data to determine the condition or changes in the quality of water being delivered to Lake Okeechobee, Everglades National Park, and the WCAs and Florida Bay. Additional pesticide residue data are collected to determine water quality conditions at the major water control structures throughout the District. The data collected for each sampling event provide information on potential short term, acute environmental effects for any of the compounds detected. An indication of possible fish toxicity, bioaccumulation for wildlife, or human health impacts can also be inferred from the data. The program has been dynamic over time, as concerns arise about pesticide use within the District, to accommodate sampling for new pesticides and the addition of sampling sites to the network. The current monitoring program consists of analyses for 66 pesticides at 37 sites within District boundaries. This set of compounds includes chemicals currently utilized in the associated agricultural areas, chemicals regulated by Florida's Surface Water Quality Standards (F.A.C. 62-302), and restricted use pesticides.

Regional 303(d) Impaired Waterways

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency, Water Quality Planning and Management Regulations (40 CFR Part 130) require States to develop Total Maximum Daily Loads (TMDLs) for their water bodies that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream water quality conditions, so that States can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources. The Section 303(d) list, which is prepared every two years, is based on priority water bodies identified as part of the Florida Surface Water Improvement and Management (SWIM) Act and data from the 1996 Florida Department of Environmental Protection 305(b) report (FDEP, 1996).

Several water bodies/segments in the C&SF Restudy region are listed on the 1998 303(d) list. The number of 1998 priority water bodies/segments in each of the basins listed in the 1996 305 (b) report relevant to the C&SF Restudy study area are as follows: Kissimmee River Basin (29), Lake Okeechobee (12), Caloosahatchee River Basin (11), Everglades-West Coast or Big Cypress Basin (14), Southeast Florida Basin (95), and the Florida Keys (0). These basins are further discussed (and are related to the corresponding region(s) designated in this PEIS) in ***Appendix H***, including Table H.1.5.1.2.2-1.

Approach to Baseline Water Quality Data Compilation

A suite of baseline water quality parameters potentially affected by the existing conditions of the C&SF Restudy region were introduced in Section 1.9.1 and described in ***Appendix H*** and its Attachment A. Subsets of these parameters of potential concern were considered "key" degraded parameters for the study area. Those considered key for each of the ten regions designated in this PEIS and is presented below by region in ***Table J-1.9.4-1***. These key parameters were selected based on the perceived relevance to the regions and study area and the reasonable availability and accessibility of published data.

Baseline water quality conditions described in this section were primarily taken from South Florida Water Management District, Florida Department of Environmental Protection, and U.S. Environmental Protection Agency references. Data in published references were chiefly relied upon, as opposed to more recent but raw sampling data. The notable exception to this approach was the use of South Florida Water Management District raw database (SFWMD, 1998: unpublished) used to compile water quality data for the Florida Bay and Whitewater Bay (areas of the Everglades National Park and Florida Bay region designated in this PEIS) for which published data were limited. This database (1991-1997) was made available by the South Florida Water Management District through personal communication (M. Slayton, SFWMD) in 1998 and was reduced to means and medians by U.S. Environmental Protection Agency contractor. In addition, summarized pesticide monitoring data (1992-1997) were obtained through 1998 personal communication with the South Florida Water Management District (R. Pfeuffer).

Table J-1.9.4-1
Listing Of Key Water Quality Parameters
Considered Degraded Within The C&SF Restudy Project Area

Physiographic Region	Water Quality Parameter
Kissimmee River	TP, NOx, DO
Lake Okeechobee	TP, NOx, Chlorophyll-a, turbidity, chlorine
Upper East Coast & Indian River Lagoon	TP, pesticides, DO, mercury and other heavy metals, NOx, salinity, coliformes
Everglades Agricultural Area	TP, pesticides, mercury, NOx, DO, conductivity
Water Conservation Areas	TP, DO, conductivity, mercury, NOx
Lower East Coast & Biscayne Bay	TP, DO, mercury, NOx, coliforms, salinity, heavy metals, turbidity, VOCs, TBT
Everglades Natl Park & Florida Bay	TP, mercury, salinity, chlorophyll-a
Florida Keys	TP, NOx, DO, turbidity, chlorophyll-a, coliforms
Big Cypress	TP, NOx, DO
Caloosahatchee River	TP, pesticides, NOx, DO, conductivity

DO = Dissolved Oxygen
NOx = Nitrite/Nitrate Nitrogen
TP = Total Phosphorus
TBT = Tributyltin
VOCs = Volatile Organic Compounds

Reliance on published data resulted in the typical period of record for the data being from the late 1980's to the early 1990's. However, the specific period of record ranged from 1973 to 1997 and included some very recent (1996-1998) published data such as the U.S. Environmental Protection Agency mercury data (USEPA, 1998), the South Florida Water Management District, Everglades data (SFWMD, 1998b), and the Florida International University Florida Keys data (Boyer and Jones, 1998). The established baseline year for this PEIS is 1995.

J.1.10 Water Supply

There is no evidence that the climate in south Florida has changed sufficiently to alter the dry and wet season rainfall patterns since the first attempts to drain the Everglades. Many people believe, therefore, that restoration is possible, even with the water supply requirements of the urban and agricultural community, given that the sharply-reduced size of the Everglades will reduce its demand for water.

One of the primary functions of the C&SF Project is to provide a highly-efficient flood control system designed to keep urban and agricultural areas dry in the wet season by discharging excess water to tide or into the WCAs and Everglades National Park. Rapid wet season flood releases, coupled with the lack of retention in Lake Okeechobee, the northern historical sawgrass plains, and the eastern peripheral wetlands and sloughs, have severely reduced storage within the system causing excessive dry season demands on the regional system. The sawgrass plains, for example, once stored and slowly passed on much of the water that overflowed from the Lake. Today, a large portion of the sawgrass plains habitat that was converted to agriculture within the Everglades Agricultural Area, quickly passes excess runoff to the WCAs and the coast during the wet season. Releases of Lake Okeechobee water are then necessary to meet dry season demands. The lack of storage, not the lack of water, is the problem.

Minimum levels for Lower East Coast canals are set by Florida Legislation principally to provide the volume of water needed to protect the Biscayne aquifer from saltwater intrusion, a major threat to this water resource. The head created in the canals raises groundwater levels, recharging the aquifer and the urban wellfields. During the wet season, wellfields are recharged by local rainfall and by the regional system that provides ongoing seepage from the WCAs and the canals. During the dry season, they are more dependent on the regional system. Unfortunately, during the wet season, “excess” storm water is passed through the canals and out to tide when it should be stored and used during the dry season. Without sufficient storage, it has been difficult to have water available during the dry season without causing flooding during the wet season.

Water users within the urban areas argue that the Lower East Coast is largely self-sufficient and efficient because the ground water seeping through the Lower East Coast would eventually reach coastal waters were it not withdrawn by the utilities. The SFWMM illustrates how this works. As demands increase, the volume of water that reaches coastal waters decreases. In the SFWMM, at Snake Creek, north of Miami, 121,000 ac-ft of water was lost through groundwater seepage during the wet season in the 1995 base. That amount decreased to 114,000 ac-ft in the 2050 base as urban water supply demand increased. In the Miami River, in the 1995 base, over 192,000 ac-ft was unrecoverable (wet and dry season total). In the 2050 base, only 121,000 ac-ft was unrecoverable.

Others argue that the urban area is far from self-sufficient. While the pattern described above occurs during wet seasons and during normal rainfall years, during extremely dry years, no water reaches the coast and the urban wellfields depend heavily on the WCAs, (including the ongoing seepage from these areas), the canals, and Lake Okeechobee for water supplies. Even during normal dry seasons when flood releases are minimal, the high demands on the system from urban water supply may be withdrawing water from the natural environment that should be kept in the system for late winter and spring biological rejuvenation. In addition, during drought years, the urban and agricultural areas create additional demands as the need for irrigation increases. Also, a significant percentage of the per capita use of water goes towards landscape maintenance, primarily watering lawns from shallow wells.

In a related issue, one concern is that, at present, the flow of water along the eastern protective levee is from the wetlands to the coast. Some argue that keeping the water levels high west of the Atlantic coastal ridge, and keeping levels low to the east of it, results in large groundwater losses from the remnant Everglades throughout the year. This situation might severely reduce the coastal groundwater flows into estuaries like Biscayne Bay and has made it necessary to import regional water to the Lower East Coast to maintain adequate coastal groundwater levels to prevent saltwater intrusion.

The amount of water needed to recharge urban wellfields is small compared to the tremendous volumes needed to prevent saltwater intrusion. Preventing saltwater intrusion is important for several reasons. For example, if significant saltwater intrusion occurred even once, the easternmost wellfields would be contaminated indefinitely and would be replaced with wells further west. This situation has already occurred in Metro-Dade County.

Although significant, the amount of water needed to prevent saltwater intrusion is much less than the wet season coastal releases. It is possible that those flows alone, if captured and stored, would be more than sufficient to maintain the dry season salinity barriers without the need to take water from the natural system. Also, retaining coastal outflows near the coast and maintaining higher groundwater levels along the coastal ridge would allow large quantities of regional water to be used for dry-season environmental benefits.

Within the Lower East Coast, there are also ecological benefits in maintaining groundwater levels. Lower groundwater levels can and have had serious negative effects on estuaries. Biscayne Bay for example, has suffered the consequences of both ground and surface water losses, including increased salinity, lower visibility, and lower water quality. Alternative 3 simulated cutting off groundwater seepage from the WCAs, which reduced flows to Biscayne Bay from 20 percent to 55 percent. In south Miami-Dade County, lowered groundwater levels have caused wetland desiccation and produced shifts in vegetation types.

J.1.11 Socio-Economics

The economic system is connected with the natural ecosystem and in general is ultimately dependent upon it for survival. Changes in the economic system can cause change in the natural ecosystem and vice versa. It is significant, therefore, to describe and understand the general economic and social environment within which such changes could take place.

Economic and demographic data for the study area, comprised of 16 south Florida counties (parts of some, others in entirety), can be viewed from a variety of vantagepoints. No matter how viewed, the picture which emerges is that of higher average incomes, and greater economic and population growth than for the rest of the state and the nation. This is particularly true of southeast Florida, and while true in terms of the overall study area, some localities do not share in this overall trend. Other key important features are agricultural activity, fishing, tourism, and recreation.

The south Florida study area is home to just over 6 million people, about half of Florida's population. This relationship between the study area's population and the state population is likely to continue. Population growth continues to exceed the national rate, although growth is slowing.

Strong wholesale and retail trade, government and service sectors characterize Florida’s economy. Florida's warm weather and extensive coastline attracts vacationers and other visitors and helps to make the State a significant retirement destination for people from all over the country. Agricultural production and fisheries are also important sectors of the state's economy, and are especially significant to portions of the study area. In comparison to the national economy, the manufacturing sector has played less of a role in Florida. High technology manufacturing has begun to emerge as a significant sector in the State over the last decade.

Most of the population and economic activity in the study area is concentrated along the Lower East Coast (Miami-Dade, Broward, and Palm Beach Counties). Per capita income (PCI) for the study area as a whole is above that for the state. The Lower East Coast, three-county area's PCI is even higher. The remaining area is by comparison sparsely populated and is the location of important natural environment and agricultural areas, as well as Seminole and Miccosukee Native American tribal lands.

J.1.11.1 Population

The 16 south Florida counties that make up the study area had a 1990 population of 6.3 million, accounting for nearly half (almost 49 percent) of Florida's total. This share has changed very little over the past 20 years and recent United States Department of Commerce projections predict it will remain stable over the next 50 years. Over 60 percent of this south Florida population is in the three southeast coast counties of Palm Beach, Broward, and Miami-Dade.

Florida is the fourth most populated state in the nation, with a 1990 estimated 12.9 million total residents. Its past is marked by rapid post World War II growth, which accelerated Florida's share of the United States population from just under 2 percent in 1950 to just over 5 percent in 1990. This trend is expected to continue, although at a more modest rate, so that over 6 percent of the U.S. population will be in Florida by 2040. The state population is expected to grow another 50 percent by 2040, reaching nearly 19 million. Growth rates for both the state and the C&SF Project counties have averaged close to three times the average annual percent growth rates for the United States as a whole during recent decades. Future growth rate differences are expected to diminish.

The Lower East Coast three-county area comprises about 9.5 percent of the state's land area, but is home to 3 percent of Florida's population. Population growth is fueled by in-migration, as it continues to be both a leading location for retirement as well as a haven for Hispanic and Caribbean immigrants. By contrast, the group of primarily agrarian counties bordering the shores of Lake Okeechobee (Glades, Highlands, Martin, Okeechobee, St. Lucie, and Hendry Counties, but excluding Palm Beach County), while similar in size to the Lower East Coast counties, contain only about 6 percent of the study area's population.

J.1.11.2 Economy

The 16-county study area had a 1990 per capita personal income about 8 percent above that for the state as a whole, while the Lower East Coast area (Palm Beach, Broward, and Miami-Dade Counties) is about 15 percent higher. Florida's per capital personal income is less than 1 percent higher than the national average. About half of the study area's counties have per capita incomes greater than either the state or the nation. Slightly over half of Florida's employment and earnings takes place in the study area. Nearly two thirds of this is concentrated in the populous Lower East Coast three county area. Excluding the northernmost counties of Polk, Orange, and Osceola, which are technically part of the study area, but which realistically fall outside of the main focus of this study, the three-county Lower East Coast area accounts for about 80 percent of the regional aggregate socio-economic activity for the study area.

Employment and income in the south Florida study area has continued to grow in recent decades at about half again faster than the national average. Growth has been significantly greater in the southwest counties and the Florida Keys (taken as a group--Monroe, Collier, Hendry, Lee, and Charlotte), and in the counties around Lake Okeechobee (Glades, Highlands, Martin, Okeechobee, and St. Lucie) than elsewhere in the study area.

The economy of south Florida is based on services, agriculture, and tourism. While manufacturing has not traditionally played a major role in the economy, this sector has experienced significant growth in recent years.

The service industry is associated with the over-65 population that constitutes nearly one-fourth of the residents of Broward and Palm Beach Counties and sixteen percent of Miami-Dade's population. These individuals have incomes independent of employment and require additional medical, financial, and household services. This relatively strong services part of the south Florida economy is reflected in percent of total employment and income in the services industry, which is consistently higher than for the state as a whole. The exception to this tendency is for those counties whose economic profiles reflect their heavy agricultural orientation. For example, in Hendry, Glades, Highlands, and Okeechobee Counties, the relative share of farm earnings and employment is roughly 20 to 30 times what it is for the other counties, while the relative share of the services industry tends to be smaller for these counties.

Agricultural production in the region, excluding the Everglades Agricultural Area, is virtually all in winter vegetables, tropical fruits and vegetables, citrus and nursery crops. Florida is the national leader in citrus fruit production and the manufacture of processed citrus products, accounting for over 80 percent of the nation's citrus production. Florida is the world leader in the production of grapefruit, accounting for nearly a third of the world's annual supply, and ranks second to Brazil in the world production of oranges, accounting for almost one fifth of the world's supply. Florida produces 100 percent of the nation's tangelos and over 95 percent of its limes. Florida also is the second ranking state in the production of fresh vegetables. South Florida shares significantly in this agricultural productivity. All but three of the top thirteen Florida agricultural production counties, as measured by total cash receipts in 1991 are within the study area. All but two of the study area's sixteen counties are in the top half of Florida's counties, as ranked this way.

The Everglades Agriculture Area economy is based largely on agriculture, the primary focus for the economies of the area's towns of Clewiston, South Bay, Belle Glade, and Pahokee. Besides being the residences of most of the permanent labor force, they support much of the agriculturally related supply and processing activities and are the headquarters of many of the agricultural enterprises. They also support the recreation industry in south Lake Okeechobee. A seasonal influx of agricultural workers increases the population of towns in this area during the winter sugarcane harvest and vegetable seasons. For instance, the City of Belle Glade estimates that its population increases by about 6,000 (plus one-third) during this period. This trend used to be more significant when sugar cane harvesting was largely a labor intensive activity. This activity is now mechanized.

Agriculture in the Everglades Agriculture Area relies on over 580,000 acres of muck soils irrigated, drained and under cultivation (B. Boyd, pers. comm.). This acreage produces sugarcane, vegetables, sod and rice. Farm employment in the Everglades Agriculture Area is very seasonal, because of the seasonal nature of the sugar cane harvest and the seasonal nature of vegetable production. Year round farm employment (as of the late 1980's) is about 4,000 full time employees.

While the vegetables are packed and shipped fresh and are not subject to extensive processing, sugar cane is locally processed, which adds considerably to its value and the output of the industry. Six sugar mills in the Everglades Agriculture Area process all the cane produced in south Florida, both inside and outside the Everglades Agriculture Area. All sugar cane is grown under contract for processing at these mills. The mills produce raw sugar, molasses and other by-products. A portion of the raw sugar receives further processing at the sugar refineries located in the Everglades Agriculture Area. A large portion of the raw sugar is processed outside of Florida.

Farm earnings as a percent of total earnings for the counties comprising the Everglades Agriculture Area ranges from 3.3 percent to 47.2 percent (3.3 percent for Palm Beach, 35.2 percent for Hendry, 47.2 percent for Glades, 17.9 percent for Highlands, 16.6 percent for Okeechobee, 7.6 percent for St. Lucie, and 8.3 percent for Martin). In comparison, farm earnings nationwide are only 1.5 percent of total earnings, and for the State of Florida this figure is 2 percent. The story is similar for farm employment for these counties.

There are also strong per capita income differences between the urbanized Lower East Coast and the agricultural areas. Compared to the state and the nation, the Lower East Coast counties have higher per capita income, while the agricultural counties bordering Lake Okeechobee (with the exceptions of Martin and Palm Beach) have lower per capita income.

In the Everglades National Park area, small-scale agricultural activities existed historically. Much of the marginal land was abandoned from the 1940's to the 1960's, and all agriculture had ceased by 1975. Prior to the official creation of Everglades National Park in 1947, there existed some small scale lumbering and logging, hunting and fishing. The Park's land use activities have been directed at preservation of the natural environment. Some low impact human activities are allowed, involving education, research, and recreation. These activities are the basis for Everglades National Park's contribution to the Florida economy.

The economic activity of the Florida Keys/Florida Bay area is somewhat indicated by its land use patterns, which illustrate a predominance of residential activities oriented toward the water and commercial activities along the main (and only) highway. Residential growth and development is occurring at a rapid rate. The rapid growth within the Keys is a result of the warm climate and extensive diversity of the natural environment.

Primary activities in the Monroe County-Florida Keys area are tourism and fishing. Both are related to some extent to conditions in Florida Bay, about which there has been growing concern. Many observers feel that these changes have been related to decreases in freshwater inflow from the Florida mainland (the Everglades), due at least in part to C&SF Project drainage and flood control features constructed in recent decades.

The relationship between tourism and fishing and the environmental health and vitality of Florida Bay is fairly obvious. These are mainstays of the Monroe County/Florida Keys economy, as reflected by the relative domination of economic activity there in the following sectors: services; retail trade; and fisheries ("agricultural services, forestry, fisheries & other"). Monroe County plays a strong role in Florida's well-developed commercial fishing industry, accounting for about 20 percent of the state's total in recent years. Shrimp has historically been the most valuable species caught, accounting for over 40 percent of total sales in the state. There is widespread concern that recent precipitous declines in commercial fish landings in conjunction with degrading conditions in Florida Bay are causally related to these changes, and that continuation of these trends will result in even more fishery declines. Earnings in the economic sector that includes commercial fishing account for nearly 4 percent of Monroe County earnings, a dramatically higher share than for the United States, and also significantly higher relatively than for the state overall. Employment in this sector accounts for over 8 percent of total employment in the county, with similar relative comparisons to the state and nation.

J.1.12 Land Use

The existing use of land within the study boundaries varies widely from agriculture to high-density multi-family and industrial urban uses. A large portion of south Florida remains natural, although much of it is disturbed land. The dominant natural features are the Federally protected Everglades National Park and Big Cypress National Preserve at the southernmost tip of the peninsula, Lake Okeechobee, and the state protected water conservation areas in the westernmost reaches of the Lower East Coast counties. Generally, urban development is concentrated along the Lower East Coast from Palm Beach County to Miami-Dade County, in the central Florida/ Orlando area, and on the Lower West Coast from Fort Myers to Naples.

Most of the interior of the study area is in agricultural use, which includes sugar cane (the dominant crop) and vegetable farms in the Everglades Agricultural Area of western Palm Beach County and Hendry County; the Agricultural Reserve Area of Palm Beach County; and the south Miami-Dade agricultural area where vegetable crops dominate, especially tropical varieties. There are citrus groves in every county, but citrus is concentrated in St. Lucie and Martin counties on the east coast and Hendry, Highlands, Collier, and Glades counties on the west. Cattle and dairy farms predominate in Glades, Highlands, and Okeechobee counties.

In the northern portion of the system, around Orlando, tourism and its attendant service-oriented land uses (for example, hotels / motels, convenience stores, souvenir shops) make up a significant portion of the landscape. Agriculture, however, continues to play an important role in the region, with over two million acres being farmed, half of which is pastureland. The area surrounding Lake Okeechobee, the second largest freshwater lake within the contiguous United States, is largely rural, with agriculture the prevailing land use. There are over 580,000 acres of irrigated farmland in the Everglades Agricultural Area (B. Boyd, pers. comm.). Farm products produced there include sugarcane, the predominant crop, rice, row crops, and sod. There is also extensive pastureland both west and north of the lake. Directly south of the Everglades Agricultural Area lie the water conservation areas. The conservation areas cover 1,372 square miles and consist mainly of sawgrass marshes and tree islands. The 1948 C&SF Project created the WCAs for the conservation of water supplies for the Lower East Coast.

The Upper East Coast is comprised of St. Lucie and Martin counties; the landscape is dominated by agricultural uses. Significant natural resources, the St. Lucie Estuary and Indian River Lagoon, are also contained within this area. Urban land use, which makes up 17 percent of the Upper East Coast, is mainly concentrated along the seaboard coastal and lagoon shorelines. The Lower East Coast extends approximately 100 miles through the coastal portions of Palm Beach, Broward, and Miami-Dade counties. Being the most densely populated area in the state, the Lower East Coast is home to one third of the state's population, more than 4.5 million people. The area is primarily an urban megalopolis, but it also contains substantial agricultural acreage, particularly in southwestern Miami-Dade County (90,000 acres) and western Palm Beach County (29,000 acres). Rapid population growth and land development practices have resulted in notable western urban sprawl; the predominant land use is single-family residential. The once significant rural population in the western areas of the counties, especially Miami-Dade and Broward, has practically disappeared, resulting in an urbanized makeup in population. Palm Beach County is not far behind.

The Florida Keys are made up of over 1,700 islands that encompass approximately 100 square miles and contains the largest reef system in the United

States. While a majority of the county is designated as conservation land, due to the land falling within either Everglades National Park, the Big Cypress National Preserve, or the National Key Deer Refuge, land use is primarily either residential or geared towards supporting the region's main industry (tourism). The county's fragile natural resources and vulnerability caused the State of Florida to designate the area as an Area of Critical State Concern in 1975; such designation is intended to protect such resources from degradation by strictly regulating development.

The southwestern counties of Collier and Lee are the fastest growing in terms of population in the state. Population growth is mainly due to the in-migration of retirees, not a high birthrate. The coast has become highly urbanized, with development spreading eastward into agricultural and natural lands. Agriculture is however, a major industry, especially in Lee County where citrus predominates.

J.1.12.1 Agricultural Land Use

The general agricultural conditions in each of the C&SF Project physiographic regions are summarized below. Because agricultural statistics are reported by county, best approximations of region boundaries were made along county lines. The information is based upon data compiled and distributed by the National Agriculture Statistical Service, and also data from the 1995 Florida Statistical Abstract. The data used are from the 1992 to 1996 time period.

Kissimmee River

Osceola, Polk, Highlands, and Okeechobee Counties were included in this region. More than two million acres in these counties are farmed, with more than half of this area devoted to pastureland (UFBEBR, 1995). This region is characterized by large farms with relatively low productivity per acre. These four counties are among the top five counties in Florida for cattle production, both beef and dairy (FASS, 1996a). More than 200,000 acres are used for citrus production. Approximately 11,000 people are employed in agricultural production and services representing a payroll of approximately $21 million (UFBEBR, 1995). The market value of all agricultural products in this region totals approximately $575 million (UFBEBR, 1995). Almost a quarter of a million acres in the Kissimmee River Basin are irrigated (UFBEBR, 1995), requiring a dependable water supply.

Lake Okeechobee

Lake Okeechobee has traditionally been a key source of water supply for irrigated crops around the lake including the Everglades Agricultural Area, the Caloosahatchee River Basin, and Martin and St. Lucie Counties (Upper East Coast). Continued access to this source of water is considered vital to sustaining agriculture in the surrounding regions.

Upper East Coast

Martin and St. Lucie Counties are included in this region. Almost one half million acres are farmed (UFBEBR, 1995). St. Lucie and Martin Counties rank first and eighth, respectively, among Florida counties for number of acres of citrus (FASS, 1996b). Although this area is known primarily for its citrus production, many acres are used for pastureland. Farms average 600 acres in size with moderate productivity per acre (UFBEBR, 1995). More than 7,500 people are employed in agricultural production and services with a payroll of approximately $9.5 million (UFBEBR, 1995). The market value of all agricultural products in this region totals approximately $362 million (UFBEBR, 1995). Approximately 200,000 acres are irrigated (UFBEBR, 1995) requiring a dependable water supply. Lake Okeechobee has traditionally been the water source for this region.

Everglades Agricultural Area

The Evergaldes Agriculture Area contains all or parts of: Palm Beach County and Hendry County. Most of Hendry County lies within the Big Cypress region, so it was discussed in that section of the report. More than 600,000 acres are farmed in Palm Beach County (UFBEBR, 1995), and sugarcane was harvested from about half of that acreage in 1996 (FASS, 1996d). Sugarcane receipts accounted for 68 percent of total field crop sales in Florida in 1996 (FASS, 1996c). The Everglades Agriculture Area is known for its sugarcane production and sugar processing, but Palm Beach County also ranks 15th among Florida counties for acres of citrus (FASS, 1996b). This region is characterized by mid-size farms averaging 690 acres each with high productivity of more than $1,300 per acre (UFBEBR, 1995). More than 18,000 people are employed in agricultural production and services representing a payroll of more than $26 million (UFBEBR, 1995). Total market value of agricultural products in Palm Beach County is almost $900 million, ranking it first among counties in the state of Florida (UFBEBR, 1995) and third among U.S. counties (FDACS, 1994).

The Everglades Agriculture Area is highly dependent upon the system of canals running through the region to provide necessary drainage of excess water during the wet season as well as supplemental water supplies for irrigation during the dry season. Approximately two thirds of the land farmed in the Everglades Agriculture Area is irrigated, totaling more than 580,000 acres (B. Boyd, pers. comm.). The Everglades Agriculture Area has traditionally relied upon Lake Okeechobee for its water supply, and looked to the Water Conservation Areas to the south to receive their excess drainage.

Continued agricultural production in the Everglades Agriculture Area has become increasingly controversial. Some of the factors that may affect Everglades Agriculture Area agriculture include water quality concerns, soil subsidence, and encroachment of urbanization. The water quality concerns, particularly phosphorus loading, are being addressed through implementation of best management practices, construction of storm water treatment areas, the growing use of organic farming practices, and rice cultivation in rotation with sugarcane production. Prevention of continued soil subsidence will depend on maintaining high ground water levels to prevent further oxidation of the soil profile. This, in turn, will require development of more water-tolerant sugarcane varieties and/or increased rice cultivation. A strong agricultural economy in the Everglades Agriculture Area, based on profitable crop production is the best defense against conversion of agricultural land to urban land.

Water Conservation Areas

No agricultural production takes place in the Water Conservation Areas, however these areas are an important resource to the surrounding agricultural regions. The WCAs provide water storage for excess water drained from the Everglades Agriculture Area.

Lower East Coast

Broward and Miami-Dade Counties are included in this region. Although Palm Beach County is also a part of this region physiographically, agriculture issues for Palm Beach County were addressed within the Everglades Agriculture Area region. More than 100,000 acres are farmed in Broward and Miami-Dade Counties (UFBEBR, 1995). This region is characterized by small farms averaging less than 50 acres, with very high productivity of more than $3,500 per acre (UFBEBR, 1995). A variety of crops are produced including vegetables, tropical fruits, and nursery plants. Hurricane Andrew, which struck southern Miami-Dade County in 1992, caused significant damage to agricultural areas. Many fruit tree orchards were damaged or destroyed. Statistics from 1996 indicate that avocado production had recovered, but mango and lime orchards had not yet recovered from the hurricane damage (FASS, 1997b). Total acres of tropical fruit production in Miami-Dade County remain approximately 7,000 less than pre-hurricane levels (FASS, 1996e). Foliage plant production is also a major business in Broward and Miami-Dade counties. More than 120 million square feet were devoted to the foliage crop in Broward, Miami-Dade, and Palm Beach Counties in 1996 (FASS, 1997a).

Agricultural production and services employ approximately 18,000 people in this region representing a $23 million payroll (UFBEBR, 1995). The total market value of agricultural products from this region is almost $400 million (UFBEBR, 1995). Miami-Dade County ranks second in the state for total market value of agricultural products (UFBEBR, 1995).

Approximately half of the acreage farmed in the Lower East Coast is irrigated (UFBEBR, 1995). This region is highly dependent on the system of canals, levees, and other structures for flood control in the wet season and water supply in the dry season. Providing adequate drainage and flood control to the south Miami-Dade County agricultural area is a serious challenge because the farmland is directly adjacent to Everglades National Park. Evidence suggests that efforts to provide flood control to agriculture have resulted in over-drying the eastern portions of Everglades National Park adversely affecting Park ecology. Agricultural land does, however, provide a buffer between urbanization and Everglades National Park. Farmland is recognized as the preferred neighbor to natural areas because of its minimal impervious areas, open green space, and low population density. A strong agricultural economy in the Lower East Coast region based on profitable crop production is the best defense against conversion of agricultural land to urban land.

Everglades National Park and Florida Bay

Little or no agricultural production takes place in these regions, which includes Everglades National Park, Florida Bay, the Ten Thousand Islands, and Whitewater Bay. However, water management decisions made for these regions may affect other regional farmland and should, therefore, be considered carefully.

Big Cypress

Hendry and Collier Counties are included in this region. More than 800,000 acres are farmed in the Big Cypress region, and almost half of that area is pastureland (UFBEBR, 1995). The region is characterized by moderate to large farms producing more than $600 per acre in market value (UFBEBR, 1995). Hendry County ranks third in the State of Florida for cattle production (FASS, 1996a). Approximately 70,000 acres of sugarcane were harvested in 1996 (FASS, 1996d). Hendry County ranks third in the state for acres of citrus with over 100,000 acres, while Collier County is ninth with over 36,000 acres (FASS, 1996b). Citrus production in the Big Cypress region is currently increasing.

More than 17,000 people are employed in agricultural production and services, and the payroll totals approximately $16 million (UFBEBR, 1995). Agricultural products in this region have a total market value of more than $525 million (UFBEBR, 1995). Hendry and Collier Counties rank third and fourth in Florida for market value of agricultural products (UFBEBR, 1995).

Caloosahatchee River

Glades and Lee Counties are included in this region. Almost one half million acres are farmed in the Caloosahatchee River region, and approximately three-fourths of that area is pastureland (UFBEBR, 1995). The region is characterized by large farms averaging 1800 acres, with relatively low productivity per acre (UFBEBR, 1995). Glades County ranks eighth in the state of Florida for cattle production (FASS, 1996a). Citrus production in the Caloosahatchee River region covers more than 20,000 acres (FASS, 1996b) and is currently increasing.

Almost 5,000 people are employed in agricultural production and services, and the payroll totals approximately $5 million (UFBEBR, 1995). Agricultural products in this region have a total market value of more than $135 million (UFBEBR, 1995).

More than 77,000 acres of farmland are irrigated in the Caloosahatchee River region (UFBEBR, 1995). Reliable water supply is a big concern in this region that has traditionally relied upon water deliveries through the Caloosahatchee River from Lake Okeechobee. Irrigation demands can be expected to increase as additional land is used for citrus production.

J.1.13 Recreation Resources

In order to determine and assess the existing recreation resources within the Restudy, a thorough review of U.S. Geological Survey maps and other available data has been completed. Recreation resource use data and information from the Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP), March 1994 and other information sources has been utilized to help define the resource use rate and importance. The discussion below is a general overview of the existing recreation resources of the ten physiographic regions as defined in Figure J-1.0-1.

The regional breakdowns will help to further define and determine the existing circumstances that influence the quality and use of recreation resources within the specific regional boundaries. Resource availability, and the influence of urbanization, agriculture, infrastructure development, exotic species, and varying water management scenarios are discussed as appropriate, to determine what influence these factors have on the quality of the visiting public's recreational experience.

J.1.13.1 Kissimmee River

Recreation resources in the Kissimmee River region are centered around a chain of connected lakes, public access points for boating and fishing, and adjacent land based recreation. Marinas, fishcamps, and public facilities (boat launching, picnicking, bank fishing) are located around many lakes in the region. Thirty-six miles of the Florida Scenic Trail were designated in June 1990, with additional trail section designations to follow. Lake Kissimmee State Park, Three Lakes, Kissimmee River and Kicco WildlifeManagement Areas, and Prairie Lakes Preserve provide upland and water based recreation resources for the region. The GFC surveyed boat traffic at six locks (20,000 passengers in 1991) and derived 26,000 annual fishing days that include local and tourist users (USACE, 1991). Population of the Kissimmee River region has more than doubled from 1970 to 1990 (Obers

1986 and 1990 Florida Census of Population, United States Department of Commerce, Bureau of Economic Analysis and Bureau of Census). Substantially altered water deliveries to this region could have a detrimental affect on many recreation resources in the area. Overall, existing regional recreation resources receive heavy annual usage and are expected to increase.

J.1.13.2 Lake Okeechobee

Recreation resources in the Lake Okeechobee region are primarily water based within Lake Okeechobee and include boating, fishing, waterfowl hunting and nature interpretation. Lake Okeechobee provides approximately 40 miles of navigable waterway for commercial navigation and many more for recreational boating. Twenty-five U.S. Army Corps of Engineers land and water-based recreational facilities are located along the Lake. The Florida National Scenic Trail encompasses Lake Okeechobee atop the Herbert Hoover Dike (approximately 140 miles long). The annual 3-day “Big O Bike Tour” is a 110-mile bike ride that occurs in the fall. It begins from the city of Okeechobee and heads south around the lake on top of the dike (Kichen, 1998). Approximately 94 percent of the recreation lands available to the public in this region are state or Federal (SCORP, 1994).

Bike riding, hiking, picnicking, camping, and nature interpretation is popular land based recreation activities in the region. Two-hour swampland tours aboard pontoon cruisers begin at the footbridge over the Kissimmee River and traverse the 28,500-acre National Audubon Wildlife Sanctuary on Lake Okeechobee. Substantially altered water deliveries to this region could result in flooding and have a detrimental affect on many natural and recreation resources in the area. The ample water based recreation resources in the Lake Okeechobee region receive extensive use and future demand is anticipated to increase. Many surrounding lakeside communities host annual recreation events that are important aspects of local economies.

J.1.13.3 Upper East Coast

Recreation resources in the Upper East Coast region are diverse, consist of variable quality, and include coastal, inland water and land based resources. The St. Lucie Canal provides approximately 34 miles of navigable waterway with four U.S. Army Corps of Engineers/County recreation facilities that include boating, fishing, camping and day-use facilities (USACE, 1991). An eight mile canoe trail winds through cypress strand lush with ferns and orchids in Jonathan Dickinson State Park (Martha, 1997). The approximately 44 miles of Intracoastal Waterway, within the Upper East Coast, provides many coastal recreational navigation opportunities. Several other river bodies offer recreational opportunities including the north section of the Loxahatchee River in Martin County which is designated a National “Wild and Scenic River” (SCORP, 1994). Substantially altered water deliveries to this region could have a detrimental affect on many recreation resources.

Public beaches in the Upper East Coast region are the most popular forms of recreation in the region. Four State of Florida Aquatic Preserves, and four State Parks and Recreation Areas are within the Upper East Coast region. Five artificial coastal reefs are popular diving and fishing spots. The region also includes high quality recreation opportunities within the Dupuis Reserve State Forest and Wildlife and Environmental Area and the St. Lucie Inlet Preserve. Overall, existing recreation resources in the region receive heavy annual usage that is expected to increase in the future.

J.1.13.4 Everglades Agricultural Area

Recreation resources in the Everglades Agriculture Area region are minimal due to the heavily developed agriculture industry in the region. The landscape is nearly flat with most of the areas under sugarcane production. The region is extensively ditched for water supply. A few community sized city and school playgrounds/parks are located within the Everglades Agriculture Area region. Some City, County, South Florida Water Management District, and U.S. Army Corps of Engineers parks are also found in the region. Recreation resources in are generally rustic and community-based.

J.1.13.5 Water Conservation Areas

Recreation resources in the WCA region are inland water and upland resources that include the Arthur R. Marshall Loxahatchee National Wildlife Refuge, Rotenberger, Holey Land, and Brown's Farm Wildlife Management Areas (SCORP, 1994). These areas provide high quality boating, fishing, and nature interpretation activities. The Miccosukee State Indian Reservation is within the WCA region boundary. Hunting, boating, and fishing occur within the Everglades Wildlife Management area, including the Miccosukee State Indian Reservation. Of note is the fact that the Everglades Wildlife Management Area is the only major natural area that is still open in south Florida for recreational airboating (GFC pers. comm.). Substantially altered water deliveries to this region could have a detrimental affect on many natural and recreational resources in the area. At present, undesirably high water in the Everglades Wildlife Management Area results in the GFC having to close areas for all forms of recreation, except for boating in the perimeter canals (GFC pers. comm.).

J.1.13.6 Lower East Coast

Recreation resources in the Lower East Coast region include an abundance of inland and coastal water resources that provide water and upland recreation opportunities. Many cities, county, State parks and recreation areas and one national recreation area are interspersed within the heavily urbanized boundaries. Approximately 115 miles of urbanized coastline provide popular seaside recreation resources where boating, fishing, swimming, diving and many others opportunities are available. The Intracoastal Waterway provides a diverse water-based recreation resource opportunity in the region.

The DuPuis Reserve State Forest, and the Loxahatchee River – Lake Worth Creek Aquatic Preserve also provide high quality recreation opportunities for boating, fishing, and nature interpretation activities within the Lower East Coast region. Altered water deliveries to this region could have a detrimental affect on many natural and recreational resources in the area. The good quality land and water based recreation resources in the Lower East Coast region receive extensive use and future demand is anticipated to increase.

Biscayne Bay offers among the most diverse quality recreation opportunities within the Restudy project area. Biscayne National Park provides opportunities for birwatching, recreational hiking, boating, fishing, snorkeling, diving and picnicking. The open bay waters are dotted with keys (islands) that add an additional element of interest and opportunity to study nature. Biscayne Bay, Card Sound and Cape Florida are designated Aquatic Preserves (SCORP, 1994). Substantially altered water deliveries to this region could have a detrimental affect on many natural and recreational resources in the region.

J.1.13.7 Everglades National Park

Everglades National Park and Florida Bay offer unique and diverse opportunities for a variety of natural resource and wilderness based recreational activities. Day use and camping (front and backcountry) facilities are available throughout the Park. There are over 150 miles of walking and canoe trails, including 2 miles of elevated boardwalk trails and three campgrounds with over 420 campsites and an additional 48 backcountry campsites in the Park. Recreation activities include: hiking, boating and canoeing, fishing, bird and wildlife viewing, and going on guided interpretive tours.

Everglades National Park has been designated a World Heritage Site, and International Biosphere Reserve, and a Wetland of International Significance. In addition, 86% of the Park is designated Wilderness under the Wilderness Act of 1964. The state of Florida has designated the Park an Outstanding Florida Water. The Park has also been listed as one of the nation's top ten most endangered parks (USACE, 1994).

Diverse ecosystems from sawgrass prairie to pinelands and hammocks to the estuarine environment of Florida Bay area easily accessible from the main park road or the Shark Valley tram road. The main park road ends at Flamingo, a former fishing village, and a main port of entry to Florida Bay, where a variety of self-guided, concession or ranger led walks and boat tours are available. U.S. 29 leads to Everglades City and the Gulf Coast Visitor Center where the island-bay-mangrove ecosystems of the 99 mile Wilderness Waterway and Chokoloskee Bay, Turner River, and the Ten Thousand Islands area can be accessed. At Shark Valley, within the Shark River Slough, there are opportunities for biking, a guided interpretive tram tour, guided interpretive walks, as well as the climb to the top of the observation tower for a spectacular view of the sawgrass prairie. Chekika, (a former state park within the East Everglades Acquisition Area and donated by the state to the Park in 1991) offers a slightly different experience with opportunities for a soak in a sulfur pool as well as for picnicking and hiking.

Recreation resources within Florida and Whitewater Bays, the Ten Thousand Islands, the Wilderness Waterway, West Lake and Nine Mile Pond are characterized primarily by water-based resources and include boating, fishing, bird and wildlife observation, and interpretive programs. The opportunity to enjoy the sounds of nature, solitude, tranquility and wilderness are also part of the recreational aspect of these areas. The Wilderness Waterway and Florida Bay are dotted with backcountry camp sites (by permit only). There are three kinds of backcountry campsites: chickees, ground sites, and beach sites. All offer opportunities for wildlife viewing and experiencing the sounds of nature, solitude, tranquility, and wilderness.

J.1.13.8 Florida Keys

Recreation resources in the Florida Keys region are mostly high quality water-based with some upland shoreline activities. Boating, fishing, diving, and nature interpretation are some of the many recreation opportunities in the region. The Florida Keys National Marine Sanctuary is located here, in addition to five wildlife refuges , the Keys Wildlife and Environmental Area, and one of the busiest state parksin Florida. Several other state parks in addition to John Pennekamp Coral Reef State Park are also within the region (SCORP, 1994). Key Largo National Marine Sanctuary designates protection for the delicate reefs outside of Pennekamp, which is also a popular diving destination. Fort Jefferson National Monument is the most southern point of the continental United States and is one of the most unique monuments in the world because of its setting. Recreation resources depend on the very fragile Florida Keys regional ecosystem. Diving is the most popular recreation activity followed by fishing, and bird watching. The overall region is a delicate natural resource that provides visitors with excellent recreation resources. Altered freshwater deliveries to this region have adversely affected many natural and associated recreational resources in the region. Development pressures could adversely affect the regional water quality and recreation resources.

J.1.13.9 Big Cypress

Recreation resources in the Big Cypress region are primarily wetland based with some upland access and facility use. Air boating, fishing, hunting, and nature interpretation are all very popular recreation activities in the region. Camping facilities are also found within the region. In the heart of the region, the Big Cypress National Preserve and Wildlife Management Area is rivaled in size statewide only by the Everglades Wildlife Management Area. Five state parks and recreation areas are located in the region as is a state preserve. The Panther National Wildlife Refuge is also within the region. Artificial reefs are located in the region's coastal area (SCORP, 1994). National Audubon Society's Corkscrew Swamp Sanctuary offers a 2 mile elevated boardwalk trail through old cypress and to a wood stork rookery.

Major roadways in the region include Alligator Alley (I-75) and Tamiami Trail (SR 41), which transect the region west to east. Several canals range north to south for many miles. Tamiami Canal runs east and west for many miles also. These represent pending concerns due to water quality issues and exotic species transport that could adversely affect recreation resources in the near future. Surrounding development pressures could also be critical to the natural and recreation resources. Substantially altered water deliveries to the Big Cypress region could have a detrimental affect on many recreation resources in the region.

J.1.13.10 Caloosahatchee River

Recreation resources in the Caloosahatchee River region are diverse and include coastal, inland water and land based resources. The Caloosahatchee River provides approximately 67 miles of navigable waterway with ten U.S. Army Corps of Engineers recreation facilities that include boating, fishing, picnicking, and camping. Several other river bodies also offer recreational opportunities in the region. The Caloosahatchee River provides approximately 67 miles of navigable waterway with ten Corps recreation facilities that include boating, fishing, picnicking, and camping. The J.N.”Ding” Darling NWR, a popular birding area, administers Caloosahatchee, Matlacha Pass, Island Bay National Wilderness area and Pine Island National Wildlife Refuge, all located near the region's western edge. Boca Grande Pass is world renowned for record tarpon, Sanibel Island is reported among the top shelling destinations in the Western Hemisphere.

Caloosahatchee State Park and Recreation Area is located near Alva on the Caloosahatchee River. Estero River and Hickory Creek State Canoe Trails are within the region and provide excellent recreation resources. Cayo Costa State Park, Sanibel Island State Park, and State Aquatic Preserves are located in the region. Areas boating, diving and fishing are popular recreational activities. Surrounding development pressures could adversely affect the areas natural and recreational resources. Substantially altered water deliveries have had detrimental affect on natural and recreation resources in the region. Recreation resource use is substantial and anticipated to increase.

J.1.14 Aesthetics

The visual characteristics of the central and south Florida region can be roughly described for the dominant three land use categories: natural areas, such as those areas within the Everglades Protection Area, agricultural lands, and urban areas. Regional aesthetics depends in a large part on one's personal perspective. Where one lives, spends recreational time, makes a living, and who one perceives oneself to be, contributes to a personal perspective and opinion of what is aesthetically pleasing, and what is not.

Very briefly, the natural areas are composed of a variety of upland and wetland based ecosystems including lakes, sloughs, ponds, and vast expanses of marsh and wet prairie with varying vegetative components. Uplands are often dominated by pine, although other sub-tropical and tropical hardwoods such as fig, gumbo limbo, and cypress occur within their ecotone. Overall the land is remarkably flat, with few natural topographic rises such as hills or other geographic undulations. Much of the visible topographic features are man-made, including ubiquitous canals and levees. Additional man-made features of the landscape include pump stations, navigation locks, secondary and primary roads, highways, electrical wires, communication towers, occasional buildings (some abandoned), borrow pits and other features which may or may not detract from the regional aesthetic. Views, when possible from a high perspective such as atop a levee, offer pleasant and unspoiled perspectives on Everglades marsh, often dotted with tree islands, and numerous birds and other wildlife.

One of the most prominent levees in the C&SF Project system is the Herbert Hoover Dike. Over 140 miles of levee surrounds Lake Okeechobee. The impact of this levee on Lake Okeechobee's regional aesthetics has been permanent and profound. What is otherwise a scenic and immense natural water body with a profusion of wildlife along the shoreline is nearly invisible to the casual observer because the Herbert Hoover Dike effectively blocks ones view. This is an example of the types of aesthetic impacts to key regional and local natural resources that the Restudy must strive to avoid.

Other key natural areas of particularly high aesthetic quality include among others, the Loxahatchee Slough in the Upper East Coast region, areas of the Big Cypress, the Ten Thousand Islands, Everglades National Park, Florida Bay, and Biscayne Bay. The Florida Keys and the coral reef tract provide important aesthetic qualities to the state as well as some of the most significant underwater aesthetics in the world.

Agricultural lands occur throughout the system outside of the Everglades Protection Area. They are comprised largely of open pastureland north of Lake Okeechobee, in the Caloosahatchee region and northern Big Cypress region, where dairy and beef cattle operations predominate. The Kissimmee River region for instance is primarily pasture, with patchy natural areas that function to retain water for the regional system. The Lower Basin of the Kissimmee River region is largely undeveloped and presents a panoramic landscape largely untouched by mankind for miles. The C-38 canal is straight and wide and in the process of being "restored". Project earth-moving equipment, as well Avon Park Bombing Range aircraft, break the panoramic scenery and detract from the otherwise high visual quality.

In the Everglades Agriculture Area sugar cane production, and to a lesser extent sod, vegetables and rice lend a uniform and organized appearance to the landscape, largely devoid of trees and other non-agricultural vegetation. The visual aesthetics are rather monotonous and of marginal value. Agriculture in the Upper East Coast and in south Miami-Dade County is somewhat less intensive than the Everglades Agriculture Area and so a more traditional agricultural landscape, with more diverse crops such as citrus and a variety of tropical trees, shrubs and landscape plants occur. Both the natural areas described above, and the agricultural areas are relatively open, with low population density, few buildings and other structures interspersed across the landscape, and are generally quiet.

The urban areas, other than the scattered small to medium sized municipalities characteristic of the interior regions, occur mostly along the highly urbanized east coast. This includes such sprawling, mostly low level cityscapes as Stuart, Fort Pierce, West Palm Beach, Boca Raton, Pompano Beach, and nearby urban areas. Fort Lauderdale and Miami and their surrounding suburban areas epitomize the highly urbanized scene described above, only with significant high rise buildings in the downtown area nearest the coast or on nearby barrier islands. These cities are visually congested with immense residential areas, composed mostly of one or two story buildings, well-trafficked roads, seemingly endless impervious surfaces, parking lots, strip malls, high rise hotels, and industrial and commercial enterprise. The urbanized east coast begins more or less at the Florida Turnpike, and extends eastward to the coast, and includes intensively developed residential communities, highways and heavily used roads, and other development immediately adjacent or nearby to protected natural areas or agricultural lands. Visual aesthetics are marginal except in areas where urban landscaping assumes a high priority.

Along the east coast, the Atlantic Ocean and Atlantic Intracoastal Waterway (IWW) shorelines provide panoramic aesthetic views from many locations. White shoreline sand contrasts sharply with tropical colored waters of the ocean and IWW in the region. High-rise structures, often hotels to serve the tourist industry, restrict visual access to the ocean's panoramic scenery and tend to diminish the visual experience from the shoreline. Visual access to the scenic IWW is also limited.

J.1.15 Cultural Resources

The earliest widely accepted date of occupation of Florida dates from around 12,000 years ago. This earliest cultural period is termed the Paleo-Indian stage and lasted until about 7500 B.C. Few Paleo-Indian archeological sites are recorded in Florida, and because sea level was as much as 35 meters (115.5 feet) lower then, a large number of coastal and riverine sites are presumed to now be inundated. However, professional investigations at Nalcrest, in Polk County, and Little Salt Springs, and Warm Mineral Springs, have helped to define the period. Until recently, Paleo-Indians were thought to be widely ranging nomadic hunters and gatherers, exploiting now extinct Pleistocene megafauna. Recently developed models of human behavior now suggest that Paleo-Indians led a more sedentary lifestyle.

The Archaic stage, (ca. 7500 B.C. - ca. 500 B.C.), is thought to be a reflection of man's adaptation to the changing environment at the start of the Holocene, when our basically modern climate and biota were established. Archaic Indians exploited a wider range of resources than Paleo-Indians, probably utilized a more restricted territory, and may have led a more sedentary existence. Seasonally available food resources, including deer and small game, hardwood nuts, freshwater snails, and marine shellfish were used during the Archaic. The Archaic is further subdivided into the Early Archaic (7500B.C. to 5000 B.C.), Middle Archaic (5000 B.C. to 3000 B.C.) and Late Archaic (3000 B.C. to 500 B.C). Few Early or Middle Archaic period archeological sites are recorded in south Florida and known sites are clustered along the Atlantic and Gulf coasts and inland waterways. Foraging and hunting are the main subsistence activities throughout the archaic stage, with Late Archaic people exploiting a larger territory and wider range of aquatic and terrestrial food resources. Archaic sites become more numerous during the Late Archaic period, when essentially modern climatic conditions had been established. Crude fiber-tempered pottery first appears in the Late Archaic. The end of the Late Archaic is characterized by changes in technology and lifestyles. By 500 B.C. sand replaces or augments fiber as a ceramic-tempering agent. A profusion of stone tool types and ceramic styles indicates increased population movement and social interaction, and more complex political and religious community organization.

Regional cultural diversity becomes apparent in the archeological record by 500 B.C. The clearest indication is that distinctive styles of pottery were made in different parts of the state. The Okeechobee Basin and Glades regions are distinct regional culture areas in south Florida through time. The St. Johns Region and the central peninsular Gulf coast region are other recognized cultural regions peripheral to the C&SF Project area which have at some points in time influenced the culture history of southern Florida.

In the Okeechobee Basin, the Belle Glades culture sequence (ca. 500 B.C. - A.D. 1500) is subdivided into four periods. Ceramic technology progresses from fiber tempered to fiber and sand tempered to sand tempered ceramics, with St. Johns ceramic types also being used during the Belle Glades culture sequence. Hunting and collecting subsistence strategies are thought to have been supplemented by maize agriculture practiced on circular and linear earthworks. A complex political system practiced by the Calusa was recorded in the late Belle Glades sequence. Objects of Spanish origin obtained from European contact or shipwreck salvage have been recovered from sites dating to the late periods of the Belle Glades.

In east and central Florida, the St. Johns culture begins about 500 B.C. and lasts into the historic period about A.D. 1500. The St. Johns has been subdivided into six temporal periods, based on changes in ceramics and other material remains. Changes in ceramic technology appear to reflect variations in the degree of interaction with indigenous groups from northern Florida through time. Limited horticulture was assumed established by the beginning of the St. Johns, although abundant marine food resources appear to be the staple throughout the 2000-year time span. Formal agricultural practices, if present, made only a minor contribution to the subsistence base.

The Caloosahatchee River is often identified as a separate cultural area. During the pre-Columbian period, the river likely served as a vital transportation route to the Okeechobee Basin and the Glade culture areas. Throughout the pre-Columbian period cultural and political boundaries were probably blurred or non-existent at times, but a ceramic chronology is recognized in the archeological record, subdivided into five sub-periods. Large shell mound and shell midden sites characterize the Caloosahatchee coastal area. Sand burial mounds and shell and earth middens are typically found inland along the river. Smaller dirt middens are found on interior hammocks near freshwater marshes.

During the early historical period, beginning with the first Spanish colonial period (1513 - 1763), European contacts were limited to the coastal areas. It is estimated that approximately 10,000 Calusas inhabited southern Florida prior to contact with Europeans. The Calusas were hunters and gatherers concentrated primarily in coastal areas, subsisting by fishing, collecting shellfish, and gathering wild plants for food.

Interaction between Spanish and French explorers and the Calusas occurred during the 16th century. The European settlers attempted to convert the Native

Americans to Christianity and alter their social structure. The Spanish retreated from Florida in the 1570's, leaving the Calusas undisturbed during the 1600's. Approximately 6,000 Calusas remained, but disease and occasional European invaders continued to reduce the population.

The Miccosukees are descendants of the Hitchiti-speaking Lower Creeks, and the Seminoles of the Muskogee-speaking Upper Creeks. These groups migrated to Florida in the 18th and 19th centuries from Georgia and Alabama. Then as now, the ethnic distinction between the Miccosukees and Seminoles stems mainly from a difference in language.

By the early 1800's, the migrant Native American population of Florida had grown to about 5,000. Miccosukee and Seminole Indians settled primarily in northern Florida originally. Removal and relocation of many Native Americans to reservations west of the Mississippi River occurred as a result of the Seminole Wars of the 1800's and the Indian Removal Act of 1830. Following the United States government policy of Native American removal, General Zachary Taylor led a force down the Kissimmee River valley during the Second Seminole War in 1873. The remaining Miccosukees and Seminoles moved farther south and established themselves in the Everglades, Big Cypress Swamp, and the Ten Thousand Islands areas. Most of the people lived on upland tree islands (hammocks), and used dugout canoes for transportation, hunting, and trading. Dwellings, called chickees, were constructed of cypress logs and palm fronds. The traditional lifestyle endured for the remainder of the century and still endures to a certain extent.

The first efforts to drain and reclaim the Everglades began in 1881. Agriculture began in the Everglades, south of Lake Okeechobee, after drainage projects of the 1906-1927 era. During this period, the first settlements, Okeelanta and Glade Crest were established just south of the lake. By 1921, there were 16 settlements on or near Lake Okeechobee, with a total estimated population of 2,000. Settlement and agricultural activities escalated during the subsequent decades.

By the early 20th century, hundreds of sport and commercial hunters were exploiting the Everglades resources. The opening of Tamiami Trail in 1928 ensured easy access for hunters and trappers to the southern Everglades. Permanent homes were rare, and the isolation and harsh environment compelled people to be self-reliant. Although soils in the area were fertile, it was the exploitation of fishery resources, along with animals and birds for skin and feathers, which was most economically important. Lumbering and charcoal making were also attempted (USDI, 1991). In 1947, most of the southern Everglades was incorporated as Everglades National Park.

Today, the Miccosukee and Seminole Indian Tribes are Federally recognized Indian Tribes living in south Florida. The Miccosukees have two main reservation areas, the 333 acre Tamiami Trail Reservation that is a permit area from the NPS; and the 76,800 acre Miccosukee Federal Indian Reservation in Broward County. Currently, none of the approximate 550 Tribal members reside at the 76,800-acre Reservation in Broward County.

The Seminole Tribe of Florida occupies Federal trust lands in five Florida locations, including the Big Cypress, Hollywood, and Brighton reservations, and the Immokalee and Tampa Indian communities. The present total population of the Seminole Tribe is estimated at 1,800.

Biscayne National Park has archeological sites both on land and underwater. A partial survey of submerged lands identified over 100 locations representing archeological remains. The earliest identified submerged site that has been discovered in Everglades National Park dates back to the mid-18th century. However, historical records indicate that European exploration of this region began in the early 16th century, so it is possible that more ancient remains exist. The region containing shipwrecks and other submerged examples of maritime casualties are listed in the National Register of Historic Places as an archeological district. This listing is currently in the process of being updated and expanded in scope and boundary (Adams, pers. com.).

The keys of BNP include numerous prehistoric archeological sites. The earliest site discovered so far is located on Sands Key. It is a midden dating back to 1000 AD. On the lands immediately adjacent to the mainland of the park lies the Cutler Fossil site dating back to 8000 BC. The presence of this site suggests that there is a potential for the existence of earlier sites located in BNP (Adams, pers. com.).

The Keys also contain more recent cultural resources. Boca Chita Key is listed on the National Register as a historic district for its ten historic structures as well as the ruins of several other structures. Elliott Key contains another archeological district, the Sweeting Homestead, which contains the remains of the first pioneering homestead on these keys. In addition to the previously mentioned sites, several other historic and prehistoric sites exist on other keys within the BNP (Adams, pers. com.).

J.1.16 Hazardous, Toxic, and Radioactive Wastes

A Phase I Hazardous and Toxic Waste (HTRW) Site Assessment was conducted in conformance with the scope and limitations of ASTM Practice E 1527. The findings and conclusions provided below reflect existing HTRW conditions based on a HTRW database search, aerial photography, review of available records, site inspections and interviews. These findings and conclusions are of existing conditions as they revealed at this time. The project conditions assume that any

HTRW found during any phase of the project would be remediated in accordance with local, state and Federal laws. Therefore, it can be assumed that the project condition will be contamination free or of low levels, which would include de minimis conditions that generally do not present a material risk of harm to public health or the environment. This assessment of existing conditions is not intended to be site specific in that definitive sites for the placement of most project features have not been decided. In some instances, tasking involved assessment of a certain area, or areas which were identified as possible conceptual locations for a project feature, subject to change, pending future detailed planning.

Several site visits were conducted over the past few years, with the most recent survey having been performed during the month of August 1998. The HTRW database search was performed on the entire study area and it indicated that overall, the majority of the proposed project areas are free of hazardous and toxic waste. Most of these properties are very remote and were farms, vacant land, or natural areas. The most common type of HTRW, hydrocarbons, was found along state highways in which the majority of the gasoline stations had leaking underground storage tanks. The leaking underground storage tanks are found on roads crossing proposed project areas at the Kissimmee River, Lake Okeechobee perimeter road, Upper East Coast roads, and Lower East Coast roads.

The database also revealed that several locations are not just leaking underground storage tanks, they are on the National Priority List (NPL). These sites are located in the Palm Beach Agricultural Reservoir, North and Central Lake Belt Storage area, in the vicinity of S-9 Structures and the Water Preserve Area south of Alligator Alley (I-75). Contaminants originating at these NPL-listed sites, which are on the edge of the proposed project, may be migrating into the project area through the movement of leachates.

There are numerous undocumented tanks and landfills that may be present in these proposed project areas which were not included in the database. These HTRW locations may be due to illegal dumping or may have simply not been documented. The project implementation requires that any HTRW problems revealed during the real estate acquisition or actual project construction be fully remediated. The following is a brief summary of existing HTRW conditions based on the ten physiographic regions that comprise the project area.

J.1.16.1 Kissimmee River

Several site visits were conducted over the past few years, with the most recent HTRW survey having been performed on 12 August 1998. The HTRW database review of the existing condition found the site to be free of hazardous and toxic materials and waste. The property surrounding the proposed project appears to be vacant land. One possible site for the 20,000 acre storage reservoir has potential sources of contamination located on the highway (underground storage tanks), however, these pose a low HTRW risk.

J.1.16.2 Lake Okeechobee

Several site visits were conducted over the past few years, with the most recent HTRW survey having been performed on 12 August 1998. The HTRW database, aerial photography review and site assessment of the existing conditions found the potential of HTRW contamination. The immediate property surrounding Lake Okeechobee consists of the Herbert Hoover Dike (dike) which was free of discolored soil or stressed vegetation, or any other indicator which may indicate contamination levels requiring clean-up on the dike. However, close to the dike, several locations have the potential of being a source of contamination. In Pahokee, on the east end of the Lake, businesses and private residences approach very close to the back toe of the Herbert Hoover Dike. It appears that the dike has been used as the "backyard fence". In some instances, private residences have installed a property fence creating a secure backyard boundary, the dike. This may have caused residents in the neighborhood to store materials close to the dike. Although no obvious contamination was observed, the potential of having past spills in these areas does exist. The physical inspection was performed by random spot check and driving along the road in the vicinity of the dike. It should be noted that rainfall and the high seepage rates in the area would have flushed-out most hydrocarbon, or smaller molecule chemical spills. Large molecule (PCB's), and metals may be less mobile and these spills may still measure residual levels. During real estate procurement and project construction further evaluations will be required. The perimeter road has several leaking underground storage tanks and several reported spills around Lake Okeechobee. All of these potential contamination problems are located within towns or along the highways that runs very close to the dike.

J.1.16.3 Upper East Coast

Several site visits were conducted over the past few years, with the most recent survey having been performed on 12 August 1998. The HTRW database review of the existing conditions found the site to be free of hazardous and toxic materials and waste. The property surrounding one possible project site appears to be vacant land and agricultural land. However, several of the roads that cross the C-44 basin storage reservoir have above ground storage tanks and underground storage tanks located on the roads within the project area. These appear to be gasoline stations. The potential of HTRW risks at these sites is low.

J.1.16.4 Everglades Agricultural Area

Several site visits were conducted over the past few years, with the most recent survey having been performed the week of 12 August 1998. The HTRW database review of the existing conditions found the site to be free of hazardous and toxic materials and waste. The property surrounding a possible project site did not have discolored soil or stressed vegetation, or any other indicator that may discover contamination levels requiring clean up. No hazardous substances in connection with identified uses were observed. However, the database search did reveal that the road adjacent to a possible site for the proposed 60,000-acre storage site did have a toxic release to the north of the northernmost 20,000-acre storage cell. This spill poses a low risk to the site.

J.1.16.5 Water Conservation Areas

Several site visits were conducted over the past few years, with the most recent survey having been performed on 12 August 1998. The HTRW database review of the existing conditions found the site to be free of hazardous and toxic materials and waste. The property surrounding the proposed project is natural vegetation.

J.1.16.6 Lower East Coast and Biscayne Bay

Several site visits were conducted over the past few years, with the most recent survey having been performed during the week of 12 August 1998. The HTRW database review of the existing conditions found one possible site to be free of hazardous and toxic materials and waste. The HTRW database has identified several locations within the Lower East Coast and Biscayne Bay region that are on the National Priority List. Throughout the study area many HTRW issues have been revealed. These sites are located in the Palm Beach Agricultural Reserve, North and Central Lake Belt Storage area, in the vicinity of the S-9 Structure, and the proposed Water Preserve Areas south of I-75. Contaminants originating at these NPL-listed sites, which are on the edge of the proposed project, may be migrating into the project area through the movement of leachates.

Within the Lower East Coast and Biscayne Bay project area, eight National Priority Listed sites exist. They are located within or are just adjacent to the proposed sites. These NPL sites described above do not include the NPL sites clustered just the south of the Central Lake Belt Storage Reservoirs.

J.1.16.7 Everglades National Park and Florida Bay

Several site visits were conducted over the past few years, with the most recent survey having been performed the month of August 1998. The HTRW database review of the existing conditions found the site to be free of hazardous and toxic materials and waste. The remoteness of this region and limited access has helped to keep this site free of HTRW. The adjoining area consists of agricultural land, former agricultural lands or are natural areas.

J.1.16.8 Florida Keys

Several site visits were conducted over the past few years, with the most recent survey having been performed on 12 August 1998. The HTRW database review of the existing conditions found this region to have a low risk of widespread hazardous waste contamination being present. Leaking underground storage tanks have been documented to exist along the highway connecting the islands to Key West.

J.1.16.9 Big Cypress

Several sight visits were conducted over the past few years, with the most recent survey having been performed on 12 August 1998. The HTRW database review of the existing condition found the site to be free of hazardous and toxic materials and waste. The area has limited access and is surrounded by natural vegetation or vacant land.

J.1.16.10 Caloosahatchee River

A sight visit to the project area was conducted on 12 August 1998. The HTRW database review of the existing condition found the project area to be free of hazardous and toxic materials and waste. Within the area negligible activities have been documented which would result in HTRW contamination. However, one possible site investigated for the proposed 20,000-acre storage reservoir has a landfill on the southern portion of the proposed project area. This landfill has also been listed on the National Priority List. There is a high probability that the southern portion of the proposed project area is contaminated.

J.2 KISSIMMEE RIVER REGION

The Kissimmee River Basin is covers 3,013 square miles, and extends from Orlando southward to Lake Okeechobee (refer to ***Figure J.2-1***). The watershed, which is the largest providing surface water to Lake Okeechobee, is about 105 miles long and has a maximum width of 35 miles.

Project works in the basin for flood control and navigation were constructed by the U.S. Army Corps of Engineers as part of the C&SF Project. Upper Basin works consist of channels and structures that control water flows through 18 natural lakes into Lake Kissimmee. The Lower Basin includes the channelized Kissimmee River (C-38) as a 56-mile earthen canal extending from Lake Kissimmee to Lake Okeechobee.

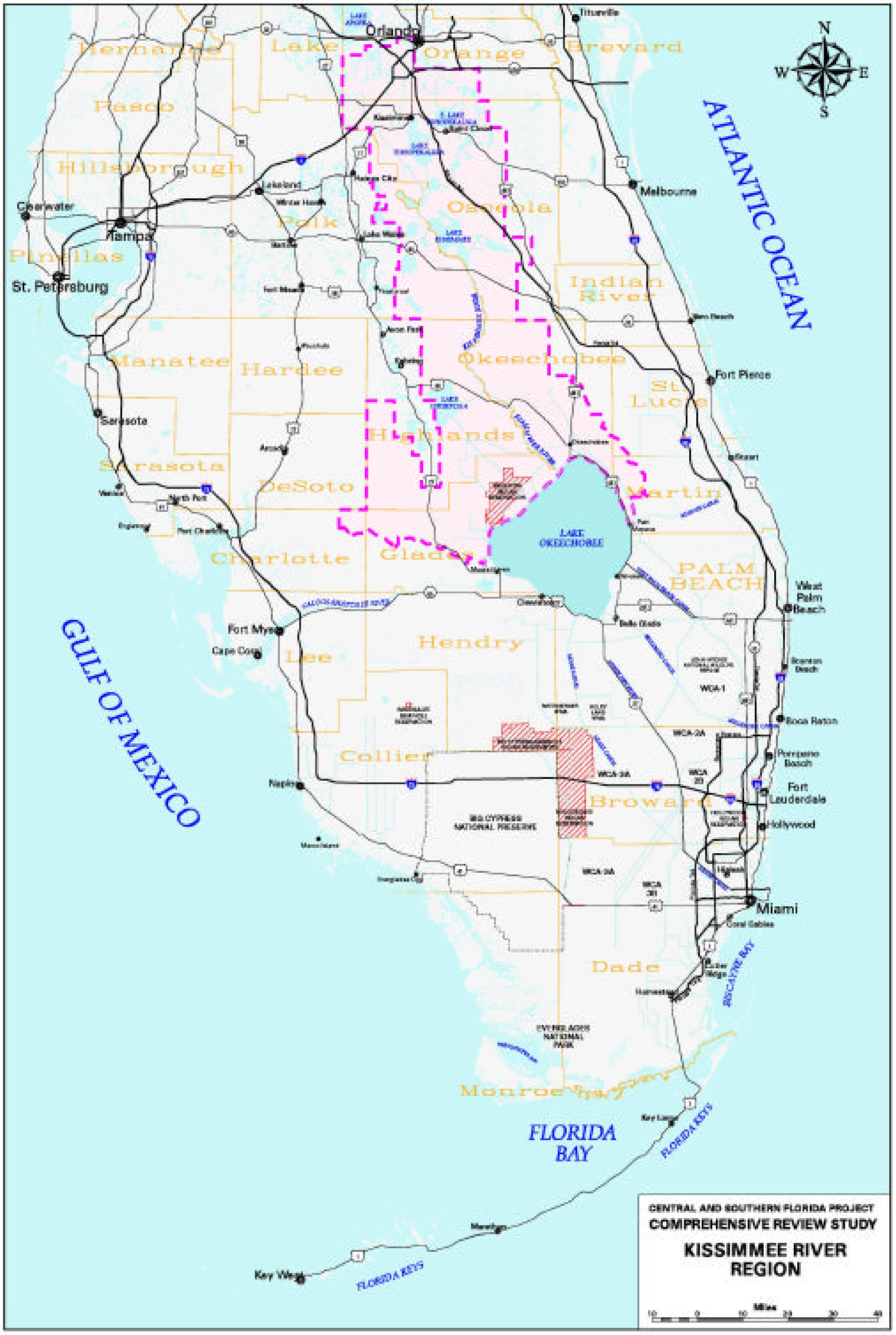


Figure J.2-1 Kissimmee River Region

The northern portion of the basin is comprised of many lakes, some of which have been interconnected by canals. This large sub-basin often termed the “Upper Basin” or “Chain of Lakes”, is bounded on the southern end by State Road 60, where the largest of the lakes, Lake Kissimmee, empties into the Kissimmee River.

The Upper Basin covers 1,633 square miles, including Lake Kissimmee and the east and west chain of lakes are in Orange and Osceola Counties. A 758-square-mile Lower Basin includes the tributary watersheds of the Kissimmee River between the outlet in Lake Kissimmee and Lake Okeechobee. The 622-square-mile Lake Istokpoga area provides tributary inflow to the Lower Basin.

J.2.1 Vegetation

The littoral zones of the lakes are among the most significant resources in the Upper Kissimmee River Basin. The distribution of plants is a result of a history of inundation, fire, grazing, nutrient input and soils. Cypress swamp, shrub swamp or emergent fresh water swamp make up the dominant vegetation communities in the littoral zones.

Flooding stage and duration are the dominant influences on vegetation composition. Flood control regulation has impacted environmental resources in the Upper Basin. Because the range of water level fluctuations and maximum annual lake stages have been reduced (***Figure J-2.1-1***), the outer fringe of littoral wetlands surrounding the lakes has been drained and associated fish and wildlife values have diminished.

The lakes are generally surrounded by pine flatwoods, dry and wet prairies, and cypress domes. The tributaries are bordered by swamp hardwood and in the case of Reedy Creek, swamp hardwood bottomlands extend for more than 25 miles to the north.

Where the cypress swamp occurs, it exists in pure stands in peripheral parts of the lakes, with little understory vegetation. The shrub swamp is dominated by willow (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), Carolina bay (*Persea* sp.) and primrose willow (*Ludwigia peruviana*). The emergent marsh is dominated by various grasses: torpedo grass (*Panicum repens*), maidencane (*Panicum hemitomon*), and cord grass (*Spartina bakeri*). Smartweed (*Polygonum* spp.), pickerelweed (*Pontederia cordata*), arrowhead (*Sagittaria latifolia*), sawgrass (*Cladium jamaicense*), cattail (*Typha* spp.), various rushes (Juncus spp.) and sedges compete with the grasses. Deeper parts of the littoral zone contain water lily (*Nymphaea odorata*), spatterdock (*Nuphar luteum*), bulrush (*Scirpus* spp.), and cattail. Hydrilla (*Hydrilla verticillata*) is a dominant submerged aquatic plant, and American lotus (*Nelumbo lutea*) is locally abundant.

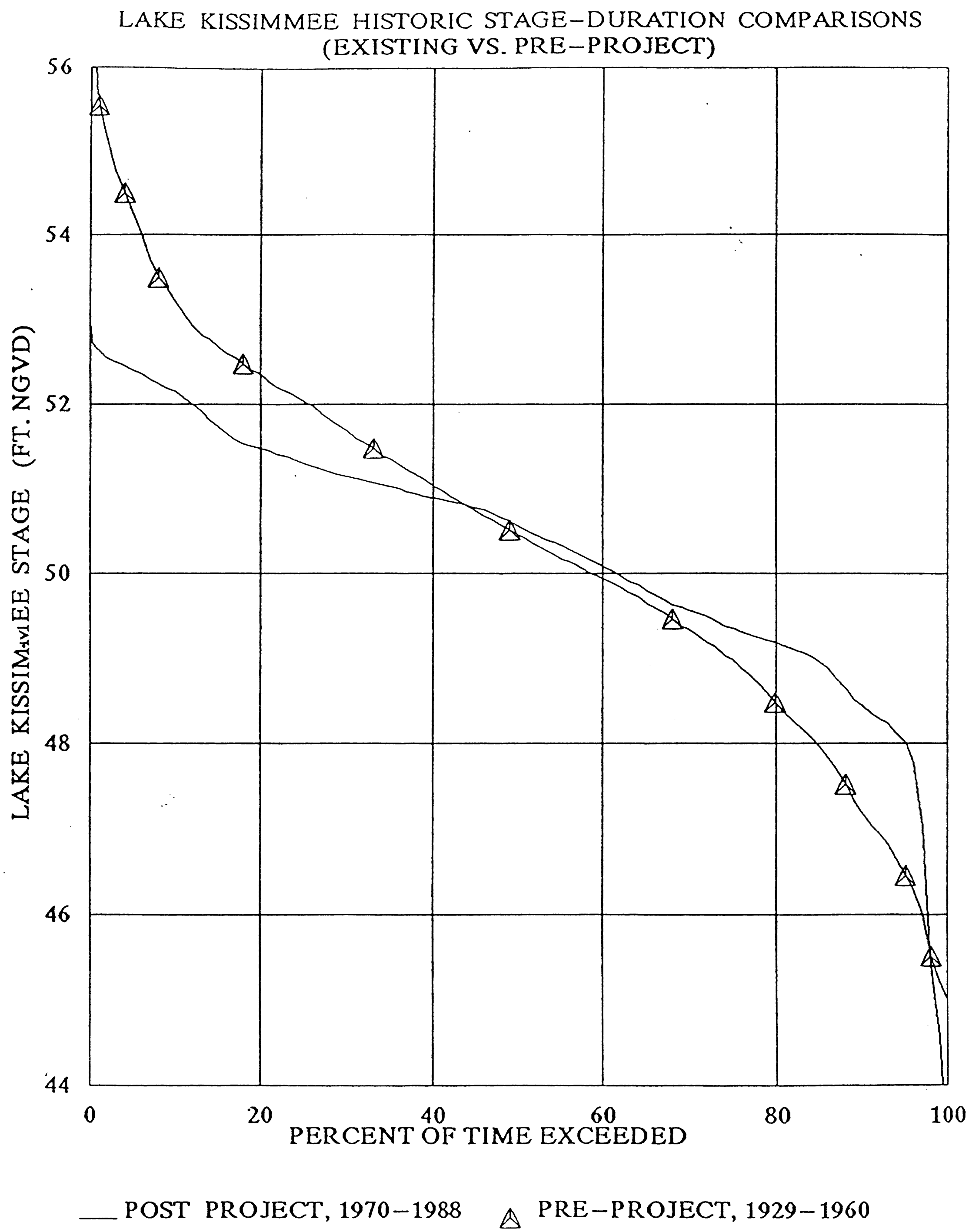


Figure J-2.1-1 Lake Kissimmee Stage Duration Comparisons

The zone around the present emergent marsh is largely pasture land dominated by short-growing carpet grass, with little cordgrass, and is subject to cattle grazing. Where cattle are excluded, the area is dominated by other grasses, such as torpedo grass. If the upper marsh has not been burned and cattle are excluded, it is dominated by broomsedge (*Andropogon virginicus*), dog fennel (*Eupatorium capillifolium*), sesbania (*Sesbania punicea*), goldenrod (*Solidago fistulosa*), and wax myrtle (*Myrica cerifera*).

The wet prairie is typically inundated about 1.5 months to 5 months each year. It is dominated by grasses and rushes, such as *wiregrass (Aristida stricta*), maidencane, spikerush (*Eleocharis* spp.), beakrush (*Rhynchospora microcarpa*), and cordgrass.

Reduced or eliminated water level fluctuations have been implicated by many authors as a major cause of undesirable changes in lake and wetland communities (Perrin, 1982). Such changes involve the accelerated accumulation of unconsolidated bottom sediments, declines in dissolved oxygen, nutrient enrichment, vegetation changes in the upper littoral zone, and ultimately the reduction of fish and wildlife populations.

In six places, on the east and west shore of Lake Kissimmee, on the southwest, northwest and east shore of Lake Hatchineha, and on the northwest shore of Lake Cypress near C-35, land owners have constructed farm levees to reduce flooding of pasture land. The levees inhibit flooding of about 3,000 acres that, historically, were marsh, contiguous with the lakes during high water periods.

This reduction in the size of the littoral zone marshes has reduced the total area for recruitment of forage to the in-lake fishery and diminished the shallow, useful zone for wading bird foraging. The present day marsh zone is approximately 16,000 acres. This is approximately a 71 percent reduction in marsh area compared to the historical extent of wetlands surrounding these lakes.

On occasion these lakes are drawn down several feet in cooperation with the GFC as a fisheries management measure to consolidate organic sediments and to permit removal of muck and debris from the littoral zones. They attempt to hold water levels down for at least 90 days, starting February 1. For Lake Kissimmee, water levels should remain below 45 feet for a minimum of 90 consecutive days for effective treatment. Extreme drawdowns were completed for Lake Tohopekaliga in 1971, 1974, and 1987, and East Lake Tohopekaliga in 1989. A drawdown of Lake Kissimmee was completed in 1977 and 1996.

Historically, the Kissimmee River floodplain was approximately one to two miles wide and sloped gradually to the south from an elevation of about 51 feet at Lake Kissimmee to about 15 feet at Lake Okeechobee.

> "*The marshes along the Kissimmee River floodplain historically occupied around 5000 km² [2,000 mi²]. Prior to its channelization in the 1960's, the river followed a 160-km [100 mi] meandering course from its headwaters at Orlando to its terminus in Lake Okeechobee. Undulating topography within the Kissimmee Valley created numerous isolated swale marshes, which blended into drier grasslands known as the Kissimmee Prairie.* (Kushlan in Myers and Ewel, 1990.)"

Based on the U.S. Fish and Wildlife Service's (1991) interpretation of 1954 photography of the Lower Kissimmee river Basin the historic flood plain contained approximately 35,000 acres of wetlands. "One of the largest marshes in the Kissimmee complex was the 12,000 ha [30,000 acre] Istokpoga (or Indian) Prairie, which originated at Lake Istokpoga and then drained southward to Lake Okeechobee. It was once covered by shallow marsh, embedded with numerous deeper marshes. Similar marshes dot the swamp forests within the Fisheating Creek basin, located southwest of the Kissimmee River valley." (Kushlan in Myers and Ewel, 1991).

Major plant communities found within the Kissimmee River wetlands included maidencane and beakrush wet prairies, broadleaf marsh, and woody shrub. Other plant communities common in the wetlands, but not distributed extensively, included wetland hardwoods, cypress stands, oak-cabbage palm hammocks, switchgrass, sawgrass, and floating mats or tussocks (Pierce et al., 1982).

Distribution and maintenance of the plant communities within the flood plain was influenced by inundation periods and seasonally fluctuating water levels (Dineen et al., 1974; Toth, 1991). A fluctuating hydroperiod, along with the undulating topography of the flood plain, a meandering river channel, oxbows, and natural discontinuous levees, enhanced and maintained habitat diversity, including a mosaic of intermixed vegetation types (Perrin et al., 1982).

The 35,000 acres of wetlands that existed prior to channelization in the Lower Basin are estimated to have declined to about 14,000 acres in the existing condition (U.S. Fish and Wildlife Service, 1991). As during prechannelization, the dominant post-channelization wetland communities are broadleaf marsh, wet prairie and wetland shrub.

J.2.2 Fish and Wildlife

The fluctuating waters of the lake littoral zones of the upper basin are important for overwintering waterfowl, which utilize these lakes during migrational periods. Coots (*Fulica americana*), ring-necked ducks (*Aythya collaris*), American widgeon (*Anas americana*), pintails (*Anas acuta*) and blue-winged teal (*Anas discors*) are the major species (Joe Carroll, USFWS. Pers. Comm., 1992). The native Florida, or mottled duck (*Anas fulvigula*) also breeds and is resident in the shoreline marshes. Normally, the common snipe (*Gallinago gallinago*) is also found in these areas in the fall and winter months.

Post-regulation waterfowl use in the Upper Basin, i.e., Lakes Kissimmee, Hatchineha and Cypress, has averaged 3,405 waterfowl days based on eight surveys between 1965 and 1980. Pre-regulation waterfowl usage, based on three surveys between 1954 and 1957, had a mean of 4,360 waterfowl days. This is a 22 percent decrease in waterfowl day usage since lake level regulation was imposed on the lakes (Perrin et al., 1982). Presently, i.e., 1994-1995, a mid-winter waterfowl survey by the Florida Game and Fresh Water Fish Commission (GFC) on lakes Kissimmee, Cypress, Hatchineha and Tohopekaliga estimated approximately 56,402 individuals were utilizing the lakes. This would represent an increase of approximately 16,000 individuals over the historic peak of 40,000 individuals since lake level regulation has been imposed. However, in comparing the data found in Perrin et al. (1982) against the 1994-95 mid-winter survey by GFC this increase is attributed to the significant increase in the populations of coots on the lakes. Lake Kissimmee had a pre-regulation (1954-1957) population mean of 2,532 ducks and 959 coots during winter surveys, while the post-regulation (1965-1980) mean population had changed to 1,437 ducks and 1,203 coots. The GFC found in their mid-winter survey of Lake Kissimmee that ducks numbered approximately 3,185 whereas coots had increased to 14,010. This change in species abundance from ducks to coots is exhibited on all the lakes of the Upper Basin. The changes in duck and coot populations on the lakes has occurred following implementation of regulated water level schedules. One of the main factors related to these changes would be the decrease in the zone of fluctuation surrounding the headwater lakes. The zone of fluctuation which provides important waterfowl habitat was reduced by 5,600 acres for all upper basin lakes following water level regulation (Huber et al., 1976). Due to topographical characteristics, the reduction of high water stages had greater impacts upon the low lying marshes bordering Lakes Kissimmee, Hatchineha and Cypress than the other lakes of the Upper Basin. The vegetation change resulting from regulated water level schedules and construction of local farm levees has resulted in conditions that favor coot utilization over ducks.

Wading birds use the littoral zone as important feeding habitat. The great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), great blue heron (*Ardea herodias*), tricolor heron (*Egretta tricolor*), and little blue heron (*Egretta caerulea*) are among those that benefit from the littoral zone. White ibis (*Eudocimus albus*) and glossy ibis (*Plegadis falcinellus*) also feed there. All are dependent on forage organisms produced in the littoral zone; i.e., fishes, reptiles, amphibians and invertebrates. One of the main reasons for recent declines in wading bird populations has been attributed to nesting failures due to inadequate food production (Ogden 1978). Ultimately, this lack of food production is attributed to increased marshland destruction and alteration of hydrological patterns (Kushlan and White 1977, Ogden 1978). Based on aerial surveys conducted over the upper and lower Kissimmee Basins by GFC from November 1978 through October 1980, wading bird population levels in the survey area seemed to reflect the degree to which wetlands habitat had been degraded. Number of species, density, and diversity of wading birds generally were lower in the Lower Basin (Kissimmee River) system than in the lake marshes of the Upper Basin.

Sport fishing constitutes the largest recreational use in the Upper Basin area. The primary quarry sought by anglers on Lake Kissimmee is the largemouth bass (*Micropterus salmoides*). From 1987 to 1991, anglers exerted 59 percent of the total fishing effort on bass, 24 percent on black crappie (*Pomoxis nigromaculatus*) and 17 percent on bream (*Lepomis* spp.). Miscellaneous species, such as channel catfish (*Ictalurus punctatus*), brown bullhead (*Ictalurus nebulosus*) and chain pickerel (*Esox niger*) also were targeted. The effects of stabilized water levels, loss of littoral wetland habitat and the increased nutrient loadings are displayed in the accumulation of muck in the littoral zones. Increased rates of organic matter deposition and flocculation of decaying plant matter have reduced the food availability for fish, limiting the habitat for fish spawning and larval and juvenile fish.

The American alligator (*Alligator mississippiensis*) is a dominant reptile in both the upper and lower basins. The alligator scavenges for carcasses of birds and hunts for fish in the deep water canals and ponds within the marsh zone.

The lower basin has experienced a substantial decline in largemouth bass and the loss of six indigenous fish species (Perrin et al., 1982). This decline has been attributed to low dissolved oxygen levels in the canal, the drainage of wetlands which have reduced food and foraging habitat for river fish species, and the lack of river habitat diversity on the channelized waterway (Toth 1990). Game and Freshwater Fish Commission data indicate the rough fish (gar and bowfish) to game fish ratio presently is about three-to-one.

During and since construction of the Kissimmee Flood Control project, several wading bird counts were made (Toland, B. 1991) and summarized (Montalbano et al., 1979; Perrin et al., 1982). An interpretation of Toland's work yields an estimate of an average population of 3,500 birds on the flood plain, exclusive of cattle egrets (2,500-4,500 range est. by Toland, B. 1991). One species, the wood stork, is Federal listed as an endangered species. Three other species are listed by the Florida Game and Fresh Water Fish Commission as endangered or as a species of special concern: tri-colored heron (endangered), little blue heron (species of special concern), and snowy egret (species of special concern). The South Florida Water Management District Demonstration Project resulted in a 1,000 percent increase in the aquatic wading bird utilization of the area (Toland, 1990).

The present waterfowl population estimate is about 140 in the Lower Basin (Toland, 1991); available winter water is estimated to be about 27,000 acre-days annually. A study by the Florida Game and Fresh Water Fish Commission (Perrin et al., 1982) reported that about 80 percent of the wintering waterfowl population utilized the Upper Basin while use of the river flood plain accounted for the remaining 20 percent. This study also disclosed that coot and water-fowl usage of the flood plain decreased by over 90 percent after channelization of the Kissimmee River. This was partly a result of shifts in continental population of waterfowl. A significant exception was Paradise Run, which is influenced by periodic water level fluctuation and hence has habitat conditions that are more attractive to waterfowl, and which had substantially more waterfowl utilization than any of the five pools of C-38.

J.2.3 Water Management

The system of water control works now in place in the Kissimmee Basin conforms closely with the general plan outlined in the 1948 report to Congress and authorized for construction in 1954. The project was designed to provide flood damage prevention for thirty percent of the standard project flood (SPF). This equates to protection against a five-year flood event. Water levels within the basin are controlled by a complex system of canals and control structures that are managed by the South Florida Water Management District in accordance with regulations prescribed by the Secretary of the Army.

The major lakes of the “Headwaters” area, (the Upper Basin) are connected by channels. Most of the channels were excavated by private interests in the 1880’s and subsequently enlarged to varying degrees under the congressionally authorized plan. Nine control structures regulate water levels and flows in the lake system. For more details on the existing flood control project, refer to the U.S. Army Corps of Engineers Kissimmee River, Florida – Final Feasibility Report and Environmental Impact Statement (1985). Operational criteria for both basins can be found in the Water Control Plan for the Kissimmee River-Lake Istokpoga Basin (1991). From time to time, operations may temporarily deviate from the water control plan. These temporary deviations may be conducted for various purposes such as control of nuisance aquatic vegetation, lake drawdowns, or construction.

Prior to the project, lake outlets within the “Headwaters” region had been dredged for drainage and navigation, but were uncontrolled, and over-drainage often occurred. Dredged outlets did not provide adequate flood control and the Upper Basin did not have enough outlet capacity (sometimes termed “get away” capacity) to remove flood waters within a “reasonable” time frame to avoid flood impacts.

To provide adequate outlet capacity from the Upper Basin, approximately 15 miles of canal, the outlet channel, was required immediately downstream of Lake Kissimmee. This length is a function of canal size, the size of the Lake Kissimmee outlet structure size (S-65), and the very flat terrain immediately downstream of the lake.

An earlier project, the Herbert Hoover Dike around Lake Okeechobee, had modified the original lower end of the Kissimmee River with a borrow area immediately upstream of Lake Okeechobee. This eight mile section of canal, known as Government Cut, was modified and enlarged during construction of C-38, and is inside the Lake Okeechobee containment levee. This section of the canal diverted flow from a downstream portion of the Kissimmee River, creating an isolated remnant of the river known as Paradise Run. Paradise Run, immediately west of Government Cut, retains most of its original topography; however, diversion of natural flows has lowered water levels and former wetland areas have been converted to grazing and pasture land.

Between the outlet channel at the upper end of the Kissimmee River (C-38), and Government Cut at the lower end, approximately 33 miles of the river and flood plain, referred to as the central reach, also was provided flood control. Some consideration was given to non-structural approaches (e.g., levee the uplands from the flood plain); however, channelization was determined to be more cost effective at that time. Combined with Government Cut, the new canal provided complete channelization of the entire 56-mile river-flood plain from Lake Kissimmee to Lake Okeechobee.

The natural fall of the land from Lake Kissimmee to Lake Okeechobee is about 36 feet. Construction of Canal 38 (known as C-38) included six water control structures, S-65, 65A, 65B, 65C, 65D, and 65E from north to south, which form a series of five pools between S-65 and Lake Okeechobee.

The S-65 structures act as dams, and were located to step the canal water level down in increments of about six feet. In doing so, the natural slope of the river was removed, and flat pools (impoundments) resembling stair-steps were created. The water level of each pool generally is held constant, with little fluctuation or slope. This action has lowered water in the northern reach of each pool, and has created flooded marsh in the southern or lower end of each pool. A water surface area of approximately 7,600 acres is included within these pool areas under the existing regulation schedules.

C-38 is generally 30 feet in depth, but varies in bottom width from 90 feet near Lake Kissimmee to 300 feet above S-65D. The canal's length, width, and water level vary in each pool. The head, or difference in water level above and below each structure, varies from structure to structure and with rate of discharge, but is typically about six feet.

During construction of C-38, a temporary easement was used to obtain areas adjacent to the canal for deposition of dredged material. The material was hydraulically deposited in linear alignments covering some 8,000 acres along the canal, with elevations averaging 15 feet above pre-project topography. The material consisted of hydraulically sifted subsoil sands and clays with limited organic fraction, and high percolation rates. The material became part of the property upon which it was deposited. A number of landowners subsequently used the material to fill low areas on their property; and, at two locations in Okeechobee County, flood free, fly-in, residential subdivisions were built on the material. Where material was left undisturbed, xeric vegetation emerged on many of these deposits.

The CS&F Project works improved navigation opportunities originally provided in the Congressional Act of 1902. Each water control structure along C-38 includes a 30-foot by 90-foot navigation lock, which can accommodate boats with drafts up to 5.5 feet. The canal provides continuous navigation; however, inter-pool navigation is limited to daylight hours of lock operations.

The approximately 68 miles of river oxbows that exist within the five C-38 pools represent secondary channels of widely varying water depths. Many of these channels are very shallow, but only those that receive tributary inflows have any substantial base flow. Culverts within the tieback levees at Structures S-65B, 65C, and 65D provide modest amounts of circulation flow in the existing river channels below the levees.

Approximately 50 tributaries provide inflow into the Lower Kissimmee Basin. These tributaries are characterized by relatively constricted central channels with pasture lands usually extending along the channel. Most channels are covered with vegetation.

J.2.4 Water Supply

The Kissimmee River Basin contributes about 30 percent of the water input to Lake Okeechobee and is second only to rainfall in the lake's water budget. Prior to channelization, the Kissimmee Basin, which included the Istokpoga Basin, contributed an average annual inflow of about 4,300 acre feet/day (2,200 cfs) at its outlet.

The volume of water reaching the Lower Kissimmee Basin has declined in recent years. The majority of the decline has occurred in the Upper Basin, where, for example, the mean discharge has declined from 1,241 to 722 cubic feet per second at the gage site near S-65. A small portion of the decline may be attributable to an increase in water supply withdrawals, and current water management practices; however, this reduction is most likely the result of a reduction in basin rainfall compared to pre-project rainfall conditions (Obeysekera and Loftin, 1990). In the Lower Basin below Lake Kissimmee, the basin yield, after adjusting for Lake Istokpoga outflow, has remained virtually unchanged.

Since 1970, the south Florida region has experienced an apparent change in rainfall characteristics, and most basins in the region have received less than normal annual rainfall. The Kissimmee River Basin has had about 10 percent less rainfall compared to pre-1970 records. Land use in the Kissimmee Basin also has undergone substantial change over the last thirty years. Combined effects of upland drainage and construction of the basin's flood control works, have changed the hydrologic response from upland/flood plain retention and slow runoff, to upland/flood plain drainage with rapid runoff. The flow regime has undergone a major shift from predominantly baseflow runoff, to surface (direct) runoff with increased volume discharged at a faster rate during flood events (Huber et al., 1976, Obeysekera and Loftin, 1990).

The net hydrologic effect of the canal and control structures was to shorten the residence time of water in the basin during periods of high water (floods) and to increase residence time during low-flow (drought) periods. Based on a review of historical U.S. Geological Survey data under similar hydrologic conditions, the overall volume of water delivered to Lake Okeechobee from the Lower Kissimmee River Basin via the canal was found to be relatively the same as those volumes experienced under pre-project conditions. The timing of those water deliveries has been changed, however, which is reflective of current water management practices for flood control and water conservation purposes within the basin.

J.2.5 Socio-Economics

The six counties that make up the study area of this report are Glades, Highlands, Okeechobee, Orange, Osceola, and Polk. Population growth and economic activity within the study area and in the state overall has influenced and is expected to continue to influence the socio-economic trends and characteristics of the Kissimmee Basin. The State of Florida began showing tremendous population growth after World War II. The state's population grew from 2,771,300 in 1950 to 12,937,900 in 1990 primarily because of migration. Over this period the state's share of the U.S. population increased from 1.8 to 5.2 percent.

Within the six-county Kissimmee River Basin study area, the 1990 population totalled 1,296,251. The majority of the population resided in Orange County, with Orlando being one of the nation's leading tourist areas. There are no major urban areas within the Lower Basin. The largest urban concentration in the area is Okeechobee, located within the Taylor Creek-Nubbin Slough sub-basin.

J.2.6 Land Use

Orlando, at the headwaters of the Kissimmee River Basin, is the primary economic and transportation center in the study area. Once the center of the state's orange production, the local economy of Orlando and the surrounding area now focuses on tourism. Kissimmee, located in Osceola County, is located eight miles east of Disney World and seventeen miles south of Orlando, and is influenced largely by tourism activities in the Orlando area. The other major incorporated area of Osceola County, the city of St. Cloud, is primarily a retirement community.

Land uses in the Upper Basin around the perimeters of Lakes Kissimmee, Hatchineha, Cypress, Rosalie, Tiger and Jackson are primarily pasture, some agriculture, and a large amount of wetlands. Marinas, fish camps, and various public facilities, such as boat launching sites and picnic areas, are located around the lakes. Lake Kissimmee State Park is on the extreme northwestern periphery of Lake Kissimmee, and the Three Lakes Wildlife Management Area and Prairie Lakes Preserve border the southeastern half of Lake Kissimmee. Small residential and commercial areas are also scattered around most of the lakes. Development is more intense upstream of Cypress Lake, particularly in the Lake Tohopekaliga – East Lake Tohopekaliga (Toho) chain.

Agriculture continues to play an important role in the region. In the Lower Basin, most of the area between Lake Kissimmee and Lake Okeechobee is in fewer than fifty large, private land holdings and several hundred subdivided property holdings. Agriculture remains the primary land use activity within the Lower Basin, being dominated by extensive beef cattle production and dairy activities.

The Avon Park Air Force Bombing Range is located within the Polk County portion of the Lower Basin. This 107,000-acre Federal facility is used both as a training facility for Armed Forces personnel, and as a management area for wetlands adjacent to the Kissimmee River.

Table J-2.6-1 provides generalized land use categories found within the Lower Kissimmee River Basin. Lower Basin lands have undergone substantial change over the last twenty years. Most notable is the conversion of unimproved pasture land to improved pasture at an accelerated pace during the period 1958 to 1972.

In the Upper Basin, most of the development susceptible to flood damage is urban, where damage is primarily a function of the depths of flooding inside structures or the stage of flooding. Single family residential land use is the primary type of development affected by flooding in the Upper Basin. Major affected areas are located around the towns of Kissimmee and St. Cloud, which cover only six

Table J-2.6-1 Land Use Lower Kissimmee River Basin			
Land Use	**1958**	**1972**	**1980**
Urban	0	1,300	3,100
Crops	300	1,600	5,400
Improved Pasture	32,900	223,200	187,100
Unimproved Pasture*	280,600	133,200	141,500
Citrus	1,300	1,000	1,700
Forest	3,200	7,500	35,800
Marsh	133,700	84,200	54,900
Total	452,000	452,000	438,500

(Source: Obeysekera and Loftin, 1990)
Most of the unimproved pasture was wet prairie.
** Area for 1980 does not include the sub-basin below S-65E.

percent of the damage susceptible flood-prone area but account for almost half of the basin's standard project flood damage. Other affected areas include Lake Hart, Lake Mary Jane, Pells Cove, Hidden Lake, Lake Hatchineha, Lake Alligator, Lake Rosalie, and the area west of the southern part of Lake Kissimmee. Existing average annual equivalent flood damages in the Upper Basin are estimated to be $1,226,100 (8 ¾ percent rate).

In the Lower Basin, mobile homes located around Pool E are the primary areas that would be affected by flooding. Although this land use would account for most of the damages from a standard project flood and 100-year event, it is not susceptible to damage during smaller floods. Other damages occur due to the duration of flooding on pasture land. Although agricultural use is the primary land use in the Lower Basin, flood damages are relatively minor for this activity due to the short duration of flooding, a result of the existing project works. Existing average annual equivalent damages in the Lower Basin are estimated to be $97,700 (8 ¾ percent rate).

J.2.6.1 Agriculture

Osceola, Polk, Highlands, and Okeechobee Counties were included in this region. More than two million acres in these counties are farmed, with more than half of this area devoted to pastureland (UFBEBR, 1995). Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value crops, including citrus. Almost a quarter of a million acres in the Kissimmee River Basin are irrigated (UFBEBR, 1995), requiring a dependable water supply. This region is characterized by large farms with relatively low productivity per acre. These four counties are among the top five counties in Florida for cattle production, both beef and dairy (FASS, 1996a). More than

200,000 acres are used for citrus production. Approximately 11,000 people are employed in agricultural production and services representing a payroll of approximately $21 million (UFBEBR, 1995). The market value of all agricultural products in this region totals approximately $575 million (UFBEBR, 1995).

J.2.7 Recreation Resources

The three counties in which the upper Kissimmee Basin is located are in two different regions according to the State Comprehensive Outdoor Recreation Plan, published in 1989. Orange and Osceola are in Region VI; Polk is in Region VII. The large urban populations around Orlando, the Tampa Bay area, and the central coastal cities are all within a one- to two-hour drive from the project area. The main highways leading to the project area are heavily traveled and well maintained. The main constraint to access lies with the condition of the secondary service roads leading from the main highways to the upper chain of lakes and the large amount of private property which is in agricultural use around some of the lakes.

Recreation in the upper Kissimmee River basin is moderate to heavy with emphasis on Recreational Vehicle (RV) camping, general boating, and boat and bank fishing. Channelization and water control provide year-round navigable water levels for recreational boating, canoeing, and fishing. During high water conditions, airboats are able to traverse many of the marshes and flooded pastures around the chain of lakes.

Marinas, fish camps, and various public facilities such as boat launching sites and picnic areas are located around the lakes. There are six public and 14 commercial boat ramps around the upper chain of lakes, which occur within the region affected by headwaters revitalization. The commercial boat ramps are associated with RV parks, marinas and fish camps located on the lakes. All but two of these commercial operations charge fees for use of their launching facilities.

Lake Kissimmee State Park encompasses over 13,000 acres along the extreme northwestern periphery of Lake Kissimmee. Lake Kissimmee State Park, located on the shores of Lakes Kissimmee, Tiger and Rosalie, offers outstanding fishing and water access, picnicking, bird watching and boating. Thirty campsites with water and electrical hookups are available. The park has 13 miles of hiking trails, which offer hikers the possibility of seeing whitetail deer, bald eagles, sandhill cranes, turkeys and bobcats. Plans to rework the park boat ramp are being developed by the State.

The Three Lakes Wildlife Management Area, located in Osceola County, is an 59,000 acre tract of land adjacent to Lakes Kissimmee, Jackson and Marian. This area is traversed by the Florida Trail. Picnicking facilities are available and primitive camping is allowed at designated campsites along the trail except during established hunting seasons for the area. Camping permits are required, but these are issued at no cost to the camper. This area has a boat ramp which can provide access to the Kissimmee chain of lakes via Lake Jackson. Parking at the ramp should not be affected by higher water conditions. The access road into the site may be subject to overtopping, however.

The Kicco and Kissimmee River Wildlife Management Areas also provide recreational amenities in this region. Kicco Wildlife Management Area comprises 7,427 acres on either side of River Ranch Resort, and Kissimmee River Wildlife Management Area is composed of eight units along both sides of the Kissimmee River and currently totaling 8,581 acres. Kissimmee River Wildlife Management Area is expected to expand as new tracts are acquired (GFC pers. comm.).

A large number of out-of-state visitors bring their boats with them to spend the winter in this portion of the State. During their stay, they participate in fishing and boating activities in and around the interconnected chain of lakes in the Upper Kissimmee Basin. Rental boats are available at many of the fish camps and marinas found along the edge of many of the lakes. Resident boat owners intensify the use of these lakes. The combined acreage of the Upper Basin lakes, plus the miles of waterways in between, offer recreational boating and fishing unlimited opportunities for residents and visitors alike.

Heaviest boat usage occurs within the Lake Kissimmee and Lake Okeechobee areas, located at the northern and southern ends of C-38. This is most likely the result of the larger numbers of boat owners who keep their boats at marinas on these lakes, more waterfront property owners with their own moorage facilities, and more convenient access to these larger water bodies than to the river. Although fishing occurs on a year round basis, heaviest fishing use occurs during the four to five months from late fall to early spring.

Recreational fishing is the largest use of species in the lakes. Based on creel data collected by the GFC, effort expended to fishing in Lake Kissimmee over the five year period, 1987-1991, averaged 451,582 hours per year. The primary quarry sought by anglers on Lake Kissimmee is the largemouth bass. From 1987 to 1991, anglers exerted 59 percent of the total fishing effort on bass, 24 percent on black crappie and 17 percent on bream. Miscellaneous species, such as channel catfish, brown bullhead and chain pickerel also were targeted. The only creel survey conducted in Lakes Hatchineha and Cypress was during the spring of 1986. The total fisherman effort was 40,832 hours at Hatchineha and 18,007 hours at Lake Cypress. As a comparison, fishermen in Lake Kissimmee fished for 213,921 hours during the same spring quarter (February 21 to May 15, 1986). Lakes Rosalie and Tiger are also popular with fishermen, but no creel census on these waters were available for this report. Lake Jackson has been a popular fishing spot in the past, but aquatic vegetation problems periodically cause fishing effort to be low. Hunting is also a very popular recreational activity in the Kissimmee River Region, particularly in terms of hogs, deer, and waterfowl.

The lakes are drawn down several feet on occasion to consolidate organic sediments and to permit removal of muck and debris from the littoral zone. Water levels are lowered for several months at a time during the draw down period. During this period the major problem in affected lakes is temporary loss of navigational access due to low water. The organized Kissimmee Boat-A-Cade utilizes the Kissimmee channel for an annual floating pilgrimage in December from the City of Kissimmee through Lake Okeechobee to the coast. The 1995 Boat-A-Cade was canceled because of a drawdown underway on Lake Kissimmee.

Recreation within the Lower Kissimmee River Basin has increased substantially in recent years, and both public and private facilities have been developed or expanded to accommodate the increasing demand for recreational opportunities. Public facilities include Okee-Tanti Park, located at the mouth of the Kissimmee River, which provides camping, picnicking, boat ramps, and restrooms with showers. Other public facilities include Lake Kissimmee State Park, located upstream of the channelized Kissimmee River, and the Avon Park Bombing Range, the latter offering camping, picnicking, hiking trails, and hunting. The Bombing Range is utilized during the week by several military bases throughout the state for practice flights. As a result, the number of low-flying jet aircraft using the range tends to disrupt the audible aesthetics of the river.

Private facilities include the River Ranch Resort located at the upper end of the Kissimmee River, which offers a marina, and multi-purpose recreational opportunities. An additional seven privately-owned fish camps are located between State Highways 60 and 70, offering boat ramps and other services along the waterway.

Recreational use in the Lower Basin is primarily concentrated at each end of C-38, with emphasis on camping, general boating, boat fishing, and bank fishing. There is limited access to the river on C-38 for bank fishing, but boaters have access to almost any point along the waterway from existing boat ramps. However, available facilities are not used at full capacity. Most of the land along the river remains in private ownership. Those using the area for fishing, hunting, and wildlife observation may only utilize the river banks and adjacent lands with permission of the landowners.

Thirty-six miles of the Florida National Scenic Trail were dedicated in June 1990 along the flood plain of the Kissimmee River. Additional sections of trail will be developed as contiguous parcels of land are acquired by the state under the Save

Our Rivers program. According to the South Florida Water Management District, the long range plan is to extend the trail the full length of the river.

A 1978-1980 fishing census by the Florida Game and Fresh Water Fish Commission found about 26,000 fishing days annually. Effort by species was 43 percent for bass, 41 percent for crappie, and 16 percent for panfish. Non-residents accounted for 28 percent of the fishing. Boat traffic through the six locks is 20,000 passages per year (1991).

Prior to construction of the C&SF Project in the Kissimmee Basin, efforts were made by local recreational boating interests to demonstrate the need to continue navigation on the river. As a result of this interest in the maintenance of navigation, locks were included in the Federal project with the local sponsor responsible for maintenance of the navigation portion of the project. The South Florida Water Management District has continued to operate and maintain the navigation locks which are used by recreational craft.

The existing flood control project modified the Congressionally-authorized 3-foot navigation project, and the waterway now provides daylight only year-round navigation from Lake Kissimmee to Lake Okeechobee. Navigation is now primarily along the canal (C-38), instead of the meandering alignment of the original river. The waterway provides opportunity for day use recreational boating, canoeing, and fishing. The organized Kissimmee Boat-A-Cade currently utilizes the channel for an annual floating pilgrimage of some 300-400 boats from the city of Kissimmee through Lake Okeechobee to the coast.

Field observations of boaters using the channelized Kissimmee River indicate that recreational powerboats are dominant crafts using the waterway. Annual lockage data for the six navigation locks on the Kissimmee also indicates to some extent the utilization of the system.

Although portions of the original river are presently unnavigable, many of the original river oxbows remain intact and are accessible via small boats or canoes. Some 60 miles of oxbow and meander area of the original river are accessible by canoe, bass boat, jon boat, and similar shallow-draft craft.

J.2.8 Aesthetic Resources

The Headwaters lakes exhibit a patchwork development pattern with numerous subdivisions as well as commercial enterprises and agriculture dotting the lakeshores. Large tracts of undeveloped land used by wildlife for roosting, feeding and nesting are interspersed along stretches of the lakes, and are more extensive than the developed shorelines. This patchwork type of development allows those who use the lakes the opportunities to view a tremendous variety of wildlife from short distances away from shorelines. The Upper Chain of Lakes provides an excellent example of the contrasts between development and a more natural lacustrine environment.

With the exception of developed areas around major road crossings, and near the various locks, the Lower Basin is largely undeveloped and presents many miles of water in which boaters can travel without seeing signs of human habitation. However, the canal offers little in the way of vegetative or scenic interest. The canal is wide and straight, and this contributes to the lack of variety.

The remnants of the old river are associated with the large, older trees and denser vegetation, as well as submerged and emergent plants. These have not established themselves on the canal cut because of deeper water and steep sides. The taller trees overhanging the oxbows provide shade which is missing from the main canal.

The aesthetics are adversely affected in the vicinity of the Avon Park Bombing Range, which is used during the week by several military bases throughout the State of Florida for practice flights. The planes approach the range from any direction at low altitudes and at high speeds with the resulting noise associated with such low flying aircraft. This has a tendency to shatter the audible aesthetics of the river.

J.2.9 Hazardous, Toxic, and Radioactive Wastes

The U.S. Army Corps of Engineers performed a HTRW Civil Works Audits in conformance with ER 1165-2-132. These audits covered property impacted by both the upper and lower restoration projects. Aerial photographs were reviewed for the purpose of delineating the actual property for detecting any signs that would indicate past activity that could have resulted in the existence of a current hazard. A south Florida Water Management District Environmental Audits determined that two inactive cattle dipping vats were identified on the concerned property.

J.3 LAKE OKEECHOBEE

Lake Okeechobee (***Figure J.3-1***) is the second largest freshwater lake within the contiguous United States, measuring 700 square miles (576,000 acres) in area, with approximately 150 square miles of littoral zone. The lake is shallow with a mean depth of 9 feet, subtropical, and eutrophic. Its storage capacity of 1.05 trillion gallons makes it the center of south Florida's water supply and flood control system. Lake Okeechobee provides water for a variety of consumptive demands, including urban drinking water, irrigation for agricultural lands, and recharge for wellfields. Habitat conditions inside and outside the lake also depend on this water supply. The lake's littoral zone supports a renowned recreational sport fishery, commercial

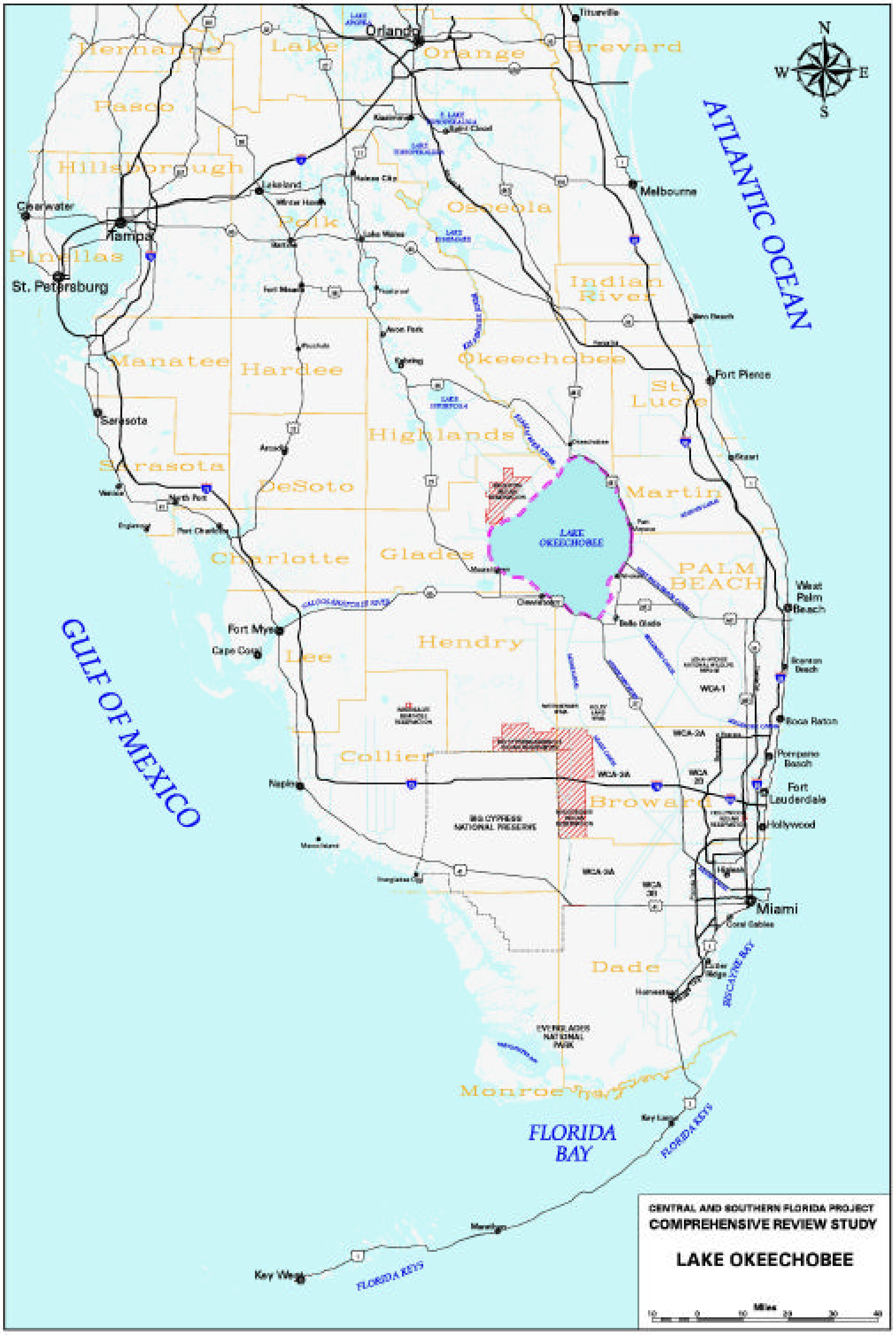


Figure J.3-1 Lake Okeechobee Region

fishery, wading bird breeding and foraging, resident and migratory waterfowl, and endangered species. Lake Okeechobee is an important source of freshwater to the Everglades, and discharges control the ecology of the St. Lucie and Caloosahatchee estuaries.

J.3.1 Vegetation

The vegetation and cover types within the Lake Okeechobee region have been greatly altered during the last century. Historically, the natural vegetation was a mix of freshwater marshes, hardwood swamps, cypress swamps, pond apple forests, and pine flatwoods. The freshwater marshes were the predominant cover type throughout, but especially along the southern portion of the Lake where it flowed into the Everglades. These marshes were vegetated primarily with sawgrass (*Cladium jamaicense*) and scattered clumps of carolina willow (*Salix caroliniana*), sweetbay (*Magnolia virginiana*), and cypress (*Taxodium* sp.). Hardwood swamps dominated by red maple (*Acer rubrum*), sweetbay, and sweet gum (*Liquidambar styraciflua*) occurred in riverine areas feeding the Lake, while cypress swamps were found in depressional areas throughout the region. Pine flatwoods composed of slash pine (*Pinus elliottii*), cabbage palm (*Sabal palmetto*), and saw palmetto (*Serenoa repens*) were prevalent in upland areas especially to the north.

Lake Okeechobee has an extensive littoral zone that occupies approximately 400 km^2 (about 25 percent) of the lake's surface. Littoral vegetation occurs along much of the lake's perimeter, but is most extensive along the southern and western borders (Milleson 1987). The littoral zone plant community is composed of a mosaic of emergent, submergent and natant plant species. Richardson and Harris (1995) refer to a total of 30 distinguishable vegetative community types in their digital cover map study. Emergent vegetation within the littoral zone is dominated by herbaceous species such as cattail (*Typha* spp.), spike rush (*Eleocharis cellulosa*), and torpedo grass (*Panicum repens*). Other emergent vegetation observed includes bulrush (*Scirpus californicus*), sawgrass (*Cladium jamaicense*), pickerelweed (*Pontederia cordata*), duck potato (*Sagittaria* spp.), beakrush (*Rhynchospora tracyi*), melaleuca (*Melaleuca quiquenervia*), wild rice (*Zizania aquatica*), arrowhead (*Sagittaria latifolia*), button bush (*Cephalanthus occidentalis*), sand cordgrass (*Spartina bakeri*), fuirena (*Fuirena scirpoidea*), primrose willow (*Ludwigia peruviana*), southern cutgrass (*Leersia hexandra*), maidencane (*Panicum hemitomon*) white-vine (*Sarcostemma clausum*), dogfennel (*Eupatorium capillifolium*), mikania (*Mikania scandens*) and carolina willow (*Salix caroliniana*).

The submergent vegetation is composed almost entirely of hydrilla, pondweed (*Potamogeton illinoensis*), bladderwort (*Utricularia* spp.),and tape-grass (*Vallisneria americana*).

The natant, or floating, component of the littoral zone consists of lotus lily (*Nelumbo lutea*), fragrant water lily (*Nymphaea odorata* and *N. mexicana*), water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), duckweed (*Lemna* sp.), rush (*Scirpus cubensis*), coinwort (*hydrocotyle umbellata*), and ludwigia (*Ludwigia leptocarpa*).

The most recent vegetation mapping of the western littoral zone and marsh, conducted by the South Florida Water Management District, clearly depicts the dynamic state of vegetative succession within the littoral zone and the spread of less desirable and invasive exotic species into new areas.). Results of this vegetation mapping show extensive areas of melaleuca along the rim canal, and nearshore, spike rush, particularly in the Moonshine Bay area, cattail, mostly interspersed in smaller stands, hydrilla (*Hydrilla verticillata*), where large monotypic floating and submergent mats dominate in Fisheating Bay, and large stands of torpedograss, which largely outcompete other species at most water levels.

Hydrilla is one of several problem species discussed below which occur on Lake Okeechobee. It seems to provide good fish habitat, but its prolific growth, as evidenced in Fisheating Bay, causes navigation and possibly water quality problems. There has also been observed a significant expansion of cattail in the littoral zone by GFC staff.

Melaleuca, a resilient species, found in a variety of habitats is one of the principal species of concern on the Lake. Melaleuca is capable of displacing native vegetation, including sawgrass marsh (Hofstetter and Parsons 1983, Stocker and Sanders 1980, Laroche and Ferriter 1992), and has been observed to displace native species in other marsh types, cypress-hardwood forests, and pine savanna (Schmitz and Hofstetter 1994). Ewel (1990) described melaleuca sites in south Florida as having hydroperiods of 6-9 months. Shomer and Drew (1982) noted that melaleuca colonization rates appeared to be inversely proportional to the length of the hydroperiod. Melaleuca may be observed adjacent to the rim canal, on spoil islands peripheral to the Herbert Hoover Dike, in wetland pockets behind the dike, and in the western littoral zone, where it has penetrated into the marsh over a mile from the rim canal near Moorehaven.

Brazilian pepper (*Schinus terebinthifolius*) is frequently associated with ditch banks (Barber 1994) and is commonly found along canal banks within the Lake. Very little is known about its hydroperiod requirements, but Duever et al. (1986) found that it thrives in areas with three to four month hydroperiods, while Doren and Jones (1994) stated that it rarely grows on sites flooded longer than three to six months, and is absent from deeper wetland communities.

Australian pine is a major invader of short hydroperiod areas where it can be found in dense stands, which preclude establishment of native species. One of the species (*Casurina quinquenervia*) is intolerant of extended inundation, but another (*C. glauca*) invades sawgrass marsh and burned hardwood hammocks in the Everglades (Doren and Jones 1994). Australian pine is commonly found along the rim canal and in monotypic stands on the berm of the Herbert Hoover Dike and in areas behind the dike.

Other exotics that continue to plague resource managers throughout Lake Okeechobee include torpedograss, which is believed spreading rapidly into areas of spike rush, forms dense rooted mats and appears to be tolerant of a wide variety of hydroperiods. There was an estimated 14,000 acres of torpedograss within the marsh as of 1992 (Schardt and Schmitz 1992), although that figure may be too low according to recent empirical data (C. Hanlon pers. comm.). Other species include waterhyacinth, native to South America, that clogs waterways and is found primarily in canals and backwater areas; and waterlettuce, found in canals and may root in wet soil. These latter two species, along with hydrilla, pose navigation problems for boaters and fisherman, flood control and water supply challenges for water managers, and are among the principal species targeted by eradication efforts by the USACE (D. Kinard, pers. comm.).

J.3.2 Fish and Wildlife

The area around Lake Okeechobee includes a wide variety of habitat opportunities for wildlife, including wading and migratory birds, many mammals, amphibians, and reptiles, as well as prey species such as crayfish, prawns, apple snails, and aquatic insects. The U.S. Fish and Wildlife Service (USFWS) has designated five species of wildlife as threatened or endangered and likely to occur around Lake Okeechobee. There are also state-listed species present within the lake, including several of the wading bird species that are not on the Federal list. The U.S. Army Corps of Engineers has conducted for the past two years, a wildlife survey within the western littoral zone of the lake, sampling key habitat types for reptiles, amphibians, and all migratory and resident birds. The study results, thus far, are briefly summarized in this section.

The study area is home to a large number of fish species, some of which are valued as commercial and sportfish, and others serving as part of the cornerstone of the littoral zone food web. In the areas being sampled as part of the wildlife utilization study, numerous small fish species, including the Cyprinodontids such as the golden topminnow (*Fundulus chrysotus*), the least killifish (*Heterandria formosa*), and the Florida flagfish (*Jordanella floridae*) have been collected and are known to be important food resources for wading birds, amphibians, and reptiles.

Additionally, Furse and Fox (1994) revealed that numerous sportfish occur in the littoral zone. The largemouth bass (*Micropterus salmoides*) is one of the most popular gamefish in the state of Florida, and is a major predator of small fish, amphibians, birds, and reptiles. Additionally, the black crappie *(Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and redear sunfish (*Lepomis microlophus*) are sportfish found in high numbers in the littoral zone.

Macroinvertebrate diversity in the western littoral zone provides yet another vital component to the food web. Macroivertebrate species incidentally sampled during U.S. Army Corps of Engineers (1997) sampling of the western littoral zone included the apple snail (*Pomacea paludosa*), an important food resource of the everglade snail kite, crayfish (*Procambarus* spp.), grass shrimp (*Paleomonetus paludosus*), and Dytiscid beetles (*Dytiscidae*).

Lake Okeechobee supports a valuable commercial and sport fishery. Trawl samples taken by the GFC from 1987 to 1991 collected twenty-five fish species from the limnetic zone. Threadfin shad (*Dorosoma petenense*) were most abundant, and black crappie, most abundant in terms of biomass. These two species, and Florida gar (*Lepisosteus platyrhincus*), gizzard shad (*Dorosoma cepedianum*), white catfish (*Ameirus catus*), redear sunfish, and bluegill represented 98 percent of the total catch in terms of number and weight in the trawl study (Bull et al. 1995). Channel catfish area also considered commercially important on the lake.

Lake Okeechobee also supports a valuable commercial fishery. Over a five year period (1987-1991) mean annual commercial harvest was 2,008 metric tons (Fox et al. 1992, 1993). Commercially important fish species include white catfish, bluegill, and redear sunfish.

The area of critical concern to the life cycle of most fish and wildlife is the western littoral zone and marsh, thus the description below will focus on this area.

The western littoral zone provides tremendous foraging and nesting habit for a wide range of avifauna. Previous studies (Smith and Collopy, 1995; David, 1994) have documented birds including the endangered wood stork (*Mycteria americana*), the Federally and state endangered snail kite (*Rostrhamus sociabilis*), great blue heron (*Ardea herodias*), white ibis (*Eudocimus albus*), pied-billed grebe (*Podilymbus podiceps*), great egret (*Casmerodius albus*), snowy *egret (Egretta thula*), little blue heron (*E. caerulea*), tricolor heron (*E. tricolor*), and common moorhen (*Gallinula chloropus*) have commonly been observed utilizing the study area.

Other birds that may utilize the littoral zone include the threatened bald eagle (*Haliaeetus leucocephalus*), black skimmer (*Rhyncops niger*), brown pelican (*Pelecanus occidentalis*), double-crested cormorant (*Phalacrocorax auritus*), and anhinga (*Anhinga anhinga*).

According to rangemaps presented in Conant and Collins (1991), herpetofaunal diversity should be quite high in littoral and marsh area. Studied species on Lake Okeechobee include the american alligator *(Alligator mississippiensis*) (L. Hord, pers. comm.) and the Florida soft-shelled turtle (*Apalone ferox*) (P. Moler, pers. comm.). Currently, no published inventories are available on the diversity of herpetofauna inhabiting the western littoral zone of Lake Okeechobee.

During a U.S. Army Corps of Engineers (1998) wildlife survey of the western littoral zone, species such as the greater siren (*Siren lacertina*) have been sampled in high numbers along with the green water snake (*Nerodia floridana*) and the banded water snake (*Nerodia fasciata*). Additional common species included frogs such as the southern leopard frog (*Rana utricularia*), the green tree frog *(Hyla cinerea*), and the squirrel tree frog (*H. squirrela*). The american alligator was the only listed species of reptile recorded in the study area and there are no listed species of amphibians currently known to utilize the study area.

Of additional interest is the possibility of colonization of exotic amphibians and reptiles within Lake Okeechobee. Several reports from local residents have confirmed sightings of non-native species of lizards, such as the green iguana (*Iguana iguana*), the spiny-tailed iguana (*Ctenosaura pectinata*), and the brown basilisk (*Basiliscus vittatus*). Established populations of such species could be extremely harmful to native herpetofaunal populations.

Lake Okeechobee also provides major resources for mammalian species. The Okeechobee Waterway, a designated channel that runs around the perimeter of the lake, as well as across the lake, provides habitat for the endangered West Indian manatee (*Trichechus manatus latirostris*). Additionally, river otters (*Lutra canadensis*), bobcats (*Felis rufus*), and the Florida water rat (*Neofiber alleni*), a species of special concern as listed by the Florida Committee for Rare and Endangered Plants and Animals, have been observed within the Lake.

J.3.3 Threatened and Endangered Species

The USFWS has identified eighteen Federally listed plant and animal species as being present in the C&SF Restudy study area, and likely to be effected by alternative plans. Of these eighteen, five animal species, and one plant species are known to occur or are likely to occur within the area of Lake Okeechobee. These include the wood stork, West Indian manatee, bald eagle, snail kite, and eastern indigo snake. The American alligator, although not identified by the USFWS as a species likely to be effected by Restudy alternatives, is an important keystone species present in the Lake. The Okeechobee Gourd is a Federally listed (endangered) plant species, which is known to occur within the Herbert Hoover Dike, on the souteast side of the Lake.

J.3.4 Water Management

Historically, water levels in Lake Okeechobee were probably much higher than they are today, perhaps as high as 6.1 m (20 feet) NGVD (Brooks 1974). Prior to large scale development, and construction of the Herbert Hoover Dike, the Lake had no channeled outflows, and water overflowed the Lake as sheet flow to the south and east. This resulted in a much larger and broader littoral zone and marsh ecosystem to the north and west than the existing one. Today, as the primary reservoir of the Central and Southern Florida Flood Control Project, Lake Okeechobee is capable of storing 2.7 million acre-feet of water between stages of 3.2 m (10.5 ft) above msl and the top of the regulation schedule at 5.3 m (17.5 ft) above msl.

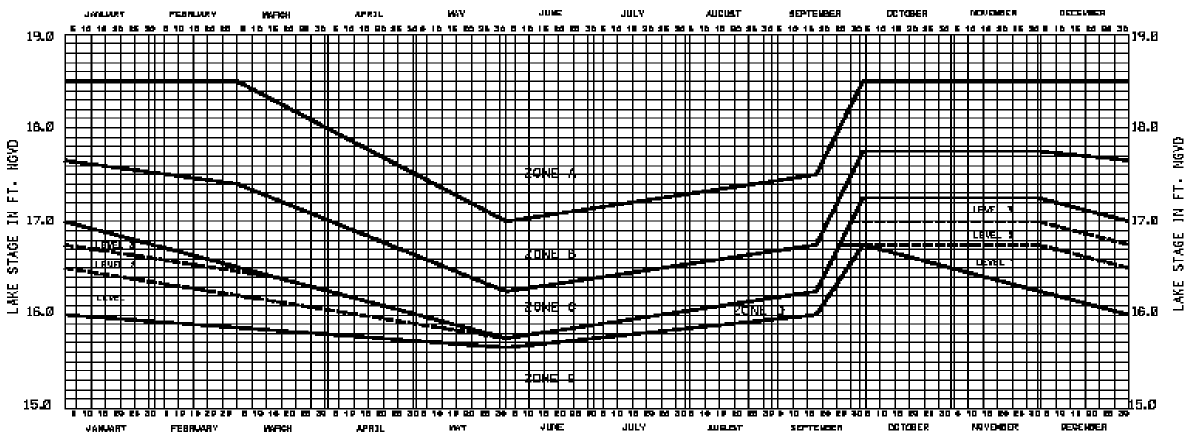
Water levels in the Lake are managed according to a regulation schedule that was developed by the South Florida Water Management District and the U.S. Army Corps of Engineers. The schedule is designed to maintain a low level of 4.7 m (15.5 ft) during the wet season in order to provide storage capacity for excessive amounts of rainfall and to prevent flooding in surrounding areas. The stage at the end of the wet season is regulated at a maximum of 5.3 m (17.5 ft) in order to store water for the dry season. The Caloosahatchee and St. Lucie canals are the primary outlets for release of flood waters when the Lake is above regulation stages.

A series of structures are situated around the Lake, which provide flood protection, control drainage, and facilitate navigation. The U.S. Army Corps of Engineers operates the primary structures and navigation locks around the Lake and is responsible for maintenance of the schedule. The South Florida Water Management District operates and maintains the secondary water control structures and pump stations.

Historically Lake Okeechobee's regulation schedule was developed primarily to meet flood control and water supply objectives, the primary purposes for construction of the C&SF Project. The environmental concerns for the lake's littoral zone and wildlife habitat and the downstream estuaries have generally been compromised in order to meet the water supply needs of south Florida.

Trimble and Marban (1988) performed an analysis of the Lake Okeechobee regulation schedule which incorporated a trade off analysis framework and resulted in the recommendation of an improved schedule known as "Run 25", which is the regulation schedule now in use (***Figure J-3.4-1***). This recommended schedule reduced the water quality impacts associated with regulatory discharges to the St. Lucie and Caloosahatchee estuaries by reducing the need to discharge large volumes of freshwater from the lake, without significantly impacting existing flood control, water supply and environmental benefits provided by the previous (15.5-

Figure J-3.4-1 Run 25-3 Regulation Schedule



RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS (2)	CALOOSAHATCHEE RIVER (2)	ST. LUCIE CANAL
A	PUMP MAXIMUM PRACTICABLE TO WCA'S	UP TO MAXIMUM CAPACITY AT S-77	UP TO MAXIMUM CAPACITY AT S-80
B (1)	MAXIMUM PRACTICABLE TO WCA'S	6500 CFS AT S-77	3500 CFS AT S-80 (3)
C (1)	MAXIMUM PRACTICABLE TO WCA'S	UP TO 4500 CFS AT S-77	UP TO 2500 CFS AT S-80 (3)
D	MAXIMUM PRACTICABLE TO WCA'S	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING (3)
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS.
(2) SUBJECT TO FIRST REMOVAL OF LOCAL RUNOFF.
(3) EXCEPT WHEN EXCEEDED BY LOCAL INFLOW.

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 27 DEC 1994

RUN 25

17.5 feet) schedule approved in 1978. This schedule was approved by the District's Governing Board in December 1991 and approved on a two year interim basis by the U.S. Army Corps of Engineers in May of 1992. Regulatory releases are to occur at lower lake stage and at lower and more environmentally sensitive rates of discharge than the previous schedule. The lower rates of discharge are made in a "pulse" fashion, which simulates a natural rainstorm event within the St. Lucie (C-44) Basin. Each pulse takes 10 days to complete. This method is designed to allow estuarine biota to tolerate changes in salinity and the discharges to remain within the natural range of freshwater flow to the estuary.

J.3.5 Water Quality

Lake Okeechobee may be considered a naturally eutrophic water body that is tending to become hypereutrophic, due primarily from nutrient inputs from the Kissimmee River and the Taylor Creek basins. Water quality conditions in the upper Kissimmee River appear to be improving, primarily due to re-routing of wastewater flows from the river to reuse and ground-water discharge sites.

However, large quantities of nutrients are still discharged from Lake Toho to Lake Kissimmee and other downstream areas. Water quality improves from Lake Kissimmee to near Lake Okeechobee, where the channel flows mostly through unimproved rangeland; however, pollutant loadings increase as cattle and dairies grow more numerous near the lake. Because the lake's phosphorus is internally recycled and a vast reservoir of the nutrient is stored in ground water as well as wetland and canal sediments, phosphorus within the lake may not reach acceptable levels for many decades or even a century.

According to the 1996 305(b) report (FDEP, 1996) for Lake Okeechobee, the major pollution sources for the lake include runoff from ranch and dairy operations in the north where pollution has elevated phosphorus and coliform bacteria concentrations and created a continuous algal bloom. In the south, historic backpumping of runoff from row crops and sugar cane has elevated nutrient and pesticide levels. The backpumping has mostly ceased but still occurs when water in the primary canal of the Everglades Agricultural Area reaches 13 feet (flood-control levels). As a result, depending on location and seasonal rainfall or drought, the lake receives varying amounts of nutrients, substances creating high biological oxygen demand (BOD), bacteria, and toxic materials. Other pollutants include high levels of total dissolved solids, unionized ammonia, chloride, color, and dissolved organic chemicals.

Biological sampling indicated variable but generally eutrophic conditions. In recent years, several widespread algal blooms (one covering about 100 square miles) and at least one major fish kill -- all of which were widely publicized -- launched the environmental community and governmental agencies into intense investigation and analysis of the lake's problems. The Lake Okeechobee Technical Advisory Committee, formed to assess the situation and recommend solutions, determined that phosphorus from dairies and agriculture was a major cause of the noxious algal blooms and that levels should be reduced by 40 percent. A few others contended that the secondary cause of increased phosphorus is the flooding of hundreds of acres of perimeter wetlands after the SFWMD decided in the late 1970's to raise the lake's water level. The higher level also reduced valuable fish-spawning grounds and waterfowl feeding and nesting habitat.

In general, the water quality trends for the lake are stable at six sites, improved at two sites, and degraded at two sites. The best water quality observations were noted for the flow entering Fisheating Creek and along the west near wetlands, while the worst water quality conditions occurred in the south by agricultural areas, and to the northeast by Taylor Creek, Nubbin Slough and the St. Lucie Canal. The reported major pollution sources in this basin were dairies and agriculture. A generalized assessment of the lake shows the lake as having fair water quality conditions, except for Myrtle Slough which was shown to have poor water quality, and the extreme south-southwest section of the lake where good water quality conditions are described by the 305(b) report (FDEP, 1996).

J.3.6 Water Supply

Lake Okeechobee functions as a multipurpose regional reservoir. The once natural fluctuations of the lake have been altered under the C&SF Flood Control Project to serve several objectives. These include: (1) flood control, (2) agricultural water use, (3) urban and industrial water supply, (4) protection of wetland and estuarine systems, and enhancement of fish and wildlife resources, (5) prevention of saltwater intrusion, (6) navigation, (7) recreation, (8) wellfield recharge and, (9) water supply for Everglades National Park. Lake Okeechobee stores vast quantities of water during the wet season for later use by agricultural and urban users. Storage is also required to provide adequate water during the dry season to meet service area demands for agricultural irrigation and regional demands for supplemental water deliveries to the water conservation areas, urban areas of Florida's southeast coast, and Everglades National Park. Other entities, such as the Seminole Tribe of Florida and Miccosukee Tribe of Indians of Florida, also rely upon water from Lake Okeechobee.

Water storage capacity is limited by the height of the Herbert Hoover Dike, which surrounds the lake and protects local communities from flooding caused by hurricane force winds. Water levels in Lake Okeechobee are closely monitored to protect the structural integrity of the dike, and ensure that sufficient storage capacity is available to prevent local flooding of cities and farms. A further constraint on the Lake Okeechobee storage capacity is the need to protect littoral zone habitat. Extended high lake stages have been found to be harmful to the littoral zone ecosystem (Milleson, 1987), while large regulatory releases of fresh water are harmful to estuarine biota (Haunert and Startzman, 1985). Major projects currently underway, such as Everglades Restoration, are also expected to have a significant impact on water supply planning from Lake Okeechobee. Because the eight functional objectives of the lake are often competing with each other, it has not always been possible to manage Lake Okeechobee to satisfy all demands.

J.3.7 Socio-Economics

The following discussion of socio-economic existing conditions focuses on the principal social and economic forces of the Lake Okeechobee region. They include: commercial navigation via the Okeechobee Waterway, agriculture in the area immediately surrounding the Lake, urban municipalities, recreation and sport fishing, and commercial fishing.

J.3.7.1 Commercial Navigation

The Lake Okeechobee Waterway connects Stuart on the Atlantic Ocean with Ft. Meyers on the Gulf of Mexico. It includes 154 miles of navigation channel and five lock and dam structures. The Port Mayaca and Moore Haven locks connect the lake to the St. Lucie canal and Caloosahatchee River respectively. Commercial navigation on this waterway has been stable over the past 10 years, with substantial year to year variation (USACE 1998). The Lake Okeechobee Waterway was used to transport 430,000 tons of freight in 1995. Petroleum products were the predominant commodities transported (USACE 1998). There are no commercial shipping lines that regularly pass through the waterway, rather traffic consists primarily of special barge traffic which takes advantage of the shortcut across the Florida peninsula, saving about 3-5 days of travel.

J.3.7.2 Agriculture

The immediate area surrounding Lake Okeechobee is largely rural, with agriculture being critical to the local and regional economy. There are estimated to be over 700,000 irrigated acres of farm land in the Lake Okeechobee Service Area (LOSA), which includes the Everglades Agriculture Area. The Everglades Agricultural Area alone, accounted for over $750 million in agricultural production, and provided employment for over 20,000 full time workers in 1989 (Snyder and Davidson, 1994). Agricultural production consists predominantly of sugarcane, as well as rice, row crops, and sod. There is also extensive improved and unimproved pastureland, particularly west and north of the Lake. The St. Lucie and Caloosahatchee basins, which also receive irrigation water from the Lake, also cultivate an estimated 138,000 and 49,000 acres, respectively of citrus crops, sugarcane, vegetables, sod, and ornamentals (USACE 1998). During prolonged droughts, significant volumes of water are also required by the agricultural community in the Lower East Coast (Lower East Coast). Row crops such as truck vegetables, are the predominant crop type in the Lower East Coast.

J.3.7.3 Urban

The urban landscape surrounding Lake Okeechobee includes the incorporated municipalities of Belle Glade, Clewiston, Moore Haven, Okeechobee City, Pahokee, and South Bay. These communities range in population from approximately 1,439 (Moorehaven) to 16,656 (Belle Glade). Residential and commercial water users depend on lake water supply for wellfield recharge, drinking water, and industrial processes.

J.3.7.4 Recreation and Sport Fishing

Lake Okeechobee is the largest recreational resource in the region. The lake provides a wide variety of water based recreation including fishing, boating, picnicking, sightseeing, camping, swimming, hunting, airboating, and hiking. The littoral zone, along the Lake's western shore, provides valuable habitat for the Lake's popular sport fishery. Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. A variety and abundance of sport fish, including largemouth bass black crappie, bluegill, and redear sunfish are targeted by sportfisherman from around the country. Consequently, sport fishing is a major activity on the Lake. There are also several major sportfishing tournaments held on Lake Okeechobee annually, which bring significant revenues to the marinas, fishing guides, hotels, and support industries along the Lake. It should be noted that the Lake supports several commercial finfishing endeavors, including fisheries for bullhead catfish, gizzard shad, striped mullet (*Mugil cephalus*), and gar (*Lepisosteus* spp.).

Heavy seasonal waterfowl utilization of the Lake attracts tourists and recreational enthusiasts, such as hunters. Common waterfowl species include ring-necked duck (*Aythya collaris*), American wigeon (*Anas americana*), Northern pintail (*Anas acuta*), green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), lesser scaup (*Aythya affinis*), and Florida duck (*Anas fulvigula*).

The Lake has also been a historic tourist destination for purely aesthetic reasons. Airboat rides are popular tourist activities on the Lake. In 1996 recreation levels at Lake Okeechobee were estimated at over 64,000 visitor-hours, with an annual value of over $78,000,000 (USACE 1998).

J.3.7.5 Commercial Fishing

The commercial fishing industry in Lake Okeechobee utilizes primarily haul seines to catch bluegill, redear sunfish, and catfish. Catfish are also caught by trot lines, and wire traps. Bullhead, shad, gar, mullet, and tilapia are also caught, although since the net ban, mullet are no longer considered a commercial species. There are also reports of commercial turtle trapping on the Lake, mostly in the canals (GFC pers. comm.). The annual wholesale value of the commercial fishery was estimated in 1998 (USACE) to be approximately $2,326,932, employing about 210 fisherman and landside workers.

There are also commercial fisheries on the Lake, which harvest the American alligator and the Florida soft-shell turtle (Diemer and Moler, 1995). Alligators are harvested from the Lake population to supplement the stock in alligator farming operations. Soft-shell turtles are harvested by commercial fishermen, with some individual yields in excess of 13,640 kilograms (30,000 pounds) annually. The majority of the harvest is prepared for shipment to Japan, or sold locally, primarily to the Miccosukee tribe.

J.3.8 Land Use

The following section will address the general land use within the immediate area of the Lake. The area is rural in character, with most lands dedicated to agriculture, very generally sugar cane is the predominant crop in the south, row crops and sugar cane in the east and pastureland with dairy production in the north. Urban areas, which are generally few and modest in population, service the agriculture sector, as well as the tourists who come to the Lake to fish, hunt, and enjoy other recreational pursuits.

J.3.8.1 Urban

A significant use of land outside the agricultural context is for urban development. Six incorporated communities are situated around the Lake and range in population from approximately 1,400 to 16,000 (***Table J-3.8.1-1***).

Table J-3.8.1-1
1996 Population Estimates For Communities Surrounding Lake Okeechobee (Usbc, 1997)

Community	Population	County
Belle Glade	16,656	Palm Beach
Clewiston	6,645	Hendry
Moore Haven	1,439	Glades
Okeechobee City	4,831	Okeechobee
Pahokee	6,993	Palm Beach

The Brighton Seminole Indian Reservation occupies a large area of land west of the Lake in Glades County. The southern end of this reservation is near the Herbert Hoover Dike just north of Lakeport.

Major transportation corridors around the perimeter of Lake Okeechobee include several highways and railroads. County Road 78 parallels the Lake along its western and northern shores from Moore Haven to Okeechobee. From Okeechobee, State Highway 98/441 follows the northern and eastern portion of the Lake to Pahokee. County Road 715 then follows the Herbert Hoover Dike from Pahokee to Belle Glade, where State Highway 27 follows the southern Lake area back to Moore Haven and County Road 78. In many cases, these highways are within 1.6 km (1 mile) of the Herbert Hoover Dike, and are often within 15 m (50 ft).

Railroad corridors in the Lake Okeechobee area include the Florida East Coast Railway and the South Central Florida Railroad. The East Coast Railway is located along the eastern part of the Lake where it comes very near to the Herbert Hoover Dike. The South Central travels along the southern end of the Lake, where it comes within 1.6 km (1 mile) of the Herbert Hoover Dike.

J.3.8.2 Agriculture

The primary land use in the Lake Okeechobee region is agricultural. Sugar cane plantations, cattle ranching, ornamental nurseries, vegetable production, and citrus make up the majority of agricultural land use in this area. Farmland within the counties that surround Lake Okeechobee (Glades, Hendry, Martin, Okeechobee, and Palm Beach), occupies from 50 to 76 percent of the total land area.

Other common land use types in the Lake Okeechobee region are frequently associated with agriculture. Sugar cane refineries, produce packaging and shipping plants, and other support activities constitute a significant use land along with direct agriculture (Purdum, 1994).

Lake Okeechobee has traditionally been a key source of water supply for irrigated crops around the lake including the Everglades Agricultural Area, the Caloosahatchee River Basin, and Martin and St. Lucie Counties (Upper East Coast). Continued access to this source of water is considered vital to sustaining agriculture in the surrounding regions.

J.3.9 Recreation Resources

Recreation resources in the Lake Okeechobee region are primarily water based within Lake Okeechobee and include boating, fishing, and nature interpretation. Lake Okeechobee provides approximately 40 miles of navigable waterway for commercial navigation and many more for recreational boating. Twenty-five U.S. Army Corps of Engineers built land and water-based recreational facilities are located along the lake. The Florida National Scenic Trail encompasses Lake Okeechobee atop the Herbert Hoover Dike (approximately 140 miles long). Approximately 94 percent of the recreation lands available to the public in this region are state or Federal (SCORP, 1994). Bike riding, hiking, picnicking, camping, and nature interpretation are popular land based recreation activities in the region. Substantially altered water deliveries to this region could result in flooding and have a detrimental affect on many natural and recreation resources in the area. The ample water based recreation resources in the Lake Okeechobee region receive extensive use and future demand is anticipated to increase.

J.3.10 Aesthetic Resources

The Lake Okeechobee region is characterized by two types of scenery: open lake views, characterized by a vast expanse of water with a vanishing horizon, and littoral zone viewsheds, characterized by various types of marshes, serving as a backdrop for wildlife. Hardwood swamps are found landward of the HHD, primarily on the west side of the lake. Significant exotic and invasive vegetation species (melaleuca, Australian pine, torpedograss, cattail) are intruding into stands of native species that tends to diminish biological diversity and existing aesthetics in those areas. In the Indian Prairie region of the lake, expansion of torpedograss and cattail particularly have affected aesthetic qualities of the lake.

Some remnants of the historical willow swamp vegetation still can be found (Lodge, 1994). The Herbert Hoover Dike sideslopes are generally well grassed but contain some exotic and or dead vegetation that degrades the distant uniform appearance. However, the dike affords a panoramic view of the lake from its crest, which can be magnificent during a sunset or sunrise. Shoreline trees generally enhance the rim canal aesthetics when viewed from a distance.

Melaleuca control programs have left hundreds of acres of dead melaleuca forest standing, which effects the overall aesthetic north of the Old Moorehaven Canal. Also, vast expanses of torpedograss, in the Indian Prairie region, and in significant areas south of Fisheating Creek where it enters the Lake, have had a detrimental effect on the areas aesthetic appeal. Substantially altered water levels to this region could have a detrimental affect on many aspects of the region’s littoral aesthetic resources. Substantially altered water levels could have a detrimental effect on many aspects of the region's viewable resources. Development is a nominal aesthetic impact to this region’s aesthetics at the present.

J.4 UPPER EAST COAST AND INDIAN RIVER LAGOON

The Upper East Coast (Upper East Coast) and Indian River Lagoon (IRL) collectively make up this geographic planning unit (***Figure J-4-1***). The Upper East Coast Planning Area covers over 1,100 square miles and has an average elevation of 20 feet. Average seasonal temperatures range from 64^{o}F degrees during the winter to about 81^{o}F degrees during the summer (University of Florida, 1993). Annual average rainfall in the Upper East Coast region is about 51 inches. About 72 percent of the annual rainfall occurs during the May through October wet season.

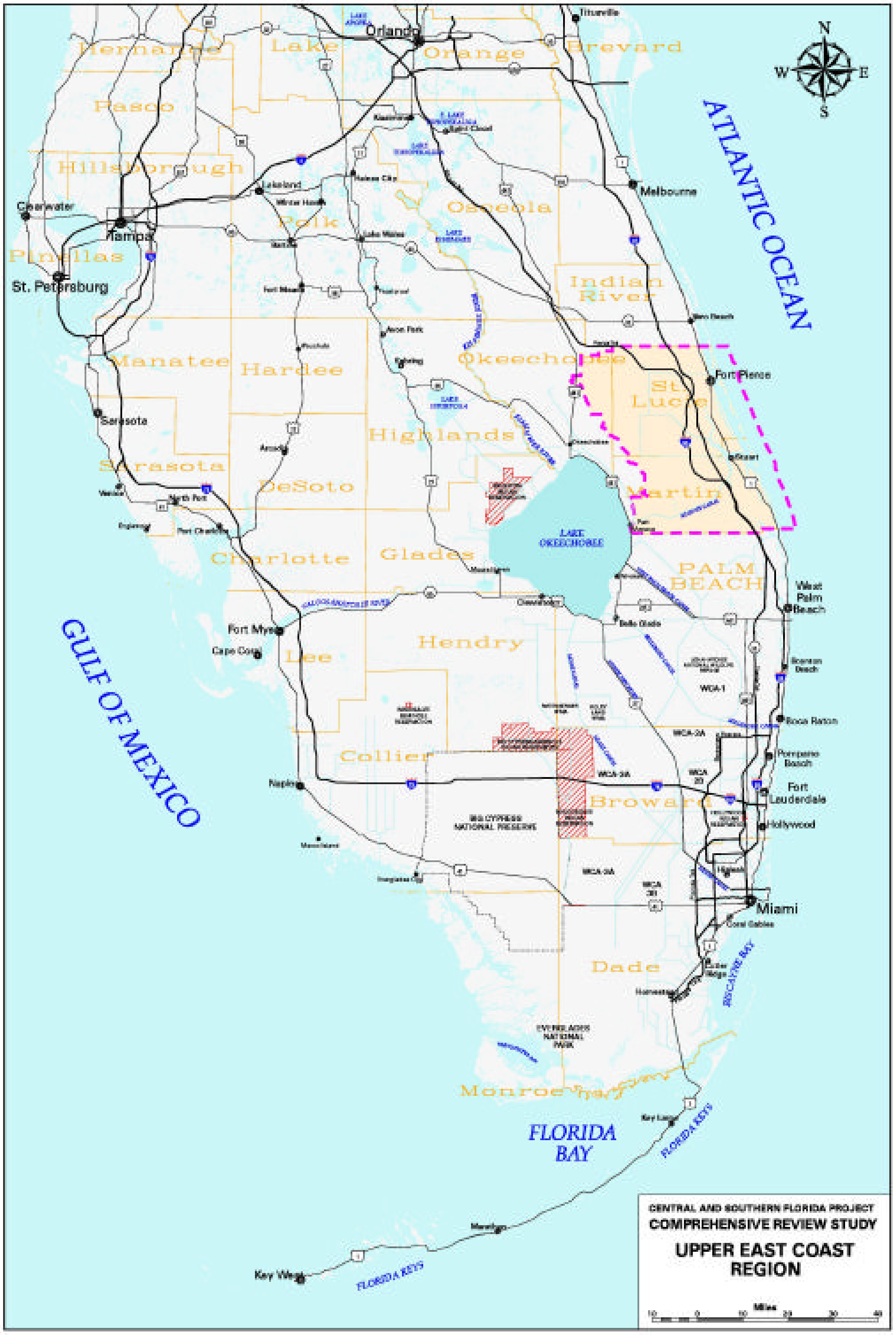


Figure J-4-1 Upper East Coast and Indian River LagoonRegion

The Upper East Coast Planning Area is characterized by three principal physiographic zones, which generally trend from east to west. These zones are identified by White (1970) as: (1) the Atlantic Coastal Ridge, (2) the Eastern Valley, and (3) the Osceola Plain. The Atlantic Coastal Ridge, made of relict beach ridges and sand bars, parallels the coast and has a width ranging from several hundred feet to a couple of miles. The ridge varies in elevation from sea level to a high of 86 feet above sea level in the sandhills of Jonathan Dickinson State Park.

West of the Atlantic Coastal Ridge is the Eastern Valley, which is a flat relict beach ridge plain. Most of the planning area lies within the Eastern Valley. The valley is generally lower than the ridge, with land elevations ranging from 15 to 30 feet above mean sea level, and an average width of 30 miles. These areas are characteristically pocketed with shallow lakes and marshes and have limited natural drainage. Prior to development and construction of canals, the valley drained by a slow drift of water through multiple sloughs to the St. Lucie River, the Loxahatchee River and the Everglades. This area contains the Savannas State Park, Pal-Mar, Loxahatchee Slough, and the Allapattah, St. Lucie and Osceola Flats.

The Osceola Plain lies west of the Eastern Valley in St. Lucie County and intrudes into the Eastern Valley in Martin County, where it terminates at Indiantown. The elevation of the plain in Martin County is approximately 40 feet.

The St. Lucie Estuary (SLE) is located on the southeast coast of Florida, encompassing portions of both Martin and St. Lucie counties within the watershed. The two forks of the St. Lucie Estuary, the North Fork and South Fork, flow together near the Roosevelt Bridge at the City of Stuart, and then flow eastward approximately six miles to the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. Tidal influences in the North Fork reach 15 miles north of Stuart in Five-Mile Creek, and to a water control structure on Ten-Mile Creek just west of the Florida Turnpike at Gordy Road. Tidal influences in the South Fork extend about eight miles south of Stuart to the St. Lucie Lock and Dam on the St. Lucie canal. Tidal influence also extends into the extremes of the nearby Old South Fork tributary (Morris, 1987).

The Estuary is divided into three major areas, the inner estuary, composed of the North and South Forks; the mid-estuary, consisting of the area from the juncture of the North and South Forks to Hell Gate, and the outer estuary extending from Hell Gate to the St. Lucie Inlet. The main body of the North Fork is about four miles long, with a surface area of approximately 4.5 square miles and a total volume of 998.5×10^6 cubic feet at mean sea level. The South Fork is approximately half the size of the North Fork with a surface area of about 1.9 square miles and a volume of 468.7×10^6 cubic feet. The mid-estuary extends approximately five miles from the Roosevelt Bridge to Hell Gate and has an area and volume similar to the North Fork (4.7 mi^2 and 972.7 x 10^6 cubic feet) (Haunert and Startzman, 1985).

Surface sediment composition within the estuary has been mapped by the South Florida Water Management District (Haunert, 1988). Sediment composition within the SLE is influenced by hydrodynamics and is somewhat correlated to depth. Sand substrates, with little organic content, are found along the shallow shorelines of the estuary and in the St. Lucie canal. This reflects the impacts of wave turbulence and rapid currents. Substrates comprised of mud and moderate quantities of sand are present in areas that are more typically low energy environments, but subjected to occasional high energy events. Mud substrates are found in low energy areas such as dredged areas and the deeper portions of the estuary. These mud sediments often contain high concentrations of organic materials.

While the Estuary encompasses about 8 square miles, the watershed covers an area of almost 775 square miles. The watershed is divided into eight basins; five major basins and three minor ones. Three of these major basins, the C-23, C-24, and C-44, represent basins now linked to the estuary by components of the Central and South Florida Flood Control Project. In addition to drainage from within the C-44 basin, the C-44 canal (St. Lucie Canal) also conveys flood control discharges from Lake Okeechobee to the St. Lucie Estuary. The other two major basins, the North Fork, and Tidal Basin, include numerous connections to the St. Lucie estuary.

J.4.1 Vegetation

The major plant communities found in the Upper East Coast are described below. These plant communities or associations of community types are based on those that are being mapped statewide as part of the Florida Game and Freshwater Fish Commission's project to develop a comprehensive statewide habitat system for Florida and the Florida Land Use, Cover and Forms Classification System (FLUCCS) Plant associations found in the region include hardwood hammocks, pine flatwoods, sand pine scrub, dry prairie, cypress swamps, hardwood swamps, mangrove swamps, salt marsh, sloughs, and estuarine SAV communities.

A number of wetland complexes exist in the Upper East Coast. These complexes include: a) isolated creeks, ponds, hammocks, sloughs, and wet prairies within the Allapattah Slough, b) isolated ponds, cypress areas, and wet prairies in cane slough, c) 21,875 acres of wet prairie, cypress domes ponds and remnant everglade marsh in the DuPuis Reserve, d) 37,314 acres of wet prairie ponds interspersed within a pine flatwood community in the Pal-Mar tract, e) St. Lucie County's remaining wetland systems including the Savannas; wetlands associated with Five Mile, Ten Mile, Cow, Cypress, and Van Swearingen creeks; remnant portions of the St. Johns marsh,; and the floodplain of the North Fork of the St.

Lucie River, f) In Okeechobee County the Upper East Coast has tracts of forested and emergent wetlands that dominate the landscape and continue into St. Lucie County.

J.4.1.1 Exotic Species

Exotic plants in the Upper East Coast include: Australian pine (*Casuarina equisetifolia)*, Brazilian pepper (*Schinus terebinthifolius)*, climbing fern (Lygodium microphyllum), melaleuca (*Melaleuca quinquenervia*), lather leaf (*Colubrina asiatica)* and calophyllum (*Calophyllum inophyllum*).

Many of the wetlands in the region have suffered decreases in water levels, changes in water quality, changes in frequency and seasonality of burning, physical damage from vehicles or wild pigs (introduced from Europe by man) or other kinds of disturbance. The most visible sign of stress in these wetlands is vegetation change with increases in the numbers of weedy native species, such as cattail and primrose willow, and exotic species, such as melaleuca and Brazilian pepper. At the same time, many native plants disappear, either directly because of the disturbed environment, or because they are crowded out by weeds.

J.4.2 Fish and Wildlife

The Indian River Lagoon system is a biogeographic transition zone, fed by the St. Lucie Estuary, rich in habitats and species, with the highest species diversity of any estuary in North America (Gilmore, 1977). Approximately 4,315 different plant and animal species have been identified in the lagoon system. Included are 2,965 species of animals, 1,350 species of plants, 700 species of fish and 310 species of birds (IRL Program). Species diversity is generally high near inlets and toward the south, and low near cities, where nutrient input, freshwater input, sedimentation, and turbidity are high and where large areas of mangroves and seagrasses have been lost. For biological communities and fisheries, seagrass and mangrove habitats are extremely important (Virnstein and Campbell, 1987). Much of the habitat loss has occurred as the result of the direct effects of shoreline development, navigational improvements, and marsh management practices.

Seagrass beds support some of the most abundant fish populations in the Lagoon, with large species diversity. Pinfish and several species of mojarra are very abundant in the seagrass habitat. These species are known to feed on seagrasses and on the epiphytes and epifauna of the seagrasses, providing a critical link in the food chain between the primary producers and the higher level consumers such as the common snook and spotted seatrout. Gilmore (1977) describes the fish community of the Indian River Lagoon System. Many seagrass beds are in decline due to various environmental problems, including Johnson's seagrass (*Halophila johnsonii*), recently listed as threatened by the National Oceanic and Atmospheric Administration.

The seagrass habitat is also a critical resource for the Florida manatee. This marine mammal depends on seagrasses for a major part of its food supply (Lain, 1978; Van Meter, 1989; Provancha and Hall, 1992). It has been reported that manatee grazing may result in up to a 68 percent decrease in seagrass biomass (Virnstein, 1987; Provancha and Hall, 1991a), illustrating the importance of seagrasses as manatee forage. Juvenile sea turtles have also been documented as foraging on turtle grass and other seagrasses in the Indian River Lagoon (Mendonca, 1981; Mendonca and Ehrhart, 1982).

The major rivers, creeks, and canals entering the Indian River Lagoon complex from the mainland provide lotic (flowing water) conditions with varying degrees of tidal influence depending upon their size, discharge, and proximity to ocean inlets. Currents in these streams vary from sluggish to moderate. The margins are usually covered with dense vegetation (unless denuded by human activity). Various types of submerged, emergent, and floating aquatic vegetation are usually present, with the species composition varying according to flow, substrate type, and other physical factors. Tributary streams and canals are much more prevalent in the southern portions of the Lagoon system, especially the southern third.

Most of the predominantly freshwater fishes recorded from the Lagoon system, such as minnows (Cyprinidae), bullhead catfishes (Ictaluridae), and sunfishes (Centrarchidae) are found mainly or exclusively in the tributary streams including the streams feeding the St. Lucie. Examples of other species in this habitat include all of the ubiquitous forms mentioned above as well as Florida gar (*Lepisosteus platyrhincus*); gizzard shad (*Dorosoma cepedianum*); flagfish (*Jordanella floridae*); bluefin killifish (*Lucania goodei*); mosquitofish (*Gambusia affinis*); least killifish (*Heterandria formosa*); sailfin molly (*Poecilia latipinna*); inland silverside (*Menidia beryllina*); gulf pipefish (*Syngnathus scovelli*); leatherjack (*Oligoplites saurus*); gray snapper (*Lutjanus griseus*); Irish pompano (*Diapterus auratus*); silver jenny (*Eucinostomus gula*); fat sleeper (*Dormitator maculatus*); bigmouth sleeper (*Gobiomorus dormitor*); and lined sole (*Achirus lineatus*). Fish species that specialize in creek-mouth habitats include yellowfin menhaden (*Brevoortia smithi*); gafftopsail catfish (*Bagre marinus*); timucu, a needlefish (*Strongylura timucu*); gulf killifish (*Fundulus grandis*); striped killifish (*F. majalis*); mosquitofish; sailfin molly; lined seahorse (*Hippocampus erectus*); chain pipefish (*Syngnathus louisianae*); gulf pipefish; tarpon snook (*Centropomus pectinatus*); Atlantic bumper (*Chloroscombrus chrysurus*); leatherjack; lookdown (*Selene vomer*); gray snapper; Irish pompano; silver jenny; great barracuda (*Sphyraena barracuda*); fat sleeper; emerald sleeper (*Erotelis smaragdus*); frillfin goby (*Bathygobius soporator*); darter goby (*Gobionellus boleosoma*); naked goby (*Gobiosoma bosc*); clown goby (*Microgobius gulosus*); bay whiff, a flatfish (*Citharichthys spilopterus*); gulf flounder (*Paralichthys albigutta*); lined sole;

planehead filefish (*Monacanthus hispidus*); striped burrfish (*Chilomycterus schoepfi*); southern puffer (*Sphoeroides nephelus*); bandtail puffer (*S. spengleri*); and checkered puffer (*S. testudineus*).

Besides marine faunal communities, the Upper East Coast contains a number of terrestrial habitats including hardwood hammocks, pine flatwoods, sand pine scrub, dry prairie, cypress swamps, hardwood swamps, marshes, and sloughs. Cypress swamps, hardwood swamps and slough communities are forests in a marsh or wet prairie matrix, and as such are surrounded by emergent vegetation of low stature and longer hydroperiod. These habitats can be used as roosting or nesting sites contiguous to surrounding marshes used for foraging. Common breeding birds utilizing this habitat include the anhinga (*Anhinga anhinga*), the green-backed heron (*Butorides striatus*), the black-crowned night heron (*Nycticorax nycticorax*), and the boat tailed grackle (*Quiscalus major*) (SFWMD, 1992). Other common vertebrates include raccoons (*Procyon lotor*), opossums (*Didelphis marsupialis*), the river otter (*Lutra canadensis*), white tailed deer (*Odocoileus virginianus*), water snakes (*Nerodia* spp), and the green anole (*Anolis carolinensis*) (SFWMD, 1992).

Marshes are longer hydroperiod wetlands that may be made up predominantly of sawgrass or mixed graminoid marshes. General resident organisms utilizing this habitat include the rice rat (*Oryzomys palustris*), cotton mouse (*Peromyscus gossypinus*), hispid cotton rat (*Sigmadon hispidus*), marsh rabbit (*Sylvilagus palustris*), king rail (*Rallus elegans*), red-winged blackbird (*Agelaius phoeniceus*), American bittern (*Botaurus lentiginosus*), long billed marsh wren (*Cistothorus palustris*), yellowthroat (*Geothlypis trichas*), squirrel tree frog (*Hyla squirella*), and the green anole. These areas have more open water components and are extremely important to wading birds and some mammals. Although sawgrass marshes are generally poorer habitat some animals utilize them seasonally. Animals utilizing sawgrass marshes include the American bittern *(Botaurus lentiginosa*), the long-billed marsh wren (*Cistothorus palustris*), the limpkin (*Aramus guarauna*), and the American alligator (*Alligator mississippiensis*).

Marsh habitats other than sawgrass marshes are utilized by a variety of water birds and wading birds. These birds include the wood stork (*Mycteria americana*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), white ibis (*Eudocimus albus*), glossy ibis (*Plegadis falcinellus*), great blue heron (*Ardea herodias*), green-backed heron (*Butorides striatus*), tri-colored heron (*Hydranassas tricolor*), black-crowned night heron (*Nycticorax nycticorax*), least bittern (*Ixobrychus exilis*) and American bittern. Other animals important in these marshes include the snail kite (*Rostrhamus sociabilis*), the pig frog (*Rana grylio*), cricket frog (*Acris grylio*), water snakes, peninsular newt (*Notophthalmus viridescens*), and several sirens.

Pine Flatwood and sand pine scrub are upland areas containing a number of vertebrates including the pine woods tree frog (*Hyla femoralis*), oak toad (*Bufo quercicus*), southern leopard frog (*Rana sphenocephala*), box turtle (*Terrapene carolina*), pine woods snake (*Rhadinea flavilata*), eastern diamondback rattlesnake (*Crotalus adamanteus*), black racer (*Coluber constrictor*), bobcat (*Lynx rufus*), grey fox (*Urocyon cineroargenteus*), striped skunk (*Mephitis mephitis*), raccoon, cotton mouse, hispid cotton rat (*Sigmadon hispidus*), marsh rabbit, white tailed deer, red shouldered hawk (*Buteo lineatus*), great blue heron, barred owl (*Strix varia*), blue grey gnat catcher (*Polioptila caerulea*). None of the mammals are found exclusively in this region, but the fox squirrel (*Sciurus niger*) is often found in flatwoods with open understory.

Dry prairies are the main habitat for the crested caracara (*Polyborus plancus*), burrowing owl (*Athene cunicularia*), and the Florida Sandhill crane (*Grus canadensis*). Additional species of interest include the box turtle, black racer, turkey vulture (*Cathartes aura*), black vulture (*Coragyps atratus*), common nighthawk (*Chordeiles minor*), least shrew, cotton rat, eastern harvest mouse (*Reithrodon tomys humulis*), and eastern spotted skunk (*Spilogale putorius*).

Ponds and creeks have the longest hydroperiod of the freshwater habitats available. They are generally wet in all but the driest of drought years. General resident organisms utilizing this area include the round tailed muskrat (*Neofiber alleni*), rice rat (*Oryzomys palustris*), otter, wading birds, black crowned night heron (*Nycticorax nycticorax*), anhinga, turkey vulture, purple gallinule (*Porphyrula martinica*), boat tailed grackle (*Quiscalus major*), American alligator, water snakes (*Nerodia spp*), Florida softshelled turtle (*Trionyx ferox*), two toed amphiuma (*Amphiuma means*), pig frog, southern leopard frog (*Rana sphenocephala*), and peninsula newt. Large salamanders, turtles, and snakes inhabit these aquatic systems. Water levels of these areas affect their usage by birds. Wading birds use sloughs depending upon the time in the water year. During periods of high water, birds such as the common moorhen (*Gallinula chloropus*), the pied-billed grebe (*Podilymbus podiceps*), anhinga and the limpkin utilize this habitat. Common mammals in this habitat include the river otter and the round tailed muskrat while many others may use the edges during dry conditions.

J.4.3 Water Management

Agricultural drainage and residential development have extensively modified the watershed of the entire St. Lucie Estuary. One major effect of these man-made alterations in the landscape and water management practices is increased drainage, manifested by a lowered groundwater table and dramatic changes in how stormwater runoff is introduced to the estuary. Typically, when a watershed is highly drained like the St. Lucie Estuary watershed, all three runoff factors (quality, quantity and timing) are negatively affected. From a yearly cycle perspective, the quantity of water drained to the Estuary is increased, the water quality is degraded and the seasonal distribution of runoff is altered such that dry season flows are of less magnitude and frequency and wet season flows are of greater magnitude and more frequent. The vast majority of runoff occurs within the first three days after a rainfall event rather than over an extended period of time. Water quality is degraded, especially by increased amounts of nutrients and suspended solids. The increased nutrients in the St. Lucie Estuary have increased primary productivity within the system to the point where unhealthy levels of dissolved oxygen occur on a regular basis in the inner estuary. The dramatic increase in sediment load has contributed significantly to the build-up of muck throughout the system. The sandy sediment loads like those that build up in the Palm City area are from primarily high discharge events. However, it is the increased organics coming from high levels of Chlorophyll a and floating aquatics introduced from the canals combining with high organic fine suspended sediments that flocculate out at the fresh-salt interface that lead to the formation of muck. As a result, the benthic environment of the estuary is a favorable habitat for mostly pollution tolerant organisms. In addition, the rapid introduction of freshwater causes salinity fluctuations that are not conducive to developing or maintaining a healthy estuarine plant and animal community. The overall result of these changes is the loss of important habitats.

The St. Lucie estuary has received increased inflows over the last 100 years because of these modifications to the watershed. Extreme salinity fluctuations and ever-increasing inflows have contributed to major changes in the structure of the communities within the estuary such as seagrass and oyster losses. Phillips (1961) described the marine plants in the St. Lucie Estuary. At the time, mangroves were abundant in the North and South Forks and seagrasses, although stressed, were still found in many areas of the estuary. Today, the presence of seagrasses is severely limited and ephemeral. Oyster populations in the Estuary are virtually nonexistent due to the continual exposure to low salinities and lack of suitable substrate (clean hard objects) for larval recolonization (Haunert and Startzman, 1980, 1985).

Regulatory discharges from the C-44 canal have been documented to adversely impact the St. Lucie Estuary by depressing the salinity range far below the normal range, and by transporting large quantities of suspended materials into the estuary. Sedimentation problems in relation to C-44 discharges were recognized as early as the 1950's (Gunter and Hall,1963). While current monthly average flows from the watershed to the SLE seldom exceed 2500 cfs, regulatory releases from the C-44 alone have produced flows in excess of 7000 cfs. The quantity of suspended solid material passing structure S-80 has reached a peak of 8000 tons a day when daily discharges reached near 7000 cfs in 1983. Much of this material passes through the estuary and into the Indian River Lagoon or Atlantic

Ocean (Haunert, 1988). It was recognized then that these discharges transported sand as well as very fine, organic rich suspended material to the estuary.

J.4.3.1 Surface Water Resources

Prior to development, most of the Upper East Coast Planning Area was characterized by nearly level, poorly drained lands subject to frequent flooding. The natural surface drainage systems included large expanses of sloughs and marshes such as St. Johns Marsh, Allapattah Slough (also referred to as Allapattah Flats), and Cane Slough. Drainage systems with higher conveyance included the North and South Forks of the St. Lucie River, Ten Mile Creek, Five Mile Creek, the Loxahatchee River and Bessey Creek. Minor creeks include Danforth, Fraiser, Hidden River, Willoughby, Krueger, Mapps, and Warner. Most of these surface water systems, especially those with poor drainage, have been altered to make the land suitable for development and to provide flood control.

Since the early 1900s, numerous water control facilities have been constructed to make this region suitable for agricultural, industrial, and residential use. The St. Lucie Canal (C-44) was constructed between 1916 and 1924 to provide an improved outlet for Lake Okeechobee floodwaters. From 1918 to 1919, the Fort Pierce Farms Drainage District (FPFDD) and the North St. Lucie River Drainage District (NSLRDD) were formed to provide flood control and drainage for citrus production in east-central and northeastern St. Lucie County. The C-25 Canal (also known as Belcher Canal) provided a drainage outlet for the FPFDD, as well as limited flood protection for western areas of the basin. The C-24 Canal (also known as the Diversion Canal) provided drainage and limited flood protection west of the NSLRDD protection levee. The C-23 Canal provided water control in Allapattah Flats during the dry season. However, large areas continued to be under water for months at a time during the wet season.

Although the primary function of the C&SF Project was for flood control and drainage, the drainage network formed by the Project canals and the secondary canals and ditches has become an important source of irrigation water and frost protection for agriculture. In general, water stored in the canals is replenished by rainfall, ground water inflow, and withdrawals from the FAS when needed.

Prior to the large-scale expansion of citrus in the 1960s, storage in the drainage network in St. Lucie County was adequate to meet irrigation demands. However, the drainage and development of the large marsh areas in western St. Lucie County have depleted much of the surface water storage. The lowering of water tables also reduced the amount of water in ground water storage. The reduction of surface and ground water storage coupled with increased acreages of citrus have resulted in inadequate supplies of surface water to meet demands during droughts. Therefore, an equitable distribution of the available surface water in the C-23, C-24 and C-25 basins is maintained by limiting the invert elevation of irrigation culverts and the intake elevation of pumps to a minimum of 14.0 feet NGVD. Artesian well water from the FAS is used as an irrigation supplement when surface water supplies become limited. Due to the high mineral content of the Floridan Aquifer, this water is generally blended with surface water before it is used as irrigation water.

J.4.3.2 Surface Water Inflow and Outflow

Within the Upper East Coast Planning Area basins, essentially all surface water inflows and outflows are derived from rainfall. The exception to this is the St. Lucie Canal (C-44), which also receives water from Lake Okeechobee. In addition, most of the flows and stages in the region's canals are regulated for water use and flood protection. The amount of stored water is of critical importance to both the natural ecosystems and the developed areas in the Upper East Coast Planning Area. Management of surface water storage capacity involves balancing two conflicting conditions. When there is little water in storage, drought conditions may occur during periods of deficient rainfall. Conversely, when storage is at capacity, flooding may occur due to excessive rainfall, especially during the wet season. Management of surface water systems is one of the main factors affecting movement of water through the regional hydrologic cycle.

C-25 Canal

The C-25 canal is the northwestern sub-basin in the south segment of the Indian River Lagoon. A complex system of canals exists in this basin for agricultural drainage. Under natural conditions, however, this basin would not discharge into the Indian River Lagoon. Generally, runoff from the eastern portion of this sub-basin flows east through the S-99 structure on the C-25 canal. Stormwater originating in the western portion of this sub-basin can be discharged into the C-24 canal through S-311.

North St. Lucie Sub-basin

The North St. Lucie sub-basin extends from Ft. Pierce Inlet southward to the St. Lucie Inlet and westward to C-24 canal. There are several drainage areas within this sub-basin. Although this sub-basin naturally discharged into the Indian River Lagoon, agricultural canals have greatly improved drainage. This sub-basin occasionally receives inflow from the C-24 canal.

The North St. Lucie Drainage District drainage area drains primarily into the North St. Lucie River. The North St. Lucie Drainage District is located in the northern portion of this area and drains to the C-25 canal from the north and to the C-24 canal from the west. South and east of the North St. Lucie Drainage District are several urban developments, of which the City of Port St. Lucie is the largest.

The Indian River Lagoon/Ft. Pierce Inlet to St. Lucie Inlet area is bordered by the barrier island to the east and the coastal hills on the west. Very little development has occurred on the barrier islands in this area with the exception of the Florida Power and Light Company's nuclear power plant on Hutchinson Island. The mainland portion of this area is very narrow and has experienced some development.

C-24 Canal Sub-basin

The C-24 canal sub-basin is located west of the North St. Lucie basin and is mostly outside the area that would naturally discharge into the Indian River Lagoon. This sub-basin discharges into the North St. Lucie River through the S-49 structure. Agricultural canals have greatly improved drainage. Besides discharge into the C-24 canal from within the sub-basin, C-24 also receives water from the western portion of the C-25 sub-basin and the western portion of the North St. Lucie Drainage District.

C-23 Canal Sub-basin

The C-23 canal sub-basin is located south of C-24. Under natural conditions much of this area would not have drained into the Indian River Lagoon. Agricultural canals have improved drainage from the area. Discharge from C-23 canal in this sub-basin is controlled by the S-97 structure, which is located just west of Florida's Turnpike.

South St. Lucie River Sub-basin

The South St. Lucie River sub-basin is the natural drainage for the South St. Lucie River and contains several drainage areas. The City of Stuart lies in the northeastern portion of this sub-basin between the South St. Lucie River and the Indian River Lagoon.

Bessey Creek is a natural creek that is located south of the C-23 canal. The S-96 structure is a weir within C-23 canal that is located immediately upstream of the confluence of C-23 canal and Bessey Creek. The eastern portion of Bessey Creek drainage area contains scattered pockets of residential development, while the western portion is mostly agricultural. Although drainage improvements have occurred, these have been less extensive than improvements that have occurred in the northern sub-basins.

The Tidal St. Lucie drainage area is the major natural drainage into the Indian River Lagoon from the South St. Lucie River. The City of Stuart lies in the northeastern portion of this basin. Although some drainage improvements have occurred in this area, there are still many of the natural isolated wetlands in the southern portion. The S-80 structure, which is the control structure for C-44 canal into the St. Lucie River, is located about one mile west of Florida's Turnpike.

The Non-Tidal St. Lucie is a small drainage area that historically would have discharged into C-44 canal just above the S-80 structure. However, drainage from this area has been blocked, causing the area to be isolated from the Indian River Lagoon basin.

The Indian River Lagoon/St. Lucie Inlet to Jupiter Inlet is the southernmost drainage area of the Indian River Lagoo. Many residential developments occur on both the barrier island and the mainland portions of this area. The major developments occur in the north, around the City of Stuart.

St. Lucie Canal

The St. Lucie Canal (C-44) sub-basin contains the C-44 canal which is a part of the major navigational route between the east and west coast of Florida, connecting Lake Okeechobee to the South St. Lucie River. The S-308 structure controls flow from Lake Okeechobee into C-44. This sub-basin has many agricultural developments, mostly pasture, which have improved drainage. However, these agricultural areas are interspersed with areas of natural, poorly drained wetlands.

The C&SF Project canal and control structures in the C-44 Basin have five functions: (1) to provide drainage and flood protection for the C-44 Basin, (2) to accept runoff from the S-153 Basin and discharge this runoff to tidewater, (3) to discharge water from Lake Okeechobee to tidewater when the lake is over schedule, (4) to supply water to the C-44 Basin during periods of low natural flow and (5) to provide a navigable waterway from Lake Okeechobee to the Intracoastal Waterway. Excess water is discharged to tidewater by way of S-80 and C-44A. Under certain conditions, excess water may backflow to Lake Okeechobee by way of S-308. Regulatory releases from Lake Okeechobee are made to C-44 by way of S-308. Water supply to the basin is made from Lake Okeechobee by way of S-308 and from local rainfall. Both S-80 and S-308 have navigation locks to pass boat traffic.

Lockages are performed on an "on-demand" basis at S-80, except when water shortages have been declared or maintenance and repairs to the structure are taking place. Although there is no water shortage plan for S-80, the U.S. Army Corps of Engineers will curtail lockages at the request of the District. Maintenance and repairs that result in stoppage of lockages are done on an as-needed basis, usually occurring every three to five years (phone conversation January 29, 1993 with Bill Mason, Lockmaster at S-80, USACE, Stuart, FL). Each lockage at S-80 releases over 1.3 million gallons of water. The average number of lockages at S-80 varies monthly. Between 1987 and 1991, there were an average of 15 lockages per day, with maximum and minimum monthly averages ranging between 19 and 11 lockages per day (facsimile received February 1, 1993 from James Vearil, Hydraulic Engineer, USACE, Jacksonville, FL.).

The S-80 structure in the Tidal St. Lucie Basin has three functions: (1) to accept flow from C-44 and to discharge those flows to tidewater in the St. Lucie River, (2) to provide a navigable waterway from the St. Lucie Canal to the Intracoastal Waterway, and (3) to provide drainage for portions of the Tidal St. Lucie Basin.

C-44 and S-80 were designed to pass the Standard Project Flood from the C-44 Basin and the S-153 Basin and to pass regulatory discharges from Lake Okeechobee to tidewater. The S-308 and S-80 control structures are operated to maintain an optimum canal stage of 14.5 feet NGVD within the Tidal St. Lucie Basin.

J.4.3.3 Ground Water Resources

A distinctive feature of south Florida's hydrologic system is the aquifer system and its use for water supply. Two vast aquifer systems, the Surficial Aquifer System (SAS) and the Floridan Aquifer System (FAS), underlie the Upper East Coast Planning Area. Ground water inflows from outside the planning area form an insignificant portion of recharge to the SAS. Rainfall is the main source of recharge, and because of this, long-term utilization of this source must be governed by local and regional recharge rates. The FAS, on the other hand, receives most of its recharge from outside of the Upper East Coast Planning Area. This fact must also be incorporated into long-term planning decisions. Within an individual aquifer, hydraulic properties and water quality may vary both vertically and horizontally. Ground water supply potential varies greatly from one place to another.

J.4.4 Water Supply

Although Lake Okeechobee is potentially a large water source, there are competing users of this water elsewhere within the Lake Okeechobee Service Area and the Lower East Coast and Lower West Coast planning areas. During periods of water shortage in the lake, water supply allocations are determined through procedures described in the Lake Okeechobee Supply-Side Management Plan. The Lake Okeechobee Supply-Side Management Plan is implemented if the projected lake stage falls below 11.0 feet NGVD at the end of the dry season, or below 13.5 feet NGVD at the end of the wet season.

Water demand in Martin County grew significantly in the 1980s, reflecting the increase both in agricultural acreage and population. Both agriculture and population in the Upper East Coast are anticipated to continue growing through the year 2050, causing the increase in water demands shown in ***Table J-4.4-1***.

Table J-4.4-1. UEC M&I Demands (Million Gallons Per Day)	
End Use	2050 Range of Unrestricted to Restricted Demand
Residential	83.6 –70.1
Commercial & Industrial	33.5 – 31
Public & Other	8.7 - 7.9
Total	125.8 – 108.9

Public utilities served 57 percent of the residential demand in 1990, accounting for just over 8 percent of the total water use. This is expected to increase to just 11 percent of water usage by 2010, with the total number of persons utilizing public utilities as their source of water nearly doubling. The urban areas of Martin County have never experienced a declared water shortage, unlike other areas of the South Florida Water Management District.

J.4.5 Socio-Economics

The commercial fisheries harvesting sector based in the Indian River Lagoon has contributed a substantial portion of both the value of the Florida east coast (65 percent dockside value) and statewide fisheries catch (21.7 percent dockside value) over the past several years (National Marine Fisheries Service, 1985). Seafood processing, the wholesale and retail sector of the commercial fisheries industry, is another current use of the lagoon. The sector generates added value to the dockside value through processing and handling, wholesale and retail sales, and expenditures for supplies and equipment. The total primary economic impact was estimated at $73 million in 1983 for seafood processing and wholesaling (Yingling, 1987).

The recreational fishing industry and the marine service sector are also major users of the lagoon. These industries include such associated user services as boat sales, rentals, engine and hull repair, launch facilities, dockage, commercial and recreational fishing bait, tackle and supplies, charter and head boats, yacht clubs, marine resort areas, and other facilities and services. The economic impact of these activities is significant. For example, in 1984, recreational saltwater fishing was estimated to account for over $46 million in expenditures in the Indian River Lagoon region (Yingling, 1987).

One of Florida's deepwater ports is located in the Upper East Coast. In terms of combined import and export values, Ft. Pierce ranked tenth, among Florida's twelve major ports in 1984. The Port of Fort Pierce exports one-third of the citrus from Florida.

J.4.6 Land Use

The record of human existence in the Upper East Coast region spans approximately 8,000 years. The lagoon system provided the Indians and early settlers with food, materials for tools and their major means of transportation. In the late 1800s, the Indian River Lagoon region was already established as a major area of commerce (tourism, fisheries, shipping and agriculture). The lagoon was used for safe harbor and transportation of cargo, especially citrus.

At present, The dominant land use in the basin is agriculture (covering approximately 45 percent of the basin). Agricultural activities include 228,000 acres of citrus, 211,000 acres in range and citrus, and 9,500 acres of vegetable crops (SCS, 1994). The present urban land use (17 percent of the basin) is concentrated along the coast and the lagoon shorelines. Urban growth is rapidly extending westward, replacing agricultural land. Future land use patterns indicate that this trend will continue as urbanization intensifies along the coast, especially in the southern counties (Swain and Bolohassen, 1987). Present forested uplands and wetlands comprise 11 and 18.8 percent of the basin, respectively.

J.4.6.1 Agriculture

Martin and St. Lucie Counties are included in this region. Almost one half million acres are farmed (UFBEBR, 1995). Of this total approximately 200,000 acres are irrigated requiring a dependable water supply. Lake Okeechobee has traditionally been the water source for this region. St. Lucie and Martin Counties rank first and eighth, respectively, among Florida counties for number of acres of citrus (FASS, 1996b). Although this area is known primarily for its citrus production, as many acres are used for pastureland. Farms average 600 acres in size with moderate productivity per acre. More than 7,500 people are employed in agricultural production and services with a payroll of approximately $9.5 million. The market value of all agricultural products in this region totals approximately $362 million (UFBEBR, 1995).

J.4.7 Recreation Resources

Recreation resources in the Upper East Coast region are diverse, consist of variable quality, and include coastal, inland water and land based resources. The St. Lucie Canal provides approximately 34 miles of navigable waterway with four U.S. Army Corps of Engineers/County recreation facilities that include boating, fishing, camping and day-use facilities (USACE, 1991). An eight mile canoe trail winds through cypress strand lush with ferns and orchids in Jonathan Dickenson State Park (Marth, 1997). The approximately 44 miles of Intracoastal Waterway provides many coastal recreational navigation opportunities. Several other river bodies offer recreational opportunities including the north section of the Loxahatchee River in Martin County which is designated a National “Wild and Scenic River” (SCORP, 1994).

Public beaches in the Upper East Coast region are the most popular form of recreation in the region. Four State of Florida Aquatic Preserves, and four State Parks and Recreation Areas are within the Upper East Coast region. Five artificial coastal reefs locations are in the Upper East Coast region as diving and fishing are very popular. The region also includes high quality recreation opportunities within the DuPuis Reserve State Forest and the St. Lucie Inlet Preserve. Overall, existing recreation resources in the Upper East Coast region receive heavy annual usage that is expected to increase in the future.

J.4.8 Aesthetic Resources

The Upper East Coast regional aesthetic overview is comprised of many components throughout its varied landscape. Waterways, canals, and roadways epitomize corridors where aesthetics are more specifically outlined, smaller in scale, and are bounded by walls of vegetation or bank sideslopes. Corridor widths, textures, colors, and wildlife are notable aspects of the region’s aesthetics. Some remnants of the historic cypress tree strands can still be found in the region (Lodge, 1994). Open pastoral settings are found where farming or grazing activities occur. Much of the interior region is ditched for farming or range practices that have altered the natural vegetation and aesthetic resources of those areas. Many of the regional rural areas possess good scenic quality on a small scale.

The coastal segments of the region possess more urban development than the interior and a completely different aesthetic quality and character. The sand shorelines of the Intracoastal Waterway and Atlantic Ocean provide a striking contrast with the tropical colored waters of those resources. Many locations offer panoramic vistas that are spectacular in some instances. Coastal underwater aesthetics are quality resources of the region. The few state parks within the region are found in the coastal section and provide pocket oasis of high quality aesthetics. Occasional air traffic is the one overriding aesthetic impediment that cannot be escaped. Future urban development could continue to pose a threat to the region’s aesthetic resources. Future water delivery schedules could adversely affect aesthetics of the region.

J.5 EVERGLADES AGRICULTURAL AREA

The historic Everglades contains the largest known contiguous body of organic soils in the world (Jones, 1948; Stephens, 1984). The area known as the Everglades Agricultural Area, located south of Lake Okeechobee within eastern Hendry and western Palm Beach counties (***Figure J-5-1***), encompasses an area totaling approximately 718,400 acres (1,122 sq mi.) of highly productive agricultural land comprised of rich organic peat or muck soils. A small portion of Everglades Agricultural Area mucklands is also found in western Martin County. Approximately 77 percent of the Everglades Agricultural Area (553,000 acres) is in agricultural production. The area is considered one of Florida's most important agricultural regions. It extends south from Lake Okeechobee to the northern levee of WCA-3A. Its eastern boundary extends to the L-8 Canal. The L-1, L-2 and L-3 levees represent its westernmost limits.

J.5.1 Vegetation

The Everglades Agricultural Area, covering 1,122 square miles south of Lake Okeechobee is the largest contiguous area of historic Everglades cover that has been converted by land use practices. The Everglades Agricultural Area historically consisted of several different plant communities. A dense swamp of pond apple, willow and elderberry formed broad bands along the southern rim of Lake Okeechobee. The remainder of what is now the Everglades Agricultural Area was dominated by sawgrass marshes. The Everglades Agricultural Area today contains primarily agricultural cropland. Approximately 77 percent or 553,000 acres support crops including sugar cane, vegetables, sod, rice and citrus. Sugar cane is the primary crop of the Everglades Agricultural Area.

Several large tracts of land at the south end of the Everglades Agricultural Area were never directly converted to agricultural lands, although their hydropattern has been greatly altered by water management practices. These areas are known as the Holey Land, Rotenberger, and Brown's Farm Wildlife Management Areas. These three areas comprise approximately 18 percent of the Everglades Agricultural Area and retain much of their historic sawgrass marsh and associated plant communities, although the plant cover has been altered by hydroperiod changes, fires, soil subsidence and invasion of exotic plant species.

The Holey Land Wildlife Management Area (aproximately 35,026 acres) has been managed for hydroperiod restoration by the South Florida Water Management District since 1990. The Florida Game & Fresh Water Fish Commission has been monitoring the growth of cattails in the Holey Land area since 1990. According to the GFC, cattail growth has increased significantly over the five year period 1990-1994. Table ***J-5.1-1*** presents the results of cattail surveys completed from 1990 through 1994.

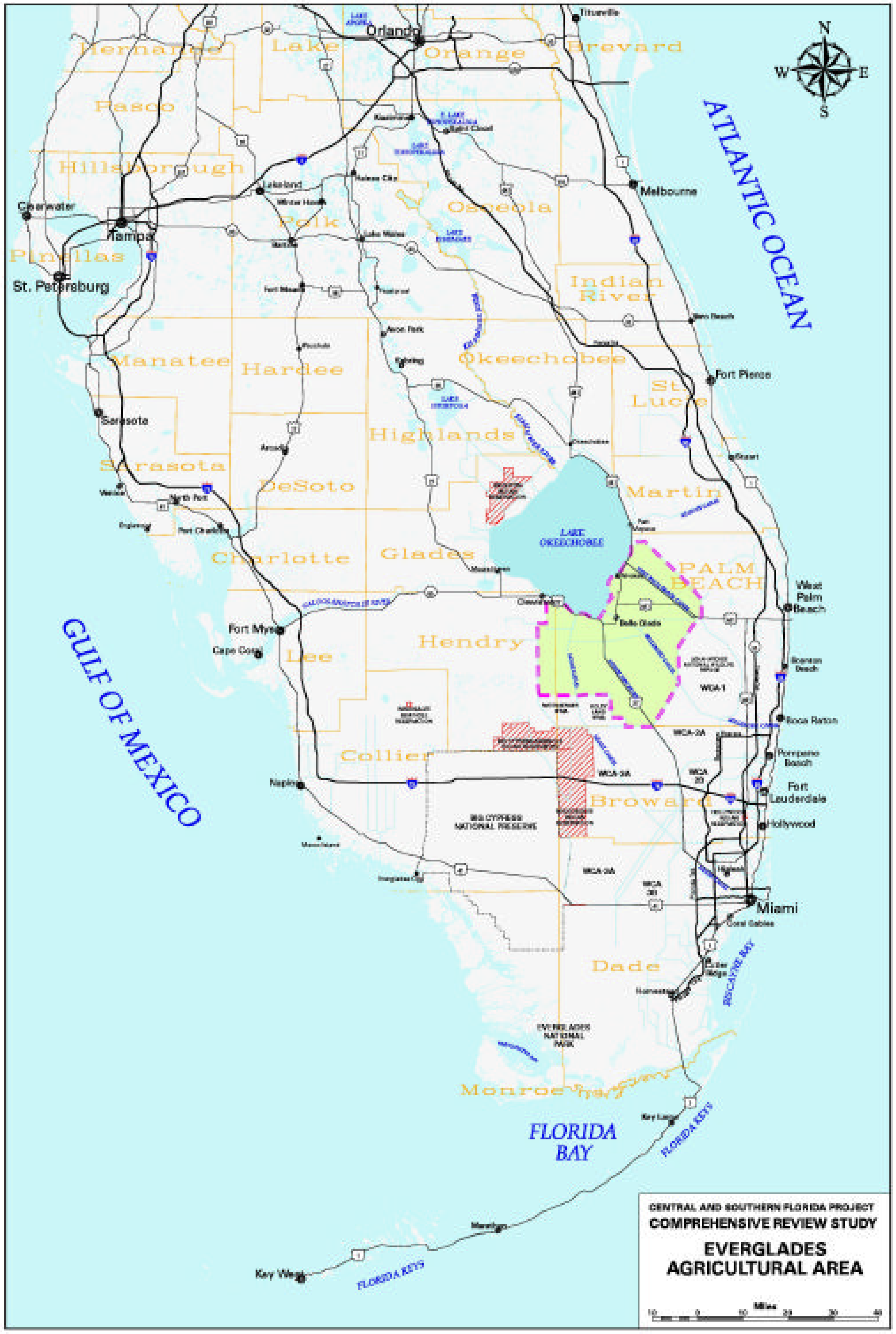


Figure J-5.-1 Everglades Agricultural Area Region

Table J-5.1-1 Holey Land Area Cattail Growth	
Year	**Acres with some cattail coverage**
1990	100
1991	538
1992	1,417
1993	3,414
1994	5,402

The cause for this increase is not completely understood. Phosphorus input from the Miami canal (the water source for hydroperiod restoration), residual phosphorus in Holey Land soils, and the hydroperiod regimes are factors contributing to the proliferation of cattails.

The Everglades Agricultural Area is bordered on the northeast by the western fringes of the Dupuis Reserve, and the Corbett Wildlife Management Area. These areas contain pine flatwoods and wet prairie plant communities. The North perimeter of the Everglades Agricultural Area is Lake Okeechobee. The west perimeter of the Everglades Agricultural Area consists of agricultural and range lands of eastern Hendry County. To the southeast and south, the Everglades Agricultural Area is bounded by the WCAs.

The natural cover of the C-139 Basin in southeastern Hendry County is of pine flatwoods, cypress domes, aquatic sloughs, and freshwater marshes. About 27 percent of the basin is considered to be wetlands (ESE, 1992). About 7 percent of the basin remain as pine flatwoods. The remaining areas of the basin have been converted to pasture and cropland.

J.5.2 Fish and Wildlife

Populations of many animal species have experienced declines throughout the Everglades. Factors that have led to population decreases include loss of habitat by land conversion, intensive harvest, altered hydroperiods, and altered fire patterns. Some wetland animal populations have been jeopardized by water management actions that have affected various aspects of their life histories (SFWMD, 1992).

Wildlife habitat within the Everglades Agricultural Area is mostly limited to the canal systems. Flooded and cultivated agricultural fields attract feeding birds, especialy waders. The Holey Land, Rotenberger, and Brown’s Farm Tracts located at the south end of the Everglades Agricultural Area are wildlife management areas that support populations of wading birds, deer, hogs and waterfowl.

J.5.3 Water Management

The existing drainage/irrigation system within the Everglades Agricultural Area is a complicated network of canals, levees, control structures and pumps. The original six major canals, (West Palm Beach, Hillsboro, Miami, North New River, Cross and Bolles canals, built in the 1920's) still serve to drain the Everglades Agricultural Area although each canal underwent major improvements during the 1960's. Historically the Everglades Agricultural Area has depended upon the flood storage capacity of Lake Okeechobee to the north and the Everglades WCAs to the south as a means of removing excess drainage water from the Everglades Agricultural Area. Prior to adoption of the IAP in 1979, the northern one-third of the Everglades Agricultural Area was routinely backpumped directly into Lake Okeechobee through Pump Stations S-2, S-3, and S-4 located on the south shore of the lake. The eastern and southern two-thirds of the Everglades Agricultural Area drained water south to the WCAs via Pump Stations S-5A, S-6, S-7, S-8.

Under the current IAP, the S-2 and S-3 Basins are now also routed south to the WCAs. Approximately 82 percent of the Everglades Agricultural Area land area (i.e. S-2, S-3, S-5A, S-6, S-7 and S-8 Basins) now pump excess drainage waters into the three WCAs via Pump Stations S-5A, S-6, S-7 and S-8. Nine much smaller Chapter 298 Drainage Districts also currently discharge surface water runoff into Lake Okeechobee. As a result the Everglades Agricultural Area depends on the flood storage capacity of the Water Conservation Areas, and to a lesser extent, on Lake Okeechobee, as a means to remove water from the basin.

The growers remove runoff water from their lands by pumping to the six C&SF Project canals serving the Everglades Agricultural Area. Growers in general are allowed a maximum removal rate that is determined by a runoff formula and is almost always in excess of the basin wide design rate of three-quarters of an inch of runoff per day (Cooper, 1989). This amount was based on three considerations: (1) that not all land in the basin would be in agricultural production at one time, (2) that some of the land would be planted to water tolerant crops, and (3) that the canals in the basin have some storage capacity. Although the capacity of the canal system is not large enough to handle all the water discharged from the Everglades Agricultural Area at one time, it was assumed that not all of the growers' pump stations would be pumping or pumping to capacity at any given time (Cooper, 1989).

J.5.4 Water Supply

Historically, the Everglades Agricultural Area has depended upon the flood storage capacity of Lake Okeechobee to the north and the Everglades WCAs to the south as a means of removing excess drainage water from the Everglades Agricultural Area. Prior to adoption of the IAP in 1979, the northern one-third of the Everglades Agricultural Area was routinely backpumped directly into Lake

Okeechobee through pump stations S-2, S-3, and S-4 located on the south shore of the lake, while the eastern and southern two-thirds of the Everglades Agricultural Area moved water south to the WCAs via pump stations S-5A, S-6, S-7, S-8.

Concerns over the accelerated rate of eutrophication in Lake Okeechobee led to a decision to change the relative distribution of flood or drainage water pumped from the Everglades Agricultural Area north to Lake Okeechobee on an average annual basis. The redistribution was called the IAP. Under this plan, 95 percent of all flood water and water released from Lake Okeechobee for water supply purposes are pumped from the Everglades Agricultural Area into the WCAs. Only an estimated 5 percent is pumped north to Lake Okeechobee during flood or drought emergency conditions. The S-2 and S-3 Basins are now also routed south to the WCAs. Approximately 82 percent of the Everglades Agricultural Area land area (i.e. S-2, S-3, S-5A, S-6, S-7 and S-8 basins) now pump excess drainage waters into the three WCAs via pump stations S-5A, S-6, S-7 and S-8. Nine much smaller Chapter 298 Drainage Districts currently discharge surface water runoff into Lake Okeechobee.

Primary Hydrologic Basins

The primary hydrologic basins of the Everglades Agricultural Area regulated under the Chapter 40E-63 Rule include the S-2, S-3, S-5A, S-6, S-7, and S-8 Basins. For the balance of this discussion, the S-8 and S-3 Basins are combined. The S-7 Basin is divided into those areas generally tributary to the North New River Canal and to the Hillsboro Canal. That part tributary to the North New River Canal is combined with the S-7 Basin; that part tributary to the Hillsboro Canal is combined with the S-6 Basin. As a result of those combinations, four primary hydrologic basins are defined:

- The S-5A Basin.
- The S-6/S-2 Basin.
- The S-7/S-2 Basin.
- The S-8/S-3 Basin.

Previous analyses of discharges from the above four basins were prepared for a period of record including water years 1979-1988 (Everglades Protection Project, Conceptual Design, 1994). The combined contributing areas for the four primary hydrologic basins are:

- S-5A: 126,910 acres.
- S-6/S-2: 121,009 acres.
- S-7/S-2: 142,160 acres.
- S-8/S-3: 133,642 acres.

A summary of the historic average annual discharge volumes from the Everglades Agricultural Area to various receiving waters is presented in ***Table J-5.4-1.***

Table J-5.4-1 Historic Everglades Agricultural Area Runoff 1979-1988 Average Annual Discharge	
Basin	**Volume (acre-feet)**
S-5A	275,537
S-6/S-2	194,394
S-7/S-2	274,245
S-8/S-3	298,068
TOTAL	**1,042,243**

298 Districts and 715 Farms

The Everglades Agricultural Area includes a number of special drainage districts and other areas that discharge at least some of their runoff directly to Lake Okeechobee. These areas include the South Florida Conservancy District, South Shore Drainagr District, East Beach Water Control District, East Shore water Control District, and the 715 Farms Area.

The five basins discussed herein encompass a total of approximately 32,081 acres along the south and east shores of Lake Okeechobee, and are situated primarily in Palm Beach County (the westerly two miles of the South Florida Conservancy District are situated in Hendry County).

South Florida Conservancy District

The South Florida Conservancy District is situated on the south shore of Lake Okeechobee immediately west of the Miami Canal, and includes a total of approximately 9,775 acres. The South Florida Conservancy District is served by a total of three pumping stations. Pump Station P-5-E is located on the west bank of the Miami Canal, and discharges to the Miami Canal. Pump Station P-5-W discharges to the Industrial Canal (in the S-4 Basin) at the west line of the South Florida Conservancy District. Pump Station P-5-N is located on the south bank of Lake Okeechobee, and discharges directly to the Lake. This station is presently operated only when the combined capacity of stations P-5-E and P-5-W is inadequate to prevent flooding in the District. While station P-5-W does not technically discharge directly to Lake Okeechobee, the majority of its discharges are eventually routed to the Lake through the Industrial Canal (and Canal C-21) via Hurricane Gate No. 2 (and Pump Station S-4).

South Shore Drainage District

The South Shore Drainagr District is located on the south shore of Lake Okeechobee, extending generally between the Miami Canal and the North New River Canal, and includes a total of approximately 4,230 acres. The South Shore Drainagr District is presently served by a total of two pumping stations. The Bean City Pump Station is located on the south shore of Lake Okeechobee, and discharges directly to the Lake. The South Bay Pump Station is located on the west bank of the North New River Canal and discharges to the canal.

East Beach Water Control District

The East Beach Water Control District is located on the east shore of Lake Okeechobee south and west of the West Palm Beach Canal, and includes a total of approximately 6,542 acres. The East Beach Water Control District is presently served by three pumping stations. Pump Station 1 is located on the east shore of Lake Okeechobee and discharges directly to the Lake. Pump Station 2 is located on and discharges to the West Palm Beach Canal. Discharges from the East Beach Water Control District are conveyed to Pump Station 2 through the C-4 Canal. Pump Station 3 is located on the C-4 Canal at the easterly boundary of the East Beach Water Control District, and discharges to the C-4 Canal at the easterly boundary of the East Beach Water Control District, and discharges to the C-4 Canal. Its discharge is subsequently routed through Pump Station 2 to the West Palm Beach Canal.

East Shore Water Control District

The East Shore Water Control District is situated between the West Palm Beach and Hillsboro Canals, and is abutted on the west by the 715 Farms area, which physically separates the East Shore Water Control District from Lake Okeechobee. It is abutted on the north by the Pahokee Water Control District, and on the east by the Highland Glades Drainage District. It includes a total of approximately 8,136 acres. The East Shore Water Control District is presently served by a single pumping station on the east shore of Lake Okeechobee that discharges directly to the Lake. Runoff from the East Shore Water Control District is carried to the pumping station through a conveyance canal following the south line of the 715 Farms area.

715 Farms

The 715 Farms are (also known as Closter Farms) consists of approximately 3,398 acres of agricultural lands. This area abuts the east shore of Lake Okeechobee, and is served by a single pumping station that discharges directly to the Lake.

Record data on discharges to Lake Okeechobee from the 298 Districts and the 715 Farms area was furnished by the Florida Department of Environmental Protection. The following is a summary of the average annual historic discharge volumes from these districts to Lake Okeechobee.

South Florida Conservancy District; 17,500 acre-feet per year.
South Shore Drainagr District; 5,199 acre-feet per year.
East Beach Water Control District; 5,383 acre-feet per year.
East Shore Water Control District; 8,555 acre-feet per year.
715 Farms; 7,820 acre-feet per year.

A portion of the runoff from these districts is delivered to the primary canal system. Volume of flow is not available, however the majority of the runoff from these districts is delivered to Lake Okeechobee.

C-139 Basin

The C-139 Basin is the most northerly of the four primary hydrologic basins forming the Western Basins; other basins include the Feeder Canal Basin, the L-28 Basin, and the L-28 Tieback Basin. These basins are all tributary to the EPA. The conceptual plan for the Everglades Protection Project directly addresses only the C-139 Basin.

The total area of the C-139 Basin, based on historical boundaries established by the District, is approximately 169,500 acres. The primary canals within the C-139 Basin consist of the L-1, L-2, and L-3 Borrow Canals. There are a total of five outfall locations for the C-139 Basin. All drainage eventually outfalls to WCA-3A. The total average annual volume from the C-139 Basin during the period water years 1979-1988 is estimated to be 98,000 acre-feet (C-139S – 87,000 ac-ft, C-139N – 11,000 ac-ft).

L-8 Basin

The L-8 Basin encompasses 171 square miles in northwestern Palm Beach County (168 square miles) and southwestern Martin County (2 square miles). The balance of the L-8 Basin (42 square miles) is considered to be ineffectively drained and not significantly contributing to L-8 Basin runoff.

Over a nine-year period of record including water years 1980-1988, the average annual runoff from the L-8 Basin was calculated to be 187,039 acre-feet. Runoff from the L-8 Basin can be delivered to a variety of receiving water bodies. A summary of historic runoff volume by receiving water body from the L-8 Basin over the period water years 1980-1988 is presented in ***Table J-5.4-2***.

Table J-5.4-2
Average Water Year
L-8 Basin Runoff And Receiving Waterbody
(Acre-Feet)

Lake Okeechobee	M Canal	C-51 via S-5AE	WCA-1	S-5A Basin	Total*
22,141	48,821	36,379	60,565	19,132	187,039*

May not add up exactly due to rounding.

Water users in the L-8 Basin can receive water not only from L-8 Basin runoff, but also from sources external to the L-8 Basin, including Lake Okeechobee (via Culvert #10A) and WCA-1, the S-5A Basin, and the C-51 West Basin via the S-5A complex. ***Table J-5.4-3*** summarizes both gross and net supplemental inflows to the L-8 Basin from Lake Okeechobee and the S-5A complex. The gross supplemental inflows represent a summation of all inflows to the L-8 Basin from the indicated source, the net inflow is the difference between inflows to the basin and discharges from the basin at the same point.

Table J-5.4-3
Average L-8 Supplemental Inflows
Supplemental Inflow By Source
(Acre-Feet)

Lake Okeechobee		S-5A Complex		Total	
Gross	Net	Gross	Net	Gross	Net
28,912	6,771	5,806	(108,316)	34,718	(101,545)

C-51 West Basin

The overall C-51 Basin has an area of approximately 164.3 square miles and is located in eastern Palm Beach County. The basin is comprised of two sub-basins, C-51 West (73 square miles) and C-51 East. State Road 7 is generally the boundary between the basins. This discussion is focused on the C-51 West sub-basin. Gauge data for runoff from the C-51 West Basin exists only at Structure S-5AE, and represents but a small fraction of the total runoff from the basin. The Jacksonville District, U.S. Army Corps of Engineers, in connection with its studies of the C-51 Basin, developed a watershed simulation model calibrated to available gage data in the C-51 Basin as a whole. That simulation model is structured to permit separate identification of runoff from the C-51 West sub-basin. That simulation model was developed and applied to the period encompassing water years 1961-1985. The calculated runoff from the C-51 West Basin resulting from application of the model is summarized in ***Table J-5.4-4*** (Everglades Protection Project, Conceptual Design, 1994).

Table J-5.4-4
Average C-51 West Basin Water Balance
(Ac-Ft)

C-51 West	Discharge at S-5AE		Discharge at S.R. 7*	
Basin Runoff (ac-ft)	**Inflow (ac-ft)**	**Outflow (ac-ft)**	**Net (ac-ft)**	**(ac-ft)**
119,002	112,489	4,264	108,225	227,226

*Includes both discharges to the east of S.R. 7 and any withdrawals from the C-51 West canal for water supply.

J.5.5 Land Use

The vast majority of land within the Everglades Agricultural Area is used for agricultural production. A significant amount of land is also set aside for wildlife management and a lesser amount for urban development.

J.5.5.1 Agriculture

Palm Beach County is included in this region. A portion of Hendry County also lies in the Everglades Agricultural Area. Also, Palm Beach County is not entirely within the Everglades Agricultural Area, but it is assumed that the majority of agricultural production is within the Everglades Agricultural Area because the remaining portion of the county is primarily urbanized.

More than 600,000 acres are farmed in Palm Beach County (UFBEBR, 1995), and sugarcane was harvested from about half of that acreage in 1996 (FASS, 1996d). Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value crops, including sugarcane and vegetables. Sugarcane receipts accounted for 68 percent of total field crop sales in Florida in 1996 (FASS, 1996c). The Everglades Agricultural Area is known for its sugarcane production and sugar processing, but Palm Beach County also ranks 15th among Florida counties for acres of citrus (FASS, 1996b). This region is characterized by mid-size farms averaging 690 acres each with high productivity of more than $1300 per acre (UFBEBR, 1995). More than 18,000 people are employed in agricultural production and services representing a payroll of more than $26 million (UFBEBR, 1995). Total market value of agricultural products in Palm Beach County is almost $900 million, ranking it first among counties in the state of Florida (UFBEBR, 1995) and third among U.S. counties (FDACS, 1994).

The Everglades Agricultural Area is highly dependent upon the system of canals running through the region to provide necessary drainage of excess water during the wet season as well as supplemental water supplies for irrigation during the dry season. Approximately two thirds of the land farmed in the Everglades Agricultural Area is irrigated, totaling more than 400,000 acres (UFBEBR, 1995). The Everglades Agricultural Area has traditionally relied upon Lake Okeechobee for its water supply, and looked to the Water Conservation Areas to the south to receive their excess drainage.

Continued agricultural production in the Everglades Agricultural Area has become increasingly controversial. Some of the factors that may affect Everglades Agricultural Area agriculture include water quality concerns, soil subsidence, and encroachment of urbanization. The water quality concerns, particularly phosphorus loading, are being addressed through best management practices, storm water treatment areas, and growing use of organic farming practices and rice cultivation in rotation with sugarcane production. Although sugarcane cultivation in the Everglades Agricultural Area has come under some sharp criticism in recent years, sugarcane is recognized as the most appropriate crop for this region. Sugarcane requires less phosphorus fertilizer than other crops grown in the Everglades Agricultural Area (Sanchez, 1990), and sugarcane has been found to remove 1.79 times more phosphorus than was applied as fertilizer (Coale et al., 1993). Florida sugarcane only requires small amounts of pesticides due to disease resistant and tolerant cultivars, and cultivation instead of herbicides for weed control. Sugarcane also tolerates greater variability in water table levels, allowing for more flexible water management strategies (Glaz, 1995).

Soil subsidence has become a potential threat to long-term crop production in the Everglades Agricultural Area. The average historic rate of subsidence of 1 inch per year has slowed to 0.56 inches per year since 1978 (Shih et al., 1997). They attributed the lower rate to several factors including higher water tables and an increased proportion of land planted to sugarcane. Surveys conducted by Shih et al. (1997) in 1997 found an average of 1.62 feet to 4.36 feet of soil remaining over 11 transects. Prevention of continued soil subsidence will depend on maintaining high ground water levels to prevent further oxidation of the soil profile. This, in turn, will require development of more water-tolerant sugarcane varieties and/or increased rice cultivation. This research is currently underway and showing promising results (Glaz, 1997). A strong agricultural economy in the Everglades Agricultural Area based on profitable crop production is the best defense against conversion of agricultural land to urban land.

J.5.5.2 Rotenberger and Holey Land Wildlife Management Areas

The Holey Land Tract (35,026 acres) is managed by the GFC as a state wildlife management area. The South Florida Water Management District as been managing the hydroperiod since completion of a perimeter levee and pump station in 1990. The Rotenberger Tract (23,970 acres) and Brown's Farm Tract (4,460 acres) are also managed by the GFC as state wildlife management areas. Lake Harbor Waterfowl Management Area is operated by GFC for management of waterfowl. The land is under rice production for both harvest and wildlife habitat.

J.5.5.3 Urban

The remaining 5 percent of the Everglades Agricultural Area includes the communities of Pahokee, Belle Glade, South Bay and Clewiston, several sugar mills, roads, canals and water control features.

J.5.5.4 C-139 Basin

Land use within the C-139 Basin of eastern Hendry County is predominantly agricultural. The land use in the basin is approximately 62 percent agricultural, 4 percent urban, and 34 percent native land cover. This rural area is primarily pasture land for cattle grazing, with increasing amounts of land being converted to citrus groves. Agricultural land uses include vegetable farms, citrus groves, improved pasture, and unimproved pasture (Mock Roos, 1993).

J.5.6 Recreation Resources

Recreation resources in the Everglades Agricultural Area region are minimal due to the heavily developed agricultural industry in the region. The landscape is nearly flat with most of the areas farmed in sugarcane. The region is extensively ditched for water supply. A few community sized city and school playgrounds/parks are located within the Everglades Agricultural Area region. Some City, County, WMD, and U.S. Army Corps of Engineers parks are also found in the region. Recreation resources in the region are minimal at best.

J.5.7 Aesthetic Resources

The aesthetic overview is one of an extensively altered landscape that is nearly flat with most of the land in agricultural production. Few areas if any of the historical, pond apple or sawgrass marsh plant communities remain in their natural state. The region is extensively ditched for water supply to farm sugarcane and appears lush and green when the cane is ready for harvest. The cane fields are burned off just before the cane is harvested which produces a huge cloud of smoke visible for miles that smells awful. Once the cane is harvested the fields appear dark black before planting and through much of the early growing cycle. Minimal aesthetic resources exist in the Everglades Agricultural Area region however some non-farmed pocket areas do possess better aesthetic quality. Agricultural development and fluctuations in the water supply and quality are concerns of the downstream properties of the Everglades system. The Everglades Agricultural

Area region affects the water quality, vegetation and aesthetics of the downstream regions.

J.5.8 Hazardous, Toxic, and Radioactive Wastes

The U.S. Environmental Protection Agency and Florida Department of Environmental Protection databases were reviewed to determine if previously reported areas of environmental concern exist in the vicinity of the proposed STAs and other Everglades Construction Project project features. The U.S. Environmental Protection Agency database includes the Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS), Facility Index System (FINDS), National Priorities List (NPL), and Resource Conservation and Recovery Information System (RCRIS) lists. The CERCLIS database includes information on sites identified by the U.S. Environmental Protection Agency as abandoned, inactive, or uncontrolled hazardous waste sites that may require cleanup. The FINDS database contains facility information and suggestions for other sources of information, e.g., RCRIS, CERCLIS. The NPL database is a subset of CERCLIS, which identifies sites scheduled for priority cleanup under the Superfund Program. RCRIS includes information on sites which generate, transport, store, treat, and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA).

The Florida Department of Environmental Protection, Bureau of Information Systems, Stationary Tank Inventory System Report includes sites which have reported petroleum product spills in accordance with state regulations. The Florida Department of Environmental Protection, Groundwater Management System report includes sites which have the potential to affect groundwater. Such sites include those with stormwater ponds, dredge and fill permits, wells, etc.

J.6 WATER CONSERVATION AREAS

The Water Conservation Areas (WCAs) cover 1,372 square miles, consisting primarily of sawgrass marshes, associated wetland communities and tree islands. The WCAs are contained by perimeter levees (***Figure J-6-1***). WCA-1, also known as Loxahatchee National Wildlife Refuge, includes 227 square miles of Everglades wetland habitat. WCA-1 represents a remnant of the northern Everglades. WCA-2, the smallest of the three WCAs, encompasses approximately 210 square miles. The area is divided in two cells by a levee constructed in 1961. The north cell, WCA-2A,

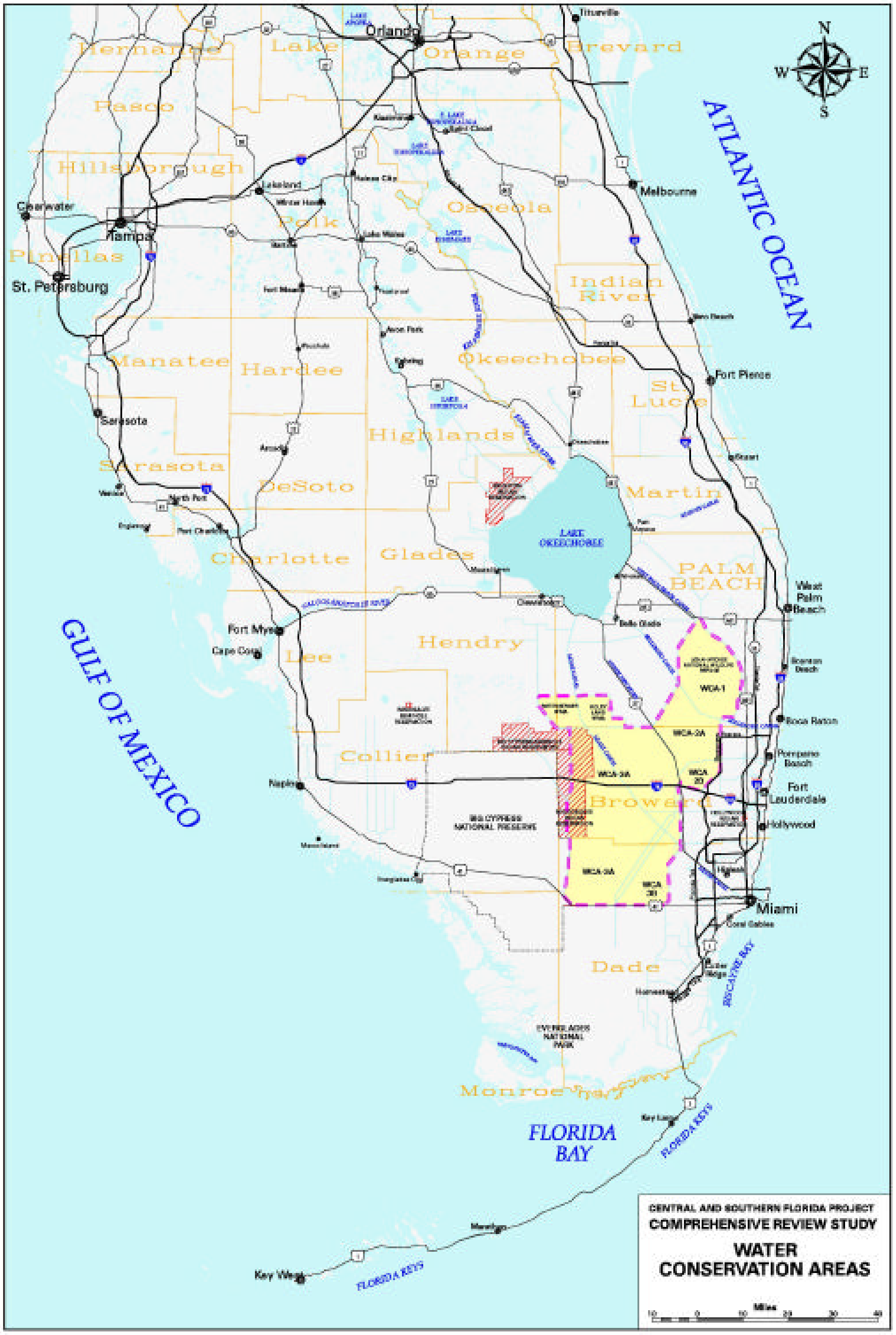


Figure J-6-1 Water Conservation Areas Region

Covers 173 square miles, and the south cell, WCA-2B, covers 37 square miles. WCA-3, the largest of the WCAs covers an area of 915 square miles.

The coverage of the Water Conservation Areas includes descriptions of existing conditions for the Holey Land Wildlife Management Area and the Rotenberger Wildlife Management Area. These two areas, located northwest of Water Conservation Area 3A, between 3A, the Everglades Agricultural Area, and the Big Cypress region, are remnant sawgrass planes and are managed by the Florida Game and Fresh Water Fish Commission. The Miami Canal is their common boundary. Their inclusion in the Water Conservation Area region is purely for organizational purposes for this report and they are not, strictly speaking, part of the Water Conservation Area system. The description of existing conditions for this region, presented below, is drawn largely from the Florida Game and Fresh Water Fish Commission, Fish and Wildlife Coordination Act Report, submitted to the U.S. Army Corps of Engineers on August 6, 1998. This Coordination Act Report is available in entirety in Annex A.

J.6.1 Vegetation

Almost all of the Water Conservation Areas are graminoid wetlands interspersed with tree islands (hammocks) and willow strands. Tree islands are a unique feature of the Everglades ecosystem. Tropical hardwoods are found on some of the relatively unaltered tree islands in the southern portion of the area.

J.6.1.1 Dominant plant communities

The dominant plant communities are listed below. Each community description is followed by a list of plant species common to that community.

Basin Marsh

This plant community type develops in broad, shallow to intermediate depth basins with peat substrate. Flooding is seasonal. Climate is temperate or subtropical; fire is frequent. Dominant plant cover is sawgrass and/or buttonbush and/or mixed emergents. In general, there are three recognizable types of basin wetland communities present:

Sawgrass marsh, composed of sawgrass (*Cladium jamaicense*), with cattail (*Typha* spp.), maidencane (*Panicum hemitomon*), arrowhead (*Sagittaria lancifolia*), pickerelweed (*Pontederia cordata*), willow (*Salix caroliniana*), button bush (*Cephalanthus occidentalis*), wax myrtle (*Myrica cerifera*), and saltbush (*Baccharis glomeruliflora*).

Wet prairie, composed of beak rush (*Rhynchospora tracyi*), spike rush (*Eleocharis spp.*), maidencane (*Panicum hemitomon*), string lily (*Crinum americanum*), and white water lily (*Nymphaea odorata*).

Aquatic slough, composed of white water lily, floating heart (*Nymphoides aquatica*), spatterdock (*Nuphar luteum*), bacopa (*Bacopa caroliniana*), and bladderwort (*Utricularia* spp.).

Strand Swamp

A strand is a broad, shallow channel with peat over a mineral substrate; seasonally inundated by flowing water; tropical or subtropical. Fire is occasional or rare. Vegetation is characterized by cypress and/or willow.

The following species are associated with this community: pond cypress (*Taxodium ascendens*), bald cypress (*Taxodium distichum*), willow (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), wax myrtle (*Myrica cerifera*), sawgrass (*Cladium jamaicense*), and royal fern (*Osmunda regalis*).

Hydric Hammock

This is a wetland forest community that occurs in lowlands over sandy, clay organic soil, often over limestone. Its water regime is; mesic to hydric; climate is subtropical or temperate; and fire is rare or not a major factor.. Vegetation is characterized by water oak, cabbage palm, red maple, bays, hackberry, hornbeam, needle palm, and mixed hardwoods. The following species are associated with this community: sweet bay (*Magnolia virginiana*), red bay (*Persea borbonia*), cocoplum (*Chrysobalanus icaco*), strangler fig (*Ficus aurea*), wax myrtle (*Myrica cerifera*), willow (*Salix* spp.), elderberry (*Sambucus simpsonii*), hackberry (*Celtis laevigata*), cabbage palm (*Sabal palmetto*), red maple (*Acer rubrum*), royal fern, dicliptera (*Dicliptera assurgens*), false nettle (*Boehmeria cylindrica*), water oak (*Quercus nigra*), hornbeam (*Carpinus caroliniana*), and needle palm (*Rhapidophyllum hystrix*).

J.6.1.2 C&SF Project Effects

Many areas of the WCAs have been affected by construction and operation of the C&SF Project. The Project has caused some areas of the northern Everglades to become overdrained, while other areas of the marsh have been subjected to deep water or stabilized water level conditions. These hydrological modifications of the original overland sheetflow system have played a major role in determining the present day vegetation characteristics of the area (Loveless *et al.*, 1970; Dineen, 1972; McPherson, 1973; Alexander and Crook, 1984). The following discussion identifies the vegetation characteristics of each WCA and points out those areas of the marsh that have been most affected by hydroperiod changes.

Water Conservation Area-1

Vegetation within WCA-1 consists of a matrix of wet prairies, sawgrass prairies, and aquatic slough communities. Tree islands are interspersed throughout the area. Plant community cover within WCA-1 has shifted as a result of impoundment of the marsh by perimeter levees and alteration of hydroperiods by operation of the C&SF Project. The southern, lower elevation areas of WCA-1 have been flooded for long periods of time, while the northern portions of the area have experienced more frequent drying. Areas which have experienced shortened hydroperiods have experienced shifts to woody vegetation (wax myrtle and willow), while lower elevations have experienced shifts to more aquatic flora. In addition, WCA-1 currently includes approximately 6,000 acres (4 percent total cover) of cattail marsh that was not present prior to the early 1960's. A number of factors influence establishment of cattails in the Everglades. These include physical disturbance of underlying soil profile by canal construction activities, proximity to seed sources, fire, hydrologic changes and the availability of nutrients. Exotic vegetation that was uncommon prior to 1965 is a growing problem. Melaleuca and Brazilian pepper are both rapidly spreading along the perimeter and into the interior marsh. In 1988, total coverage of Melaleuca was estimated to be near 4,000 acres (2.8 percent).

Water Conservation Area-2A

Detailed descriptions of the plant communities that existed within WCA-2A prior to impoundment of the area are provided by Davis (1943a,b) and Loveless (1959). Vegetation that was characteristic of the area prior to impoundment included tree islands, sawgrass and extensive communities of beakrush (*Rhynchospora tracyi*), maidencane (*Panicum hemitomon*) and spikerush (*Eleocharis cellulosa*). The wet prairie communities occurred primarily in the central and eastern portions of WCA-2. A generalized 1956 vegetation map of WCA 2 showed more than 50 major tree islands in what is now WCA-2A (SFWMD, 1978). During the 1960s and 1970s, WCA-2A was managed as a regional water storage area. The water regulation schedule for WCA-2A during this period ranged seasonally between 13.0-14.5 ft. NGVD. Stabilization of water levels resulted in the elimination of the natural flood-drought cycle. This stabilization, combined with an increased frequency of flooding, increased water depths, reduction of the frequency of fire and high nutrient loading associated with agricultural runoff, produced a number of ecological changes. Changes include the elimination of wet prairie communities, drowning of tree islands, loss of sawgrass communities along slough edges and accumulation of a flocculent layer of plant detritus (up to 14 inches deep) in sloughs. The detritus level in the sloughs caused high oxygen demand and periodic fish kills. Wading bird feeding habitat was also lost (Dineen, 1972, 1974).

Major plant communities in WCA-2A now consist of remnant drowned tree islands, open water sloughs and large expanses of sawgrass, and sawgrass intermixed with dense cattail (*Typha domingensis*) stands. Remaining tree islands are found primarily at higher ground level elevations, located in the northwest corner of WCA-2A. Remnant (drowned) tree islands, dominated primarily by willow, are found scattered throughout the central and southern sections of WCA-2A. In recognition of these problems, the South Florida Water Management District initiated several experimental drawdown studies of WCA-2A for the purpose of stimulating more natural drying conditions that would promote the re-growth of wet prairie vegetation and tree island communities. An experimental drawdown was conducted in 1973, which allowed WCA-2A to dry out for 71 days before summer rains refilled the area. Many areas of the marsh failed to dry out due to the late timing of the drawdown. Some success was observed in consolidating the flocculent layer of organic detritus as well as stimulating the re-growth of a few species of wet prairie and woody tree island vegetation (Dineen, 1974). Wading birds (white ibis, herons and wood storks), migratory waterfowl and snail kites were observed utilizing WCA-2A on a more frequent basis during the drawdown as compared to years when the higher water level schedule was in effect (Kushlan, 1974).

In 1980, a second attempt was initiated to achieve a drawdown of the area over a four-year period (1980-1984). The second drawdown reduced the regulation schedule from 13.0-14.5 ft. NGVD to 9.5-12.5 ft. NGVD. The initial 1980-81 drawdown coincided with a regional drought. Concerns for regional water supplies suspended the drawdown during 1982 until the late dry season. The result was that only a partial drying of the marsh was accomplished. The dry seasons of 1983 and 1984 were unusually wet and prevented the planned drying of the system. In large part due to extreme climatic conditions, the drawdown effort overall was only partially successful. Lowered water levels created favorable conditions that allowed for some expansion of wet prairie communities and increased sawgrass densities (Worth, 1988).

Concerns have focused on the problems of nutrient-enrichment and cattail expansion in the northwest portion of WCA-2A. The increase in cattails in WCA-2A over time is supported largely by long-term field observations by government scientists (Davis and Harris, 1978; Reeder and Davis, 1983; Davis, 1982, 1984 1989, 1991; Swift, 1981; Swift and Nicholas, 1987; Toth, 1987, 1988; Worth, 1983; 1988; Urban, 1984) who conducted water quality and environmental studies within WCA-2A from 1977 to 1989. These researchers noted an increase in cattail abundance downstream from water control structures S-10C and S-10D in areas that were originally dominated by sawgrass, (where cattail was typically observed as rare or absent). Field observations noting increases in cattail distribution also coincided with observed increases in surface water nutrient concentrations measured downstream from these two water management structures. Scientists documented the existence of a defined nutrient gradient downstream of S-10C (Swift, 1981; Swift and Nicholas, 1987). A set of seven sampling points arranged in a straight line south of S-10C was established in 1978 and labeled "Transect B". High concentrations of nutrients existed at sites dominated by cattail (sites B-1 through B-3) while low concentrations of nutrients existed at sites dominated by sawgrass vegetation (Sites B-5 through B-7). In a follow-up study, conducted from 1980 - 1982, Swift and Nicholas (1987) reported that the nutrient gradient had shifted further south, affecting the microbiology (periphyton community) of site B-5, located 3.7 km downstream of S-10C. These data provide evidence that nutrients had penetrated the marsh interior several kilometers further downstream than originally observed in 1978-1979.

The most current data available (Richardson, C. as cited in LOTAC-II, 1988, Planning Document) concerning the present distribution of cattails in WCA-2 show 4,400 acres in which cattails represent more than 50 percent of the vegetation in coverage and 24,000 acres of mixed or scattered cattail (<50 percent coverage) present in the northeast portion of WCA-2A. Since this survey was conducted in the middle of a long-term regional drought, the species composition data presented in this study may be unrepresentative of average conditions. At the time there was an extensive invasion by pigweed (*Amaranthus* sp.) and temporary thinning of cattails, resulting from extremely dry conditions. There is a relationship between the occurrence of cattail stands in WCA-2A and phosphorus loadings through the three S-10 discharge structures. A similar relationship is noted downstream of pump station S-7.

Several studies conducted within WCA-2A show that cattails out-compete sawgrass in their ability to absorb nutrients. There is increased cattail production during years of high nutrient inflows (Toth, 1988; Davis, 1991). Cattails are considered a high nutrient status species that is opportunistic and highly competitive, relative to sawgrass, in nutrient-enriched situations (Toth, 1988; Davis, 1991). Davis (1991) concluded that both sawgrass and cattail increased annual production in response to elevated nutrient concentrations, but that cattail differed in its ability to increase plant production during years of high nutrient supply.

Infestation of melaleuca, an introduced exotic, in WCA-2A is considered to be relatively light (scattered single or small clumps of outlier trees), and currently covers less than 10 percent (<11,000 acres) of the sawgrass marsh (Melaleuca Task Force, 1990). Low numbers of trees are thought to be related to the higher water levels that were maintained in the area prior to 1980, as well as an experimental melaleuca control program. Existing melaleuca trees are generally restricted to higher ground elevations such as tree islands and sawgrass ridges (Worth, 1983). Control of melaleuca was initiated in 1980 as part of a larger environmental study to evaluate the effects of a drawdown of WCA-2A. Efforts were directed at eradicating or controlling the existing melaleuca seed sources to prevent further spread as a result of the drawdown effort (Worth, 1983, 1988).

Water Conservation Area-2B

Due to the highly permeable nature of the aquifer underlying WCA-2B, it has been difficult to maintain historic water levels within this impoundment. As a result, no water regulation schedule is currently maintained for WCA-2B, although the area should not be allowed to exceed 11.0 ft. NGVD unless the outlet structure is open. Impoundment of WCA-2B by construction of L-35B in 1972 resulted in a lowered water table and a shortened hydroperiod, setting the stage for melaleuca invasion throughout WCA-2B. Since 1980, the hydrology of WCA-2B has changed considerably. Drawdown efforts in WCA-2A during the 1980's resulted in increased volumes of water being diverted to WCA-2B. These efforts have somewhat helped to slow down the invasion of melaleuca.

In the south end of WCA-2B there still exists an extensive wet prairie community dominated by spikerush (*Eleocharis cellulosa)* and maidencane (*Panicum hemitomon*) which has been reported to serve as a important feeding area for wood storks, snail kites and other wading birds over the last several years. Approximately 30 snail kites were observed utilizing the south end of WCA-2B in 1987.

Heavy infestations of melaleuca (large heads and solid forests) occur throughout WCA-2B, and threaten to dominate the marsh within the next several decades. 1990 estimates indicated that about one-quarter of WCA-2B (10,000 acres) was heavily infested by this introduced exotic (Melaleuca Task Force, 1990).

Water Conservation Area-3A

The original plant communities of WCA-3A were first described by Davis (1943a,b) and Loveless (1959). Many areas of WCA 3A still contain vast tracts of Everglades habitat consisting of tree islands, sawgrass marsh, wet prairies and aquatic sloughs, that are very similar in appearance to the descriptions provided by these early studies. However, a number of major changes have occurred as a result of canal and levee construction and impoundment of the area.

WCA-3A North. The community structure and species diversity of Everglades vegetation located north of Alligator Alley (WCA-3A North) is very different from the wetland plant communities found south of the trans-Everglades highway (WCA-3A South). Improvements made to the Miami Canal and impoundment of WCA-3A by levees have over-drained the north end of WCA-3A and shortened its natural hydroperiod. These hydrological changes have increased the frequency of severe peat fires that have resulted in loss of tree islands, aquatic slough, and wet prairie habitat that were once characteristic of the area prior to construction of the C&SF project. Today, northern WCA-3A is largely dominated by sawgrass and lacks the natural structural diversity of plant communities seen in southern WCA-3A.

Over drainage of the northwestern portion of WCA-3A has allowed the invasion of a number of terrestrial species such as salt bush (*Baccharis halmifolia*), dog fennel (*Eupatorium capillifolium*), and broom sedge (*Andropogon* spp.). Melaleuca has become well established in the southeastern corner of WCA-3A North, and is spreading to the north and west.

WCA-3A South. Everglades vegetation located in the central and southern portion of WCA 3A South probably represents some of the best examples of original, undisturbed Everglades habitat left in south Florida. This region of the Everglades appears to have changed little since the 1950's, and contains a mosaic of tree islands, wet prairies, sawgrass stands, and aquatic sloughs similar to those reported by Loveless (1959).

Although the majority of vegetation within WCA-3A south can be described as typical Everglades habitat, several localized problem areas exist. Construction of Alligator Alley (State Road 84) in 1967 cut off sheet flow to the central and southern portions of WCA-3A. The construction of canals and the roadbed has resulted in excessive drainage of the marsh both north and south of the highway. Areas of the marsh located several miles south of the highway and west of the Miami Canal have experienced a shortened hydroperiod, and an increased frequency of peat fires. Severe peat fires during the droughts of 1981, 1985, and 1989 burned tree islands down to bare rock in many places, causing the loss of tree islands north and south of Alligator Alley as well as increasing soil subsidence rates in WCA-3A (Zaffke, 1983; Schortemeyer, 1980). Two environmental enhancement structures, S-339 and S-340 were constructed on the Miami Canal (C-123) in 1980 to divert canal water across WCA-3A north and WCA-3A south in an effort to prolong the marsh hydroperiod, increase water table levels, and reduce flow rates to the south end of WCA-3A (Zaffke, 1983).

The east-central portion of WCA-3A South, located upstream from pump station S-9, has few tree islands and is covered primarily by aquatic slough and sawgrass vegetation. Large stands of cattail exist in this general area. This area, located south of Alligator Alley and east of the Miami Canal, periodically experiences prolonged deep-water conditions as a result of S-11 inflows during the wet season. There are several canals that converge in this area, bringing inflows from the S-11s, and other upstream inflows influenced by agricultural drainage. The S-9 contributes a mix of urban and rural runoff from rapidly developing west central Broward County. The multiple hydrologic connections to this area make it difficult to clearly identify specific sources of influences on vegetation patterns. Apparent impacts to vegetation also have been noted in the western portion of

WCA-3A, along C-60 downstream from pump station S-140, and at the terminus of the L-28 Interceptor Canal.

Completion of L-29 across the southern end of WCA-3 in 1962, coupled with improvements to several major canals (Miami Canal, L-67A Canal, L-29 Canal, and L-38W Canal) interrupted the historic flow of water southward, causing the ponding of water at the extreme south end of WCA-3A. This construction resulted in longer periods of inundation and relatively deeper water levels in the southern portion of WCA-3A as compared to the central portion of the marsh. These hydroperiod changes resulted in a loss of wet prairie habitat, with an increase in aquatic slough communities which may have benefited snail kite populations in this area by providing favorable habitat for the production of apple snails, the primary food source of this endangered species.

Water Conservation Area-3B

Plant communities within WCA-3B exhibit typical Everglades vegetation consisting of a mosaic of tree islands, wet prairies, sawgrass stands, and aquatic slough communities. This area has changed little since the enclosing levees were completed in the early 1960s. Tree islands in this area, however, are threatened by the invasion of melaleuca, which has become firmly established as a seed source within the Bird Road/Pennsuco wetlands located just east of WCA-3B in western Miami-Dade County.

Holey Land Wildlife Management Area

The Holey Land Wildlife Management Area is an extensive sawgrass marsh. The plant communities that occurred historically in the area experienced marked changes in the past due to increased drainage, decreased hydroperiod, drought and fire. The area is now beginning to recover from this damage in response to the restoration project, but problems remain. The Holey Land Wildlife Management Area is located in the north end of the Everglades ecosystem, in an area that has historically been dominated by nearly monospecific plains of sawgrass. Since drainage projects were initiated in the late 1800s, 74 percent of these sawgrass plains have been lost to agriculture. Holey Land Wildlife Management Area represents nearly 23 percent of the remainder of this important component of the original Everglades habitat. The following plant associations can be recognized.

The natural tree island association has been reduced by muck fires and soil subsidence. This association exists on elevated sites and is composed of varying quantities of red maple (*Acer rubrum*), dahoon holly (*Ilex cassine*), wax myrtle (*Myrica cerifera*), elderberry (*Sambucus simposonii*), and willow (*Salix caroliniana*). Fifty-four artificial tree islands were created in the southwest portion of the area in the early 1970s and are now mostly vegetated.

The weed and brush association occurs on slightly less elevated sites and along the borders of the area. The overstory vegetation is primarily salt bush *(Baccharis halimifolia*) and wax myrtle. The understory consists of fennels (*Eupatorium* spp.), goldenrods (*Solidago* spp.), Southern fleabane (*Erigeron quercifolius*), thistles (*Cirsium horridolum*), asters (*Aster* spp.) and loosestrife (*Lythrum lineare*). This area had expanded in response to the overdrainage that Holey Land had experienced, but since hydropattern restoration was achieved in 1991, brush has been greatly reduced, especially along the northern and southern borders of the area.

The sawgrass/wet prairie association occupies wetter sites on the area. The predominant species in this association are sawgrass (*Cladium jamaicensis*) and maidencane (*Panicum hemitomon*). Other species that occur in reduced numbers include cattails (*Typha* spp.), arrowhead (*Sagittaria lancifolia*), pickerel weed (*Pontederia lanceolata*) and smartweed (*Polygonum* spp.). The Holey Land has experienced an explosion of cattail growth since hydroperiod restoration in 1991. Aerial surveys begun in 1990 found only about 100 acres of cattails, but by 1995 this had grown to 6,480 acres. The cattails were initially found in the deep-water sloughs and expanded outward from these bases. A small fringe of cattails found along the distribution canal may be the result of increased nutrient levels, but high water levels are believed to be responsible for most of the cattails in Holey Land.

The willow/shrub association has been greatly reduced due to higher water levels, and is now found mostly in a sparse band running from the northwest to the southeast across the north-central portion of the area and around solution holes. It is composed of willow brush or trees with almost no understory.

The muck burn-barren association consists of areas where muck soils have been oxidized or burned to the limestone substrate. Vegetation is very sparse, consisting mainly of algae and bladderworts (*Utricularia* spp.). During periods of drought, bare rock is apparent.

Exotic vegetation and other undesirable plants have invaded the area. Melaleuca seedlings are regularly found in the southern half of the area, though no permanent stands have yet taken hold. Brazilian pepper is common along levees, spoil banks, and several artificial islands. Wax myrtle and other brush species hare found along levees in a thick band. The 54 artificial islands built in Holey Land in 1974-75 were planted with a variety of species at the time of construction, but it appears that in some cases, these plantings have failed. At least 5 of these islands have been invaded with Brazilian pepper. A series of spoil banks about a mile in length associated with the northern distribution canal have been taken over by Brazilian pepper.

Rotenberger Wildlife Management Area

The Rotenberger Wildlife Management Area is an extensive sawgrass marsh. The plant communities that occurred historically in the area experienced marked changes due to increased drainage, decreased hydroperiod, drought, and fire. The natural tree island association has been reduced by soil subsidence and muck fires in the 1970s and in 1981. This association exists on elevated sites and is composed of varying quantities of red maple (*Acer rubrum*), dahoon holly (*Ilex cassine*), wax myrtle (*Myrica cerfera*), elderberry (*Sambucus simposonii*), and willow (*Salix caroliniana*). Florida Game and Fresh Water Fish Commission personnel have planted almost 450 trees and bushes of varying sizes on seven remnant islands since 1990. The following plant associations can be recognized.

The old field-weed and brush association occurs on slightly less elevated sites along the borders of the area and in the abandoned Cousin's Ranch and Holper properties. The overstory vegetation is primarily salt bush (*Baccharis halimifolia*) and wax myrtle. The understory consists of fennels (Eupatorium spp.), goldenrods (*Solidago* spp.), Southern fleabane (*Erigeron quercifolius*), thistles (*Cirsium horridolum*), asters (*Aster* spp.), and loosestrife (*Lythrum lineare*). This area has expanded in response to drainage of surrounding lands.

The sawgrass/wet prairie association occupies wetter sites on the area. The predominant species in this association are sawgrass (*Cladium jamaicensis*) and maidencane (*Panicum hemitomon*). Other species that occur in reduced numbers include cattails (*Typha* spp.), arrowhead (*Sagittaria lancifolia*), pickerel weed (*Pontederia lanceolata*), and smartweed (*Polygonum* spp.).

Approximately 3,600 acres of the Rotenberger Wildlife Management Area is covered with cattails, mostly in an area that experienced a severe muck fire in 1981. The areal extent of this cattail invasion has remained relatively constant since yearly vegetative surveys began in 1990. However, depending upon the quality of water provided to the area, and other hydrological factors, cattails may increase following hydropattern restoration until cattail control efforts can be implemented.

The muck burn-barren association is mostly found in the northwest corner of the Rotenberger Wildlife Management Area in the vicinity of a 1995-muck fire. It consists of areas where muck soils have been oxidized or burned to the limestone substrate, resulting in sparse vegetation, consisting mainly of algae and bladderworts (*Utricularia* spp.).

Changes in historic hydropattern have impacted vegetative communities in the Rotenberger Wildlife Management Area. Shorter hydropatterns have permitted brush to invade much of the area, allowed wildfires to damage tree islands, and provided the conditions for muck fires to convert several thousand acres of sawgrass to cattails. Exotic plants have invaded the area and undesirable plant coverage has expanded. Melaleuca seedlings are regularly found in the southern half of the area, though no permanent stands have yet taken hold. Brazilian pepper is common along levees and other disturbed areas. Wax myrtle has invaded former agricultural land, and is found near levees and in the southwestern corner of the area.

J.6.2 Fish and Wildlife

The American alligator, more than any other species, is most often identified with the Everglades and its unique wetland ecosystem. The alligator has made an impressive comeback in terms of population numbers since the 1960s, when the reptile was placed on the endangered species list by the USFWS. Today, alligator populations in the WCAs and throughout Florida have increased in sufficient numbers to support a controlled harvest program (Florida Game and Fresh Water Fish Commission, 1986). Due to concerns over mercury contamination however, alligator harvesting is not permitted within the Water Conservation Areas.

Alligators have been cited to serve an important ecological function by maintaining "gator holes", or depressions, in the muck, which are thought to provide a refuge for aquatic organisms and constitute a concentrated food source for wading birds and other Everglades predators during drought (Kushlan, 1974, 1976a). The validity of this concept is currently being questioned.

Water levels represent the important factor influencing nesting success of alligators in the WCAs. High water levels during the period of nest construction, which occurs from June to early July (Woodward *et al.,* 1989), decrease the availability of nesting sites, which in turn results in decreased nesting efforts (Joanen and McNease, 1979). Optimum nesting effort and success is observed when water levels remain stable or decrease throughout the nesting season (June - September). Significant nest loses due to increasing water levels during the nesting season have been reported by several workers (Joanen, 1969; Jacobsen and Kushlan, 1986; Hines *et al.,* 1968). Joanen *et al.* (1977) reported total submergence of eggs for 48 hours resulted in mortality.

Low water levels during the spring have been associated with decreased nesting (Joanen and McNease, 1972a, b, c; Palmisano *et al.*, 1973; Schemnitz, 1972). Aerial nest surveys were conducted in WCA 2 and WCA 3 in 1988 and 1989 (L.J. Hord, Feb. 8, 1990, Florida Game and Fresh Water Fish Commission comments on Nov. 8, 1989 SWIM Plan). Three hundred and fifty nests were observed in 1988. Only 75 were found in 1989 when the WCAs experienced low water levels in the spring. A water management scheme that promotes maximum habitat and species diversity, while maintaining adequate water levels in the spring, and minimizes water level increases from June through September, would be most beneficial to alligator nesting success (Florida Game and Fresh Water Fish Commission comments on Nov. 8, 1989 Everglades SWIM plan).

Colonial wading birds (Order Ciconiformes) are a conspicuous component of the wildlife communities that utilize the WCAs as both feeding and breeding habitat. These include 11 species of herons and egrets, two species of ibis, the wood stork, and the roseate spoonbill (Robertson and Kushlan, 1984). Historically, white ibis (*Eudocimus albus*) has been the most abundant colonial wading bird species within the Everglades WCA study area. Surveys indicate that the great egret *(Casmerodius albus)* is the second most abundant species (Frederick and Collopy, 1988). The great blue heron (*Ardea herodias*), little blue heron *(Egretta caerulea)*, tricolored heron *(E. tricolor*), green backed heron *(Butorides striatus*), snowy egret *(E. thula*), cattle egret (*Bubulcus ibis*), black crowned night heron *(Nycticorax nycticorax*), and yellow crowned night heron (*N. violacea*), are also common wading bird species found throughout the WCAs. The roseate spoonbill *(Ajaia ajaja)*, a state species of special concern, and the wood stork *(Mycteria americana)*, a Federally listed endangered species, both occur within the study area.

Most wading bird species utilizing the Everglades exhibit seasonal changes in numbers, being, more abundant during the dry season than during the wet season. The majority of species nest in late winter or early spring, although a few, such as the great egret, are reported to nest at different times throughout the year (Kushlan and White, 1977a). The WCAs support additional aquatic avifauna, such as the limpkin *(Aramus guarauna)*, two bitterns *(Ixobrycus exilis* and *Botarus lentiginosus*), the anhinga *(Anhinga anhinga)*, as well as a number of resident and migratory waterfowl.

The reproductive cycle of most Everglades wading birds is tightly linked with seasonal water level fluctuations within the marsh. During the rainy season, when water levels are high, fish and invertebrate prey species repopulate the newly flooded marsh and begin to increase in abundance. As water levels recede during the dry season, the density of these prey species (topminnows, mosquitofish, killifish, crayfish, freshwater prawns and insect larvae) increase as they concentrate in remnant pools and along the edge of the drying marsh. Concentration of aquatic prey species during the dry season provides an easily harvested food source for wading birds. It has been estimated that the standing stock of fish increases from about 50 kilograms per hectare to about 500 kilograms per hectare between the rainy season and the dry season (Kushlan *et al.*, undated). Concentration of these food resources has been shown to be a major factor in the initiation of nesting for the wood stork (Kahl, 1964) as well as for other wading bird species.

Loss of habitat and man-induced changes in the natural hydrologic cycle (i.e. distribution of historical water flows and the timing of seasonal drying of the marsh) are thought to represent the major factors affecting the decline of colonial wading bird species in south Florida. Historically, the Everglades WCAs supported large numbers of wintering and breeding wading birds (Robertson and Kushlan, 1974). South Florida wading bird populations have suffered two major declines in this century. Plume hunting at the turn of the century nearly wiped out several species. Most scientists agree that Federal protection measures enacted in 1910 allowed wading bird populations to rebuild to healthy levels by the 1930s (Allen, 1964; Robertson and Kushlan, 1974; Ogden, 1978; Kushlan and Frohring, 1986; Frederick and Collopy, 1988). Sometime between the late-1940s and the mid-1960s, numbers of breeding wood storks, tricolored herons, snowy egrets, and white ibis declined several orders of magnitude (Kushlan and White, 1977a; Ogden, 1978; Kushlan *et al.*, 1984; Kushlan and Frohring, 1986; Frederick and Collopy, 1988). Kushlan and Frohring (1986) suggest that the decline of the wood stork population coincided with changes in the regional water management system initiated in the 1960s, rather than the gradual declines observed since the 1940s (Sprunt and Kahl, 1960). Although the extent of the population decline is a subject of controversy, much of it has occurred since construction of the regional water management system, largely completed in 1962. The physical compartmentalization of the Everglades by levees and canals has caused major changes in historical flow patterns, water depths, the natural timing of water level fluctuations, and the distribution of water within the WCAs and Everglades National Park (Kushlan, 1987). Water bodies in some areas of the system are now much deeper than they were historically, while other areas of the system are substantially drier. Under both conditions, the natural timing of these water level fluctuations has been altered (Kushlan, 1987). Implementation of the minimum delivery schedule for delivery of water to Everglades National Park in 1970 and the addition of the L-67 extension canal and associated levee has exacerbated these timing and delivery problems, and is thought to be directly related to the poor nesting success of wood storks within Everglades National Park (J. Ogden, pers. com.).

Loss of wading bird habitat due to the conversion of seasonal wetlands to agriculture has also been cited as an important factor. Browder (1976) reported that wading bird feeding habitat south of Lake Okeechobee has been reduced by 35 percent since the turn of the century, resulting from the conversion of sawgrass wetlands to sugarcane farming. It is generally believed that the combined effects of habitat destruction, loss of feeding areas and disruption of historical hydroperiod patterns represent the primary factors affecting the decline of wading bird populations in south Florida.

The majority of wading bird species require shallow water for efficient feeding. White ibis rarely forage in waters deeper than 6 inches, while almost all of the smaller heron species are too short to wade in waters deeper than 8 inches (Custer and Osborne, 1978; Kushlan, 1974). Construction of water management canals and levees have rendered many areas of the WCAs unsuitable as wading bird feeding habitat due to the ponded, deep-water conditions that prevail in these areas.

Regardless of whether a wading bird is a tactile or sight feeder, all species rely heavily on receding water levels during the dry season and the associated concentration of prey species (crustaceans and fish) for optimum reproductive success. The physical concentration of prey species produced by the natural drying of these wetlands is essential for the nesting success of such tactile feeders as the wood stork and white ibis (Kahl, 1964; Kushlan, 1974; Kushlan, 1976a; Frederick and Collopy, 1988). The wood stork is considered to be highly sensitive to seasonal water level fluctuations. Successful nesting requires that a concentration of fish be present within a certain distance of its nesting colony for the entire length of its nesting period (Kahl, 1964). Nesting may not be initiated if there is insufficient concentration of fish due to poor fish production during the rainy season, or due to high water levels during the dry season. Similarly, nest failure is likely if water levels rise before the end of the nesting period. Of all colonial wading birds, the wood stork exhibits the most dramatic response to water level changes. The nesting success of wood storks parallels many other colonial wading bird populations, and is considered a good indicator of the effects of water level changes on colonial wading bird populations in the Everglades. Poor feeding conditions and poor nesting success result from changes in the natural hydrologic cycle (i.e. timing of the seasonal drying of the marsh). Increased or rising water levels during the nesting season cause wood storks, white ibis, and small herons to abandon their nests (Frederick and Collopy, 1988). Slow drying, interrupted drying rates, or late drying of the marsh relative to the normal nesting period all contribute to poor reproductive success of colonial wading birds (Frederick and Collopy, 1988). Stabilized water levels, extended hydroperiods or long term, deep-water conditions provide poor foraging habitat for the majority of Everglades wading birds. The duration of optimal feeding conditions is also an important factor in wading bird nesting success. Prime feeding conditions must be available during the entire nesting period to achieve maximum reproductive success. Optimum conditions for successful breeding would be a long, protracted drying of the marsh that would encompass the entire breeding cycle (nesting and providing forage for fledgling and juvenile birds (Frederick and Collopy, 1988).

White ibis, the most abundant wading bird found in the WCAs, feeds primarily on crayfish (*Procambarus alleni*). This crustacean makes up about 66 percent of its diet by energy content, with other invertebrates comprising 25 percent (Kushlan and Kushlan, 1975). In contrast, wood storks feed almost exclusively on fish (Ogden *et al.,* 1976). Although both species are tactile foragers, differences in prey preference and foraging strategies allow both species to utilize drying wetlands with minimum competition. The diet of sight- feeding wading birds (herons and egrets) generally includes forage fish (topminnows, killifish and mosquitofish), small reptiles (snakes and lizards) and frogs, crustaceans (crayfish, fresh water prawns), snails and insect larvae.

Aerial surveys (Systematic Reconnaissance Surveys or SRF flights) are being conducted to determine the foraging habitat requirements and to map the movement of colonial wading birds (herons, egrets, wood storks and ibis) within the WCAs. Results of these surveys have indicated that white ibis, great egrets, great blue herons, wood storks, little blue herons, snowy egrets, cattle egrets, and glossy ibis are the most common wading bird species utilizing the WCAs, with populations varying widely in relationship to seasonal water level fluctuations. Peak wading bird use of the WCAs often occurs in January in synchrony with receding water levels, with over 121,000 birds being observed at times. Lowest counts have occurred during August with less than 15,000 birds counted. The white ibis is typically the most abundant wading bird observed, with total monthly counts varying as the birds move in and out of the WCAs in response to changing water levels. Great egrets represented the second most abundant species of wading birds observed.

Population estimates showed two residency patterns. Great blue herons and great egrets are residents in the WCAs during the dry season, with consistent population sizes during this period. White ibis, wood storks, and small white and dark herons fluctuate in numbers in response to rising and falling water levels. Peak populations occur during the winter months (often during March), with numbers declining in the spring. These birds leave the WCAs during the wet season. The WCAs provide an important staging habitat for ibis, wood storks, and small white and dark herons prior to their migration to the north.(Hoffman *et al*., 1989).

White-tailed deer (*Odocoileus virginianus)* have lived in the Everglades for centuries, long before the marsh was impounded by a system of levees and water control structures. Information collected in recent years indicates that Everglades deer herds fluctuate widely in response to flood and drought cycles. However, little information is available on the original carrying capacity of the system prior to construction of the present day water management system. In the past, deer populations were generally described as a "boom or bust" proposition, increasing during an extended dry period, and decreasing during prolonged wet periods, depending on water levels. (Florida Game and Fresh Water Fish Commission, 1983).

During high water periods, deer concentrate on tree islands, levees and spoil banks. This creates intense competition for available forage and resting areas, increases the transmission of diseases and parasites, and causes physical and behavioral stress to the animals. If high water levels persist, the food supply becomes exhausted and malnutrition develops, resulting in a large-scale die-off of the herd.

Newly born fawns and crippled or diseased animals are usually the most susceptible individuals within the population. Highest fawning activity occurs in February. If high water levels are experienced during this critical time, then fawn mortality is high. Regression analysis shows a strong negative correlation (r = 0.7) between herd recruitment and marsh water levels. High recruitment is experienced during low water, while low recruitment is typical during high water periods.

The Florida Game and Fresh Water Fish Commission manages essentially four separate deer herds within the WCAs. These are identified as WCA-2A and 2B (managed as one unit), WCA-3A north, WCA-3A south, and WCA-3B. Assessment of these four areas in 1987 indicated that the WCA deer herd was healthy and in good condition based on analysis of percent kidney fat and counts of liver fluke and stomach parasites (Ault, 1989). Prior to 1979, the deer population fluctuated widely from year to year, with higher numbers of animals maintained in the area as compared to levels maintained since 1982.

In 1979 and 1982, two highly publicized water-related die-offs occurred in WCA-3A. The die-off in 1982 required a controversial Special Emergency Deer Hunt (July, 1982) to protect the remaining herd and minimize the extent of deer mortality (Florida Game and Fresh Water Fish Commission,1983). Since 1982, the Commission's policy has been to maintain deer herd size at a carrying capacity that will prevent the large scale die-off experienced in 1982, resulting from prolonged high water levels. The strategy developed to meet this objective was to establish an index (Norton-Griffins index) of the deer population that could survive prolonged high water conditions without having much effect on the overall health of the herd, while keeping the adult sex ratio between 1:2 and 1:3. The population index objectives established for each of the four deer management areas located within the WCAs were 1,000 for WCA-3A north, 1,500 for WCA-3A south, 500 for WCA-3B and 250 for WCA-2A and 2B.

Since 1983, the Florida Game and Fresh Water Fish Commission has collected data and tested management practices, demonstrating that it is possible to control both herd size and adult sex ratios. From 1983 to 1986, the primary short-term objective was to control the sex ratio and herd size. This was achieved by regulating the doe harvest. However, because of this emphasis, herd size remained below the Florida Game and Fresh Water Fish Commission population objectives. In 1987, the Commission initiated a number of management practices designed to allow for an increase in herd size up to the objective. Justification for these actions were based on the following: (1) Only a small die-off resulted from the high water events recorded in the summer of 1986; (2) Herd size was below Florida Game and Fresh Water Fish Commission objectives for each management zone; (3) Sex ratios were at desired levels with the Florida Game and Fresh Water Fish Commission demonstrating their ability to regain control of the population if ratios become skewed; and (4) Increased herd size provides more hunting opportunities.

In 1987, the primary management action taken to increase herd size up to the carrying capacity of these wetlands was to reduce the number of doe tags issued by 83 percent. This strategy however, has not yet produced the desired result, with 1987 and 1988 experiencing below average recruitment. Low recruitment may also be related to the time lag required for herd composition changes to show up in older age class individuals. For 1989, the Commission recommended (a) continuing the restricted doe harvest; and (b) moderate hunting pressure on the buck population to increase recruitment levels.

The Everglades fish community has adapted to a number of severe environmental conditions such as periodic drying of the marsh, high temperature extremes, low dissolved oxygen concentrations, and generally poor water quality experienced during low water periods. Native Everglades fish have developed physiological and behavioral adaptations to accommodate extremes in water level fluctuations and water quality (Dineen, 1974; Schomer and Drew, 1982). Several forage fish species are able to extract oxygen from the water surface, and are therefore not affected by periodic anaerobic conditions. Flagfish, mosquito fish, and the sailfin molly (*Poecilia latipinna*) have been found to be extremely hardy species tolerant of very poor water quality conditions (Dineen, 1974). Many of these fishes have developed reproductive strategies, that allow them to reproduce rapidly to repopulate a newly flooded marsh.

Kushlan (1980 and 1976a) reported that the number and size-class distribution of fishes within the Everglades WCA study area is determined by the annual pattern of water level fluctuations. The seasonal water level variation results in a community dominated by small-bodied, omnivorous fishes with high reproductive potential. Kushlan (1976a) also reported that when natural water level fluctuations are stabilized, there is a shift in the community structure towards a population dominated by larger-bodied, carnivorous fishes, and predation replaces hydrology as the dominant factor influencing community structure.

An accumulation of organic flocculent (dead plant material), can build up as a result of plant growth and mortality during periods of extended high water. This material interferes with fish spawning. Degradation of this material exerts a large biological oxygen demand, which has been correlated with the occurrence of fish kills within the WCA-2A marsh (Dineen, 1972; Worth, 1988).

Generally, Everglades sport fish are harvested from the borrow canals that surround the marsh. As water levels in the canal and marsh rise, fish populations disperse into the interior marsh and reproduce with minimum competition and predation. As water levels recede, fish concentrate into the deeper waters of the surrounding canals, where they become available as prey for wildlife and fishermen. In some instances, the canal fishery has experienced major fish kills due to overcrowding and oxygen depletion.

Studies conducted by the Florida Game and Fresh Water Fish Commission in WCA-2A during 1987 found the abundance and distribution of fish species within the interior marsh and perimeter canals to be quite different. Morello *et al.* (1988) sampled fish populations in the southern portion of the WCA-2A interior marsh and within the L-35B Canal that separates WCA 2A from WCA-2B. Total standing crop of fish in the marsh was low, averaging 24 pounds per acre, but density was extremely high, averaging 24,000 fish per acre. Two small forage fish, the Florida flagfish and bluefin killifish, accounted for 86 percent of the total fish density. Juvenile largemouth bass were collected in the marsh, indicating successful reproduction for the second consecutive year. Higher minimum water levels implemented in 1986 improved spawning habitat for these fish. Between 1982 and 1987, fish standing crop in the marsh varied from 10 to 70 pounds per acre.

The L-35B Canal supported a higher standing crop, but lower densities, of fish as compared to the interior marsh. Total fish biomass and density in the canal averaged 347 pounds and 1,400 fish per acre, respectively. Sport fish were 64 percent of all fish collected. Since 1983, fish standing crop and density were highly variable and dependent on water level. When water levels were low in 1983, standing crop and density averaged 3500 pounds and 8,000 fish per acre, respectively. Similarly during the following five years, there was an negative relationship between water level and electroshocking catch-per-unit effort for density (r = -0.96) and weight (r = -0.97). Under drought conditions, fish become highly concentrated in WCA canals, and at times the Florida Game and Fresh Water Fish Commission removed or greatly increased creel limits as low oxygen levels became critical to fish life (Morello *et al.*, 1988).

The WCAs provide a valuable sport fishery to south Florida. In WCA-2A, 65 percent of the fisherman sought largemouth bass and 22 percent preferred to catch sunfish (Morello *et al.*, 1988). Success rates were high compared to other water bodies in Florida; catch-per-hour for largemouth bass, sunfish, and oscar was 0.66, 2.55, and 3.12 respectively in 1987-88. However, a 34 percent decline in angler use was noted between 1986-87 and 1987-88. During the six-month survey in 1987-88, largemouth bass anglers spent an estimated $265,000.

In WCA-3A, fish sampling in 1988 within the L-67A Canal indicated that gar and bowfin (rough fish species) dominated the sample collection by weight (64 percent) (Morello *et al.*, 1988). Largemouth bass, sunfish, and catfish were also collected. Angler effort for largemouth bass was four times greater in WCA-3A compared with WCA-2A. However, success for largemouth bass, sunfish, and oscar were 0.26, 0.67, and 1.23 fish-per-hour, lower than that observed for WCA-2A.

Besides supporting a valuable recreational fishery for the region, WCA-fish communities provide a major food source for Everglades wading birds, alligators, and other carnivorous reptiles and mammals. Fish community structure and abundance is highly dependent on water levels. Consequently, fishing success by humans or wildlife is also dependent on water levels (Dineen, 1974).

A diversity of mammals, birds, reptiles and amphibians are known to occur in the Holey Land Wildlife Management Area. The species present are indicative of those found in a sawgrass marsh ecosystem. Many of the terrestrial species have been reduced in numbers as a result of hydroperiod restoration, and animals more associated with Everglades marsh habitat have returned to Holey Land Wildlife Management Area.

Several game species occur on the area white-tailed deer (*Odocoileus virginianus*), common snipe (*Capella gallinago*), and marsh rabbit (*Sylvilagus palustris*). Blue-winged teal (*Anas discors*), mottled ducks (*Anas fulvigula*) and other game waterfowl are found in the sloughs of the northeast corner.

A diversity of non-game mammals birds, reptiles, and amphibians are known to occur in the Rotenberger Wildlife Management Area. The species present are indicative of those found in a sawgrass marsh ecosystem. Several game species occur on the area white-tailed deer (*Odocoileus virginianus*), (*Capella gallinago*), marsh rabbit (*Sylvilagus palustris*), feral hogs (*Sus scrofa*) and various waterfowl species.

J.6.3 Water Management

WCA-1 is encircled by 56 miles of levees and canals. A network of pump stations, levees and water control structures, controls water levels. WCA-1 is the only conservation area completely encircled by canals. The water management facilities hydrologically are connected with Lake Okeechobee, the Everglades Agricultural Area, WCA-2, WCA-3 and the Atlantic Ocean. Rainfall represents the major source of water inflow into WCA-1, accounting for about 54 percent of the refuge's water budget. Pump station S-5A, located at the northern tip of the refuge near 20-Mile Bend, moves water into the refuge from the West Palm Beach Canal, accounting for approximately 30 percent of the inflow water. Pump station S-6, located on the refuge's western border, pumps water from the Hillsboro Canal into the southwest portion of the refuge, accounting for about 15% of WCA-1 inflow water. Approximately 45% of the WCA-1 water inflow originates as drainage from agricultural land located north and west of WCA-1. Two small pumps operated by the Acme Improvement District are located in the L-40 levee on the northeastern boundary of the refuge. These pumps drain primarily residential/urban lands (Wellington) and can move water in and out of the refuge. Acme represents only a minor fraction (<1%) of the refuge's water budget. Four water control structures (S-10A, S-10C, S-10D, and S-10E) exist along WCA-1 on the southern levee of L-39 (Hillsboro Canal). The S-10 structures allow water to flow southward out of the Hillsboro Canal and WCA-1 into WCA-2A if so desired. The Hillsboro Canal (L-39), located in the extreme southeast corner of the refuge, drains WCA-1 to the east through S-39, which provides water supply to urban areas and discharges drainage waters to tide water. To the north, the S-5A structure can be used to move water north out of the refuge into the L-8 canal. There are four other small privately operated structures in the L-40 levees; one of these is operated by the USFWS. These structures constitute less than 1% of the refuge's annual water budget. Water management operations for WCA-1 are governed by a water regulation schedule adopted in 1994 (***Figure J-6.3-1***).

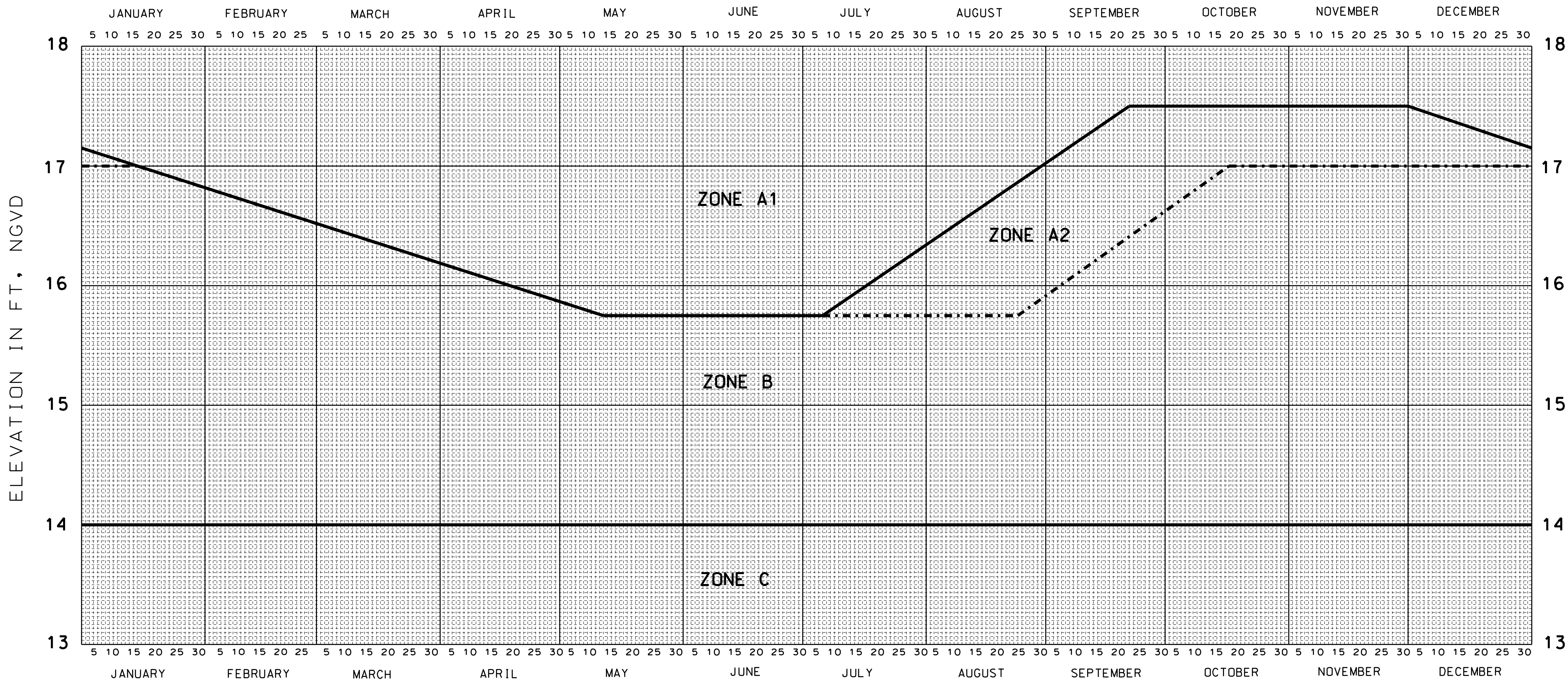
Major developments in the WCAs have been the construction of canals, levees, water control structures and roads. WCAs-2 and 3 are almost completely enclosed by a levee and canal system that is approximately 150 miles in length. The only portion of the area not completely enclosed by the levee system is WCA-3A where a seven-mile section of the western border remains hydrologically connected to the Big Cypress Preserve. Four canals and their associated levees pass through the WCAs: the Miami Canal, L-35B Canal, L-67A Canal, and L-67C Canal.

Many water control structures have been constructed to move water throughout the WCAs. Facilities designed to provide flow into the area include the S-6, S-7, S-8, S-9, and S-140 pump stations, and a series of gated spillways referred to collectively as the S-10 structures. Water is moved from WCA-2A to WCA-3A via the S-11 structures and through WCA-3A via the Miami Canal and a series of bridged openings under Alligator Alley (I-75). Water is released from WCA-3A through the S-12 and S-333 structures and the Pompano and North New River canals. The canals, levees, and water control structures were constructed and are currently operated by the U.S. Army Corps of Engineers and the South Florida Water Management District. The WCAs were constructed primarily to provide flood protection to adjacent agricultural and urban areas, and to serve as a source of fresh water for the heavily populated Lower East Coast. Secondary considerations were the need to manage the areas to benefit fish and wildlife, and to provide public recreation.

Water regulation schedules represent water level targets that govern the operations to store and release water from the WCAs. The water regulation schedule for WCA-2A was originally set too high to support Everglades habitat, and has been the subject of extensive research and experimentation. The original 1961 schedule called for water levels to fluctuate from 12 to 14.5 feet. The schedule was revised even higher in 1970 to a range of 13 to 14.5 feet with only a 30-day period at the lower end. Observed changes in the ecology of WCA-2A caused scientists in the early 1970s to initiate efforts to lower the water schedule and provide for annual drying of the interior marsh. Extended high water killed significant stands of trees, eroded islands, and caused other undesirable vegetation changes in the area (Dineen, 1972, 1974; Worth, 1988). In 1980, the schedule was revised to an interim plan of 9.5 to 12.5 feet, an extreme drawdown that was in place for eight years. Extensive research during this time led to an interim schedule of 11 to 13 feet, which was adopted in 1989 (***Figure J-6.3-2***).

The regulation schedule for WCA-3A is perhaps the most complicated and difficult schedule to describe or implement. The schedule ranges from 9.5 to 10.5 feet, but includes a series of five zones to modify discharges to Everglades National Park when water levels are above or below the optimum target (***Figure J-6.3-3***). The size of WCA 3A and the number of inflow and discharge points preclude intensive management of water levels in the area. Discharges at the southern end of the area flow directly into Everglades National Park. These discharges were modified three times in the past decade to alleviate problems resulting from too little discharge in the early years, and heavy flood discharges during the dry season, which impacted nesting wading birds and other wildlife during the 1970s and early 1980s. The original schedule was set shortly after Everglades National Park and the South Florida Water Management District's predecessor agency was created. In 1970, Congress adopted an Everglades National Park-backed plan to establish a minimum monthly volume of water to be delivered to Everglades National Park. This resulted in significant flood damages from dry-season floodwaters, which were discharged from WCA-3A when the water schedule was exceeded. In 1983, Congress authorized an Experimental Program of Water Deliveries to Everglades National Park, which allowed an experiment with water releases based on rainfall and evaporation over the Everglades. This rainfall-based plan distributes water over a broader area than the original operating schedule whenever possible.

Other problems within WCA-3A, primarily overdrainage in the northern end, are not due to the schedule but instead are caused by the design of water-control facilities. These regulation schedules are open to review and change if the agencies involved find better ways of regulating the water levels.



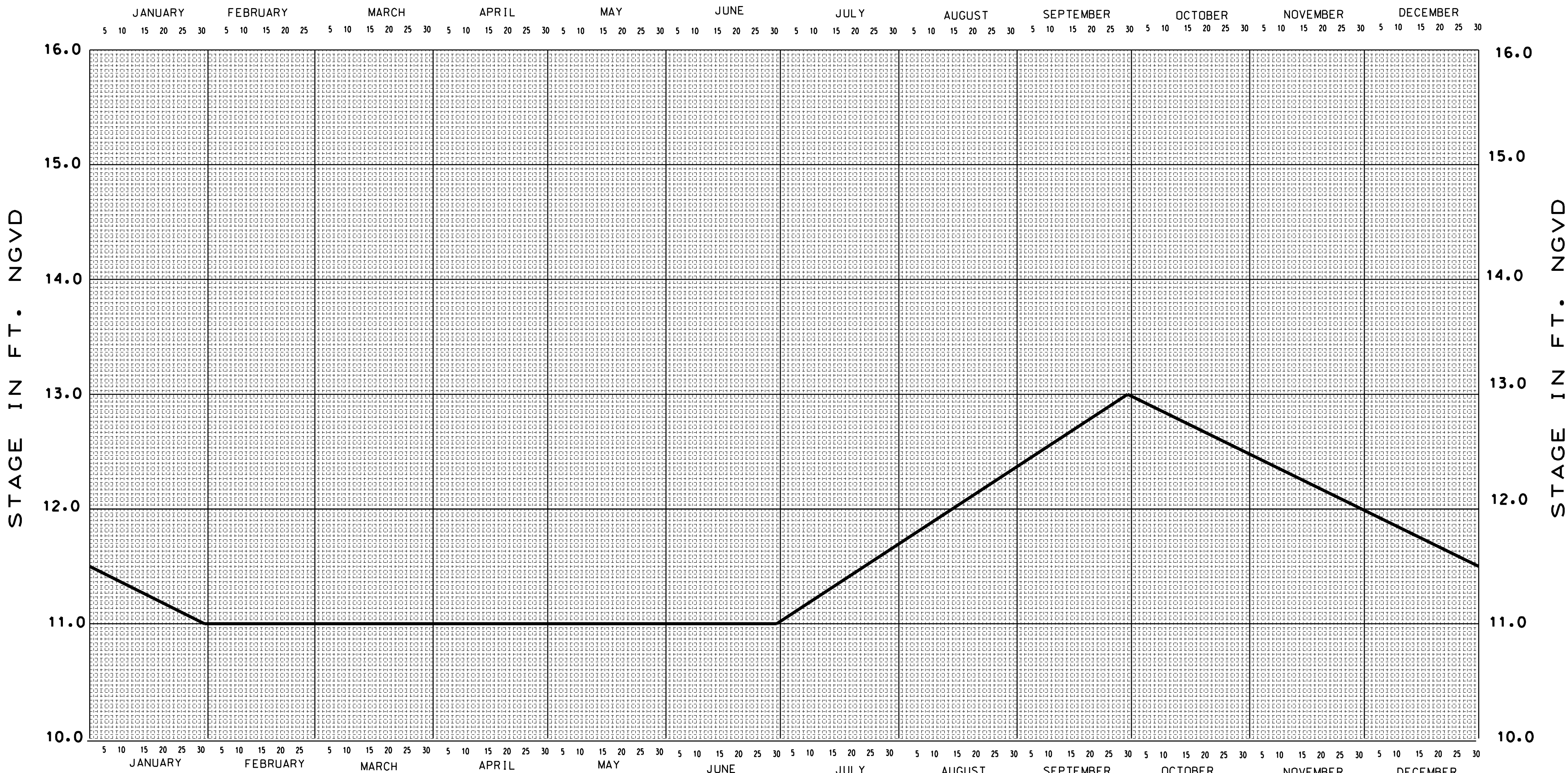
ZONE	RELEASES
A1	UP TO MAXIMUM AT S-10 (AND S-39 WHEN AGREED BETWEEN CORPS AND SFWMD). WATER SUPPLY RELEASES AS NEEDED.
A2	S-10 RELEASES BASED ON CORPS FORECASTS. WATER SUPPLY RELEASES AS NEEDED. IF LAKE OKEECHOBEE STAGE IS ABOVE WCA-1 STAGE OR NO MORE THAN ONE FOOT BELOW WCA-1 STAGE, THEN WATER SUPPLY RELEASES FROM WCA-1 MUST BE PRECEEDED BY AN EQUIVALENT VOLUME OF INFLOW.
B	WATER SUPPLY AS NEEDED. IF LAKE OKEECHOBEE STAGE IS ABOVE WCA-1 STAGE OR NO MORE THAN ONE FOOT BELOW WCA-1 STAGE, THEN WATER SUPPLY RELEASES FROM WCA-1 MUST BE PRECEEDED BY AN EQUIVALENT VOLUME OF INFLOW.
C	NO NET RELEASES FROM WCA-1. ANY WATER SUPPLY RELEASES MUST BE PRECEEDED BY AN EQUIVALENT VOLUME OF INFLOW.

DATES	USE GAGE	CONDITIONS
1 JAN - 30 JUN	1-8 CANAL	ALL
1 JUL - 31 DEC	1-8 CANAL	EXCEPT AS NOTED BELOW
	AVG. 1-7, 1-8T, 1-9	DURING RISING STAGES WHEN CANAL STAGE EXCEEDS AVERAGE.

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE

WATER CONSERVATION AREA NO. 1

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DATED: 03 MAY 1995



ZONE	RELEASES THROUGH OUTLETS AS INDICATED
A	UP TO MAXIMUM CAPACITY AT S-11; MAXIMUM CAPACITY AT S-144, 145, & 146; MAXIMUM PRACTICABLE AT S-143 & S-38 WHEN REQUESTED BY THE CORPS OF ENGINEERS BUT NOT TO EXCEED 11.0 FT., NGVD, IN POOL 2B. L-35B & L-38 BORROW CANALS SHOULD NOT BE DRAWN DOWN BELOW 10.5 FT., NGVD.
B	WATER SUPPLY. L-358 & L-38 BORROW CANAL SHOULD NOT BE DRAWN DOWN BELOW 10.5 FT., NGVD, UNLESS WATER IS SUPPLIED FROM ANOTHER SOURCE.

INDICATOR GAGES FOR REGULATION WILL BE AS FOLLOWS:

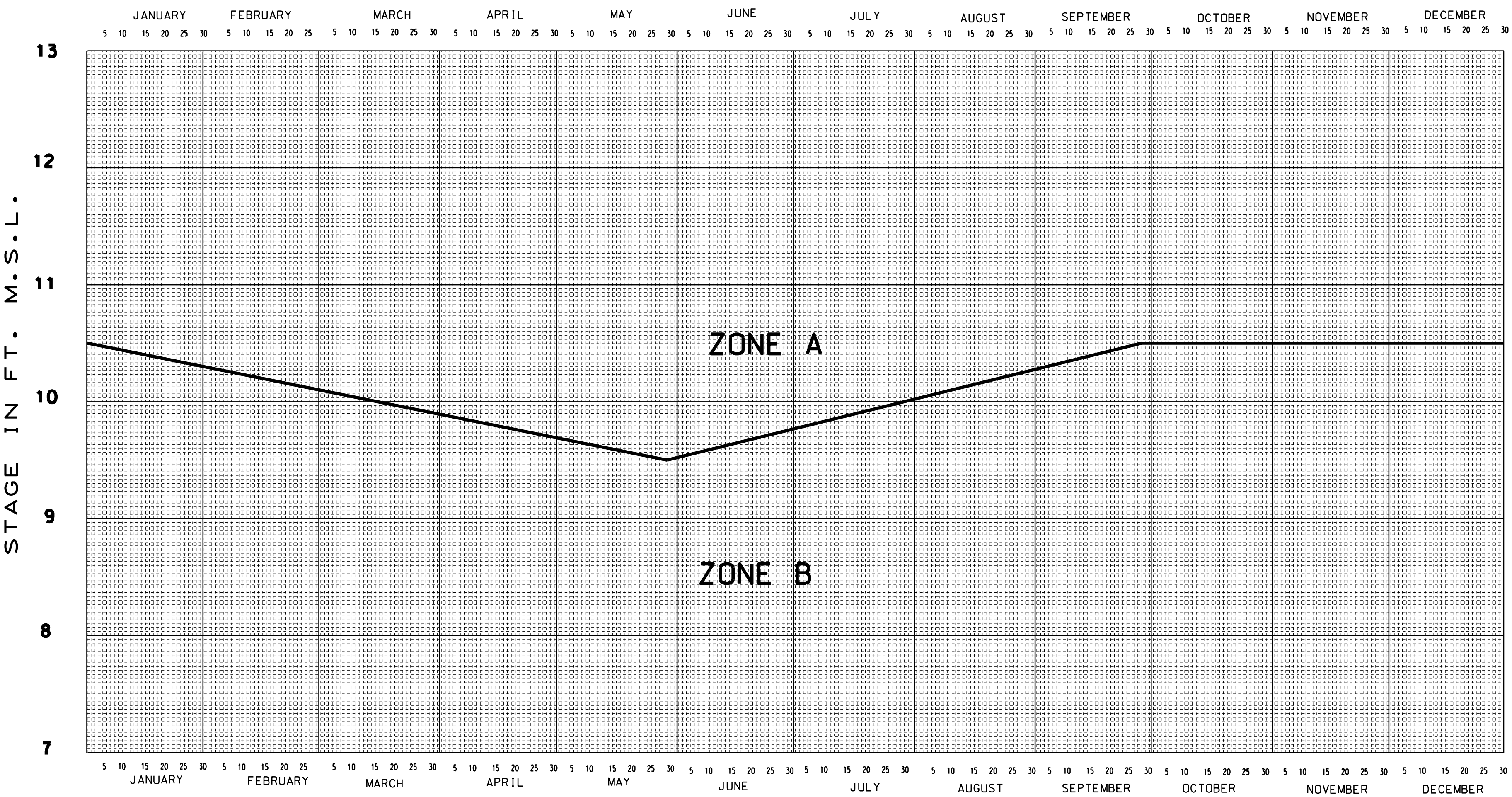
DATE	USE GAGE	CONDITIONS
1 JAN - 31 JAN	2-17	IF 2-17 STAGE RECEDES TO 11.5 FEET, NGVD SWITCH TO S-118 HEADWATER GAGE.
1 FEB - 30 JUN	S-118	ALL
1 JUL - 31 DEC	2-17	ALL

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE

WATER CONSERVATION AREA NO. 2A

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

PROPOSED 3/28/88
COORDINATED 6/21/89



ZONE	RELEASES
A	Up to max. capacity at S-12. Max. practicable capacity at S-151 and S-31 when requested by Corps of Engineers in emergencies.
A & B	To supply project demands and ENP water supply only when agreed to between F.C.D. and Corps.

Note:

During droughts, an optimum floor level will be agreed upon for ecological purposes below which no releases from storage are permitted.

CENTRAL AND SOUTHERN FLORIDA
REGULATION SCHEDULE

WATER CONSERVATION AREA NO. 3A

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

AUGUST 1960

Currently, Holey Land Wildlife Management Area's water regulation schedule is based upon the initial operating plan agreed to by the South Florida Water Management District and the Florida Game and Fresh Water Fish Commission 28 June 1990. This schedule dictates that water stages in Holey Land Wildlife Management Area vary between a low of 11.5' MSL on May 16 to a high of 13.5' on November 1. When direct rainfall is unable to provide enough water to meet the schedule, water is pumped onto the area from the Miami Canal at the G-200 pump station in the northwest corner of the area. Other water enters the area from the G-201 pump station, which returns water to Holey Land from the exterior seepage canal. Outflow is through three set of culverts along Holey Land's south boundary. In accordance with the 1990 Operational Agreement, after cattail coverage exceeded 2,000 acres, flashboards were placed in the outflow culverts and were set at 13.5' in order to retain water in the area as long as possible to reduce the need for pumping untreated water from the Miami Canal. Detailed topographic data on Holey Land Wildlife Management Area, collected after restoration began, found that average ground elevation was approximately 0.5' lower than previously thought and a verbal agreement was made between South Florida Water Management District and Florida Game and Fresh Water Fish Commission in July, 1993 to change the operational schedule to one that lies between 11-13'. Additional research conducted by Florida Game and Fresh Water Fish Commission and the South Florida Water Management District staffs indicated that high water levels in Holey Land Wildlife Management Area contributed to the explosive growth of cattails in the area after restoration began, and that water levels above 12.5' drove deer from the marsh onto surrounding levees. In response to this information, on January 20, 1995, the Florida Game and Fresh Water Fish Commission proposed that the water schedule be again lowered, to 10.5-12.0', a level that has since been used as a guideline by the South Florida Water Management District. A similar (10.75-12.0') schedule was proposed by the Florida Game and Fresh Water Fish Commission on June 11, 1997, and discussions are currently underway to finalize an agreement recognizing this proposed level. The water management plan is designed to simulate a natural hydroperiod for the purpose of restoring and preserving natural Everglades habitat.

The Rotenberger Wildlife Management Area is located in the north end of the Everglades ecosystem, in an area that has historically been dominated by nearly monospecific plains of dense sawgrass. Since drainage efforts began in the late 1800s, 74 percent of these sawgrass plains have been lost to agriculture. The Rotenberger Wildlife Management Area represents nearly 18 percent of the remainder of this important component of the Everglades. Because of development and drainage of surrounding areas, the hydropattern in the Rotenberger Wildlife Management Area has shortened, causing a shift away from its historically sawgrass-dominated community. The distribution, timing, and depths (hydropattern) of water in the Rotenberger Wildlife Management Area have been dramatically changed by drainage to the north and west, as well as in several parcels inside the boundaries. This development, along with construction of canals and levees, has blocked the sheetflow of water southward from Lake Okeechobee; a process which will probably not be reversed. The Rotenberger Wildlife Management Area itself is drained by a series of culverts linked to the L-4 canal. Several sets of culverts drain farmland on existing inholdings while two sets drain abandoned farms on the eastern border into the Miami Canal.

While the current hydropattern in the Rotenberger Wildlife Management Area does mimic the natural rise and fall associated with the wet and dry seasons, it does not receive enough rainfall to reach historic water levels during the wet season and dries much more quickly than normal due to the culverts mentioned above. The 1983 agreement between the Florida Game and Fresh Water Fish Commission, South Florida Water Management District and the Department of Environmental Regulation calls for the restoration of 0-1' water levels in the area. As part of the Everglades Construction Project, these levels have been used as initial goals of hydropattern restoration within the Rotenberger Wildlife Management Area. Achievement of this goal will be a two stage process. First, all drainage culverts will be closed and the effects of this upon the hydropattern will be assessed. This information will be used to devise an operational schedule for the area which will become effective upon completion of STA 5, and installation of the pumps allowing inflow into the Rotenberger Wildlife Management Area.

J.6.4 Water Supply

The Biscayne Aquifer lies beneath the WCAs. The aquifer is a limestone bed 200 feet thick lying along the Broward/Dade coast, tapering to an edge 35-40 miles inland. It is one of the most porous and productive aquifers in the world. Because of its importance and sensitivity to urban and agricultural systems, it has been designated a "Sole Source" aquifer by the U. S. Environmental Protection Agency. Currently, it is common practice to use the WCAs for water storage during high rainfall years. Conversely, during dry periods water is removed for urban and agricultural water supply. These practices result in a detrimental exaggeration of the natural wet-dry cycle. As the population expands in south Florida, competition for water could leave the WCAs with serious water shortages. WCA-3A is used for water supply to Everglades National Park.

J.6.4.1 Water Conservation Area-1

WCA-1, part of Loxahatchee National Wildlife Refuge, includes 227 square miles of Everglades wetland habitat. WCA-1 is part of a huge freshwater storage area connected by a series of canals and levees built by the U.S. Army Corps of Engineers. The essential water management features of the northern WCA system are shown in ***Figure J-6.4.1-1***. The western boundaries of WCA-1 border the Everglades Agricultural Area. The area east of WCA-1 includes a number of

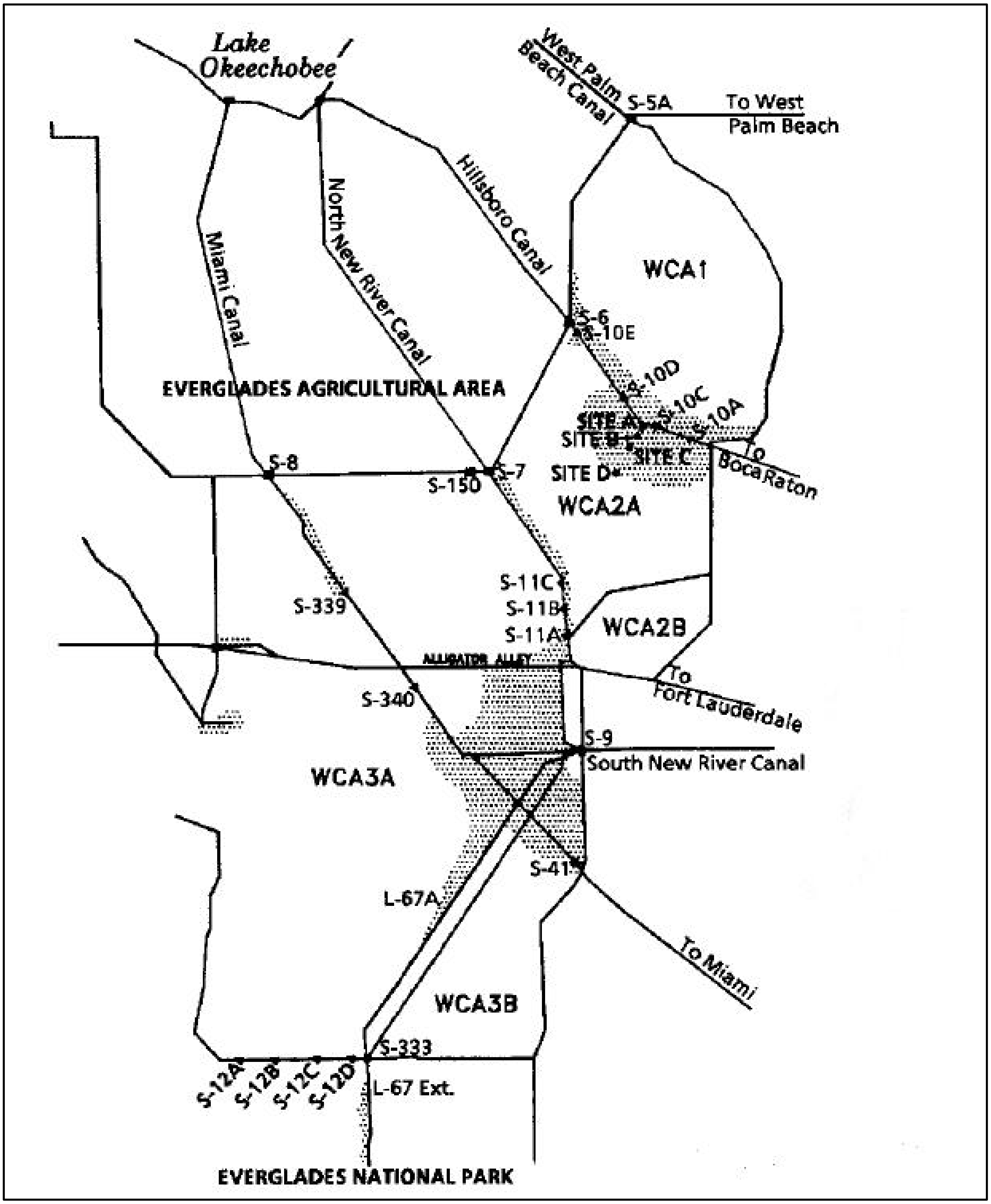


Figure J-6.4.1-1 Cattail Distribution

rapidly expanding urban communities, although several sections immediately adjacent to WCA-1 are undeveloped and contain extensive wetlands. To the south and southwest of the refuge lie WCA-2A and WCA-3A.

WCA-1 is encircled by 56 miles of levees and canals (Everglades SWIM Plan, South Florida Water Management District, 1992). Water levels are controlled by a network of pump stations, levees and water control structures. WCA-1 is the only conservation area completely encircled by canals. The water management facilities hydrologically are connected with Lake Okeechobee, the Everglades Agricultural Area, WCA-2, WCA-3, and the Atlantic Ocean. ***Table J-6.4.1-1*** presents the average annual water budget for WCA-1.

Table J-6.4.1-1
Water Budget For WCA-1
Average Annual Water Volumes
Water Years 1979-1988

Input Source	**Volume (million area feet)**	**Percent of Total**
S-5-A	.314	30%
S-6	.157	15%
Rainfall	.576	55%
Total Input	**1.048**	100%
Output	**Volume**	**Percent**
S-39	.078	7%
S-10A	.084	8%
S-10C	.103	10%
S-10D	.138	13%
S-10E	.047	4%
E.T.	.619	58%
Total Output	**1.086**	100%

Source: Everglades SWIM Plan, South Florida Water Management District, 1992

Rainfall represents the major source of water inflow into WCA-1, accounting for about 54 percent of the refuge's water budget. Pump Station S-5A, located at the northern tip of the refuge near 20-Mile Bend, moves water into the refuge from the West Palm Beach Canal accounting for approximately 30 percent of the inflow water. Pump Station S-6, located on the refuge's western border, pumps water from the Hillsboro Canal into the southwest portion of the refuge, accounting for about 15 percent of WCA-1 inflow water. Approximately 45 percent of the WCA-1 water inflow originates as drainage from agricultural land located north and west of WCA-1. Pump Station S-5A lifts water from this area into WCA-1. Two small pumps operated by the Acme Improvement District are located in the L-40 levee on the northeastern boundary of the refuge. The pumps drain primarily residential/urban lands (Wellington) and can move water in and out of the refuge. Acme represents only a minor fraction (<1 percent) of the refuge's water budget.

Four water control structures (S-10A, S-10C, S-10D and S-10E) exist along WCA-1 on the southern levee of L-39 (Hillsboro Canal). The S-10 structures allow water to flow southward out of the Hillsboro Canal and WCA-1 into WCA-2A, if desired. The U.S. Army Corps of Engineers retains operation and maintenance responsibility for the S-10, S-11, and S-12 structures which control water movement into and out of the WCAs. The District operates these structures under contract with the U.S. Army Corps of Engineers and simply carries out the U.S. Army Corps of Engineers's orders with respect to their operation. The Hillsboro Canal (L-39), located in the extreme southeast corner of the refuge, drains WCA-1 to the east through S-39, providing water supply to urban areas and discharging drainage waters to tide. To the north, the S-5A structure can be used to move water north out of the refuge into the L-8 Canal. There are four other small privately operated structures, which constitute less than 1 percent of the refuge's annual water budget (Everglades SWIM Plan, South Florida Water Management District, 1992).

J.6.4.2 Water Conservation Area-2

WCA-2 encompasses an area of 210 square miles and represents the smallest of the three Everglades WCAs. The essential water management features of the WCA system are shown in Figure J-6.4.1-1. The area is bordered on the west by U.S. 27 and WCA-3A, and on the south by Interstate 75. WCA-2 was created as a critical component of the C&SF Project in the early 1960s. This project was designed to provide flood protection, water supply and environmental benefits for the region. Water levels in this area are controlled by a system of levees and water control structures that encircle the WCA-2A marsh. In 1961, a levee (L-35B) was constructed across the southern portion of WCA-2, dividing the area into two smaller units, WCA-2A, (173 sq. mi.) and WCA-2B (37 sq. mi.), in an effort to reduce water seepage losses to the south and to improve the water storage capabilities of WCA-2A.

Approximately 58 percent of the inflow water entering WCA-2A originates from the Everglades Agricultural Area. Nutrient enriched canal water enters the marsh from the north via four water control structures (S-10A, S-10C, S-10D, and S-10E) located on the L-39 levee (Hillsboro Canal), which drain WCA-1 and the Everglades Agricultural Area, and from the west via Pump Station S-7. The absence of an interior perimeter canal along the marsh's northern levee allows nutrient enriched canal water to sheet flow across the marsh. When surface water stages exceed the regulation schedule, water is discharged from the area, principally through the three S-11 structures (S-11A, S-11B, and S-11C) located along the southwestern levee of WCA-2A. Other minor discharges occur through the C-13 and C-14 basins by way of S-38 (gated culvert) to the southeast, and the S-144, S-145 and S-146 structures which discharge to WCA-2B to the south (Cooper, 1990, in press).

Table J-6.4.2-1 presents the average annual water budget for WCA-2. In contrast to WCA-1 and WCA-3A, which receive the majority of their water from direct rainfall, WCA-2A receives the majority of its water (59 percent) from surface water inflows, including drainage from Everglades Agricultural Area lands and outflows from WCA-1. Rainfall accounted for only 41 percent of the inflow to WCA-2A over the period of record, while the four S-10 discharge structures (S-10A, S-10C, S-10D, and S-10E) and S-7 Pump Station represented 37 and 22 percent, respectively, of the source water inflows into the WCA-2A marsh (Everglades SWIM Plan, South Florida Water Management District, 1992).

Forty-one percent of the water lost from WCA-2A is due to evapotranspiration. The S-11 control structures (S-11A, S-11B and S-11C) account for 45 percent of the water leaving the marsh. Other water losses include discharges through S-38 (4 percent) and discharges to WCA-2B through S-144, S-145 and S-146 (9 percent).

J.6.4.3 Water Conservation Area-3

WCA-3, the largest of the three Everglades WCAs, lies to the west and southwest of WCA-2A. Its boundaries are the L-5 levee, the Rotenberger and Holey Land Wildlife Management Areas and the Everglades Agricultural Area to the north; the L-29 levee, Tamiami Trail (US 41) and Everglades National Park to the south; the boundaries to the east are levees L-30, L-33, L-37 and L-38; boundaries to the west are levee L-28, the Big Cypress National Preserve, and the Miccosukee and Seminole Indian reservations.

WCA-3 is over twice the size of WCA-1 and WCA-2 combined, covering an area of 915 square miles. The area is predominantly a vast sawgrass marsh dotted with tree islands, wet prairies and aquatic sloughs. A cypress forest fringes its western border along the L-28 Gap and expands south to Tamiami Trail. WCA-3A is the only WCA that is not entirely enclosed by levees. A 7.1 mile stretch has been left open on the mid-western side of WCA 3A. This opening, the L-28 Gap, allows overland flows to enter WCA-3A from the Big Cypress and other western basins (Leach *et al.*, 1972). WCA-3 is bisected by several interior canal systems. Major inflows include drainage from the Everglades Agricultural Area to the north (Miami Canal) and a combination of agricultural and WCA-2A sheet flow from the northeast (L-67A Canal). In 1962, WCA-3 was divided into WCA-3A and WCA-3B (786 and 128 sq. miles, respectively) by construction of two interior levees (L-67A and L-67C) so that water losses due to levee seepage could be reduced.

Table J-6.4.2-1 Water Budget For WCA-2A Average Annual Water Volumes Water Years 1979-1988		
Input Source	**Volume (million acre feet)**	**Percent of Total**
S-7	.219	22%
S-10A	.084	8%
S-10C	.103	10%
S-10D	.138	14%
S-10E	.047	5%
Rainfall	.412	41%
Total Input	**1.002**	**100%**
Output	**Volume**	**Percent**
S-38	.043	4%
S-144	.036	3%
S-145	.039	3%
S-146	.030	3%
S-11A	.174	15%
S-11B	.180	15%
S-11C	.179	15%
E.T.	.485	42%
Total Output	**1.166**	**100%**

Source: Everglades SWIM Plan, South Florida Water Management District, 1992

Table J-6.4.3-1 presents the average annual water budget for WCA-3. Rainfall is the major contributor of water to WCA-3A, accounting for over 59 percent (1.85 million acre feet) of its measured annual average inflows from 1978-1988. Primary surface water inflows include the following:

1) The S-11A, S-11B, and S-11C (S-11 structures) account for about 17 percent of all inflows to WCA-3A. These three water control structures transfer water from WCA-2A and the L-38E Canal under U.S. 27 into the northeast section of WCA-3A;
2) Pump Station S-8 (10 percent of all inflows) which drains a 178 sq. mile portion of the Everglades Agricultural Area (S-3 and S-8 basins) served by the Miami Canal;
3) Pump Station S-9 (4 percent) which drains urban lands located in the western C-11 basin in western Broward County;
4) The L-3 Canal (2 percent) which drains the northwest portion of the Everglades Agricultural Area and transfers this water to WCA-3A;

5) Pump Station S-140 (3 percent) located on the western L-28 borrow canal, which drains a 110 sq. mi. drainage area served by the L-28 borrow and the L-28 interceptor canals;
6) The S-150 structure (2 percent) located on the L-5 borrow canal which gravity drains a portion of the Everglades Agricultural Area (the S-7 Basin);
7) The L-28 Interceptor Canal (2 percent) which drains lands west of WCA-3A (i.e. Feeder Canal basin);
8) The L-28 gap which receives drainage waters from the Big Cypress and the L-28 Tie back levee borrow canal; and
9) From the North New River Canal by way of G-123 and S-142 (Cooper, 1990, in press).

Table J-6.4.3-1
Water Budget For WCA-3A
Average Annual Water Volume
Water Years 1979-1988

Input	**Volume (million acre feet)**	**Percent**
S-8	.312	10%
L-3**	.074	2%
S-140	.104	3%
S-11C	.179	6%
S-11B	.180	6%
S-11A	.174	6%
L-281	.071	2%
S-150	.057	2%
S-9	.136	4%
Rainfall	1.851	59%
Total Input	**3.138**	**100%**
Output	**Volume**	**Percent**
S-151	.182	6%
S-12A	.080	3%
S-12B	.075	2%
S-12C	.160	5%
S-12D	.168	6%
S-333	.139	5%
E.T.	2.227	73%
Total Output	**3.031**	**100%**

** = L-3 inflows based on a flow distribution of 75% inflow into the N.W. corner of WCA-3A. PDR 1977-1988; Percents may not equal 100 due to round off error. Source: South Florida Water Management District, unpublished data.

When water levels exceed WCA regulation schedules, water can be discharged to Everglades National Park principally through S-12A, S-12B, S-12C and S-333 to the Tamiami Canal via the S-343 structures; to WCA-3B by way of S-151; and the Big Cypress (BICY). through the S-344 structure. When WCA-3A is being managed for water supply, discharges can be sent to Everglades National Park, southeast Miami-Dade County, South Miami-Dade Conveyance System, WCA-3B, and BICY. Due to the vast size of WCA-3A, nearly three quarters (2.23 million acre-feet) of the water entering the marsh is lost from the system as ET. The S-12 structures (S-12A, S-12B, S-12C and S-12D) located at the extreme southern border of WCA-3A, discharged about 15 percent (0.48 million acre-feet) of WCA-3As water budget into Everglades National Park over the ten-year period of record, while S-333 delivered another 5 percent (0.14 million acre feet). Water control structure S-151 accounted for another 6 percent (0.18 million acre feet) of the water lost from the system.

J.6.4.4 Combined Water Conservation Area Water Budget

Table J-6.4.4-1 presents a detailed summary of the annual water budget prepared for all three WCAs (WCA-1 + WCA-2A + WCA-3A) using a ten year period of record, October 1, 1978 to September 30, 1988 (based on water year). This table includes average rainfall and water volumes for each of the 20 inflow/outflow structures for the entire system.

J.6.5 Land Use

The WCAs are located in western and southwestern Palm Beach, western Broward and northwestern Miami-Dade counties, Florida. They consist of WCAs 1,2 and 3 and encompass approximately 878,000 acres. For management purposes, the area has been subdivided into several units: WCA-1, WCA-2A, WCA-2B, WCA-3A, and WCA-3B. The WCAs are bordered on the east by the Sawgrass Expressway, U.S. Highway 27, and Krome Avenue; on the south by U.S. Highway 41, on the west by the Levee 28 (L-28) and the Miccosukee Tribe of Indians of Florida Federal Reservation; and to the north by L-4, L-5, and L-6.

The WCAs are located near several State and Federal land and water resources. Lake Okeechobee is approximately 25 miles north. State and Federal lands that border the WCAs includes Holey Land Wildlife Management Area, Rotenberger Wildlife Management Area, Miccosukee Tribe of Indians of Florida Federal Indian Reservation, Big Cypress Indian Reservation (Seminoles), Big Cypress National Preserve, and Everglades National Park. The Big Cypress Area of Critical State Concern is adjacent the southwest boundary of WCA 3A.

Table J-6.4.4-1 Combined Water For WCA-1, WCA-2A And WCA-3A Average Annual Water Volumes Water Years 1979-1988		
Input	**Volume (million acre feet)**	**Percent**
S-5A	.314	7%
S-8	.312	7%
S-6	.157	4%
S-7	.219	5%
L-3	.074	2%
S-140	.104	2%
L-281	.071	2%
S-150	.057	1%
S-9	.136	3%
Rainfall	2.823	66%
Total Input	**4.283**	**100%**
Output	**Volume**	**Percent**
S-151	.183	4%
S-12A	.080	2%
S-12B	.075	2%
S-12C	.161	4%
S-12D	.168	4%
S-333	.139	3%
S-38	.043	1%
S-39	.078	2%
S-144	.036	1%
S-145	.039	1%
S-146	.030	1%
E.T.	3.331	76%
Total Output	**4.362**	**100%**

As part of the Central and Southern Florida Project (C&SF), land and flowage easements were obtained for the construction of the three WCAs. Construction of the required levees and canals began in 1949 and the WCAs became functional in 1962. The U.S. Army Corps of Engineers designed, constructed, and currently participates in the management of the WCAs and the water resource. The South Florida Water Management District (South Florida Water Management District) serves as the local management agent under the direction of the U.S. Army Corps of Engineers. WCA 1 became the Loxahatchee National Wildlife Refuge in 1961, and is managed by the U.S. Fish and Wildlife Service. WCAs 2 and 3 were designated as the Everglades Wildlife Management Area in 1952, and are operated by the Florida Game and Fresh Water Fish Commission (Florida Game and Fresh Water Fish Commission) under the terms of a cooperative management agreement with South Florida Water Management District (formerly Central and Southern Florida Flood Control District). The agreement became effective on 1 March 1952 with an initial term of 25 years and three automatically successive terms of 15 years each.

The South Florida Water Management District holds fee title to approximately 27 percent of the WCAs, and has flowage easements over the remainder. The Board of Trustees owns approximately 55 percent, with other public agencies owning approximately 4 percent. Approximately 14 percent of the area is owned by private landowners. The identity of the private landowners and the location of the inholdings are, for the most part, unknown; Palm Beach, Broward and Miami-Dade counties have little or no land records for lands in the Everglades Water Management Area.

In 1982, an agreement between the Board of Trustees of the Internal Improvement Trust Fund, the Florida Game and Fresh Water Fish Commission, the South Florida Water Management District and the Miccosukees was prepared to clarify the documentation and respective rights and responsibilities of the State and the Miccosukees in the 189,000 acres of reservation lands within WCA 3.

South Florida Water Management District has used "Save Our Rivers" (SOR) funds since 1982 to purchase land in the Everglades Water Management Area. Section 373.59, Florida Statutes, created the SOR program, and established the Water Management Lands Trust Fund that contains monies designated for the purchase of environmentally sensitive riverine lands. Funds for SOR are provided by a portion of documentary stamp tax on properties purchased in Florida. Save Our Rivers legislation calls for the management and maintenance of lands acquired with SOR funds in an "environmentally acceptable manner, and to the extent practicable, in such a way as to restore and protect their natural state and condition." The legislation encourages the use of SOR lands for public outdoor recreational activities compatible with the primary goal of environmental protection and enhancement.

Governor Bob Graham initiated the "Save Our Everglades" program on 9 August 1983. This program was designed to improve environmental conditions in the Everglades system. Two of the seven program initiatives directly affected the management of the Everglades Water Management Area. Initiative 4 required the Florida Game and Fresh Water Fish Commission to manage the Everglades Water Management Area deer herd at a level that could survive moderate flooding conditions. Initiative 5 incorporated hydrological improvements in the conversion of State Road 84 to Interstate 75 (Alligator Alley). The five remaining program initiatives provided secondary benefits to the Everglades Water Management Area by providing for land acquisition and hydrological improvements that enhanced water quality and delivery to the area.

In 1989, 14,720 acres in WCA-3A were purchased from the Seminole Indian Tribe of Florida with funds from the South Florida Water Management District and the CARL Program. This tract was added as an amendment to the Rotenberger Wildlife Management Area lease, which names the Florida Game and Fresh Water Fish Commission as lead managing agency. This amendment has a perpetual flowage easement granted to the South Florida Water Management District. The Seminole Tribe has retained non-exclusive use rights in parts of WCA-3A.

The State of Florida passed the "Everglades Forever Act" in 1994. The legislation was written to address environmental concerns related to the quality, quantity, and timing of waters entering the Everglades system. The act provided for the creation of stormwater treatment areas (STAs), set water quality standards for water entering the Everglades system, and required the agricultural community to implement Best Management Practices to reduce phosphorous inputs into the Everglades drainage basin.

The three major roadways that affect the WCAs are U.S. Highway 27, which separates WCA-2 from WCA 3, U.S. Highway 41 (Tamiami Trail) which borders WCA-3 to the south, and Interstate 75, which bisects WCA-3. The roadways, in combination with the existing levee and water delivery systems, have altered the natural hydroperiod of the area and disrupted sheet flow throughout the Everglades Water Management Area. In the past, there has been substantial environmental damage to the WCAs due to severe flooding and drought caused by these alterations.

The Holey Land Wildlife Management Area is a tract of Everglades marsh comprising 35,350 acres, located in the southwest corner of Palm Beach County. It is located immediately north of WCA 3, on the east side of the Miami Canal. It is 17 miles south of Lake Okeechobee and approximately 43 miles north of Everglades National Park. A large portion of the property came to the Trustees of the Internal Improvement Trust Fund (Trustees) through statehood as part of the Federal Swamp and Overflowed Lands Act of 1850. Some of the property may have been acquired under the Environmentally Endangered Lands (EEL) acquisition fund in the early 1970s. The remainder of the property was purchased in order to facilitate restoration of the hydroperiod for the area, possibly through the Save our Everglades Program. Lease #2343, dated July 30, 1968 and issued by the Trustees, leased the area to the Florida Game and Fresh Water Fish Commission for fish and wildlife management purposes. Since that time, the Florida Game and Fresh Water Fish Commission has managed the area for public hunting, fishing and recreational use. From 1968 until 1975, the area was apparently included as part of the Everglades Wildlife Management Area. In 1975, it was established by the Florida

Game and Fresh Water Fish Commission as the Holey Land Wildlife Management Area. Past uses, prior to 1968, are unknown.

Man-made structures include levees associated with the Miami Canal and the L-5 canal. A series of canals and borrow pits enclose the area's northern and eastern boundaries. Boat ramps are located at the northwest (G-200) and southwest (G-201) pump stations. There are three water gauges (Holey G, Holey 1, Holey 2) within the marsh, with another located in the eastern boundary levee (G-203D). These structures are operated by the South Florida Water Management District in accordance with a management agreement with the Florida Game and Fresh Water Fish Commission. The South Florida Water Management District also maintains public roads associated with the Miami Canal and L-5 levees. The road along the crest of the northern and eastern boundary levee is closed to the public because it is too narrow to accommodate two-way public vehicular use. Florida Power and Light maintains high-tension power lines and support pads on the southern boundary of the Water Management Area, and a small electrical transmission line along the Miami Canal levee. A series of 54 artificial islands were constructed in the south- and east-central portions of the area in 1974 and 1975.

The Rotenberger Wildlife Management Area is an area of Everglades marsh comprising 27,810 acres located in the southwest corner of Palm Beach County. The Rotenberger Wildlife Management Area is located immediately north of WCA 3 on the west side of the Miami Canal. It is 17 miles south of Lake Okeechobee and approximately 43 miles north of Everglades National Park. Holey Land Wildlife Management Area is immediately along the east boundary of the Rotenberger Wildlife Management Area. The area was named for Ray Rotenberger, who constructed a small camp and airfield in the area during the late 1950s or early 1960s. Approximately 6,300 acres of the original Environmentally Endangered Lands (EEL) project were purchased by the State on February 17, 1975. Since that time all but about 3,500 acres have been acquired. Although biologists were performing surveys and checking harvests in the Rotenberger area as early as 1970, and it may have been part of the Sawgrass Hunt Area at this time, the area was not included in the Florida Game and Fresh Water Fish Commission wildlife management area system until August 26, 1975. The Rotenberger Wildlife Management Area has been operated under lease # 3581 dated November 13, 1979 from the Board of Trustees of the Internal Improvement Trust Fund (Trustees) since that time, with 6 major lease amendments (1987, 1989, 1990, 1994). This lease also includes some lands on the east side of the Miami Canal that are managed as part of the Holey Land Wildlife Management Area and some 14,000 acres south of the L-4 in Broward County that are operated as part of the Everglades and Francis S. Taylor Wildlife Management Area (known as the Seminole Indian Lands).

Man-made structures include levees associated with the Miami Canal, Manley Ditch, L-4 Canal, the Florida Power and Light Powerline, the Guerry sugar cane farm (834 acres), and the abandoned Cousin's Ranch (940 acres) and Holper (100 acres) properties. An airstrip (formerly known as the Matthews Airfield) was built in the late 1950s or early 1960s by Ray Rotenberger, and there are several cabins and other structures associated with that camp. There used to be a cabin on Wall's Head, but it was abandoned and fell apart some years ago. Another cabin on Cousin's Ranch near the Miami Canal (Wildlife Officer's Camp) has also been abandoned, but is still standing. Several sets of culverts drain from Rotenberger Wildlife Management Area into the Miami Canal and L-4 Canal, and there are a series of culverts underneath the Powerline road. There are two South Florida Water Management District water gauges in Rotenberger Wildlife Management Area (Rotenberger North and South). Sometime in the late 1950s or early 1960s an exploratory oil well was drilled near the south-central boundary. Using shellrock and material dredged from the wetlands a 2-acre support pad and access road to the L-4 North and Powerline levees was constructed, but this site was soon abandoned.

J.6.6 Recreation Resources

All of WCA-1 and some adjacent lands are operated by the USFWS as The Arthur R. Marshall Loxahatchee National Wildlife Refuge. The refuge consists of 227 square miles of Everglades Wetland Habitat including WCA-1 and several out parcels. Created in 1951, the Refuge has the following management objectives: 1) To provide optimum habitat and wildlife protection for endangered and threatened species of wildlife which are native to the Everglades; 2) To provide wintering habitat for migratory waterfowl; 3) To provide habitat for a natural diversity of wildlife species; and 4) To provide opportunities for environmental education, interpretation and wildlife-oriented activities.

Currently the refuge attracts approximately 500,000 visitors a year for wildlife observation, environmental education, sport fishing, waterfowl hunting and other wildlife oriented activities (SFWMD, 1992).

Responsibility for wildlife management within The Everglades Wildlife Management Area (WCA-2 and WCA-3) is delegated to the Florida Game and Fresh Water Fish Commission under lease from South Florida Water Management District. The WCAs have traditionally been used by the public for a variety of recreational activities including hunting, fishing, frogging, airboating, nature appreciation, and camping. Utilization of the interior marsh is limited due to physical constraints and lack of access. Airboats are the primary mode of transportation, while other boats are generally restricted to the canals. Other off-road vehicles (ORVs: tracked vehicles, swamp buggies, all-terrain vehicles, and airboats) are used to access the area when hydrological conditions permit. Recreational users obtain access to the area at fourteen boat ramps and access sites.

The WCAs provides hunting, fishing, boating, ORV use and camping opportunities. Hunting occurs in the fall and winter. The most popular sportfish are bass and sunfish. The majority of fishing activity occurs in the canals. Frogging is permitted throughout the year and, unlike fishing and hunting, does not require a license unless the person is engaged in commercial activity (capturing for sale). Although most fishing can be done from the banks or from a variety of boats, frogging and most hunting is done from airboats. Swamp buggies and tracked vehicles are also used for hunting. Commercial airboat rides are available throughout much of the WCAs. Many of the approximately 65 camps in the WCAs are used throughout the year as weekend retreats and hunting camps.

Recreational access to the WCAs along I-75 is presently limited to four boat ramps. The combined use by shore anglers, anglers fishing the canals by boat, sightseers, airboaters, and ORV operators has resulted in overcrowded and unsafe conditions at established boat ramps. Overcrowding has been a factor identified in the number of people violating Federal Department of Transportation (FDOT) parking regulations to access the WCAs along I-75. Safety concerns are being addressed by constucting four new boat ramps and a large rest area along I-75. Access for recreation enthusiasts such as walk hunting also exist along the L-5 and L-6 levees.

There are several recreation areas located along the boundary of the WCAs: Loxahatchee Recreation Area, Sawgrass Recreation Area, Everglades Holiday Park, Thompson Park, and Mac's Fish Camp. These facilities, along with several along Tamiami Trail, provide boat ramps, camping facilities, boat rentals, airboat tours, fishing guides, bait and tackle supplies, and food.

J.6.7 Aesthetic Resources

The visual landscape of the WCAs is overwhelmingly flat. Landscape features include typical canals, levees and prairie wetlands communities. Access points to the interior of the areas are limited, as discussed in the preceding paragraph. WCA-1 is operated as a wildlife refuge and offers opportunities for observation of migratory game birds during winter months. Although some of the marshlands have been degraded in visual quality by over-flooding and loss of tree islands, other areas, such as WCA 3A south, still preserve good examples of original, undisturbed Everglades communities, with a mosaic of tree islands, wet prairies, sawgrasss expanses, and deeper sloughs. From the elevated viewpoint of the Eastern Perimeter Levee system, or EPL, the view westward to the marshes is panoramic, though mostly homogenous.

J.7 LOWER EAST COAST AND BISCAYNE BAY

The Lower East Coast region (***Figure J.7-1***) extends about 100 miles in a north-south direction, through the coastal portions of Palm Beach, Broward and Miami-Dade Counties. To the north it is bounded by the Palm Beach - Martin County line. Its western boundary is, from north to south, (1) Lake Okeechobee; (2) the Everglades Agricultural Area; (3) the eastern edges of WCAs 1, 2A, 2B, 3A, 3B; and (4) Everglades National Park. In southern Miami-Dade County its southwestern boundary is the Overseas Highway. Thus, the Lower East Coast region includes the north end of Key Largo, all of Biscayne Bay, and the West Lake and Lake Worth Lagoons. The region includes the cities of West Palm Beach, Ft. Lauderdale and Miami and the urban strip that connects them. This is the most densely populated region of Florida, supporting more than 4 million people. It also includes the protected resources of Biscayne National Park.

The following physiographic provinces are represented in the region: Coral reefs (the northern end of the Florida reef tract), Atlantic barrier islands (beaches and dunes), extensive estuarine lagoons and bays (Lake Worth, West Lake and Biscayne Bay), coastal plains (often mangrove-lined), the Atlantic Coastal Ridge (a slightly elevated limestone outcropping that parallels the coast), the Lakebelt limestone mining area, pine rocklands, and the nearly flat marl or peat marsh lowlands to the west of this ridge (Everglades proper) (Science Sub-Group, 1994).

Of all the regions, the Lower East Coast may present the most extreme contrasts between intense urban development and full exploitation of natural resources, on one hand, and preserved remnants of natural ecosystems, on the other. The freshwater surface drainage has been converted almost completely to a series of artificial canals. In the Lakebelt region, limerock mining has created a series of deep, vertically walled pits that have replaced significant portions of the original marshes. Residential development, especially in and around Miami, has virtually filled all available space, and is now expanding vertically. Miami is a fast-growing metropolis whose demands for horizontal space, water resources and other regional services are felt throughout the region. However, this region still advertises itself as a mecca for outdoor life; showing the watery resources of Biscayne Bay, the glades, the waterbirds and the coastal islands as a backdrop in its promotional material.

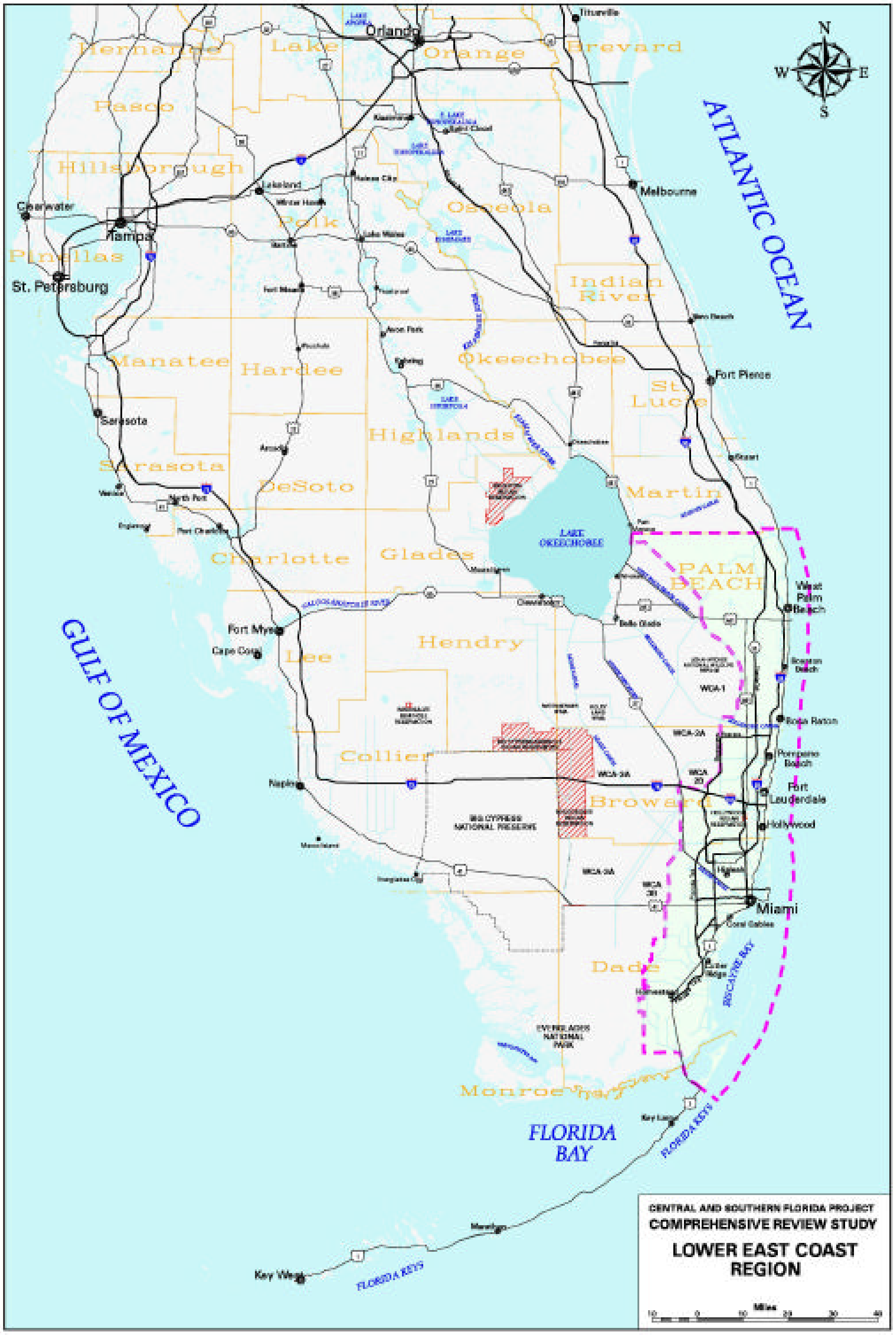


Figure J.7-1 Lower East Coast and Biscayne Bay Region

J.7.1 Vegetation

Plant cover types in the inland zone (behind the coastal ridge) are basically all wetland types. Roughly from west to east, and from north to south, they are: emergent marshes (glades) and wet pine flatwoods in the north, and glades and pine rocklands in the south. The freshwater marshes of the north generally developed over peat and are dominated by sawgrass, (*Cladium jamaicense)*. Toward the south, a second, shorter hydroperiod wetland type, over a marl substrate, is generally dominated by muhly grass (*Muhlenbergia*) and associated species. Smaller fractions of the interior landscape are occupied by hardwood hammocks (tree islands), freshwater sloughs (dominated by floating leaved or floating herbaceous plants), and scrub-shrub wetlands (dominated by willows and buttonbush). Coastal plant communities include mangrove-salt marsh communities, seagrass communities lining the lagoons and bays, dune scrub and coastal hardwood hammocks on the barrier beaches and Atlantic Coast Ridge.

Due to the intense development of the Lower East Coast region, many typical cover types are now represented as tiny relicts in county parks, State or Federal reserves. This is especially true of the least flood-prone types such as coastal hammocks and hardwood hammocks of the Atlantic Coastal Ridge, as well as the pine rocklands and short-hydroperiod rocky glades. Farther north, development has all but eliminated coastal scrub, dune and the drier pine flatwoods communities, leaving only the wetter western pine flatwoods. Examples of upland and coastal plant cover types are preserved in Biscayne National Park, Matheson Hammock County Park, Fairchild Tropical Garden, Crandon Park, Cape Florida and Oleta River State Recreation Areas in Miami-Dade County; John Lloyd State Recreation Area in Broward County, and Spanish River Park and John D. MacArthur State Park in Palm Beach County.

Today, all the natural habitats of the Atlantic coastal area have been so reduced in extent that examples of any natural community in good condition are considered environmentally sensitive areas by county governments. The loss of so much upland and wetland habitat along the Atlantic coast has greatly diminished the abundance and diversity of native plants and animals in southeast Florida. Because important wildlife, particularly birds, move great distances across south Florida, losses in this area clearly affect the WCAs and Everglades National Park.

Many of the wetlands in the region have suffered decreases in water levels, changes in water quality, changes in frequency and seasonality of burning, physical damage from vehicles or wild pigs (introduced from Europe by man) or other kinds of disturbance. The most visible sign of stress in these wetlands is vegetation change with increases in the numbers of weedy native species, such as cattail and primrose willow, and exotic species, such as melaleuca and Brazilian pepper. At the same time, many native plants disappear, either directly because of the disturbed environment, or because they are crowded out by weeds.

The following paragraphs describe the wetland areas that occur in the Lower East Coast and that are considered to be regionally significant. These wetlands may be impacted by changes in regional operations, such as changes in seepage due to higher or lower stages within the WCAs. Some major wetland areas may be examined as potential detention areas for possible backpumping scenarios.

Loxahatchee Slough. The slough, located in northern Palm Beach County, is a diverse area of native wetland habitat interspersed with pineland, oak and subtropical hardwoods. Large portions of this area have been acquired through the Save Our Rivers Program.

Strazzula. This tract is located east of, and adjacent to, the Arthur R. Marshall Loxahatchee National Wildlife Refuge, which is also known as Water Conservation Area 1 (WCA-1). The area is a combination of sawgrass marsh and cypress slough. Water supply to this area comes from rainfall and seepage from WCA-1.

Everglades Buffer Strip. This land is located in Broward County along L-37 and between the North and South New River Canals. Approximately 2,044 acres of the buffer strip have been purchased by the South Florida Water Management District. The area has been impacted by invasion of exotic vegetation and rock mining. Water supply to the area is primarily by rainfall and seepage from WCA-3 under L-37 and L-33.

Dupuis Reserve / J.W. Corbett Wildlife Management Area / Pal-Mar. These areas are contiguous. They are very large areas of natural habitat in Palm Beach and Martin counties. The Dupuis Reserve and the J.W. Corbett Wildlife Management Area are in public ownership. The Pal-Mar tract is under consideration for purchase by Save Our Rivers. Only those portions within Palm Beach County will be considered in this plan. Water supply to these areas is primarily from rainfall.

Bird Drive / Pennsuco / North Trail / Dade-Broward Levee. These areas once were part of the Everglades and are located in the general area of north central Miami-Dade County. These areas are influenced by development, including extensive rockmining, and are in the cone of influence of the Miami-Dade County's Northwest Wellfield. Adjacent canals overdrain portions of these areas.

C-111. A high percentage of the C-111 area wetlands, which are east of Everglades National Park, are undeveloped. Some of the other C-111 wetlands generally are areas that have a low to moderate level of disturbance. The C-111 wetlands provide habitat for several endangered species. Land cover includes pineland remnant, tropical hardwood hammocks and sawgrass glades. Restoration of sheetflow to Florida Bay through the C-111 area is in the planning stages.

Endangered and threatened plant species reported from the Lower East Coast region include crenulate lead-plant (*Amorpha crenulata*), deltoid spurge (*Chamaesyce deltoidea* ssp.), Small's milkpea (*Galactia smallii*), tiny milkwort (*Polygala smallii*), four-petal pawpaw (*Asimina tetramera*), Garber's spurge (*Chamaesyce garberi*), and beach clustervine (*Jacquemonatia reclinata*).

In their natural state, the coastal communities were capable of recovering from disturbances. However, exotic plant and animal species have become prominent on the barrier islands and spoil islands. When areas are disturbed, these species invade and prevent native species from becoming re-established. Many of the exotic species are West Indian or tropical in origin. As such, they are vulnerable to freezes, leaving occasional windows of opportunity for re-establishment of native species.

Nuisance exotic plant species include the common tropical "Australian pine" (*Casuarina equisetifolia*), Brazilian pepper (*Schinus terebinthifolius*), climbing fern (*Lygodium microphyllum*), melaleuca (*Melaleuca quinquenervia*), lather leaf (*Colubrina asiatica*), and calophyllum (*Calophyllum inophyllum*).

J.7.2 Fish and Wildlife

This section contains a brief description of the major faunal groups within the Lower East Coast and Biscayne Bay.

J.7.2.1 Fish

Biscayne Bay contains a large and diverse fish fauna. At least 512 species occur in the bay. Both temperate and tropical species are represented. Tropical species are more prevalent in the summer. and temperate species partially replace them in the winter (SFWMD, 1995). Large number of marine invertebrates inhabit Biscayne Bay. Over 800 species have been documented. The abundant fauna results from the presence of both the tropical West Indian Province and the temperate Carolinian Faunal Province (SFWMD, 1995).

Marine invertebrate diversity on the western side of the bay is greatly affected by canal inputs. Large freshwater pulses into the bay tend to move as masses of low salinity water that do not immediately mix with the marine water. These low salinity plumes can be detrimental to marine invertebrates. Relict oyster shell beds at the mouth of creeks have been documented. Living oyster groups no longer inhabit these areas because of increased salinity. The canals reduce the amount of freshwater in natural creeks thus increasing the salinity levels and killing off the oysters.

Freshwater fish found in south Florida canals include most of the species that are common to the rest of the south Florida region. Mosquitofish and killifish dominate remnant glades and sloughs. Lakes and ponds are often stocked with such gamefish as largemouth bass, bluegill and other sunfish, and black crappie. An interesting fresh water sport fishery has developed around the introduced exotic peacock bass.

J.7.2.2 Wildlife

Major bird rookeries in Biscayne National Park include Chicken Key, Bird Key, the Arsenicker Keys, and the mangrove shoreline on the western bank of the park (SFWMD, 1995). Additional Lower East Coast rookeries include Greynolds Park (North Miami), Fisherman's Island (Lake Worth Lagoon), and islands in the Fort Lauderdale executive airport lakes. Local bird nesting, roosting, and feeding habitat is shrinking due to increased urbanization on lands adjacent to the park. In addition, some colonial nesting shore birds (i.e. ibis) have been targeted for population reduction to make flight traffic safer in south Florida. City, county and state parks, Biscayne National Park, and tree islands in the interior wetlands are vital habitat for migrants that pass through south Florida. In urbanized areas the commonest birds belong to the perching bird group (passerines), and constitue a mix of exotics, such as the rock dove, starling and the English sparrow, and human tolerant natives such as the kingbird and the mockingbird. A very large number of exotic species belonging to the parrot family has escaped and become naturalized in the Lower East Coast region. In agricultural areas west of the urban ridge, cattle egrets and other long-legged wading birds are the most conspicuous group. Other species include typical marsh birds such as the red-winged blackbird, marsh wren, rails, other herons, and bitterns.

Mammal species in the wetland dominated western edge of the region include white-tailed deer, racoon, marsh rabbit, water rat and otter. Mammalian life near urban areas is limited to tolerant speces, including introducted European house mouse and roof rat, bobcat and grey fox, opossum, armadillo, grey squirrel and feral housecats and dogs.

Common amphibians include many species of frogs, including leopard frog, pig frog, bullfrog, green tree frog, fire-bellied newt and dwarf newt. Reptiles are not common in urban areas. In agricultural areas and in the western wet flatwoods and marshes, many species of turtles and snakes, and the American alligator are common. Alligators once seriously threatened by overhunting, are ubiquitous in suburban drainage canals, rainwater detention ponds and canal. Loggerhead, and to a smaller degree, green sea turtles, nest on the Atlantic barrier beaches opportunistically (mostly along stretches of unlighted beach).

Endangered or Threatened wildlife species in the Lower East Coast region include the Stock island tree snail, American crocodile, American alligator, wood stork, eastern indigo snake, Atlantic salt marsh snake, Florida panther, West Indian manatee, loggerhead, leatherback, green, hawksbill, and Kemps Ridley sea turtles, Florida scrub jay, bald eagle, snail kite, Audubon's crested caracara, red-cockaded woodpecker, Kirtland's warbler, Bachman's warbler, and the piping plover.

J.7.3 Water Management

The Lower East Coast functions as a multipurpose canal system with several objectives including: Flood control, urban water supply, industrial water supply, agriculture water use, protection and enhancement of wetland and estuarine systems, prevention of saltwater intrusion, and recreation. The Lower East Coast system is capable of moving vast quantities of water during the wet season as well as supplying water (if available) during the dry season or as needed. Important freshwater canals are, from north to south, C44, C18, C17, C51, Hillsboro canal, North New River canal, Miami canal, New River canal, C9, C8, C7, C4, C100, C100c, C1, C102, C103, C109, C110, C111, and the South Dade Conveyance System.

Approximately half of the acreage farmed in the Lower East Coast is irrigated (UFBEBR, 1995). This region is highly dependent on the system of canals, levees, and other structures for flood control in the wet season and water supply in the dry season. Providing adequate drainage and flood control to the South Miami-Dade County agricultural area is a serious challenge because the farmland is directly adjacent to Everglades National Park. Evidence suggests that efforts to provide flood control to agriculture have resulted in over-drying the eastern portions of Everglades National Park and adversely affecting Park ecology. Agricultural land does, however, provide a buffer between urbanization and Everglades National Park. Farmland is recognized as the preferred neighbor to natural areas because of its minimal impervious areas, open green space, and low population density. A strong agricultural economy in the Lower East Coast region based on profitable crop production is the best defense against conversion of agricultural land to urban land.

The major estuaries in the Lower East Coast are Lake Worth Lagoon in Palm Beach County, West Lake in Broward County and Biscayne Bay in Miami-Dade County. Lake Worth Lagoon was predominantly a freshwater system as recently as 100 years ago but was converted into a marine system with construction of permanent inlets to the ocean. West Lake is 1,400 acres of coastal wetland and mangroves in Hollywood along the Intracoastal Waterway. Biscayne Bay is a subtropical lagoon about 40 miles long that extends the length of Miami-Dade County.

Prior to urban development, freshwater discharge to Biscayne Bay consisted of flows through natural drainageways, overland flow and groundwater discharge from the aquifer. However, the flow has changed from short bursts of rainy season flow through low drainageways, to regulated releases through drainage canals and decreased periods of groundwater discharge (SFWMD, 1995). The construction of the canal system lowered the regional water table and subsequently reduced the amount of groundwater flow into the bay. Groundwater discharge into Biscayne Bay is believed to occur through both seepage and flow through subsurface leakage channels. A zone of seepage occurs around the perimeter of the bay where the water table elevation is higher than sea level. Subsurface flow occurs through natural leakage channels in the rock formations. Prior to the construction of drainage canals, springs flowed along the shore and emanated from the bottom of the bay. However, present day rates of groundwater discharge into the bay are insufficient to produce such flowing springs (SFWMD, 1995).

Surface water flows into Biscayne Bay and Lake Worth Lagoon are primarily controlled by the system of canals, levees, and control structures built as part of the Central and South Florida Flood Control Project. Biscayne Bay receives freshwater surface flows from 17 surface water basins through 12 major coastal structures (SFWMD, 1995). Lake Worth Lagoon's freshwater input is principally from the C-51 canal. The mechanism of surface water flow into Biscayne Bay and Lake Worth lagoon are short, intense pulses of freshwater discharged at discrete locations. This flow has replaced the historic sheet flow through the wetlands adjacent to the bay that existed before development of the canal system. Dry season flows into these water bodies are much lower than pre-drainage levels because most of the discharge into the bay is from storm water release from the canals. The canal discharge can bring sediments, heavy metals, pesticides, fertilizers, herbicides, nutrients and low salinity plumes, which can all adversely affect the biota (SFWMD, 1995).

J.7.4 Water Supply

Water availability in Subregion 9 depends on rainfall and storage capacity in surface and groundwater systems. The Lower East Coast is a producer, as well as south Florida's largest consumer, of fresh water. Florida's heaviest rainfall occurs along the Atlantic Coastal Ridge between Boynton Beach and Miami, where the annual average is as high as 64 inches (1975 data). Rainfall decreases inland and is only 52 inches over Lake Okeechobee (Davis 1943; Klein et al. 1975; McPherson et al. 1976)

The Lower East Coast is dependent on shallow, unconfined surface aquifers for urban and agricultural fresh water. Broward and Miami-Dade counties rely entirely on groundwater. Groundwater accounts for 80-90 percent of Palm Beach County's potable water. Most groundwater (100 percent in Miami-Dade, 90 percent in Broward, 85 percent in Palm Beach) is pumped from depths of less than 46 m. (150 ft.); many wells are much shallower (Alvarez and Bacon 1988; Rodis and Land 1976). The Biscayne Aquifer, the largest and most productive unit of the surface aquifer system, is one of the area's most valuable natural resources. It underlies an area of about 7,770 km^2 (3,000 mi^2), including all of Miami-Dade County and most of Everglades National Park, all of Broward County, and part of south Palm Beach County. The aquifer is composed of sandy limestone and calcareous sandstone with many solution holes and cavities. It is one of the most permeable aquifers ever investigated and probably the most permeable water-table aquifer in the world (Brown and Parker 1945; Kreitman and Wedderburn 1984; Parker et al. 1955; SFWMD 1994a; Schroeder et al. 1958). Aquifer recharge is mainly by direct infiltration from rainfall, supplemented by water carried into the area by canals to supply wellfields and prevent coastal saltwater intrusion during the dry season.

The Biscayne Aquifer was designated a sole-source aquifer for Miami-Dade and Broward counties in 1979 by the EPA under the Safe Drinking Water Act. It is also the primary source of drinking water for Palm Beach County North of Boca Raton, except West Palm Beach, which is supplied by another component of the surficial aquifer that is not as productive as the Biscayne Aquifer. West Palm Beach is the only major municipality supplied by surface water. The source is Clear Lake just inland from the coast (Klein et al. 1975; SFWMD 1992, 1993, 1994a).

Table J-7.4.1-1 lists the total water demand of 1,000.53 MGD for the 3 county area (Miami-Dade, Broward, and Palm Beach) in 1995. Public supply is the primary demand in all three counties.

J.7.5 Socio-Economics

Agricultural land is a prominent feature of the Lower East Coast region. The South Miami-Dade Agricultural area encompasses 90,000 acres in Miami-Dade County. Vegetables are the major products, at 56 percent of total sales. Nurseries and fruit products comprise the balance at 30 and 14 percent, respectively. Agriculture in Palm Beach County covers approximately 29,000 acres in citrus and vegetables. Nurseries are also present and expected to expand in this county. Broward County's agricultural resources are present, but diminishing as residential development expands. Although 34,000 acres were in agriculture in 1935, the amount of agriculture had decreased to 6,000 acres by 1989. This trend is expected to continue with agriculture almost nonexistent by 2010 (Science Subgroup 1996).

Table J-7.4.1-1
Water Use Estimates For Miami-Dade[2], Broward, And Palm Beach Counties (MGD)

Use Category	Palm Beach	Broward	Miami-Dade	Three County Total
Domestic PS	124.85	144.57	245.76	515.18
Commercial PS	28.88	38.56	60.68	128.12
Industrial PS	5.12	6.54	11.93	23.59
Other PS	2.99	2.84	4.24	10.07
Public Use	25.04	29.79	49.92	104.75
Public Subtotal	186.88	222.39	372.53	781.71
Domestic SS	17.19	2.16	12.71	32.06
Comm/Industrial SS	22.95	0.34	43.38	66.67
SS Subtotal	40.14	2.50	56.09	98.73
Golf Courses	43.10	23.44	13.75	80.29
Thermoelectric	0	0.49	1.35	1.84
Other Irrigation	8.28	28.64	3.04	39.96
Total	278.40	277.37	446.76	1000.53

PS – Public Supply SS – Self Supply

[1] Data is from Water Withdrawals, Use, Consumption, and Trends in Florida, 1995, USGS Water Resource Investigation Report 98-4140, and unpublished USGS data.

[2] Miami-Dade county demands includes Florida Keys (Monroe county); the Keys are supplied from Miami-Dade County well fields.

Citrus farming has been practised in the Lower East Coast, but is on the decline. Miami-Dade County lost over 50 percent of its citrus during Hurricane Andrew and by 2020 only 1,667 acres will still be farmed for citrus. By 2020, citrus farming in Broward County is projected to be insignificant and Palm Beach County will have approximately 10,121 acres in citrus production.

Limerock mining is also a substantial industry in the Lower East Coast region. Miami-Dade and Broward County mining operations provide more than half the construction grade rock used in Florida. Rock mining converts three to four hundred acres of land into deep lakes annually (Science Subgroup).

Biscayne Bay is fished both commercially and recreationally. The major economic fisheries include sport fish, such as tarpon, bonefish, snook and permit; food finfish, such as groupers, pompano, snappers, hogfish and mackerels; shellfish, such as shrimp, spiny lobster and crabs; and bait, such as shrimp, pilchard, ballyhoo, pinfish, mullet, thread herring, Spanish sardines and anchovies (SFWMD, 1995).

The dockside value of the commercial fishing industry for the combined years of 1982 and 1983 was estimated at $1.3 million. At the retail level, the commercial catch from the bay excluding lobsters was worth about $2.75 million for the same period. These figures only include the dockside value and do not take into account income which is generated in the fishing industry itself or from sport fishing (SFWMD, 1995).

In 1996 over 573,000 pounds of fish were reported to the Florida Marine Fisheries Commission from commercial fishing as being taken from Biscayne National Park and surrounding waters (Card Sound and Barnes Sound). Bait shrimp accounted for 335,118 pounds of the commercial catch. Finfish accounted for 67,800 pounds, shrimp for 51,194 pounds, and lobster and crab for 115,289 pounds.

In 1996, over 55,000 boats used Everglades National Park with 59 percent engaged in recreational fishing. The areas of the park that were most often fished were those along the reef tract. The second most popular area was inside the bay in the Caesar Creek vicinity. Most of the recreational fishermen were from the local area with less than 0.5 percent from northern Florida or out of state. For the period of April 1996 through March 1997, an estimated 548,297 fish were caught in BNP from hook-and-line fishing, and 16,729 fish were caught from spearfishing. For the spiny lobster season, which lasts from August through March, an estimated 67,329 spiny lobster were caught. This number does not include data gathered from the two-day mini-season, which occurs before the commercial season opens.

In addition to fishing, BNP supports a large tourist industry. Concession-run tour boats leave from Convoy Point daily for snorkeling trips, scuba diving trips, and glass bottom boat tours. People come to see the coral reefs and the associated marine organisms. Tourists are increasingly coming from foreign countries (BNP, 1983). The number of visitors coming into the visitor center as calculated by park staff for 1996 was 25,602 and for 1997 was 33,887. In 1996, 20 environmental education programs were conducted for 517 students. In 1997, the number of programs increased to 75 to accommodate 2,815 students. In addition, 8,565 visitors participated in the 300 public programs, including boat tours, island tours, snorkeling, and diving programs led by park staff in 1996. In 1997, 8,968 visitors took part in 253 public programs.

South Miami-Dade County faces large population increases in the next two decades. Population data from 1994 estimates that south Miami-Dade supports 151,625 people. Between 1994 and 2015, the south Miami-Dade population is expected to increase by 200 percent, supporting about 450,000 residents by 2015.

The region around the former airforce base is expected to support much of this growth, reaching nearly 138,000 people by 2015. The 1994 population distribution in south Miami-Dade was higher east of US Highway 1 on lands closer to BNP.

J.7.6 Land Use

The Lower East Coast supports the densest population in the state of Florida. Population in the Lower East Coast is expected to increase by 35 percent, from 4,518,401 in 1995 to 6,086,700 in 2020. Land use in the Lower East Coast is primarily related to urban activities and the infrastructure (such as transportation and utilities) needed to support this large number of people. Urban demands are expected to increase by 39 percent by 2020. If however, the Lower East Coast experiences a 1-in-10 year drought during the planning period, than the projected urban and agricultural demand will increase about 43 percent.

J.7.6.1 Urban

South Miami-Dade County is defined as the area south of SW 184th St. (Eureka Drive). US Highway 1 bisects the area. West of US 1, land uses are primarily estate and low-density residential uses within the Urban Development Boundary (UDB). Other higher density residential uses, business/office, and industrial uses are found in Homestead and Florida City. The Redlands and other agricultural areas are west across the UDB and make up most of the approximately 55,000 acres of agricultural lands that remain in south Miami-Dade County. The Urban Expansion Area designation identifies agricultural lands in south Miami-Dade County as the next place for development.

Additional Lower East Coast urban-related land uses include the Florida Power and Light nuclear power plant at Turkey Point, landfills, rock mining, Homestead Airforce Base, and a number of marinas scattered throughout Biscayne Bay and Lake Worth Lagoon.

J.7.6.2 Agriculture

Palm Beach, Broward and Miami-Dade Counties are included in this region. More than 100,000 acres are farmed (UFBEBR, 1995). This region is characterized by small farms averaging less than 50 acres, with very high productivity of more than $3,500 per acre (UFBEBR, 1995). A variety of crops are produced including vegetables, tropical fruits, and nursery plants. Hurricane Andrew, which struck southern Miami-Dade County in 1992, caused significant damage to agricultural areas. Many fruit tree orchards were damaged or destroyed. Statistics from 1996 indicate that avocado production had recovered, but mango and lime orchards had not yet recovered from the hurricane damage (FASS, 1997b). Total acres of tropical fruit production in Miami-Dade County remain approximately 7,000 less than pre-hurricane levels (FASS, 1996e). Foliage plant production is also a major business in

Broward and Miami-Dade counties. More than 120 million square feet were devoted to the foliage crop in Broward, Miami-Dade, and Palm Beach Counties in 1996 (FASS, 1997a).

Agricultural production and services employ approximately 18,000 people in this region representing a $23 million payroll (UFBEBR, 1995). The total market value of agricultural products from this region is almost $400 million (UFBEBR, 1995). Miami-Dade County ranks second in the state for total market value of agricultural products (UFBEBR, 1995).

J.7.7 Recreation Resources

Recreation resources in the Lower East Coast region include an abundance of inland and coastal water resources that provide water and upland recreation opportunities. Many City, County, State parks and recreation areas are interspersed within the heavily urbanized boundaries. Approximately 115 miles of urbanized coastline provide popular seaside recreation resources where boating, fishing, swimming, diving and many other opportunities are available. The Intracoastal Waterway also provides a diverse water-based recreation resource in the region.

Biscayne National Park, DuPuis Reserve State Forest, and the Loxahatchee River – Lake Worth Creek Aquatic Preserve also provide high quality recreation opportunities for boating, fishing, and nature interpretation activities within the Lower East Coast region. J.W. Corbett Wildlife Management Area and Southern Glades Wildlife and Environmental Area are large tracts of land that provide recreational ammenities and may be affected by the Restudy. Altered water deliveries to this region could have a detrimental affect on many natural and recreational resources in the area. The good quality land and water based recreation resources in the Lower East Coast region receive extensive use and future demand is anticipated to increase.

Recreational activities of Biscayne National Park include both land and water related activities. During the summer, as many as 1,000 boaters visit the park each day (BNP, 1995). Pleasure boating, sailing, swimming, snorkeling, scuba diving, sunbathing, bird watching, water-skiing, and fishing are some of the water-based recreational activities. Land activities are mostly concentrated on Elliott Key, Adams Key and Boca Chita Key because these islands have facilities. Camping and picnicking accommodations and interpretive/nature trails exist on both Boca Chita and Elliott keys. The historic lighthouse on Boca Chita Key is open to visitors while a ranger is present. Interpretive programs led by park rangers are available throughout the year. Most of the programs emphasize the unique naturalness that BNP provides within the Miami-south Miami-Dade County metroplex.

J.7.8 Aesthetic Resources

The Lower East Coast visual resources include the heavily developed urban strip, with high-rise apartments, hotels and condominiums, extensive pavement and little green space, broad sandy beaches, tropical colored Bay waters, inland marshes and mangroves of Biscayne National Park, and the contrasting low-relief inland agricultural areas, drained by parallel canals, and planted to row crops, tropical fruit trees, or citrus. Many large commercial, industrial, and residential areas in the Lower East Coast are not in optimal condition. Sprawling warehouse and trade zones around Miami Airport exemplify industrial "aesthetics". Residential developments continue to spread and change the visual character of the regional landscape.

The Atlantic Ocean and Intracoastal Waterway (IWW) shorelines provide panoramic views from many locations. White shoreline sand contrasts sharply with tropical colored waters of the ocean and the sound of surf or trade winds are important aesthetic characteristics of the coastal area. However, high-rise structures in many locations restrict visual access to the ocean panorama and tend to diminish the visual experience from the shoreline. Visual access to the scenic IWW is also limited. Heavily used highways intersect the region from Palm Beach to Homestead. Air traffic noise is an increasingly adverse aesthetic impact.

In contrast, Biscayne National Park offers these intangible aesthetic values by providing visitors with an escape from the surrounding metropolitan area. BNP is a place where people can come to enjoy the natural scenery and the quiet of nature. Most of the visitors come to appreciate the picturesque vistas of Biscayne Bay. Others opt to explore the underwater seascape. They are interested in seeing the reefs along with the associated fish and other marine organisms. Glass bottom boats and diving/snorkeling trips give visitors the opportunity to view marine life up close. Aesthetic values are often degraded by aircraft noise and city light intrusion during the nighttime hours.

J.8 EVERGLADES NATIONAL PARK AND FLORIDA BAY

Everglades National Park covers over 2,000 square miles at the southern tip of the Florida Peninsula. It is bounded on the west by the Gulf of Mexico, on the north by Big Cypress National Preserve and Water Conservation Areas (WCAs) 3A and 3B. On the east it is bounded by residential suburbs of Miami and farmlands of Homestead and Florida City. The Park's southern boundary encloses about 85 percent of Florida Bay. Florida Bay includes the waters between the Everglades National Park coastal land and the Florida Keys, from Cape Sable on the northwest to Blackwater Sound, on the east. ***Figure J.8-1*** shows regional boundaries.

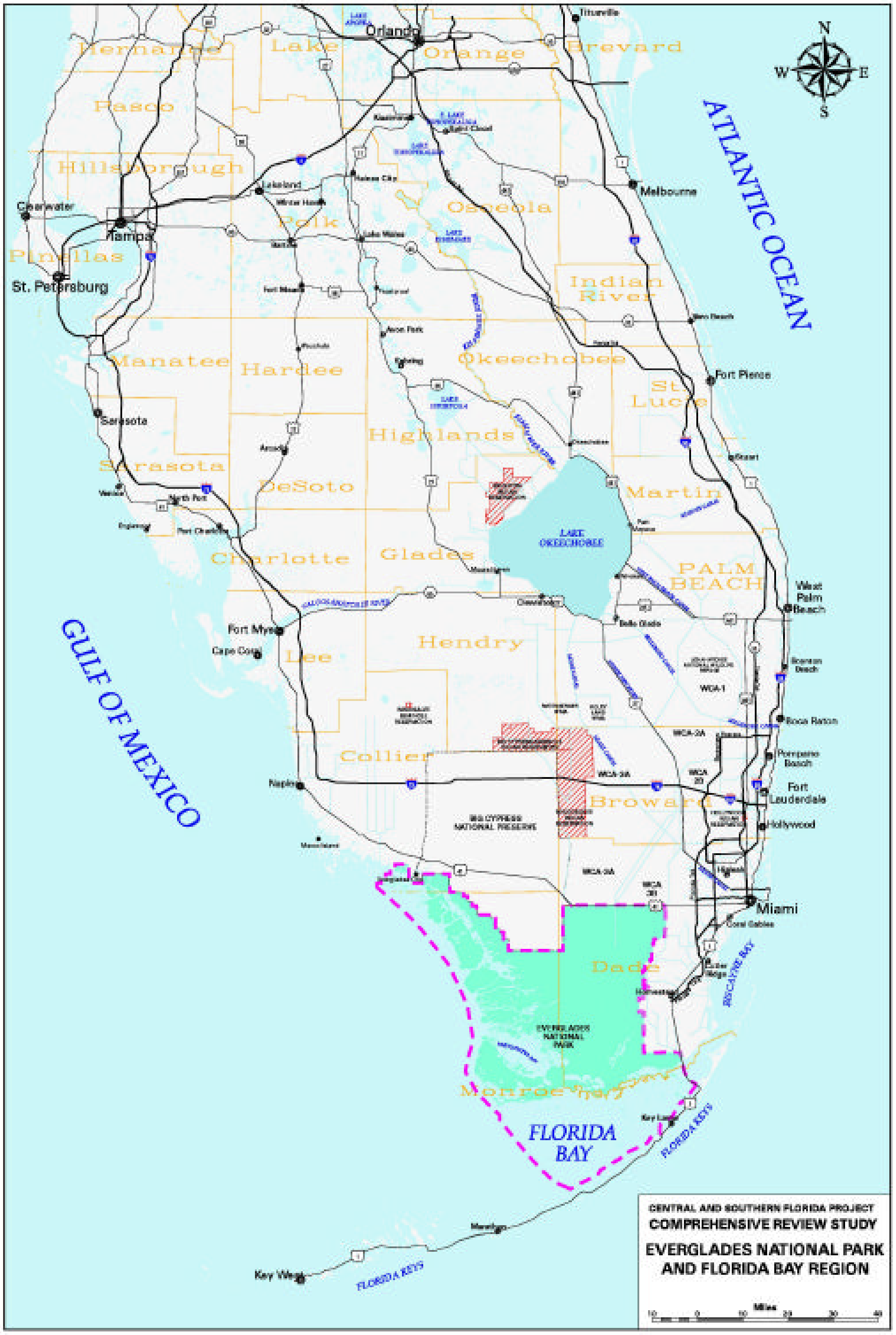


Figure J.8-1 Everglades National Park and Florida Bay Regions

J.8.1 Vegetation and Wetlands Communities

Everglades National Park covers most of the tip of south Florida. It is one of the largest freshwater wetlands in North America. ThePark contains a complex and diverse set of interdependent communities, all driven to a large extent by hydrology and fire (Gunderson and Loftus, 1993). Fire has been recognized as a dominant force in structuring pinelands, forests, and prairie communities. (Additional factors shaping Everglades communities are alligators, which actively keep open water available as refugia during the dry season (Fogarty, 1984); hurricanes (Armentano *et al*. 1995) and prior human use and disturbance. The diverse plant communities comprising the Everglades landscape have been grouped by a variety of methods and conventions. These communities are discussed here according to the conventions used by Gunderson and Loftus (1993).

J.8.1.1 Major Plant Communities

Major plant communities are generally divided between wetland and upland plant communities with further division into freshwater and marine or salt tolerant plants. Benthic communities of Florida Bay are discussed separately.

In the Everglades ecosystem and within Everglades National Park, plant communities are interspersed forming a vegetation mosaic. This heterogeneity is required to sustain the existing natural inter-relationships and natural diversity of Everglades National Park. The following list (***Table J-8.1.1-1***) of the principal plants of the major plant communities is derived from South Florida Water Management District (1992) and Gunderson and Loftus (1993) and was supplemented with other references. Major upland plant communities within Everglades National Park are; pine rockland, tropical hardwood hammock and salt tolerant coastal strand. Major wetland plant communities found within Everglades National Park, ranging from longest to shortest hydroperiod are; ponds, sloughs, sawgrass marsh, wet prairies, Bayhead/swamp Forest, willow heads, cypress forests. Saline wetlands found within Everglades National Park include *Batis* marsh, halophytic graminoid prairie, coastal transition marsh, coastal prairie, salt marsh, mangrove scrub forest, buttonwood scrub forest, mangrove forest, and buttonwood forest. Marine communities include; hard bottom, soft bottom, seagrass, mixed seagrass-macroalgal communities; and plankton (Schomer and Drew, 1982; SFWMD, 1992).

Table J-8.1.1-1 Characteristic Vegetation By Community Type Everglades National Park	
Community Type	**Characteristic Vegetation**
	Freshwater and Upland Communities
Wetland Communities	
Ponds- a. c.	(D) White water lily (*Nymphaea odorata*); (D) Floating heart (*Nymphoides aquatica*) Bladderwort (*Utricularia foliosa*); Water hyssop (*Bacopa caroliniana*) Fire flag (*Thalia geniculata*); Pickeral weed (*Pontederia cordata*);Spatterdock (*Nuphar luteum*)
Sloughs Long hydroperiod a. c.	(D) White water lily (*Nymphaea odorata*);(D) Floating heart (*Nymphoides aquatica*) Bladderwort (*Utricularia spp.*); Spatterdock (*Nuphar luteum*)
Sawgrass Marsh Tall a. c.	(D) Sawgrass (*Cladium jamaicense*); *Justicia angusta*; Spikerush (*Eleocharis cellulosa*) Cattail (*Typha latifolia*)
Sawgrass Marsh Intermediate height a. c.	(D) Sawgrass (*Cladium jamaicense*); Swamp lily (*Crinum americanum*); Arrow arum (*Peltandra virginica*); Spider lily (*Hymenocallis latifolia*);Shy leaf (*Aeschynomene pratensis*); Everglades morning glory (*Ipomoea sagittata*)
Wet Prairies (peat) a. Eleocharis marshes	(D) Spikerush (*Eleocharis cellulosa*); (D)Spikerush (*Eleocharis elongata*)
Rhynchospora flats a.	(D) Beak rush (*Rhynchospora tracyi*); Water rush (*Rhynchospora inundata*)
Maidencane Flats a.	(D) Maidencane (*Panicum hemitomon*); Water pricon (*Paspalidium geminatum*) Swamp lily (*Crinum americanum*); Water hyssop (*Bacopa caroliniana*) Arrowhead (*Sagittaria lancifolia*); Water drop-wort (*Oxypolis filiformis*)
Wet Prairies (marl) a. c.	(D) Sawgrass (*Cladium jamaicense*); Muhly grass (*Muhlenbergia filipes*) *Schizachyrium rhizomatum*; White-topped sedge (*Dichromena colorata*) Black-topped sedge (*Schoenus nigricans*); *Aristida purpurescens*; *Panicum tenerum*; *Rhynchospora divergens; Rhynchospora microcarpa*
Wetland Forests	
Bayhead Swamp Forests a. c.	(D) Red Bay (*Persea borbonia*); (D) Sweet Bay (*Magnolia virginiana*) D) Dahoon holly (*Ilex cassine*) (D) Willow (*Salix caroliniana*);(D) Wax myrtle (*Myrica cerifera*);Cocoplum (*Chrysobalanus icaco*); *Sabal palmetto* ; Swamp fern (*Blechnum serrulatum*); Leather fern (*Acrostichum danaeifolium*); Red maple (north) (*Acer rubrum*); Red Mangrove (South) (*Rhizophora mangle*)
Willow heads a. c.	(D) Willow *(Salix caroliniana*); Wax myrtle (*Myrica cerifera*);Button brush (*Cephalanthus occidentalis*); Sawgrass (*Cladium jamaicense*)
Cypress Forests a. c.	(D) Cypress (*Taxodium ascendens*); Sawgrass (*Cladium jamaicense*) *Schizachyrium rhizomatum*; White-top sedge (*Dichromena colorata*)
Upland Forests	
Pine Savanna c. d.	(D) Pine (*Pinus elliotti* var. *densa*); *Randia aculeata*; Myrsine (*Myrsine floridana)*; Willow bustic (*Bumelia salicifolia*); Rough velvet seed (*Guettarda scabra*); *Tetrazygia bicolor*; Varnish leaf (*Dodonea viscosa*)
Hardwood Hammocks a. c. b.	Strangler fig (*Ficus aurea*); Gumbo Limbo (*Bursera simaruba*);Oak (*Quercus virginiana*); Poison wood (*Metopium toxiferum*); Wild tamarind (*Lysiloma latisiliquum*); Cabbage palm (*Sabal palmetto*); Mahogany (*Swietenia mahogoni*);Paurotis palm (*Acoelorraphe wrightii*); Royal Palm (*Roystonea elata*)
Coastal Strand g.	Jamaica dogwood (*Piscidia piscipula*), Blackbead (*Pithecellobium keyensis*) West Indian bluestem (*Schizachyrium semiberbe*) , Sea Grape (*Cocoloba uvifera*)

Table J-8.1.1-1 Characteristic Vegetation By Community Type Everglades National Park	
Community Type	**Characteristic Vegetation**
	Salt Tolerant Communities
Saline Wetland Marshes	
Herbaceous Halophytic Prairie d. c.	(D)*Batis maritima*; (D)Glasswort (*Salicornia virginica*); (D) Sea purselane (*Sesuvium portulacastrum*) (D) Saltgrass (*Distichlis spicata*); Smutgrass (*Sporobolus* spp.)Keys grass (*Monanthocloe littoralis*); (*Paspalum vaginatum*)
Coastal Transition e. f.	Dwarfed red mangrove (*Rhizophora mangle*); Spikerush (*Eleocharis cellulosa*) Sawgrass (*Cladium jamaicense*), Periphyton
Coastal Prairies c.	(D) Gulf Cordgrass (*Spartina spartinae*); Sea-oxeye (*Borrichia frutescens*)
Salt Marshes c.	Sand Cordgrass (*Spartina bakeri*); (D)Gulf Cordgrass (*Spartina spartinae*); (D) Black rush (*Juncus roemerianus*); Fringe rush (*Fimbristylis castanea*)
Forest Associations	
Mangrove Scrub d.	Red mangrove(*Rhizophora mangle*);Black mangrove (*Avicennia germinans*); White mangrove (*Laguncularia racemosa*) (any of the three may be dominant)
Buttonwood Scrub d.	Buttonwood (*Conocarpus erectus*) (D)

a - Gunderson and Loftus, 1993; b. Craighead, 1971; c. SFWMD, 1992; d. Welch *et al*., 1995; e. Egler, 1952; f. Tom Smith, personal communication June 9, 1998, g. Johnson and Barbour, 1990.
D = dominant plants

J.8.1.2 Physical and Physiographic Features

The Park is composed of two primary physiographic regions, the western Lower Everglades Basin and the more eastern Taylor Slough / Florida Bay Basin (Schomer & Drew, 1982). The Lower Everglades Basin has been further sub-divided into Shark River Slough, the Broad River / Lostman's River area, Coastal Swamps and Lagoons, and 4) Cape Sable. The Taylor Slough / Florida Bay Basin has been modified to include the Rocky Glades as part of this basin. The Taylor Slough / Florida Bay Basin is further sub-divided into six physiographic subzones: Rocky Glades; Taylor Slough Headwaters; Upper, Middle, and Lower Taylor Slough; Taylor Slough Coastal Drainage; Coastal Swamps and Lagoons; and Florida Bay. The Rocky Glades or Rocklands are a transition zone between Taylor and Shark Sloughs.

The two main natural water courses through Everglades National Park are Shark River Slough and Taylor Slough. Shark River Slough is a broad southwesterly trending arc of continuous wetland, interspersed with numerous tree islands. The area of freshwater wetlands to the west of Shark River Slough between the Everglades trough and the Big Cypress Basin is known as the Broad River / Lostmans River Drainage (Schomer and Drew, 1982). Taylor Slough is located east of Shark River Slough. It encompasses more than 158 sq. miles of freshwater marsh and extends approximately 20 miles, from its northern source in the rocky glades to Florida Bay (Van Lent, *et al.* 1993).

Florida Bay is a triangular-shaped bay that lies between the northern Florida Keys chain (to about Long Key) and the southern coast of the Florida mainland. It is a mosaic of banks, basins, and small islands. The general bottom contours grade from a depth of less than 1 meter in the east to 2 meters in the west. Basins are as deep as 3 meters, and are separated by a network of shallow, flat-topped banks. These irregular mud banks are the most conspicuous features of Florida Bay covering nearly 75 percent of western Florida Bay (Wanless and Tagett, 1989), and about 10 percent of the northeastern part of the Bay.

J.8.1.3 Plant Community Descriptions

Upland plant communities are restricted mostly to central areas of the main park and have been converted to agricultural area or residential areas within the East Everglades expansion area (SFWMD, 1992). Upland hammocks are found as a component of the freshwater matrix, in association with some portions of pinelands, and as coastal communities. Freshwater wetland communities include forested associations, graminoid (grassy or grasslike) communities and open water habitats (ponds and sloughs). Salt tolerant communities include saline wetland marshes and saline forest associations (mangroves). These communities are found within Everglades National Park in the southern areas bordering Florida Bay and on the Gulf coast in the Shark Slough – Broad River/Lostman's - Ten Thousand Island drainage. They are characteristic of the coastal swamps and lagoons, the lower Taylor Slough area and Cape Sable. These areas represent the downstream drainages of the major sloughs and water courses of Everglades National Park.

Upland Forests

Upland forest types include pine rocklands, tropical hardwood hammocks a coastal strand.

Pine Savanna or Pine Rocklands

Pine forests of Everglades National Park are characterized as a savanna and have an open overstory of south Florida slash pines (*Pinus elliotti* var. *densa*) (SFWMD, 1992). Pine savannas are fire adapted communities that depend upon fire as a controlling factor (Snyder *et al*., 1990). They are greatly reduced in cover, in comparison to historic cover, within Miami-Dade county (SFWMD, 1992). The largest remaining intact pine forests in the region are found within Everglades National Park (Gunderson and Loftus, 1993). The pine rockland habitat has a high species richness within the understory, with approximately 186 species in this association, so that it is the most naturally diverse community within Everglades National Park (SFWMD, 1992).

Tropical Hardwood Forests

These upland forests are locally called hardwood hammocks. They are dominated by a mix of south temperate and West Indian species and represent the most diverse tree association in Everglades National Park (Snyder *et al*., 1990; Gunderson and Loftus, 1993). Hammocks are found in association with pine forests, occur on elevated outcroppings on the upstream side of some tree islands, and are found in association with the saline areas of Everglades National Park. Their species composition is influenced by regional gradients in rainfall, minimum temperature, fire, hurricanes, salinity gradients, surrounding vegetation types, and elevation and character of the underlying limestone. Royal Palm hammock, found adjacent to Taylor Slough, is one of the largest and most distinct hammocks in Everglades National Park. It is distinguished by emergent royal palm trees, *Roystonea elata* and the fact that it was the first protected as a state park in 1916, which was later expanded to what would become Everglades National Park (Small, 1916; Beard, 1938; SFWMD, 1992). These sites have a history of habitation by native American populations and are often the site of archeological artifacts (Beard, 1938; Davis, 1943a).

At least 120 hardwood hammocks are found in conjunction with the pine forests of Long Pine Key (Johnson *et al*. 1983; Olmsted *et al*. 1983). The dominant overstory trees in the hammocks of Long Pine Key are live oak (*Quercus virginiana*), wild tamarind (*Lysiloma latisiliquum*), and gumbo limbo (*Bursera simaruba*). These trees attain heights of 60 feet (18 meters) and diameters of 6.6 feet (2 meters) (Olmsted *et al*. 1981). Other, less common, tree species in the overstory include sugarberry (*Celtis laevigata*), mastic (*Mastichodendron foetidissimum*), and mahogany (*Swietenia mahogani*)(in the southern hammocks). Trees commonly found in hammocks include willow bustic (*Bumelia salicifolia*), lancewood (*Nectandra coriacea*), many species of stoppers (*Eugenia* spp.), pigeon plum (*Coccoloba diversifolia*), marlberry (*Ardisia escallonioides*) (Gunderson and Loftus, 1993; Snyder et al., 1990). Few plants are found on the ground in intact hammocks due to heavy shading by the dense canopy (Snyder *et al*., 1990). Most of the herbaceous flora are epiphytes, including vines, orchids, and bromeliads (SFWMD, 1992).

Coastal Strand

This vegetation is found on coastal dune located behind the saltmarsh or halophytic zone behind the foredune (Johnson and Barbour, 1990). It is influenced by its proximity to saltwater and exposed coast. This area is characterized by Jamaica dogwood (*Piscidia piscipula*), blackbead (*Pithecellobium keyensis*), and West Indian bluestem (*Schizachyrium semiberbe*) with less frequently occurring sea grape and saw palmetto (Johnson and Barbour, 1990).

Freshwater Wetland Vegetation Complex

Freshwater wetlands of the Everglades include forested and non-forested communities. The forested wetlands include bayheads, willow heads, and cypress forests. The nonforested or herbaceous wetlands of Everglades National Park include sawgrass marshes, wet prairies, ponds, and open water sloughs.

Bayhead/Swamp Forests

The clumps of broad-leafed trees that stand out over the low, flat prairies of the Everglades are collectively called tree islands. Tree islands form over slightly elevated areas of peat, marl or rock, where flooding is less frequent than in the surrounding herbaceous marsh. Average annual flooding duration in these forests is 1 - 4 months. Many of the hardwood species cannot sustain prolonged flooding (Gunderson *et al.* 1988). Tree islands primarily contain wetlands species, although some rocky outcrops of relatively higher elevation support tropical hardwood hammocks. The larger tree islands within Everglades National Park are in the shape of an elongated teardrop, generally oriented with the main axis parallel to the main axis of surface water flow. The bayhead or swamp forest is the most common and abundant forested wetland type in Everglades National Park.

Typically, a two "bay" species are canopy co-dominants in this association, hence the name bayhead. Dominant canopy species include red bay (*Persea borbonia*), swamp bay (*Magnolia virginiana*), dahoon holly (*Ilex cassine*), pond apple (*Annona glabra*), and wax myrtle (*Myrica cerifera*). Other, less common species include willow (*Salix caroliniana*) and strangler fig (*Ficus aurea*). These canopy species attain heights of between 26 to 33 feet (8 to10 meters) (Olmsted *et al.* 1980). A dense shrub layer is generally found beneath the canopy, composed primarily of cocoplum (*Chrysobalanus icaco*) but including smaller individuals of the above mentioned overstory species. Other plants in the shrub stratum include buttonbush, (*Cephalanthus occidentalis*) and the large leather fern (*Acrostichum danaeifolium).* The soils in swamp forests are primarily gandy peat, with measured depths of 1 foot to 6.6 feet (30 to 200 centimeters) (Olmsted *et al.* 1980). The surficial soils are composed mainly of decomposing leaf material from the extant vegetation.

Willow Heads

Stands of southeastern coastal plain willow (*Salix caroliniana*) are also called willow heads. These stands have a monospecific overstory and understory, with willow the dominant woody plant. Other, less common, associated herbaceous taxa include phragmites (*Phragmites australis*), sawgrass, and flag (*Thalia geniculata*). Herbaceous vines such as *Sarcostemma clausa*, hemp-vine (*Mikania scandens*), and *Ipomoea sagittata* are commonly found. Willow heads are found on sites with a history of severe soil disturbance, such as a peat fire, lumbering, farming, or alligator excavation (Craighead, 1968a&b). Willow heads are common in the northern central areas of Taylor Slough (Olmsted *et al.* 1980). Large areas of willow are found along the western edges of the Shark Slough, where severe fires burned through bayheads during the early 1970s (Gunderson *et al.* 1987). Willow is also commonly found around alligator holes or ponds. Craighead (1968b) reports that willow is much more widespread now than in previous times, due to changes in the hydrology and impacts of dry season fires. According to Hilsenbeck *et al.* (1979), willow thickets are ecologically important because they serve as feeding, resting, and roosting habitats for many of the herons, egrets, and other wading birds.

Cypress Forests

Cypress forests are relatively minor features of Everglades National Park, occurring east and west of the Long Pine Key area. Two types of forests occur, domes and cypress prairie (Gunderson and Loftus, 1993). Both are dominated by pond cypress (*Taxodium ascendens*). Domes of pond cypress occur in bedrock depressions in northern Taylor Slough (Rintz and Loop, 1979). The domes are characterized by dense stands of pond cypress with diameters up to 1.6 feet (50 centimeters) and heights to 80 feet (25 meters). The domes with lowest soil surface elevations support little other flora, except perhaps a few aquatic species. Domes with higher soil elevations support many of the hardwood species found in bayheads including red bay, swamp bay, wax myrtle, and cocoplum, and have been called cypress heads (Olmsted *et al.* 1980). Cypress prairies of the Everglades were first described by Small (1932). These forests have also been described as dwarf or hatrack cypress (Craighead, 1971). The cypress trees attain heights of less than 16 feet (5 meters) and diameters of less than 8 inches (20 centimeters). The trees are widely spaced. Understory plants include sawgrass, muhly grass, and other herbs and grasses (Rintz and Loope, 1979).

Herbaceous Wetlands

Herbaceous wetland types include sawgrass marshes, wet prairies, sloughs and ponds. Arranged by hydroperiod, wet prairies have the shortest inundation period and ponds and creeks the longest.

Sawgrass Marshes

Sawgrass (*Cladium jamaicense*) is a characteristic plant of the freshwater everglades marsh. Sawgrass marsh is the dominant cover type of the freshwater Everglades. This association is characterized by primarily monotypic stands of sawgrass. Sawgrass grows best on deep peat soils, which result in tall marsh. When it is found on shallower depths of peat a smaller plant form results (Gunderson and Loftus, 1993). It is well adapted to variable flooding and fire regimes. However if exposed to prolonged high water levels during flood conditions, it looses viability (Gunderson and Loftus, 1993; Davis, 1989; Hofstetter and Parsons, 1979). Sawgrass' low nutrient requirements allow it to survive in the oligotrophic waters of the Everglades (Steward and Ornes, 1975.

Wet Prairies

These communities are a group of low-stature marshes defined by soil type and dominant plant species. They include spikerush (*Eleocharis)* marshes, beakrush (*Rhynchospora)* flats, maidencane (*Panicum hematomon)* flats associations that occur over peat soils while marl prairies are dominated Muhley grass and sawgrass (Gunderson and Loftus, 1993). Wet prairie communities occur in Everglades National Park in the central areas of both Shark and Taylor Sloughs as well as in portions of the park expansion area. Loveless (1959) described the associations over peat as Eleocharis, Rhynchospora, and Maidencane flats. Craighead (1971) described them as spikerush and sedge flats. Common emergent aquatic plants in these wet prairies include spikerush (*Eleocharis cellulosa*), beak rush (*Rhynchospora tracyi),* maidencane (*Panicum hemitomon*), arrowhead (*Sagittaria latifolia*), and pickerel weed (*Pontederia cordata*).

The wet prairies over marl are a conspicuous feature of Everglades National Park. Marl prairies occur on the east and west margins of Shark and Taylor Sloughs and in the east Everglades park expansion area. In these areas bedrock elevations are slightly higher and hydroperiod shorter. These communities have been called the southern coastal marsh prairies (Davis 1943a), southeast saline Everglades (Egler 1952), marl Everglades (Kuchler, 1964), marl prairies (Harper, 1927; Werner, 1976; Olmsted and Loope, 1984) and *Muhlenbergia* prairies (Olmsted *et al.* 1980). Most of the marl prairies in Everglades National Park are dominated by the species muhly grass (*Muhlenbergia filipes*) and sawgrass (SFWMD, 1992). Other locally dominant species in this community include the black top sedge (*Schoenus nigricans*), *Aristida purpurascens*, narrow beardgrass, and *Eragrostis elliotti* (SFWMD, 1992). Beak rush is common in the lower, wetter areas of the marl prairies (Gunderson and Loftus, 1993).

Sloughs

Slough communities are deep water areas dominated by floating aquatic plants. These associations are found on the lowest, wettest sites in the central portions of Shark River and Taylor Sloughs. Dominant plants include white water-lily (*Nymphaea odorata*), floating hearts (*Nymphoides aquatica*), and spatterdock (Gunderson and Loftus, 1993). The remainder of the flora in these associations are composed of submerged aquatics plants, primarily bladderworts (*Utricularia foliosa* and *U. biflora*) and periphyton. These submerged aquatic communities provide structure for attachment by periphyton and are a key component in what is described as the periphyton mat complex.

Ponds and Creeks

Ponds are small, typically less than 2.5 acres (1 hectare), open water areas scattered throughout the Everglades with little or no macrophytic vegetation. The ponds are often bordered by spatterdock (*Nuphar luteum* subsp. *macrophyllum*), water lilies (*Nymphaea* spp.), fire flag (*Thalia geniculata*), pickerel weed (*Pontederia cordata*), and woody plants such as willow or primrose-willow (*Ludwigia peruviana*) (Gunderson and Loftus, 1993). Creeks are open water areas found in the southern portions of the Everglades National Park occurring at the interface of the freshwater and saline zones originating in the freshwater marshes.

Periphyton

"Periphyton" is a general term, which is used here to describe the algal assemblages in the open-water areas of the Everglades. This community is most abundant in sloughs but is found in all marsh and prairie associations of the everglades. Hydroperiod and water chemistry determine the species composition of the periphyton community whose algae precipitate calcium carbonate from water forming the calcitic mud or marl found in marl prairies (Gleason, 1972; Swift, 1984). The algal assemblage of this community is structured by characteristics of the areas in which they occur including; hydroperiod, water chemistry, nutrient availability, and soil composition (Browder *et al*., 1981; Swift, 1984). Calcareous blue-green algae and diatoms dominate the community in shorter hydroperiod sites, which are more alkaline and higher in carbonates (Browder *et al.* 1981). Periphyton provide primary production which forms the basis of the detrital based food web of the Everglades while also influencing oxygen levels in free water and acting as biological mediators in nutrient cycling (Hunt, 1961; Brock, 1970; Wilson, 1974; Wood and Maynard, 1974; Gleason, 1972 Browder *et al.* 1982).

Saline Wetlands

The salt influenced area of Everglades National Park consists of halophytic marshes, prairie, and forest communities. Although most of these area are tidally influenced, soil salinity is believed to be the major determinant of the vegetation (SFWMD, 1992). Salinity in the coastal zone ranges from freshwater in the upland waters during the rainy season, to hypersaline (saltier than seawater) during extreme droughts. Saline wetlands include the areas characterized as coastal swamps and lagoons, Cape Sable, and lower Taylor Slough by Schomer and Drew (1982). This area parallels the coast and reaches a maximum width of 15 miles in the area of Shark River and tapers to the east and west (Craighead, 1971).

Saline Wetland Marshes

The herbaceous communities of the saline zone include *Batis* marshes, coastal prairies, and salt marshes. This area was described by Davis (1943a) as saltmarsh and serves as a transition habitat between the mangroves and the strickly freshwater marshes upstream. The salt marshes include both *Juncus* and *Spartina* marshes. The black rush (*Juncus roemarianus*) and fringe rush (*Fimbristylis castanea*) dominate the *Juncus*-gulf cordgrass marshes. *Spartina* marshes with greater freshwater influences are dominated by sand cordgrass (*S. bakeri*); whereas in the more saline areas gulf cordgrass (*S. spartinae*) dominates. Common plants in the *Batis* marshes include *Batis maritima*, glass wort (*Salicornia virginica*), and sea-purselane (*Sesuvium portulacastrum*). McPherson (1973) described this area as “salt water prairies”. Coastal prairies are dominated by gulf cordgrass and sea-oxeye (*Borrichia frutescens*).

Saline Forest Associations - Mangrove Forests

Three species of mangroves occur in Everglades National Park: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*). Buttonwood (*Conocarpus erectus*) also occurs in similar habitats and so is considered to be a mangrove associate (Odum and McIvor, 1990). Mangrove forests can occur as monospecific stands dominated by one of these species and also as mixed forests including combinations of these species (SFWMD, 1992). Additional species that may be present in the understory vegetation include: antwood (*Bumelia angustifolia*), joewood (*Jacquinia keyensis*), christmas berry (*Lycium carolinianum*), rubber vine (*Rhabdadenia biflora*), moonflower (*Ipomoea tuba*), and sawgrass (SFWMD, 1992). Scrub mangrove associations are primarily composed of trees 3-6 feet tall (1 to 1.5 meters) (Craighead, 1971). Buttonwood tree islands are scattered throughout the saline mangrove zone growing on soil elevations 1.5-3 feet above high tide (Craighead, 1971).

The mangroves cover extensive areas of coastal swamps and lagoons, higher points on the mud islands of Florida Bay, Cape Sable and the Ten Thousand Island area. Distribution of stand types within the mangrove zone is determined by topography, salinity gradients, lightning strikes, human disturbance (such as lumbering), and hurricanes (Craighead, 1971; Odum and McIvor, 1990)Currently the largest trees are found in the areas along banks of rivers where organic soil depths are greatest. Along the inland (freshwater) margin of the mangrove forests, large areas of stunted red mangroves are found. At these sites, the mangroves only attain heights of 6.6 feet or less. Distribution of buttonwood is controlled primarily by topography, this species is primarily found on higher ground (Odum and McIvor, 1990). Buttonwood is the least salt-tolerant of New World "mangrove" species. The mangrove islands of Florida Bay show a zonation typical of mangrove islets, (Lugo and Snedaker, 1974) with an outer fringe of red mangrove, growing on a raised berm, often encircling a central hypersaline mud flat or lagoon. Succulent salt-tolerant herbs often colonize the inner lagoon or shrubs, including stunted black mangroves or *Batis*.

Benthic Marine Communities

Benthic communities of Everglades National Park are found in Florida Bay, Whitewater Bay, the coastal lagoons of the mangrove fringe of Florida Bay and along the Ten Thousand Island area of Everglades National Park. Benthic communities can be divided into mud, bank top, seagrass (sparse, intermediate, and dense), hard bottom, and submerged macroalgal ("seaweed") communities. Parts of the west coast and interior lake areas have mud bottoms that are bare or sparsely vegetated. Plant cover in these coastal benthic communities is likely controlled by salinity, temperature, hydroperiod (for emergent communities) and interactions among these factors. For instance, hypersaline, shallow areas can develop greatly elevated water temperatures during periods of high sunshine, effectively limiting the species that can colonize and become established there.

Bank habitat is found at depths of less than 2 feet on mud banks throughout Florida Bay. Its plant cover inlcudes including mixed algal - seagrass communities. It is subject to periodic exposure during extreme low tide and wind events (Prager and Halley, 1997a). Turtle-grass (*Thalassia testudinum*) is the dominant species. Shoal-grass (*Halodule wrightii*) and manatee-grass (*Syringodium filiforme*) occur where conditions prevent dense seagrass growth . Hard bottom communities are characterized by less than 5 cm of sediment covering limestone bedrock. Dominant components of this community are gorgonians, sponges, calcareous algae and some stony coral of the genera *Siderastrea* and *Solenastrea* (Prager and Halley, 1997). The macroalgal community is characterized dominance of the following species: *Laurencia* spp., *Batophora* spp., and *Acetabularia* spp. Factors controlling distribution of benthic flora and fauna in Florida Bay include light penetration, temperature, and nutrient availability (Lapoint, 1989).

Since 1987, there has been a significant loss of turtle grass cover in Florida Bay. There have also been frequent occurrences of algal (plankton) blooms, which diminish water clarity. These changes are of concern because of the seagrass beds' importance as habitat for pink shrimp and commercially significant fish. Research on the causes of the massive seagrass die-off is ongoing, but it is believed partly due to spread of a slime mold. This pathogen appears to affect mostly stressed plants, especially in hypersaline areas (Everglades National Park, 1997). Mass mortality of the turtlegrass plants releases nutrients into the water column, which may also be responsible for triggering algal blooms.

J.8.2 Fish and Wildlife

The following section is a discussion of the fish and wildlife resources found within Everglades National Park and Biscayne Bay.

J.8.2.1 Faunal Groups

Fish and wildlife communities are dependent upon habitat types and upon the natural hydrologic cycle for their continued healthy survival. This section contains a brief description of the major faunal groups within Everglades National Park and then a description by habitat type.

Invertebrates

Although the invertebrate community is of primary importance in sustaining the food webs of the Everglades, comparatively little information is available on the invertebrates of the Everglades. Important members of this community include amphipods, dragonflies, mayflies, flies, water beetles and water bugs (Kushlan, 1990). Macroinvertebrates are important components of the aquatic food chains and are represented by prawns, crayfish (*Procambarus alleni*), and snails such as the apple snail (*Pomacea paludosus*) and *Ligus* tree snails.

Fish

The fish fauna of the Everglades is listed as comparatively depauperate with most species derived from the North American temperate freshwater fauna (Kushlan, 1990). Primarily important species are listed by habitat in ***Table J-8.2.1.2-1.***

Reptiles and Amphibians

At least 44 species of amphibians and reptiles occur within the Everglades (Duellman and Schwartz, 1958; Dalrymple, 1988). Most of the herpetofauna are reptiles (30 species), with snakes comprising the majority of these species (16 species) other species include 9 species of turtles and 5 species of lizards (Duellman and Schwartz, 1958; Dalrymple, 1988). Fourteen species of amphibians have been recorded (Duellman and Schwartz, 1958; Dalrymple, 1988).

Birds

Robertson and Kushlan (1984) indicate that even though nearly 400 species of birds have been recorded in southern Florida, the regional avifauna is characterized by about 300 taxa. Of these species listed approximately 60 percent are wintering and migrant birds while about 116 species comprise the native breeding avifauna. A checklist of the birds of Everglades National Park lists 347 taxa (Robertson *et al*. 1984). Toops and Dilley (1986) also provided a broad overview of bird life in southern Florida with emphasis on the Everglades. The heron (*Ardeidae*) and hawk (*Accipitridae*) families are the most speciose groups in Everglades National Park (Gunderson and Loftus, 1993).

Table J-8.2.1.2-1 **Common Fish Species By Habitat Type** (After Gunderson And Loftus, 1993)				
Common Name	Species	Eleocharis Marsh	Ponds	Sawgrass
Florida Gar	*Lepisosteus platyrhincus*	UC	C	UC
Bowfin	*Amia calva*	UC	UC	UC
Golden shiner	*Notemigonus crysoleucas*	UC	C	-
Tailight shiner	*Notropis maculatus*	UC	UC	-
Coastal shiner	*Notropis petersoni*	UC	C	-
Lake chubsucker	*Erionyzon sucetta*	UC	C	-
Yellow bullhead	*Ictalurus natalis*	UC	C	UC
Brown bullhead	*Ictalurus nebulosus*	UC	UC	-
Tadpole madtom	*Noturus gyrinus*	UC	C	UC
Diamond killifish	*Adinia xenica*	UC	-	UC
Sheepshead minnow	*Cyprinodon variegatus*	C	UC	-
Golden topminnow	*Fundulus chrysotus*	C	C	C
Marsh killifish	*Fundulus confluentus*	C	UC	UC
Seminole killifish	*Fundulus seminolis*	UC	UC	-
Flagfish	*Jordanella floridae*	C	UC	C
Bluefin killifish	*Lucania goodei*	C	C	C
Rainwater killifish	*Lucania parva*	UC	-	-
Mosquitofish	*Gambusia affinis*	C	C	C
Least killifish	*Heterandria formosa*	C	C	C
Sailfin molly	*Poecilia latipinna*	C	C	UC
Brook silverside	*Labidesthes sicculus*	UC	UC	-
Everglades pygmy sunfish	*Elassoma evergladei*	C	UC	C
Bluespotted sunfish	*Enneacanthus gloriosus*	UC	UC	-
Warmouth	*Lepomis gulosus*	C	C	UC
Bluegill	*Lepomis macrochirus*	UC	C	-
Dollar sunfish	*Lepomis marginatus*	C	C	C
Redear sunfish	*Lepomis microlophus*	UC	C	-
Spotted sunfish	*Lepomis punctatus*	C	C	C
Largemouth bass	*Micropterus salmoides*	UC	UC	-
Swampdarter	*Etheostoma fusiforme*	UC	UC	-

Uncommon (UC), Common (C)

Mammals

Schwartz (1952) and Layne (1984) listed the mammals that occur within the Everglades National Park. Layne (1984) lists up to 30 species, which have been seen or collected. The most diverse group of mammals is the carnivores, while the most abundant group is the rodents (Layne, 1984). A noted feature of the mammal fauna is the near absence of bats (Layne, 1984).

J.8.2.2 Habitats

Habitat types can be divided based upon hydroperiod since these two components determine animal usage to a large extent. Most animals can use a variety of plant communities and range across the landscape on differing scales depending upon their biology and ecological requirements. Habitats discussed are slightly different from those appearing in ***Table J-8.2.1.2-1*** and are more closely based on hydroperiod. Large portions of this material are derived from the Surface Water Improvement and Management Plan on the Everglades (SFWMD, 1992) and from internal Park information.

Table J-8.2.2-1
Resident Organisms By Habitat
(After SFWMD, 1992)

Species	**Occurrence**
Hardwood Hammock	
Bobcat (*Lynx rufus*)	Resident, widely ranging
Grey fox (*Urocyon cineroargenteus*)	Resident
Striped skunk (*Mephitis mephitis*)	Resident
Raccoon (*Procyon lotor*)	Resident, especially during high water
Opossum (*Didelphis marsupialis*)	Resident, especially at high water
Cotton mouse (*Peromyscus gossypinus*)	Resident
Hispid Cotton rat (*Sigmadon hispidus*)	Resident
Marsh rabbit (*Sylvilagus palustris*)	Resident
White tailed deer (*Odocoileus virginianus*)	Resident, especially at high water
Red Shouldered Hawk (*Buteo lineatus*)	Resident; important nesting site
Great Blue Heron (*Ardea herodias*)	Nests in Bayheads
Barred owl (*Strix varia*)	Resident
Blue-Grey Gnat catcher (*Polioptila caerulea*)	Winter resident
Various warblers (*Parulidae*)	Migrants, some winter residents
Cardinal (*Richmondena cardinalis*)	Resident
Penisula cooter (*Chrysemys floridana peninsularis*)	Uses edges for nesting
Red-bellied slider (*Chysemys nelsoni*)	Uses edges for nesting
Everglades rat snake (*Elaphe obsolet*	Resident

Table J-8.2.2-1 Resident Organisms By Habitat (After SFWMD, 1992)	
Species	**Occurrence**
rossalleni)	
Black racer (*Coluber constrictor*)	Resident
Florida kingsnake (*Lampropeltis getulus floridana*)	Resident
Southern leopard frog (*Rana sphenocephala*)	Breeds along flooded edges
Southern toad (*Bufo terrestris*)	Breeds along flooded edges
Sawgrass Marshes	
Rice Rat (*Oryzomys palustris*)	Resident
Cotton mouse (*Peromyscus gossypinus*)	More common in dry season
Hispid Cotton rat (*Sigmadon hispidus*)	More common in dry season
Marsh rabbit (*Sylvilagus palustris*)	Resident
King rail (*Rallus elegans*)	Resident
Limkin (*Aramus guarauna*)	Seasonal resident
Red-winged blackbird (*Agelaius phoeniceus*)	Resident
American bittern (*Botaurus lentiginosus*)	Winter resident
Long billed Marsh Wren (*Cistothorus palustris*)	Winter resident
Yellowthroat (*Geothlypis trichas*)	Resident
American Alligator (*Alligator mississippiensis*)	Important nesting site
Squirrel tree frog (*Hyla squirella*)	Resident
Green Anole (Anolis carolinensis)	Resident
Wet Prairies And Sloughs	
White tailed deer (Odocoileus virginianus)	Resident
Round tailed muskrat (*Neofiber alleni*)	Resident
Everglades mink (*Mustela vison evergladensis*)	Resident
Otter (*Lutra canadensis*)	Resident
Hispid Cotton rat (*Sigmadon hispidus*)	Resident
Cotton mouse (*Peromyscus gossypinus*)	Resident

Table J-8.2.2-1 Resident Organisms By Habitat (After SFWMD, 1992)	
Species	**Occurrence**
Wading birds (*Egretta* spp. *Ardea*, *Casmerodius*, *Nycticorax*)	Important dry season feeding areas
White Ibis (*Eudocimus albus*)	Feeds and breeds in shallow areas
Wood Stork (*Mycteria americana*)	Feeds in drying marshes
Common moorhen (*Gallinula chloropus*)	Feeds and nests in marshes
Pied-Billed grebe (*Podilymbus podiceps*)	Feeds and nests in winter
Belted Kingfisher (*Megaceryle alcyon*)	Winter resident
Boat tailed grackle (*Quiscalus major*)	Resident
Common grackle (*Quiscalus quiscula*)	Winter resident
Limkin (*Aramus guarauna*)	Resident
American Alligator (*Alligator mississippiensis*)	Resident
Greater Siren (*Siren lacertina*)	Resident
Southern cricket frog (*Acris gryllus gryllus*)	Resident
Pig frog (*Rana grylio*)	Resident, usually near ponds
Water snakes (*Nerodia* spp)	Resident
Wet Prairies (Marl)	
Striped crayfish snake (*Regina alleni*)	Resident
Black swamp snake (*Seminatrix pygemaea*)	Resident
White tailed deer (*Odocoileus virginianus*)	Resident
Hispid Cotton rat (*Sigmadon hispidus*)	Resident
Rice Rat (*Oryzomys palustris*)	Resident
Marsh rabbit (*Sylvilagus palustris*)	Resident
Florida panther (*Felis concolor coryi*)	Resident
Least shrew (*Cryptotis parva*)	Resident
American bittern (*Botaurus lentiginosus*)	Winter resident
Cattle Egret (*Casmerodius albus*)	Resident
Great Egret (*Casmerodius albus*)	Feeds in flooded prairies

Table J-8.2.2-1
Resident Organisms By Habitat
(After SFWMD, 1992)

Species	**Occurrence**
Red-Shouldered Hawk (*Buteo lineatus*)	Resident
King Rail (*Rallus elegans*)	Resident
Common Nighthawk (*Chordeiles minor*)	Summer nester
Eastern Meadowlark (*Sturnella magna*)	Resident, common in dry season
Yellowthroat (*Geothlypis trichas*)	Resident
Cape Sable Seaside sparrow (*Ammodromus maritima mirabilis*)	Resident
Green Anole (*Anolis carolinensis*)	Resident
Southern leopard frog (*Rana sphenocephala*)	Resident
Oak toad (*Bufo quercicus*)	Resident
Narrow-mouthed toad (Gastrophryne carolinensis)	Resident
Ponds And Creeks	
Round tailed muskrat (Neofiber alleni)	Nests along margins
Rice Rat (*Oryzomys palustris*)	Resident
Otter (*Lutra canadensis*)	Occasional
Wading Birds (*Egretta* spp, *Mycteria*, *Casmerodius*, *Eudocimus*)	Feed along margins at low water
Black crowned night heron (*Nycticorax nycticorax*)	Feeds and nests along pond edges
Anhinga (*Anhinga anhinga*)	Feeds and nests near ponds
Turkey Vulture (*Cathartes aura*)	Feeds along edges at low water
Purple Gallinule (*Porphyrula martinica*)	Feeds and nests in marginal vegetation
Boat tailed grackle (*Quiscalus major*)	Feeds and nests in marginal vegetation
American Alligator (*Alligator mississippiensis)*	Digs and maintains ponds
Water snakes (*Nerodia* spp)	Common at low water
Florida Softshelled turtle (*Trionyx ferox*)	Resident
Two Toed amphiuma (*Amphiuma means*)	Resident
Pig Frog (*Rana grylio*)	Resident

Table J-8.2.2-1 Resident Organisms By Habitat (After SFWMD, 1992)	
Species	**Occurrence**
Southern Leopard frog (*Rana sphenocephala*)	Resident
Peninsula newt (*Notophthalmus viridescens*)	Resident

Upland-Rockland Habitats

Upland habitats include primarily tropical hardwood hammocks and rockland pine forests, which together comprise rockland ecosystems. General resident organisms utilizing this habitat are listed in Table J-8.2.2-1. Most truly terrestrial animals are found in these communities, generally utilizing both habitats. Some animals, however, may utilize either tropical hardwood hammocks or rockland pine forests exclusively. Large mammals with the need for broad home ranges such as the Florida panther (*Felis concolor coryi*), the black bear (*Ursus americanus floridanus*) and white-tailed deer (*Odocoileus virginianus*) utilize both upland habitat types as well as other seasonally inundated wetlands. Small rodent utilizing hammocks include the cotton mouse (*Peromyscus gossypinus*), the hispid cotton rat (*Sigmadon hispidus*), and the rice rat (*Oryzomys palustris*). These animals have been documented to occur in densities of 117, 27, and 19 individuals per hectare (Smith and Vrieze, 1979). Other mammal utilizing these tropical hammocks beyond those listed in Table J-8.2.2-1 include shrews (*Blarina* sp.) and the grey squirrel (*Sciurus carolinensis*) (SFWMD, 1992).

Native vertebrate fauna of south Florida rockland ecosystems is primarily derived from southeastern temperate North American fauna (Robertson, 1955; Duellman and Schwartz, 1958; Robertson and Kushlan, 1984; Layne, 1984; Snyder *et al*., 1990). Examples of this fauna include, the southern toad (*Bufo terrestris*), the green tree frog (*Hyla cineria*), the black racer (*Coluber constrictor*), the rough green snake (*Opheodrys aestivus*), the green anole (*Anolis caroliniensis*), the red bellied woodpecker (*Melanerpes carolinus*), the Carolina wren (*Thryothorus ludovicianus*), the pine warbler (*Dendroica pinus*), the northern cardinal (*Cardinalis cardinalis*), the opossum, the hispid cotton rat, the raccoon and the white-tailed deer (Snyder *et al*., 1990; Gunderson and Loftus, 1993). The West Indian vertebrate fauna is limited in the areas of southern Florida and found mostly in the Florida Keys, islands in Florida Bay, and the southern most extent of the peninsula and along the Miami rockridge (Snyder *et al*., 1990). Some examples of this fauna include the black-whiskered vireo (*Vireo altiloquus*), the white crowned pigeon (*Columba leucocephla*), the smooth-billed ani (*Crotophaga ani*), the grey kingbird (*Tyrannus dominicensis*), and the mangrove cuckoo (*Coccyzus minor*) (Snyder *et al*., 1990).

Wetland Forest Habitats

This habitat includes bayheads, cypress forests, willow heads, swamp forests, and pond apple forests. These communities are forests in a marsh or wet prairie matrix, and as such are surrounded by emergent vegetation of low stature and longer hydroperiod. These habitats can be used as roosting or nesting sites contiguous to surround marshes used for foraging. General resident organisms utilizing this habitat are listed in Table J-8.2.2-1. Common breeding birds utilizing this habitat include the Anhinga (*Anhinga anhinga*), the green-backed heron (*Butorides striatus*), the black-crowned night heron (*Nycticorax nycticorax*), and the boat tailed grackle (*Quiscalus major*) (SFWMD, 1992; Gunderson and Loftus, 1993). Other common vertebrates include raccoons, opossums, the river otter (*Lutra canadensis*), white tailed deer, water snakes (*Nerodia* spp), and the green anole (SFWMD, 1992). Kushlan and Kushlan (1977) listed thirty-eight species of birds as utilizing wetland forest habitats, including thirteen species of breeding birds.

Prairies

Prairies are short to intermediate hydroperiod habitats. They comprise an important habitat type within the Everglades and Everglades National Park. General resident organisms utilizing this habitat are listed in Table J-8.2.2-1. These seasonally inundated prairies can occur over marl or peat substrate. Within Everglades National Park these prairies have a relatively high variation in topography with solution holes forming aquatic refugia within the shorter hydroperiod prairies (Loftus and Kushlan, 1987; Dalrymple, 1988). Prairies form an important habitat and support a diverse herpetofauna. Duellman and Schwartz (1958) recorded 46 species of reptiles and amphibians in this habitat. Dalrymple (1988) found the most common reptiles and amphibians in this habitat to be the green anole, the leopard frog, and the oak toad (*Bufo quericus*). This habitat type has had some of the highest development pressure within the system on it. Everglades National Park has a large proportion of the remaining short hydroperiod prairies within the south Florida system. Due to their hydroperiod, they are the first marshes to dry out and as such offer wading birds forage habitat following the drying front. This habitat is extremely important to wading birds, which depend upon it for forage habitat. Wet prairie habitat within Everglades National Park is designated as critical habitat for the Cape Sable Seaside sparrow. The Florida panther also uses the shallow and short hydroperiod portions of these prairies for forage and crosses them regularly.

Marshes

Marshes are longer hydroperiod wetlands which may be made up predominantly of sawgrass or mixed graminoid marshes. General resident organisms utilizing this habitat are listed in Table J-8.2.2-1. These areas have more open water components and are extremely important to wading birds and some mammals. Although sawgrass marshes are generally poorer habitat some animals utilized them seasonally. Animals utilizing sawgrass marshes include the American bittern (*Botaurus lentiginosa*), the long-billed marsh wren (C*istothorus palustris*), the Limpkin (*Aramus guarauna*), and the American alligator (*Alligator mississippiensis*) (Craighead, 1968a; Fogarty, 1984; Kushlan and Kushlan, 1980; Gunderson and Loftus, 1993).

Marsh habitats other than sawgrass marshes are utilized by a variety of water birds and wading birds. These birds include the Wood Stork (*Mycteria americana*), Great egret (*Casmerodius albus*), Snowy Egret (*Egretta thula*), White ibis (*Eudocimus albus*), Glossy ibis (*Plegadis falcinellus*), Great blue heron (*Ardea herodias*), Green-backed heron (*Butorides striatus*), Tri-colored heron (*Hydranassas tricolor*), Black-crowned night heron (*Nycticorax nycticorax*), Least bittern (*Ixobrychus exilis*) and American bittern (Kushlan and Kushlan, 1977; Gunderson and Loftus, 1993). Other animals important in these marshes include the Snail kite (*Rostrhamus sociabilis*), the pig frog, cricket frog (*Acris grylio*), water snakes, peninsular newt, and several sirens (Gunderson and Loftus, 1993).

Ponds and Sloughs

Ponds and creeks have the longest hydroperiod of the freshwater habitats available. They are generally wet in all but the driest of drought years. General resident organisms utilizing this habitat are listed in Table J-8.2.2-1. Many natural ponds are either created or maintained by alligators (Craighead, 1968a &b; Kushlan, 1974). Large salamanders, turtles, and snakes inhabit these aquatic systems (Gunderson and Loftus, 1993). Water levels of these areas affect their usage by birds. Wading birds use sloughs depending upon the time in the water year. Sloughs are used during periods of high water by birds such as the common Moorhen (*Gallinula chloropus*), the pied-billed grebe (*Podilymbus podiceps*), Anhinga (*Anhinga anhinga*) and the limpkin. Common mammals in this habitat include the river otter and the round tailed muskrat while many others may use the edges during dry conditions (Craighead, 1968b).

J.8.2.3 Mangroves and Coastal Ecosystems

Twenty-four species of amphibians and reptiles have been identified in marine, mangrove, wetland and upland habitats (Odum *et al*., 1982). The mangrove and coastal ecosystems are habitat to a variety of amphibians and reptiles including: various species of frogs, the Diamondback terrapin (*Malaclemys terrapin rhizophorarum*) and (*Malaclemys terrapin macrospilota*), the American crocodile (*Crocodylus acutus*), the Eastern indigo snake (*Drymarchon corais couperi*), the Miami black-headed snake (*Tantilla oolitica*), and the mangrove water snake (*Nerodia fasciata compressicauda*) (SFWMD, 1992; Snyder *et al*., 1990).

Odum *et al*. (1982) listed 181 birds that utilize the south Florida mangrove zone, and classified them into six categories based on feeding habits: wading birds, probing shorebirds, floating and diving water birds, aerially searching birds, birds of prey, and arboreal birds. Wading, aerially searching, and floating and diving birds are the most prominent. The tricolored heron (Louisiana heron) (*Egretta tricolor*) and snowy egret (*Egretta thula*) are the most abundant wading birds, while the white ibis (*Eudocimus albus*) and wood stork are found less frequently (Kushlan, 1979; Schomer and Drew, 1982). The double-crested cormorant (*Phalacrocorax auritus*) is the most prominent floating and diving bird. Of the 25 probing shorebird species, only two, the Wilson's plover and willet, are permanent residents of the mangrove zone. Most of the surface and diving birds are present all year (Odum *et al*., 1982). Nesting colonies of aerially searching birds are restricted to the mangrove islands of Florida Bay, but utilize the inland mangrove zone for foraging. Mammals utilizing this habitat include the Manatee (*Trichechus manatus*), the everglades fox squirrel (*Sciurus niger avicennia*), the everglades marsh rabbit (*Sylvilagus palustris*), and the bobcat (Gunderson and Loftus, 1993).

J.8.2.4 Exotic Fauna

Habitat disturbance and introduction of non-native species are known to be primary sources of exotic fauna within south Florida. Much of the exotic fauna within south Florida was either transported unintentionally in international shipments of goods or occurred as part of the trade in exotic species (SFWMD, 1992). These sources have resulted in the survival of reproductively viable colonies of exotic fauna. Some restoration components may affect the existing balance of these organisms. Species of exotic fish known to breed in Everglades National Park are listed in ***Table J-8.2.4-1***. Exotic species within Everglades National Park include wild hog (*Sus scrofa*), house mouse (*Mus muscalus*), nine banded armadillo (*Dasypus novemcinctus*), red fox (*Vulpes vulpes*), jaguarundi (*Felis yagouroundi*), red whiskered bulbul (*Pysnonotus jocosus*), Hill myna (*Gracula religiosa*), five species of parrots, Blue-Grey Tanager (*Thraupis episcopus*), java sparrow (*Padda oryzivora*), starling (*Sturnus vulgaris*), cuban tree frog (*Hyla septentrionalis*), marine toad (*Bufo marinus*), five type of geckos, and five types of anoles (SFWMD, 1992).

J.8.3 Hydrology

The hydrology of Everglades National Park is dependent upon the underlying formations and resulting hydrogeology. This portion of the everglades is underlain by a shallow unconfined surficial aquifer, the Biscayne, and a deep confined brackish aquifer, the Floridan (SFWMD, 1992). The shallow unconfined Biscayne Aquifer serves as the primary source of groundwater to Everglades National Park and is the sole source aquifer for drinking water for Miami-Dade, Broward, and Monroe counties.

Table J-8.2.4-1 Exotic Fish Breeding In Everglades National Park By Habitat			
	Taylor Slough	Shark Slough	Estuarine Zone
Family Clariidae Walking catfish (*Claris batrachus*)	X	X	X
Family Poeciliidae Pike killifish (*Belonesox belizanus*)	X	X	X
Family Cichlidae			
Oscar (*Astronotus ocellatus*)	X	X	
Black acara (*Cichlasoma bimaculatum*)	X	X	
Mayan cichlid (*Cichlasoma urophthalmus*)	X	X	X
Blue tilapia (*Oreochromis aureus*)	X	X	X
Spotted tilapia (*Tilapia mariae*)	X	X	X
Mozambique tilapia (*Oreochromis mozambicus*) *	X		
Butterfly Peacock bass (*Chichla ocellaris*) *		X	

*observed, not known to breed within Everglades National Park

Due to the unconfined nature of the surficial aquifer, surface water and ground water are interchangeable within the area affecting Everglades National Park. Differences in the permeabilities of the sands, limestones, marls, and silts that compose the aquifer system influence the direction and rate of ground water movement. Drawdown in areas outside of Everglades National Park boundary and outside of the defined hydrologic basin affects the hydrology and groundwater resources of Everglades National Park. For this reason, flood protection and conveyance capacity for the adjacent urban areas and the Everglades Agricultural Area affect the management of water, water delivery schedules and operation of structures delivering water to Everglades National Park. Physical structure of the area is based upon the Florida Plateau and the chemical and biological processes leading to deposition and formation of its features as shaped by transgressing and regressing sea level changes (Schomer and Drew, 1982).

J.8.3.1 Groundwater Resources

The hydrogeology of south Florida is extremely diverse. Two aquifer systems are of primary interest, the Surficial Aquifer system and Floridan Aquifer system. The surficial or Biscayne aquifer is of primary importance within Everglades National

Park. This aquifer is the only source of potable water within Everglades National Park and represents the primary source of water for the natural environments of Everglades National Park. The Floridan Aquifer is a regionally extensive, deep aquifer that contains non-potable water throughout south Florida. Jarosewich and Wagner (1985) found two distinct zones within the surficial aquifer system underlying Everglades National Park. These zones consisted of an upper zone of permeable limestones and clastics, and a more heterogeneous lower zone of relatively impermeable fine grained sands and silty sands interbedded with permeable sands, limestones, and shelly marls. Due to the permeability of these two zones, they are considered hydraulically connected as a single surficial aquifer system with the presence of a regionally continuous "green clay bed" of the lower Tamiami Formation defining the base of the aquifer system.

J.8.3.2 Physiographic Subregions of ENP

The area comprised by Everglades National Park has been divided into two physiographic regions by Schomer and Drew (1982), the Lower Everglades Basin and the Taylor Slough/Florida Bay Basin. This division is based on previously published records (Davis, 1943a; Puri and Vernon, 1964; White, 1970; Craighead, 1971)(***Figure J.8.3.2-1***).

Lower Everglades Basin

The Lower Everglades Basin has been further sub-divided into physiographic subzones by Schomer and Drew (1982) which have been modified to include the Rocky Glades as part of Taylor Slough/Florida Bay: 1) Shark River Slough, 2) Broad River/ Lostmans River, 3) Coastal Swamps and Lagoons, and 4) Cape Sable.

Shark River Slough

Shark River Slough is a broad southwesterly trending arc of continuous wetland, interspersed with numerous tree islands. Expansive transitional areas of slightly higher bedrock elevation distinguish its northwestern and southeastern boundaries. The slough is defined by the center of the Everglades trough which is a wide, slightly concave depression in the underlying limestone (White, 1970).

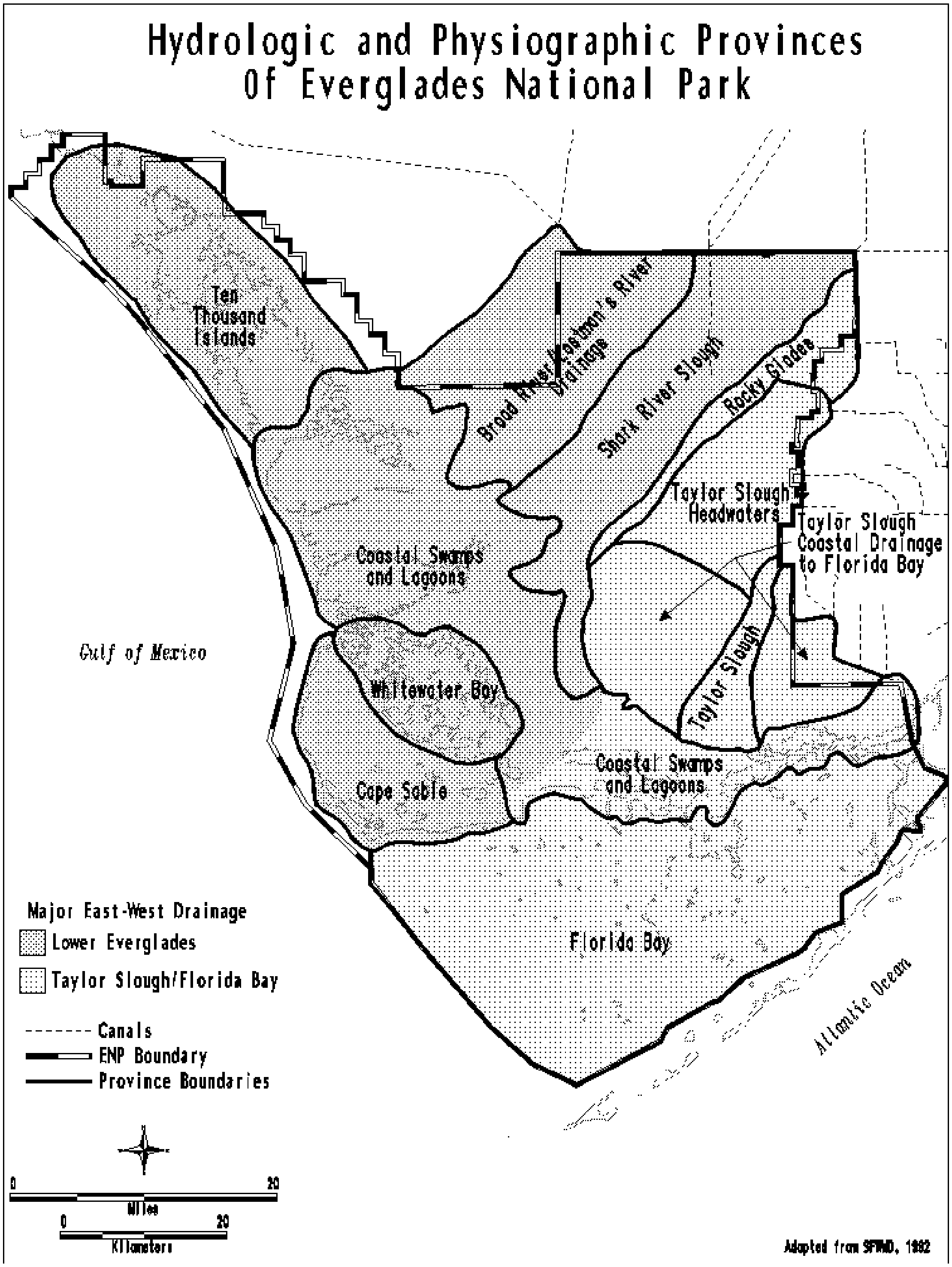


Figure J.8.3.2-1 Everglades National Park Physiographic Regions

Historically natural water movement in Shark Slough depended on the timing, duration, and magnitude of regional and local meteorological events particularly flood and drought conditions. Currently water movement is primarily controlled by the operations of the C&SF Project. Recent isotopic data suggests that groundwater underlying Everglades National Park is derived primarily from recent surface waters, and is heavily affected by recent rainfall recharge, while waters under Alligator Alley in Water Conservation Area 3 is much older and less directly affected by rainfall (Swart 1989, unpublished data).

Broad River/Lostmans River

Northwest of Shark River Slough, the bedrock of the Everglades trough rises gradually toward the Big Cypress Spur, an extension of the Immokalee Rise (Puri and Vernon, 1964; White, 1970). These latter features generally define the Big Cypress Basin. The area of freshwater wetlands located between the Everglades trough and the Big Cypress Basin is known as the Broad River/Lostmans River Drainage (Schomer and Drew, 1982). This transitional area is distinguished from Shark Slough by subtle differences in hydrology, hydroperiod, and geology. Miami Limestone in this area is covered by a veneer of Pamlico sands which encroach upon the Fort Thompson Formation of the Everglades trough (Cooke, 1945). This is area and the Big Cypress Basin form the primary freshwater drainage for the Ten Thousands area of Everglades National Park.

Coastal Swamps and Lagoons

Puri and Vernon (1964) referred to the low mangrove and salt marsh areas at the lower end of Shark Slough drainage as reticulated coastal swamps. These coastal swamps and lagoons extend from the upland limit of periodic salt water influence to the Gulf of Mexico, a distance of about 10 to 25 miles (16 to 40 kilometers). According to Schomer and Drew (1982), the prominent features that delineate the area are:

1) salt marshes, which lie relatively upland;
2) mangrove forests that lie in vast wetland expanses and along shorelines;
3) "back bays" or lagoons--distinct physiographic features that become more prominent north along the coast.

The coastal swamps and lagoons receive most of the surface runoff from the Everglades. Prior to the recent Flandrian sea level rise of the Holocene epoch, a larger area was inundated by freshwater. As surface waters flowed over this area, differential solution of the less-resistant bedrock limestone formed freshwater channels (Schomer and Drew, 1982). Freshwater runoff increased the various peat- and/or marl-forming environments. As sea level rose to its current level, some areas of underlying peat eroded and oxidized, leaving a network of lagoons and "back bays" (Spackman *et al*., 1964; White, 1970).

The largest and most conspicuous of these lagoons is Whitewater Bay. The drainage pattern along the northern edge follows the numerous southeasterly trending channels of Watson River, North River, and Roberts River. The bay to the southeast is confined by an extension of the Atlantic Coastal Ridge that terminates in the "Cape Sable High" (White, 1970). Where the main flow of the Lower Everglades Basin drains to the Gulf of Mexico, conditions are less favorable for the formation of lagoons or back bays (White 1970). Consequently, a wide area of coastline north of Whitewater Bay contains only one small lagoon-like body of water (Tarpon Bay in the Harney River) (Schomer and Drew, 1982).

Cape Sable

Cape Sable is one of the most distinctive features of the southwestern tip of Florida. White (1970) claims that the cape overlies a degenerate westerly extension of Miami Limestone of the Atlantic Coastal Ridge. He refers to the terminal end of this extension as the "Cape Sable High." It is believed that the beaches of Cape Sable first formed as a result of a shallow submarine scarp cut into bedrock (White, 1970). The coastal prairies behind the beaches are composed of a succession of troughs and low dunes (Craighead and Gilbert, 1962). On the upland side of these prairies, the highest elevations support a continuous ridge of hammocks (Craighead, 1971). A series of shallow ponds, the largest of which is Lake Ingraham, extend from the north of the middle Cape to Flamingo. Craighead (1971) considers these ponds remnants of former open waters that have not been completely filled in by marl and peat.

Taylor Slough/Florida Bay Basin

Taylor Slough encompasses greater than 158 square miles of freshwater marsh and extends approximately 20 miles from its northern source in the rocky glades to Florida Bay (Van Lent, *et al*. 1993). Schomer and Drew (1982) separate the Taylor Slough/Florida Bay Basin into six physiographic subzones.

1) Rocky Glades
2) Taylor Slough Headwaters
3) Upper, Middle, and Lower Taylor Slough
4) Taylor Slough Coastal Drainage
5) Coastal Swamps and Lagoons
6) Florida Bay

Rocky Glades

The Rocky Glades or Rocklands are a transition zone between Taylor and Shark Sloughs. They lie southeast of Shark Slough forming portions of the headwaters of Taylor Slough (Davis, 1943a; Schomer and Drew, 1982). The Rocky Glades are formed by solution and differential weathering of bryozoan limestone from the Pleistocene (Schomer and Drew, 1982) The formations resulting from such weathering are also called pinnacle rock and form a unique habitat type within Everglades National Park due to its unusual structure. Geologically, the Fort Thompson Formation underlies much of the Everglades trough as a surface bedrock feature, while the back slope of the Atlantic Coastal Ridge (Miami Limestone) forms the surface rock for the area farther east (SFWMD, 1992). These bedrock features make the Rocky Glades a hydrologic transition between the Shark River Slough drainage to the southwest and the Taylor Slough drainage to the south.

Taylor Slough Headwaters

Historically, sheet flow through the Everglades followed a south by southwest curve, as outlined by the arc of Shark Slough. Some of the sheet flow, however, has been transverse to the main axis of the Miami Rock Ridge, the Everglades Keys, and the Rocky Glades. Erosion of the thin layer of marl soils and solution of the underlying Miami Oolite created a solution-riddled landscape cutting across the limestone toward Taylor Slough.

Upper, Middle, and Lower Taylor Slough

This physiographic subzone originates where L-31W intersects the main channel of Taylor Slough (Olmsted *et al*., 1980). This area is referred to by Olmsted *et al*. (1980) as Upper Taylor Slough. It is a well defined 3.4-mile (5.5-kilometer) long segment running from the intersection of the slough and the canal levee structure L-31W south to State Road 27 (Anhinga Trail). Middle Taylor Slough is defined as the segment of the slough from State Road 27 south 4 miles (6 kilometers) (Olmsted *et al*. 1980). Lower Taylor Slough is defined as the segment lying south of this point and draining to Florida Bay.

Taylor Slough Coastal Drainage

Schomer and Drew (1982) described the areas immediately east and west of Taylor Slough and north of the coastal swamps. This area is referred to as the Taylor Slough Coastal Drainage. The limestone ridges, Long Pine Key and Everglades Keys, that run west/southwest from upper Taylor Slough form a barrier inhibiting sheet flow from Shark River and the lower Rocky Glades.

Coastal Swamps and Lagoons

In the coastal area west of Taylor Slough, Puri and Vernon (1964) distinguish two physiographic provinces lying within the Taylor Slough drainage basin. The first of these provinces refers to the series of lagoons from Seven Palm Lake to West Lake. A broad continuous strip of land covered by coastal prairie occupies the area north of these lagoons, running southeast to the mangroves bordering Madeira Bay. The northern border of these lagoons roughly corresponds to a partial barrier between fresh and saline waters known as the Buttonwood Embankment (Craighead, 1971). A distinct band of pioneer red mangrove (*Rhizophora mangle*) occurs 2 to 5 miles (3 to 8 kilometers) inland of this barrier (Schomer and Drew 1982). The second physiographic province corresponds to black (*Avicennia germinans*) and white (*Laguncularia racemosa*) mangrove communities that occur in the areas south to Florida Bay. This second region is known as Reticulate Coastal Swamps (Schomer and Drew, 1982). On the eastern side of Taylor Slough the coastal lagoons are less prominent, and the surface drainage is better defined. This hydrologic structuring leads to a land and vegetation pattern that radiates out from the surface drainage pattern (Schomer and Drew, 1982).

Florida Bay

Florida Bay is the downstream receiving waters for the Taylor Slough drainage. It is a negative estuary, evaporating more water on an annual basis than falls in rainfall. The Taylor slough drainage is an important source of freshwater for this area.

J.8.4 Water Management

The Everglades National Park drainage basin is described in Cooper and Roy, 1991. The basin has an area of 1684.5 square miles and is located in western Miami-Dade County (886.5 sq. miles), northwestern Monroe county (773.9 sq. miles) and southwestern Collier county (24.1 sq. miles) (Cooper and Roy, 1991). The Park boundaries and the basin boundary are shown in ***Figure J.8.4-1***. The basin includes all of Everglades National Park, the Everglades National Park expansion area, the remainder of the east everglades and portions of the southern Glades Wildlife Environmental Area.

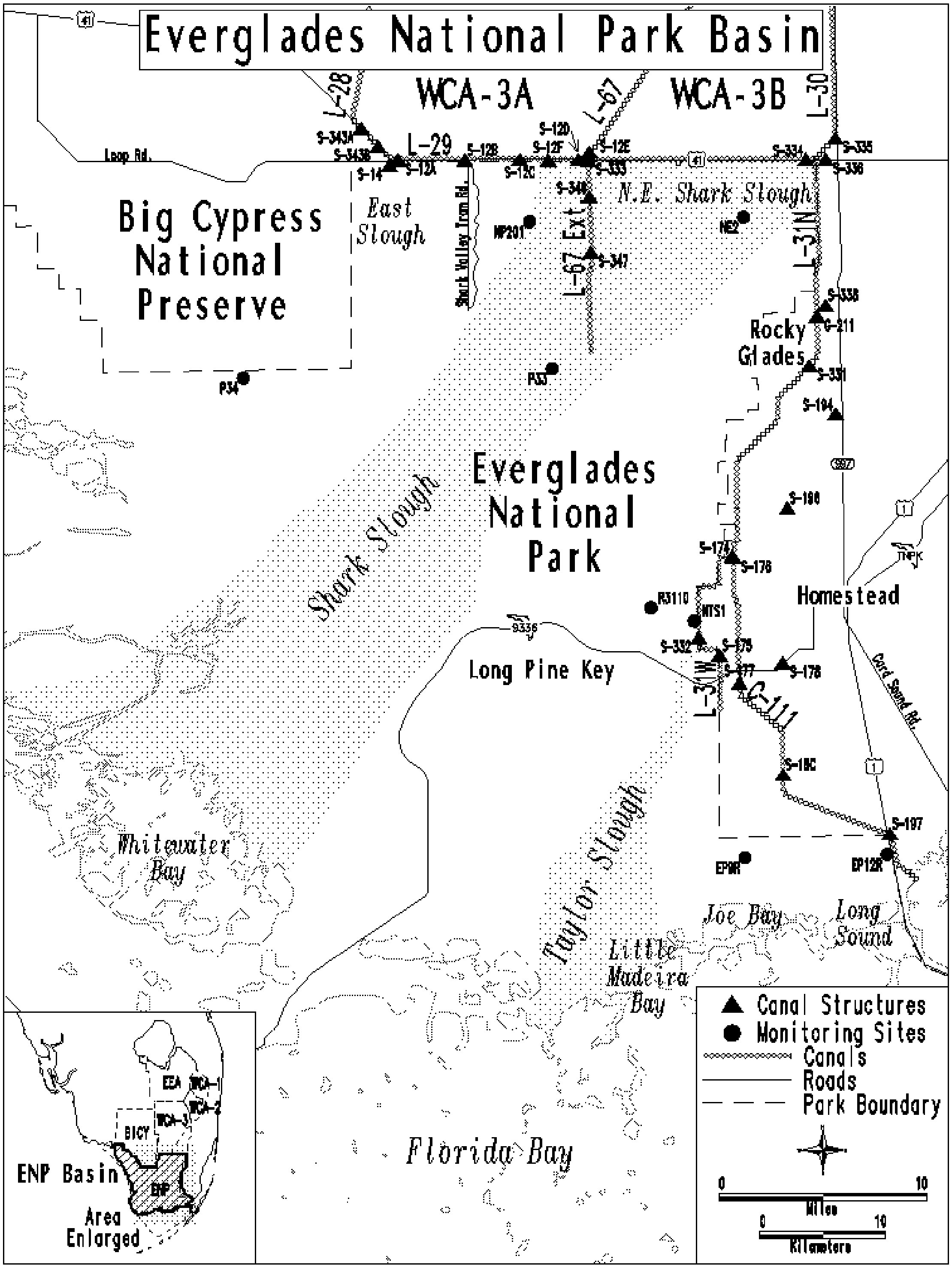


Figure J.8.4-1 Everglades National Park Basin Boundaries

J.8.4.1 Internal Project Structures

The drainage basin for Everglades National Park represents primarily undeveloped land managed for the National Park and its inflows. Central and South Florida Project structures are generally external to the basin and installed primarily for environmental purposes for the National Park or to separate drainage between the National Park and the area to the east of the L-31N and L-31. There are six project structures internal to this basin: the L-67 extension, the plug in the Buttonwood Canal, S-175, S-332, S-346, and S-347. L-67 extension was installed to separate the portions of Everglades National Park, Western Shark Slough from the privately owned lands east, which included the northeastern portions of Shark Slough. The associated canal serves as a getaway channel allowing water to move away from the S-12 structures (Cooper and Roy, 1991). The Buttonwood Canal plug was installed at the mouth of the Buttonwood canal on Florida Bay to prevent further intrusion of saltwater and improve conditions upstream of the canal. The S-175 and S-332 are used to deliver water to Taylor Slough, while S-346 and S-347 are used to control flow in the L-67 extension.

J.8.4.2 External Project Inflows

Managed inflows to Everglades National Park are from the eastern farmland and from the north as an outlet of Water Conservation Area (WCA) 3A and 3B. The managed flows delivered from WCA 3A through the S-12 structures, S-333, and from WCA 3B through G-69. Other inflow points include the L-31W borrow canal through S-332 and S-175 and from the C-111 between S-18C to S-197 as overland flow though the degraded canal berm into the Panhandle of Everglades National Park.

J.8.4.3 Project Structures Controlling Inflow

Project structures controlling flow to the Everglades National Park basin are: S-12A; S-12B; S-12C; S-12D; G-69, S-175; S-18C; S-197; S-332; S-333; and S-334. There are two internal structures controlling flow; the S-346 and S-347, which control flow in the buttonwood canal. There are three project structures, which are located in the basin but are not currently operated; the S-12E, S-12F and S-14. The S-12A, S-12B, S-12C, and S-12D are identical gated spillways located in the L-29 between L-28 and L-67. They connect Water Conservation Area 3A to the Everglades National Park basin. The first connection between WCA-3A and the south Miami-Dade canals occurred in 1978 with the completion of structures S-333 and S-334 in the L-29 Canal. These structures were installed to provide additional dry season water deliveries to L-31N. Structure G-69 connects WCA 3B to the Everglades National Park basin via the L-29 canal. Project works are largely peripheral to the Everglades National Park basin and have as their primary function providing a supply of water to the basin.

J.8.5 Water Supply

Most of the surface flow entering Everglades National Park occurs through the Central and South Florida Project. The primary function of the C&SF Project is to supply water to the basin and to pass floodwater flows from adjacent basins into the Everglades National Park. The first overall plan for flood protection and water control for southern Miami-Dade County was presented in the Survey Review Report on the Central and Southern Florida Project, South Miami-Dade County (USACE, 1961). The L-31W Canal system was not included as part of this plan. The remaining major flood control and water supply facilities for southern Miami-Dade County were addressed in the General Design Memorandum (GDM), South Miami-Dade County (USACE, 1963). The L-31W Canal and control structures S-174 and S-175 were added to the project as part of the memorandum following recommendations by the NPS and the U.S. Fish and Wildlife Service.

Water control works that were constructed immediately adjacent to Shark River Slough, Taylor Slough, the East Everglades and the panhandle of the Everglades National Park allowed water managers to regulate flow across park boundaries. Several water delivery plans were implemented from 1962 to 1982 to meet delivery goals for the Everglades National Park and are summarized in ***Table J-8.5-1.***

Table J-8.5-1
Summary Of Water Delivery Schedules To Everglades National Park

Description	Summary of Operation
Conservation Area 3A Stage (Dec. 1962 – March 1965)	Park only to get excess water once Conservation Areas Filled
Conservation Area 3A Stage (March 1965- March 1966)	• All excess water to Everglades National Park through the S-12's • 3stage zones dictated 3 different monthly delivery schedules. • P-33 served as an over-ride
Lake Okeechobee Stage (March 1966-Feb. 1970)	• 13.5 – 15.5 ft. – 1000 cfs through S-12's • 12.5 – 13.5 ft. 140 to 150 cfs through S-12's • Below 12.5 ft. no delivery
Lake Okeechobee Stage (Feb. 1970-Sept. 1970)	• Above 12.5 ft. – 260,000 acre-ft. through S-12's • Below 12.5 ft. – reduced % of schedule • P-33 as over-ride.
Congressionally mandated Minimum Delivery Schedule (1972 – 1982)	• 260,000 acre-ft. minimum delivery schedule through the S-12's • Provisions for reduction of flow to share adversity in drought.
Rainfall Plan (June 1985 – present)	• Base the amount and timing of water deliveries to Shark Slough on recent rainfall and evapotransporation upstream in WCA-3A • Moderate sudden changes in flow resulting from the minimum delivery schedule • Redistribute flow across the entire width of the slough, restoring flow to the eastern flow section and North East Shark Slough. • Included a flow redistribution component for passing 55% of flow through NESS and 45% through the remainder of Shark Slough.

J.8.5.1 Minimum Delivery Schedule

A minimum delivery schedule was implemented in 1970 as a step towards recognizing the importance of surface water delivery to Everglades wetlands. The minimum allotments for water supply to Everglades National Park were identified as 315,000 acre-feet per year and were divided among the major drainage basins as follows: Shark Slough-270,000 acre-feet, Taylor Slough-37,000 acre-feet, Eastern Panhandle-18,000 acre-feet. ***Table J-8.5.1-1*** provides a summary of water delivery schedules to Shark River Slough for the period 1962 to 1982.

Table J-8.5.1-1
Minimum Delivery Schedule
Shark River Slough, Taylor Slough
And Eastern Panhandle
(Acre-Ft)

Month	Shark River Slough (S-12's) (acre-feet)	Taylor Slough (S-332) (acre-feet)	Eastern Panhandle (S-18C) (acre-feet)
January	22,000	740	1,540
February	9,000	370	630
March	4,000	185	290
April	1,700	185	110
May	1,700	370	110
June	5,000	6,660	340
July	7,400	7,400	510
August	12,200	2,960	860
September	39,000	5,920	2,690
October	67,000	7,770	4,630
November	59,000	3,700	4,060
December	32,000	740	2,230
Total	**260,000**	**37,000**	**18,000**

Source: C&SF Project C-111, EIS, 1994

The effects of this delivery schedule are well documented and summarized as follows:

- The water releases to Everglades National Park, through the four S-12 control structures were still constrained by the needs of other consumers and the requirement for releasing excess water during high water periods,
- Water releases to Everglades National Park were directed to the west side of the historic flow-way,

- Water releases, in conjunction with the construction of the L-67 extension, resulted in abbreviated and lower water levels in the Northeast Shark Slough,

- As consequence of these operations, it has been possible for the relatively high ground along the eastern edge of the Northeast Shark Slough to be developed for agricultural and urban use, and

- Further consequences of these actions has been the continued deterioration of the ecological conditions within the park

J.8.5.2 Experimental Program of Water Deliveries to ENP

Recognition of the adverse effects to Everglades National Park prompted the Congress to enact provisions within the Supplemental Appropriations Act (Public Law 98-181) on November 30, 1984. Section 1302 of this act authorized the Secretary of the Army to conduct a two year experimental program for delivering water to Everglades National Park. This authorization allowed for modifications to the existing schedule of water deliveries from the Central and South Florida Project. Provisions of this law also called for the acquisition of lands in agricultural production which may be adversely affected by the modifications to the delivery schedule. The Secretary was also authorized to construct necessary flood protection measures for the protection of homes in the area affected by the modifications to the delivery schedule.

J.8.5.3 Modified Water Deliveries to ENP

In response to PL 98-181, the Secretary of the Army completed the General Plan for Implementation of an Improved Water Delivery Schedule to Everglades National Park, Florida in January 1985 and approved by the Secretary on February 28, 1985. This document contained two recommendations:

(1) Preparation of a General Design Memorandum (GDM) and an Environmental Impact Statement (EIS) addressing modifications to improve water deliveries to Everglades National Park, and

(2) Extension of the two-year time limit specified in PL 98-181 based on a written agreement between the U.S. Army Corps of Engineers, Everglades National Park, and South Florida Water Management District.

The Shark Slough feasibility report examined the redistribution of waters into Northeast Shark Slough (NESS) with principle study objectives of determining as way to provide more manageable and flexible water delivery system by redistributing flows through NESS into Everglades National Park and Florida Bay.

Six alternatives were examined each involving redistribution of up to 50 percent of the recorded S-12 flows into NESS. These alternatives required both structural and operational changes. Structural modifications included the removal of the bottom 4 miles of the L-67e, additional outflow capacity in L-28 and a 1000 cfs structure in the middle of the L-67 to distribute flow into WCA-3B. Operationally water would be allowed to flow from WCA-3A into L-29 using S-333.

30-day and 90-day field tests were conducted in the period from 1983-1985 for a flow through experiment conducted to provide data to evaluate the effects on adjacent areas of re-inundating NESS. The 30 day test was conducted and the end of the dry season, 1984 during very dry conditions to test the introduction of water into NESS via S-333. The resulting analysis by MacVicar and VanLent (1984) indicated the effectiveness of the flow diversion in reducing the S-12 flows when there is storage in the NESS showing a decrease in water levels in WCA-3A and western Shark Slough.

The U.S. Army Corps of Engineers's General design memorandum for Modified Water Deliveries to Everglades National Park (USACE, 1990) addresses the Shark Slough portion of Water Deliveries and developed a plan for structural improvements to the water delivery system. The GDM authorized in 1985, describes the latest plan to redesign the surface water inflow patterns in an attempt to restore the Shark Slough hydrologic regime.

The Modified Water Delivery and C-111 Programs are the structural components for two different geographic regions encompassing Everglades National Park for redistribution of water to Everglades National Park. The Experimental Water Delivery Program is a series of iterative operational changes in water delivery to Everglades National Park until structural modifications are complete. The resulting Experimental Program of Water Deliveries to Everglades National Park is intended to build upon the results of previous tests as a means to restore more natural water deliveries. The overall goal of the Modified Water Delivery Program is to provide operational flexibility to Everglades National Park for further ecosystem restoration, while maintaining levels and flood protection for other interests in the area (USACE, 1995). This program was intended to provide a mechanism to field test water delivery methods and assess potential impacts to Everglades National Park, to other parts of the C&SF project, and the water supply ability of the U.S. Army Corps of Engineers and the South Florida Water Management District (USACE, 1995). This program is intended to provide a practical means of testing ecosystem responses to water deliveries with the goal of ecologic restoration for the natural systems of Everglades National Park.

The Modified Water Delivery Program and current schedule of Experimental Water Deliveries to Everglades National Park were initiated as a response to the requests outlined in the 7 Point Plan by Everglades National Park. As a response to this request, the U.S. Army Corps of Engineers initiated a series of tests, authorized under Public Law 98-181 Section 1302, to "conduct an experimental program for the delivery of water to the Everglades National Park from such project [the C&SF project] for the purpose of determining an improved schedule for such delivery" (USACE, 1995). These tests of experimental water deliveries to Everglades National Park were divided between schedule changes to both Shark Slough and to Taylor Slough. The first five iterative tests were conducted in the Shark Slough drainage. Test 6 incorporated Taylor Slough into the experimental program for the period beginning June 1993 through October 1995. Test 6, therefore involved changing operating practices for the existing structural features of the C& SF system that affect water deliveries and hydrologic conditions in both Shark Slough and Taylor Slough.

Authorizations for the Modified Water Delivery Program are found under the following statutes:

1) Minimum Water Deliveries to the C&SF project by Congress in 1969 under PL 91-282.

2) The Supplemental Appropriations Act of 1984, which authorized the U.S. Army Corps of Engineers with Everglades National Park and the South Florida Water Management District to deviate from the minimum delivery schedule.

3) PL 98-181, which allowed for land acquisition of impacted agricultural lands that were in agricultural production in 1983.

4) Section 107 of PL 102-104, which amended PL 98-181 to allow continuation of the Experimental Delivery program until modifications to the C&SF Project authorized by sections 104 of the Everglades National Park Protection and Expansion Act of 1989 (PL 101-229) were completed and implemented.

Experimental Water Delivery Program, Test Iteration 7 Features

The C-111 General Reevaluation Report (GRR) recommends that an operational plan be developed for both Shark Slough and Taylor Slough as part of the Experimental Program. Test 7 was designed as a means of examining the impacts of refinements recommended from Test 6. Test 7 is the implementation and examination of the effects of changes recommended at the conclusion of Test 6.

As described by the U.S. Army Corps of Engineers (1995) Test 7 includes:

1) Northeast Shark Slough water deliveries through the S-12 and S-333 structures as an extension of the Test 6 program.

2) Taylor Slough water deliveries changed to maintaining water levels in the L-31W canal between S-174 and S-175 based on a rainfall/canal stage formula developed by Everglades National Park for Taylor Slough.

3) L-31W Flood Conveyance Capacity, where 500 cfs flood conveyance capacity is maintained by the addition of a pump station (S-332D) at S-174.

4) Add up to 125 cfs in additional pumping capacity at S-331.

5) Monitoring: Ecological and hydrological monitoring will be carried out for the period of Test 7.

6) Public acquisition of the Frog Pond, to eliminate the need for planting season drawdowns and allow increased stages beyond design stage in L-31W.

7) Provide plugs in the east-west Aerojet canal south of S-175 and in the north-south S-175 getaway canal.

8) Raise S-18 C operating criteria

9) Adjust S-174 and S-175 operating criteria

10) Test Duration: Test 7 will continuously operate for up to four years and then undergo an evaluation of six months or less in duration to determine whether the test should be continued or a new test implemented.

J.8.6 Socio-Economics

The purpose of this section is to provide an overview of the socio-economic environment of the 5 south Florida Counties (Palm Beach, Broward, Miami-Dade, Monroe and Collier) most intimately tied to Everglades National Park (Park). The Park lies within Collier, Miami-Dade, and Monroe counties. It is, however, affected by conditions within Broward and Palm Beach counties due to urban and agricultural pressure on the entire Everglades ecosystem. This section will also discuss the contributions of Everglades National Park to the region.

J.8.6.1 Population and Demographics

The area under consideration falls within several planning and regulatory jurisdictions. The primary land use planning and regulatory jurisdictions include the south Florida, southwest Florida, and Treasure Coast Regional Planning Councils under the Florida Department of Community Affairs, while the South Florida Water Management District is the primary water management and regulatory agency. The South Florida Regional Planning Council's jurisdiction includes Monroe, Miami-Dade, and Broward Counties. Collier County is included within the Southwest Florida Regional Planning Council and Palm Beach County is part of the Treasure Coast Regional Planning Council. The South Florida Water Management District jurisdiction includes 16 counties: all of Broward, Miami-Dade, Monroe, Glades, Lee, Palm Beach, St. Lucie, Collier, Hendry, and Martin counties and part of Highlands, Osceola, Charlotte, Okeechobee, Orange and Polk counties (SFWMD, 1992). Additionally the water management district has divided their water supply planning into several regions, of particular interest is the Lower East Coast, which includes all of Palm Beach, Broward, Miami-Dade and Monroe Counties (SFWMD, 1997). Collier County primarily falls under the planning auspices of the South Florida Water Management District's Big Cypress Basin Board or the Southwest Regional Planning Council.

Southeast Florida, or the Lower East Coast, defined as Broward, Miami-Dade, Monroe, and Palm Beach Counties, has experienced tremendous growth since 1900. In 1910, the population of southeast Florida was just under forty thousand, half of whom lived in the Florida Keys (Shultz 1991). This growth had begun to dramatically increase by 1920, doubling to 86,000. By 1930 the population had increased to 228,000, by 1940 it had increased to 400,000 and by 1950, about the time that construction of the Central and South Florida Project had begun, there were 700,000 people in the area (Shultz 1991). In 1970, there were 2.3 million people living in southeast Florida and by 1990 the area had a population of 4.1 million people (Shultz, 1991; Bureau of Economic and Business Research, 1995). On the west coast, Collier County, now recognized as one of the fastest growing counties in the state, had a population of 2,883 in 1930, by 1940 it had grown to 5,102, by 1950 to 6,488, and by 1960 the population had more than doubled to 15,753 (Bureau of Economic and Business Research, 1995). ***Table J-8.6.1-1*** shows the average annual rates of population growth in the region in the decades between 1950 to 1995.

Table J-8.6.1-1
Average Annual Rates Of Population Growth
(%)

Period	Broward	Miami-Dade	Monroe	Region	Florida
1950/1960	14.8	6.6	4.8	8.0	6.0
1960/1970	6.4	3.1	0.9	4.0	3.2
1970/1980	5.1	2.5	1.9	3.4	3.7
1980/1990	2.1	1.8	2.1	1.9	2.9
1990/1995 *	1.5	0.6	1.5	1.0	1.8

(*) Projections Source: Bureau of Economic and Business Research, Projections of Florida Population by County, 1993-2020, as presented in SFRPC (www.sfrpc.com/region/prof.peop.htm).

There are now approximately 6 million people in the South Florida Water Management District's 16 county service area. The South Florida Water Management District (1993b) expects population to triple by 2050. ***Table J-8.6.1-2*** shows the University of Florida Bureau of Economic and Business Research’s estimates of the median projected population for the five south Florida counties under review.

Table J-8.6.1-2
Population Projection Estimates
For 5 South Florida Counties

County	1994	1995	2000	2005	2010	2015	2020
Broward	1,340.2	1,362.9	1,471.1	1,569.8	1,665	1,760.2	1,854.2
Colllier	180.5	187.8	224.0	256.6	288.6	321.0	353.5
Miami-Dade	1,990.4	2,016.3	2,140.8	2,254.3	2,363.8	2,473.2	2,581.2
Monroe	82.3	83.5	89.2	94.4	99.5	104.5	109.5
Palm Beach	937.2	960.8	1,074.4	1,177.8	1,277.9	1,378.7	1,478.7

Florida Statistical Abstract 1995: Bureau of Economic and Business Research, College of Business Administration) (in thousands rounded to hundreds)

The characteristics of this population and of the population growth rate, have changed over the years. The South Florida Regional Planning Council reports in its Regional Profile (SFRPC, 1996) that the composition of in-migration to the region has changed. Migration, through the end of the 1950’s, consisted primarily of people from the northern United States; beginning in the 1960’s south Florida began to see a shift to immigration from Latin America. This immigration was first characterized by hundreds of thousands of Cuban refugees in the period from the 1960’s to the 1980’s and then in the 1970’s and 1980’s by immigrants form other Central and South American countries and from the Caribbean. The volume of this new inflow of population has also increased relative to migration from the northern United States. The Treasure Coast Regional Planning Council also notes a significant increase in the Hispanic population reflecting these shifted demographics.

In addition to the ethnic changes there is also a change in the age of the population and the immigrants (domestic and international). Traditionally the south Florida area has been a mecca for retirees, in part due to the lack of a state income tax and to the balmy climate. In 1990, the counties of the SFRPC were home to 544,000 people 65 years old or older, representing 17 percent of the region’s population. Increased population density and resulting congestion are thought to be part in part responsible for the declining proportion of the elderly immigrants drawn to the region covered by the SFRPC. The SFRPC notes that the previous generations of elderly immigrants are not being replaced by new ones (SFRPC Regional Profile 1996).

Collier County shows similar changes in the age composition of its population; historically a resort and retirement community, the recent rapid population growth has brought younger, permanent households to the county (Collier County, 1997). ***Table J-8.6.1-3*** shows the median age and percentage of population over 65 years old for the decades between 1970 and 1990 for the 5 counties. The projected population by age group and County is shown in ***Table J-8.6.1-4***. The new character of the current south Florida population results in altered demands on the ecosystem, increased urban development pressures and altered resource management problems.

Table J-8.6.1-3
Age Characteristics Of Population
Median Age

County	**Census**			**Projections**		
	1970	1980	1990	2000	2005	2010
Broward	37.5	38.7	37.6	40.5	42.0	43.2
Colllier	35.2	38.0	40.6	41.0	41.3	40.4
Miami-Dade	34.2	34.7	34.2	36.6	37.6	38.2
Monroe	27.3	35.5	38.8	43.3	45.7	47.5
Palm Beach	35.5	39.7	39.8	43.0	45.0	46.8

Florida Statistical Abstract 1995: Bureau of Economic and Business Research, College of Business Administration

Table J-8.6.1-4
Age Projections
(In Thousands Rounded To Hundreds)

	2000			**2005**			**2010**		
County	0-24	25-64	65 and over	0-24	25-64	65 and over	0-24	25-64	65 and over
Broward	429.8	765.9	275.4	463.1	826.7	280.0	485.5	880.5	289.9
Colllier	68.7	103.1	52.1	83.1	118.1	55.4	98.0	132.8	57.7
Miami-Dade	744.1	1098.6	298.0	778.4	1152.8	313.0	815.6	1212.2	336.0
Monroe	22.7	49.1	17.4	24.8	50.7	18.9	26.2	52.5	20.8
Palm Beach	295.1	530.4	248.9	322.5	598.8	265.5	342.0	642.9	293.0

Florida Statistical Abstract 1995: Bureau of Economic and Business Research, College of Business Administration

J.8.6.2 Park Contributions to Economics and Recreation

Everglades National Park is contained within Collier, Miami-Dade, and Monroe counties. The cities of Homestead and Florida City serve as the gateway communities to the eastern portion of Everglades National Park, while Everglades

City is the gateway to the Ten Thousand Islands section of the western portions of Everglades National Park. The Park's extensive fresh and salt water areas, open Everglades prairies, mangrove forests, and Florida Bay provide a home for abundant wildlife including many endangered and threatened species of flora and fauna. The Park has over 150 miles of walking and canoe trails, including 2 miles of elevated boardwalk trails. There are three campgrounds with over 420 campsites with another 48 backcountry campsites available to boaters and canoeists. The Park has a national and international reputation as a tourist destination and is an important part of the south Florida tourism industry. The park is the largest remaining sub-tropical wilderness in the continental United States, 1,296,500 acres of Everglades National Park are protected as designated wilderness. In 1997, this wilderness was re-dedicated as the Marjory Stoneman Douglas Wilderness. The Park is also home to the Miccosukee Tribe of Indians of Florida who use and occupy 333.3 acres on the northern boundary. It is designated as a World Heritage Site, an International Biosphere Reserve, and a Wetland of International Significance.

The diverse and unique beauty and character of Everglades National Park draw visitors from all over the world: in the spring of 1996 international visitors accounted for 21 percent of Park visitation. Of these international visitors, over half are from Germany, 13 percent from the United Kingdom, and 10 percent from Canada. Thirty six percent of domestic visitation is from Florida, while Illinois and Michigan are the next most represented states with 6 percent each of the domestic total. Visitors come to Everglades National Park to view wildlife, for the solitude and wilderness experience, for birdwatching and to visit a wetland. They also come specifically to visit the International Biosphere Reserve and World Heritage Site.

An understanding of the economic value of National Park Service lands on the local economies in south Florida is outlined in the recent draft of a study entitled "Compilation of Available Data on Economic Impacts of Federal Interest Lands in south Florida" which reports the following combined benefits to Miami-Dade County attributable to Everglades National Park in FY94. Combined Sales Benefits: $119,165,051; Combined Increased Tax Revenue Benefits $7,745,728; and Combined New Jobs Created 4,930. An update completed for Everglades National Park for FY 97 calculated Combined Sales Benefits of $128,186,563; Combined Increased Tax Revenue Benefits of $8,332,127; and Combined New Jobs Created 5307.

Everglades National Park has three major concession operations. AMFAC is located at Flamingo, at the end of the main park road, 38 miles from the main entrance. They employ about 150 people and operate a restaurant, lodge, bar, gift shop, marina store (including equipment rentals), boat tours and boat rentals. Shark Valley Tram Tours operates tram tours, vending machines and bicycle rentals within the Shark Valley area. They are located off the Tamiami Trail near the Shark Valley Visitor Center and employ 12 people. Everglades National Park

Boat Tours Inc. is located at Everglades City and offers boat tours of the 10,000 islands area, equipment rentals, snacks, books, etc. This firm employs 20 people. Gross receipts for the concessions in FY 96 were approximately $ 6.7 million dollars. An additional component employment and income is the Incidental Business Permit (IBS) program under which boat tour operations, canoe outfitters and fishing guides operate. Visitors can use these services for sightseeing, photography, fishing and canoeing. In FY 96, the IBS gross receipts came to $3.4 million dollars and IBS permit holders employed 300 people.

J.8.7 Land Use

As the region has grown its land use patterns have dramatically changed. In south Florida the character of the land has acted as one of the constraints dictating early settlement patterns. Topography, soils, and aquifer maps illustrate the vulnerability of south Florida to inundation. On the east coast, the Atlantic Coastal Ridge (coastal ridge) and associated pine rocklands, due to its higher elevation and more stable soils, were the first to develop. As the coastal ridge developed and available lands were depleted, particularly over the last few decades, other, less suitable lands were developed in the sprawl pattern characteristic of current day south Florida.

J.8.7.1 East Coast Land Use

Miami-Dade and Broward Counties have the most pronounced sprawl patterns. The SFRPC describes the change:

> "Essentially rural areas in the western extremes of Broward and Miami-Dade Counties have given way to sprawling suburban residential development and shopping centers. Indeed, these have been an important component of the economic growth that has taken place in the Region. During the process, the once significant rural population has virtually disappeared, resulting in the emergence of a distinctly urban character to the Region. Miami-Dade County was already 94 percent urban in 1950, and 77 percent of Broward County's population lived in urban areas. By 1980, both counties were 99 percent urban. Only in Monroe County did a significant portion of the population still live outside of urban areas in 1990 (27 percent), consistent with the special characteristics of that county's political geography." (SFRPC, 1996).

Palm Beach County is experiencing a similar change. The Treasure Coast Regional Planning Council reports that while the coastal area of Palm Beach County from Riveria Beach to Boca Raton, is heavily urbanized, much of the recent population growth has occurred in the western unincorporated areas (TCRPC, 1996). This sprawling urbanization tended to push agricultural land uses off of prime farmlands into the less suitable wetlands fringing the coastal ridge. As the development continues to expand it is expected that it will consume the remaining agricultural lands (both historic and recent) and eventually make its way into the remaining unprotected wetlands of the counties. The SFRPC explains that the region, in the response to the pressure of continued population growth, is likely to yield to the pressure to continue to urbanize.

J.8.7.2 Southwest Coast Land Use

Collier's population is currently heavily concentrated on the northwestern coastline (Continental Shelf Associates, Inc, 1990) within the communities of Naples, Marco Island, Golden Gate, and Everglades City. Of the 1,994 square miles of land within the county 780 are in conservation and another 528 are currently proposed for public acquisition and preservation.

J.8.7.3 Increased Pressure on Open Land

As this trend continues the availability of developable land decreases putting pressure on the unprotected wetlands and agricultural lands. There is a fear that agriculture lands will come under increased pressure as lands are converted into subdivisions or set aside for environmental protection. South Miami-Dade County typifies this trend. As people continue to move into the county pushing the north and central regions to capacity, the remaining undeveloped areas in south Miami-Dade County become the easiest option for future growth. The 80,000 acres of agricultural lands in the Redland region and other parts of unincorporated Miami-Dade County are increasingly under development pressure. In the 1995 Evaluation and Appraisal Report Miami-Dade included a recommendation that a Farmland Retention Study be conducted, noting that: "By [the Evaluation and Appraisal Report for 2000], the currently planned Urban Development Boundary will be substantially built out and the County will be facing the prospect of having to plan for the urbanization of an additional 20 square miles of land, if we continue the past trend of low-density development."

There are several other efforts to halt these land conversion and development trends including the following: Eastward Ho!, Brownfields, and the South Miami-Dade U.S. 1 Corridor Project.

J.8.8 Recreation Resources

Everglades National Park and Florida Bay offer unique and diverse opportunities for a variety of natural resource and wilderness based recreational activities. Day use and camping (front and backcountry) facilities are available throughout the Park. There are over 150 miles of walking and canoe trails, including 2 miles of elevated boardwalk trails and three campgrounds with over 420 campsites and an additional 48 backcountry campsites in the Park. Recreation activities include: hiking, boating and canoeing, fishing, bird and wildlife viewing, and going on guided interpretive tours. The C&SF Restudy regional boundaries include the authorized boundary of the park although not all lands within the East Everglades Expansion Area have been acquired by the federal government.

Everglades National Park has been designated a World Heritage Site, and International Biosphere Reserve, and a Wetland of International Significance. In addition, 86% of the Park is designated Wilderness under the Wilderness Act of 1964. The state of Florida has designated the Park an Outstanding Florida Water. The Park has also been listed as one of the nation's top ten most endangered parks (USACE, 1994).

Diverse ecosystems from sawgrass prairie to pinelands and hammocks to the estuarine environment of Florida Bay area easily accessible from the main park road or the Shark Valley tram road. The main park road ends at Flamingo, a former fishing village, and a main port of entry to Florida Bay, where a variety of self-guided, concession or ranger led walks and boat tours are available. Anhinga Trail, at the U.S. 29 leads to Everglades City and the Gulf Coast Visitor Center where the island-bay-mangrove ecosystems of the 99 mile Wilderness Waterway and Chokoloskee Bay, Turner River, and the Ten Thousand Islands area can be accessed. At Shark Valley, within the Shark River Slough, there are opportunities for biking, a guided interpretive tram tour, guided interpretive walks, as well as the climb to the top of the observation tower for a spectacular view of the sawgrass prairie. Chekika, (a former state park within the East Everglades Acquisition Area and donated by the state to the Park in 1991) offers a slightly different experience with opportunities for a soak in a sulfur pool as well as for picnicking and hiking.

Recreation resources within Florida and Whitewater Bays, the Ten Thousand Islands, the Wilderness Waterway, West Lake and Nine Mile Pond are characterized primarily by water-based resources and include boating, fishing, bird and wildlife observation, and interpretive programs. The opportunity to enjoy the sounds of nature, solitude, tranquility and wilderness are also part of the recreational aspect of these areas. The Wilderness Waterway and Florida Bay are dotted with backcountry camp sites (by permit only). There are three kinds of backcountry campsites: chickees, ground sites, and beach sites. All offer opportunities for wildlife viewing and experiencing the sounds of nature, solitude, tranquility, and wilderness.

J.8.9 Aesthetic Resources

The Everglades National Park regional aesthetic overview is comprised of historical landscape communities that create a mosaic of textures, colors, and viewsheds. The Shark River Slough community is characterized the wet prairie-slough-sawgrass-tree island mosaic (D&O, 1994). The views of this vegetative community are panoramic and of interest. The Shark River slough is bordered on its east and west by fresh water marl prairie. The dominant vegetative community is sawgrass with few spotted tree hammocks. This area is characterized by broad, panoramic views of good aesthetic quality.

In the southeast portion of the Everglades National Park region are cypress stands and pinelands. These areas possess good quality aesthetics but are viewed from the entrance road that provides a vehicle corridor of limited access and perspective. Taylor Slough is located to the southeast of the pinelands and is a much smaller version of the Shark River Slough with very similar aesthetics. South of these areas the marl prairie begins and provides expansive scenic views above the Florida Bay and its diverse viewshed. Few roads and canals cross the Everglades National Park Region, which helps to maintain the aesthetic resource. Air traffic noise is an increasing adverse aesthetic impact. The Everglades National Park has been designated as one of the nation's top ten most endangered parks (USACE, 1994). Development and its water terms are an increasing threat to the park natural and aesthetic resources.

Marine and estuarine open and closed viewsheds of good quality aesthetics and panoramic coastal prairie views of expanse characterize the Florida Bay regional aesthetic overview. Wildlife is an integral aspect of the aesthetic quality of the region and adds interest and spur reactions. The open prairie viewsheds extend into the waters and islands of Florida Bay on the very southern portion of the Florida Bay region. To the northwest are more coastal prairies and islands amongst the marine and estuarine communities. These communities provide waterways and trails that have varying corridor widths, environmental interest and unique aesthetic resource characteristics. The trade winds ameliorate the temperatures in the region like nowhere else and provide a comfortable climate year round.

Development and its water requirements are an increasing threat to the park's natural and aesthetic resources. Reduced water deliveries to the wetland areas has allowed saltwater concentrations to adversely affect the natural and aesthetic resources of the region.

J.9 FLORIDA KEYS

The Florida Keys (***Figure J.9-1***) are a limestone island archipelago extending southwest over 200 miles from the southern tip of the Florida mainland to the Dry Tortugas, 60 miles west of Key West. The relatively shallow waters of Biscayne Bay, Barnes and Blackwater Sounds, Florida Bay, and the Gulf of Mexico, bound them on the north and west. Hawk Channel lies to the southeast, between the mainland Keys and the extensive reef tract 5 mi offshore. The Keys are made up of over 1,700 islands encompassing approximately 100 square miles. They have little relief (generally less than one meter), have a shoreline length of 1,870 miles,

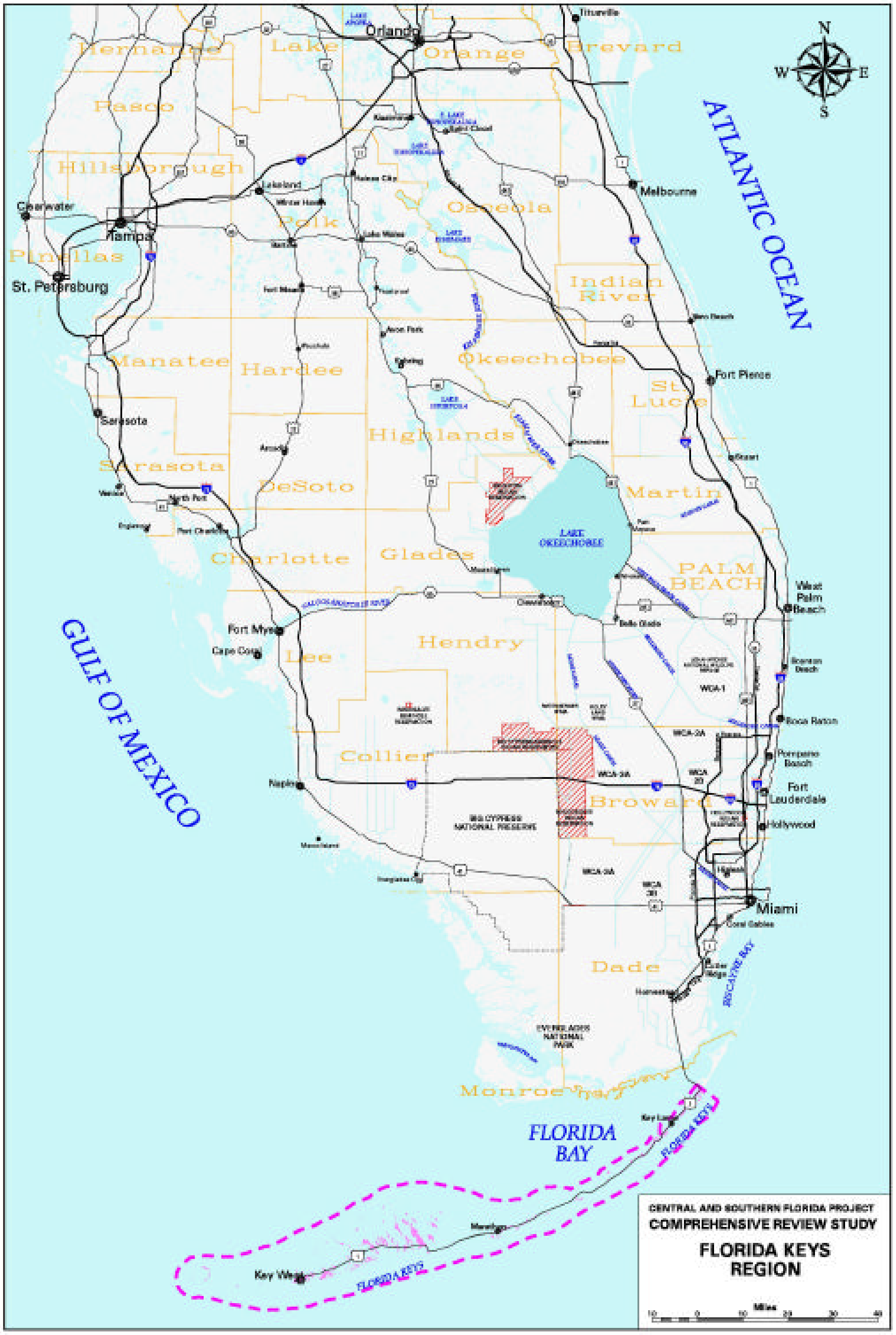


Figure J.9-1 Florida Keys Region

and are inhabited from Soldier Key to Key West. Key Largo (25 mi^2) and Big Pine Key (10 mi^2) are the largest individual islands in the archipelago (Monroe County, 1992).

This region also encompasses the Florida Keys National Marine Sanctuary, an area of approximately 3,700 mi^2 of submerged lands and waters between the southern tip of Key Biscayne and the Dry Tortugas Bank. The Sanctuary contains partof Florida Bay and the entire Florida Reef Tract, the largest reef system in the continental United States. Approximately 2,150 mi^2 (58 percent) of Sanctuary waters are under State jurisdiction. Numerous State and Federal parks and reserves are located within the Sanctuary's boundaries.

J.9.1 Vegetation

Plant Communities found on the Keys include seagrass beds, algal flats, mangroves, salt marsh, pine rocklands, tropical hardwood hammocks, coastal berm, open beach / dune strand and coastal rock barrens. Seagrass beds are described in the Florida Bay chapter.

Algal flats are communities that occur in lagoons and shallows adjacent to the Keys, especially in high-salinity areas. Algal species, including the calcareous agal species *Halimeda spp., Acetabularia crenulata, Caulerpa verticillata,* and *Udotea wilsoni*, dominate low energy, shallow, open-water flats, especially on the Bay side of the Keys. These algae are resistant to elevated water temperatures and salinity. The red algae *Dasya pedicellata* and *Gracilaria confervoides* are observed when salinities are greater than 20-25 ppt (Tabb *et al.*, 1962). Calcareous algal communities are often found interspersed in finger coral (*Porites)* rubble of the shallowest waters on the Atlantic side. Wherever they are predominant calcareous algal assemblages generate large quantities of carbonate sediments. Off the Upper Keys Ginsburg (1956) found that more than 80 percent of the sediment was derived from the calcareous alga *Halimeda*. Shinn *et al.* (1990) reported that an average of 48 percent of the sands in an area 35 miles west of Key West (the Quicksands) was derived from *Halimeda*.

Seagrass beds occur on both the Florida Bay and Atlantic sides of the Keys, in low energy areas where the water is clear and there is sufficient soft bottom sediment that they can root. In many areas where a shallow lagoon is found on the protected side of the offshore reef tract, this area is also covered with mixed seagrasses. Grassy bottoms are also found bordering inlet channels between the Keys, and generally in low energy, protected areas that are deep enough that they are never exposed to the air at low tide. Turtlegrass (*Thalassia testudinum)* is the predominant species in waters deeper than 1-2 feet. Associated with the turtlegrass is manatee grass (*Cymodocea manatorum*). Shallower areas may have a thin cover of shoal grass (*Halodule wrightii*). Seagrass beds are essential habitat for juvenile fish and invertebrates. Calcareous algae often occur interspersed with seagrasses in mixed assemblages.

Mangrove forests are the most extensive habitat type in the Lower Everglades and Florida Keys areas (Schomer and Drew, 1982; Minerals Management Service, 1990). In 1974 Florida's Coastal Coordinating Council (CCC) estimated that there were 235,000 acres of mangroves in Monroe County. Mangrove communities are composed of an association of unrelated tropical hardwood tree species adapted to grow in saline soils under conditions of intermittent flooding. Mangrove species are not generally frost hardy, and are found throughout the tropical world along low energy coasts. In the Keys and coastal Florida the red mangrove (*Rhizophora mangle*) dominates the intertidal zone of outer fringes and mangrove cays, while black mangrove (*Avicennia germinans*) occupies the inner side of fringing stands, as well as lower-energy hypersaline flats and deeply flooding basins. White mangrove (*Laguncularia racemosa*) is found in lower salinity areas, as well as forming extensive “dwarfed” stands over rocky flat areas of the lower Keys. Mangrove stands and cays are important wildlife habitat. Most mangrove stands export particulate and dissolved organic matter to surrounding waters, supporting a diverse food web (Odum, 1982). Red mangrove prop roots provide vital nursery and grow-out habitat for many species of commercial fish and such invertebrates as lobsters and crabs, and many species of wading birds utilize mangrove canopies and islets for roosting and nesting.

Salt marsh formations are nearly absent in the Keys proper, except in recently disturbed areas, where cordgrass (*Spartina)* may act as a pioneer species in the intertidal zone, eventually being replaced in succession by slower-growing red mangrove trees.

Upland terrestrial habitats within the Keys may be grouped into five major ecosystem types, based on their geographic location and dominant plant species. These habitats include: pine rockland, tropical hardwood (rockland) hammocks, coastal berm, open beach dune/strand, and coastal rock barren.

Pine rockland communities occur mainly in inland areas and are associated with fresh (or low-salinity) groundwater. While there were once pine forests in the Upper Keys, the habitat is now found only in the Lower Keys. On Key Largo, only charred pine logs, stumps, and some persistent species typical of the understory remain. Approximately 2,200 acres of undisturbed pinelands remain in the Keys (Monroe County, 1986). These communities are most common in the lower Keys, with the greatest acreage occurring on Big Pine, Little Pine, No Name, Sugarloaf, and Cudjoe keys (Schomer and Drew, 1982). Pine stands generally contain three layers of vegetation. The most visible species is the south Florida slash pine or

Caribbean pine (*Pinus elliottii* var. *densa*), a distinct variety found only in south Florida (Hardin, 1991). The understory may be tall, dense, or nearly absent, and is composed of trees, shrubs, palms, and young pines. The ground layer is composed of numerous wildflowers and grasses (Hardin, 1991). Some pinelands appear prairie-like, with wildflowers and grasses (including *Cassia* and *Ruellia*) on the ground layer more conspicuous than the few scattered pines. Pine rockland is the habitat of the endangered Key deer and of several endemic plant species.

Tropical hardwood hammocks are the most extensive upland plant community in the Keys. Monroe County has estimated that there are about 7,000 acres of hardwood hammock between North Key Largo and Lower Sugarloaf Key, with over 3,600 acres in the Upper Keys (to Marathon) and over 3,200 acres between Big Pine Key and Lower Sugarloaf Key. Hammocks in the Keys consist of closed, broadleaf forests containing a large number of evergreen and semievergreen trees. They develop on elevated, rocky, rarely flooded and fire-free sites. More than 150 species of trees and shrubs are found in this habitat within south Florida and the Keys. Tropical species are found in the Keys more often than in south Florida. Keys vegetation is similar to that of the Bahamas and Greater Antilles, with many of the plants at the northern limits of their range.

Common tree species found in both the Upper and Lower Keys include poisonwood (*Metopium toxiferum*), Spanish stopper (*Eugenia foetida*), saffron plum (*Bumelia celastrina*), black bead (*Pithecellobium keyensis*), pigeon plum (*Coccoloba diversifolia*), Jamaican dogwood (*Piscidia piscipula*), gumbo limbo (*Bursera simaruba*), white stopper (*Eugenia axillaris*), white indigo berry (*Randia aculeata*), blolly (*Pisonia discolor*), torchwood (Am*yris elemifera*), and yellowroot (*Morinda royoc*). Many other species of trees, shrubs, and cacti are present, including live oak, mahogany, mastic, wild coffee, lancewood, wild tamarind and strongbark.

Over 4,000 acres of excellent quality hammock remain in the Upper Keys due to a lack of recent disturbances, with 89 percent in eight publicly owned sites, mostly in Biscayne National Park and on North Key Largo (Kruer, 1992). Of almost 3,000 acres of hammocks reported in the Lower Keys, 54 percent are publicly owned, 44 percent are private, and two percent remain in nonprofit ownership.

The term coastal berm is used to describe the mostly wooded upland plant community that develops on high ridges of storm-deposited sand, shell, and marine debris. It includes forested sections of large dunes. There are only 159 acres of this cover type in the Keys. Kruer (1992) reported 84 plant species as occasional to abundant in the coastal berm habitat. Of the 10 most frequent, black bead, Spanish stopper, poisonwood, buttonwood, seagrape, blolly, and gumbo limbo were also reported as dominant in the Lower Keys hardwood hammock habitat. Seven-year apple, bay cedar (*Suriana maritima*), wild sage, silver palm, Bahama nightshade (*Solanum bahamense*), broadleafed spider lily, Australian pine, and green knickerbean were also reported as common. Australian pine is an undesirable exotic tree that invades this community.

Dune strand habitats are similar to the dune environments of Florida's southeast coast. Dunes are typically located in open areas, with pioneering vegetation occurring on coarse carbonate sand, shell, and marine debris of biogenic origin. The upper beach is vegetated with pioneer species, especially sea oats. Kruer (1992) reported sea purslane (*Sesuvium portulacastrum*), sea lavender (*Limonium* spp.), sea oats, picnic grass, broadleafed spiderlily (*Hymenocallis lafifolia*), bay cedar (*Suriana maritima*), wild sage (*Lantana involucrata*), sea blight, yellowtop (*Flaveria linearis*), coastal dropseed, and spurge from this habitat. Seven of the 11 genera found on Florida's southeast coast also dominate the habitat in the Keys. Sea lavender sites are of particular significance, as the species is seriously threatened in other parts of the state.

Coastal rock barren habitats are unusual upland communities, vegetated by sparse drought tolerant plants and cacti on flat rocklands with considerable exposed limestone. Most sites contain several species of cactus,. The rare three-spined prickly pear *(Opuntia priacantha*) occurrs in this cover type. Plants frequently found include the endemic *Indigofera keyensis, Evolvulus convolvuloides, Cienfugosia yucatensis, Sida cilans, Jacquemontia penthantha,* false sisal, prickly pear, and shrubby hardwoods.

J.9.2 Fish and Wildlife

The limited land area and relative isolation of the individual islands making up the Keys have limited the species-richness of its land animal fauna. In contrast, the surrounding waters support a great variety of fish and invertebrate species. On land, the mangroves, rocky pinelands and tropical hardwood hammocks all provide important wildlife habitat.

J.9.2.1 Fish

Warm temperate zone fish species arrive in the Keys as larvae from the Gulf of Mexico circulation, while tropical forms arrive on the Florida Current from the Caribbean. The Keys serve as a partial barrier between the two regions, with numerous major tidal passes separating the islands of the Lower to Middle Keys. Water exchange through these passes allows for a mixing of biota in the area's nearshore transitional habitats. The following discussion is organized by habitat type, beginning with hardbottoms, through seagrass beds, mangrove roots and coral reefs.

Hardbottoms in shallow Bay waters provide habitat for many species of invertebrates, including molluscs, crustaceans, and echinoderms, including species of sea urchins, sea stars, sea cucumbers, many shrimp species, lobsters, portunid and calappid crabs, conchs, bivalves, nudibranchs, and annelids (Minerals Management Service, 1987). Hardbottom habitats with high-relief ledges or solution holes often support commercially important species such as lobsters (*Panulirus argus*, *P. guttatus, Scyllarides* spp., and *Scyllarus* spp.). Stone crabs are often found in burrows or solution holes.

Diverse and abundant fish assemblages are found within the Keys seagrass habitats. These areas are important nursery and feeding grounds for many species that will ultimately have commercial or sportfishing value (Zieman, 1982). Fish populations are a mix of temperate and tropical species, and seagrasses serve as nursery grounds for seasonal residents (i.e., those fishes that spend only part of their life cycle in these areas). Examples include drums (*ciaenids*), porgies (*sparids*), grunts (*haemulids*), snappers (*lutjanids*), cobia (*rachycentrids*), and mojarras (*gerrids*) (Zieman, 1982).

The seagrass community is vital habitat for a variety of commercially important fish species. Snapper, an important species to the seafood industry, spends much of its life cycle in the seagrass habitat. Examples include the mangrove (gray) snapper (*Lutjanus griseus*), lane snapper (*L. synagris*), schoolmaster (*L. apodus*), and mutton snapper (*L. analis*). Recreationally important species utilizing the seagrass community include spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), bonefish (*Albula vulpes*), permit (*Trachinotus falcatus*), tarpon *(Megalops atlanticus*), great barracuda (*Sphyraena barracuda*), and various sharks. These species are sought by professional fishing guides and sportfishermen from all over the world, and form the basis of an important recreational industry. Although these species are found in the Gulf region and throughout the Keys region, they are most common in the Keys' nearshore habitats and tidal channels.

The seagrass beds also support commercially important invertebrate species such as shrimp and lobster. South Florida's commercial shrimp fishery is based on the region's pink shrimp population (Saloman, 1968). Although the brown shrimp (*Penaeus aztecus aztecus*) and the pinkspotted shrimp (*Penaeus brasiliensis*) are also present, they are not as important (Saloman, 1968).

Pink shrimp are historically common in the estuaries and shallow marine waters surrounding southern Florida and in the deep waters (approximately 100 m) southeast of the Keys, and are the dominant species within the Dry Tortugas shrimping grounds and Florida Bay (Saloman et al., 1968).

The commercially important spiny lobster begins their existence in the Keys as larvae arriving by oceanic currents. They then metamorphose into a transitional swimming stage, travel through channels between the Keys, and enter nursery areas in the seagrass beds in Florida Bay and the Gulf. They then metamorphose into juveniles and take up solitary residence in the Bay. They remain in these nurseries for 18 months to two years (Hunt et al., 1991).

Adult lobsters move to deeper waters and the coral reef environment, where they occupy dens or holes during daylight hours. They are nocturnal feeders and predominantly prey on molluscs and crustacea, including hermit crabs and conch.

Stone crabs are distributed in various habitats throughout the Keys regions. They inhabit warm-temperate, subtropical, and tropical waters, and although found in harvestable quantities along parts of Florida's west coast from Cedar Key to the Ten Thousand Islands, the greatest concentrations occur in the coastal waters adjacent to Collier County and throughout Florida Bay (Bert et al., 1978). They occur, but are less abundant, in nearshore habitats and tidal passes with suitable substrate. Although stone crab fishermen set traps on the Atlantic side of the Keys, the majority of the fishery is within Gulf waters.

Mangrove-related fish communities can be organized along various environmental gradients including salinity, mangrove detritus dependence, and substrate (Odum *et al*., 1982). The sheltered backwater pools of the black mangrove basin forest community are harsh environments inhabited by killifishes (*Cyprinodonts*) and live bearers (*Poeciliids*) (McPherson, 1971; Odum et al., 1982). However, it is the shaded, sheltered community of the red mangrove prop roots and the surrounding shallow waters that provide the most significant juvenile fish habitat in the Keys mangrove community. Among fish species associated with the mangrove habitat as juveniles or adults, mullet (*Mugil curema*), tarpon (*Megalops atlanticus*), and, as juveniles, several species of snappers (lutjanids), grunds (haemulids) and groupers (serranids). Many of these fish exploit the detritus-based mangrove food chain, feeding on forage fish supported by the mangrove detritus.

Coral reefs attract a diverse assemblage of fish. Resident and transient species include wrasses, angelfish, tangs, parrotfish, surgeonfish, porkfish, cardinals, blennies, damselfish, grunts, and hogfish. Commercially important species such as grouper and snapper are seasonally abundant, and migrate shoreward and seaward between spawning events. Examples of tropical fish include the blue chromis (*Chromis cyanea*), redspotted hawkfish (*Ambiycirrhitus pinos*), and Spanish hogfish (*Bodianus rufus*).

J.9.2.2 Wildlife

The native vertebrate (mammal, bird, reptile and amphibian) fauna of south Florida rockland ecosystems is primarily derived from southeastern temperate North American fauna (Robertson, 1955; Duellman and Schwartz, 1958; Robertson and Kushlan, 1984; Layne, 1984; Snyder *et al*., 1990). Invertebrate groups show both southeastern and West Indian relationships. A large number of resident butterflies and skippers are primarily West Indian in origin (Snyder *et al*., 1990). Included in this group is the endangered Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*) (Loftus and Kushland, 1984; Snyder *et al*., 1990). The Florida tree snail (*Liguus fasciatus*) is native to hammocks of the Florida Keys. Mangrove forests have a rich invertebrate fauna that includes insects, molluscs and crustaceans. The mangrove tree crab (*Aratus pisonii*) is an important ecological component (Schomer & Drew 1982).

Twenty-four species of amphibians and reptiles have been identified in mangrove and upland habitats (Odum *et al*., 1982). The Florida Keys are habitat to a variety of amphibians and reptiles including: various species of frogs, the Diamondbacked terrapin (*Malaclemys terrapin*), the endangered Eastern indigo snake (*Drymarchon corais couperi*), the Miami black-headed snake (*Tantilla oolitica*), and the mangrove water snake (*Nerodia fasciata compressicauda*) (SFWMD, 1992; Snyder *et al*., 1990). Although not terrestrial, all species of sea turtle found in the U.S. are sighted in waters around the Keys. Hawksbill (*Eretmochelys imbricata)* and occasionally, loggerhead (*Caretta caretta*) females nest on Keys beaches, and subadult turtles are observed over reef and seagrass habitats. The endangered American Crocodile inhabits Florida Bay and the bayside of Key Largo.

Birds in the Florida Keys area come from both the southeastern temperate fauna and the West Indian fauna. Typical West Indian species include the black-whiskered vireo (*Vireo altiloquus*), the Cuban yellow warbler (*Dendroica petechia gundlachi*), the antillean nighthawk (*Chordeiles gundlachii*) the white crowned pigeon (*Columba leucocephla*), the smooth-billed ani (*Crotophaga ani*), the grey kingbird (*Tyrannus dominicensis*), and the mangrove cuckoo (*Coccyzus minor*) (Snyder *et al*., 1990).

There is extensive use of the Keys by southeastern birds and migrants from northern continental areas. The Keys are particularly important for raptors migrating along the Central and East Coast flyways. Mangroves are significant bird habitat. The tricolor heron (*Egretta tricolor*) and snowy egret (*Egretta thula*) are the most abundant wading birds, while the white ibis (*Eudocimus albus*) and wood stork are less common (Kushlan 1979; Schomer & Drew, 1982). The commonest diving bird is the double-crested cormorant. The Wilson's plover and willet are present all year.

Odum et al. (1982) listed 181 birds that utilize the south Florida mangrove zone, and classified them into six categories based on feeding habits: wading birds, probing shorebirds, floating and diving water birds, aerially searching birds, birds of prey, and arboreal birds. Wading, aerially searching, and floating and diving birds are the most prominent. Eighteen species of birds of prey are found in the mangrove and upland habitats.

Typical land mammals include such small rodents such as the Key Largo woodrat, and the Keys' best recognized endangered species, the Key deer (*Odocoileus virginianus clavium*). Twenty species of mammals have been identified in the mangrove zone (Odum et al., 1982). Of these, the mangrove fox squirrel (*Sciurus niger avicennia*) is also Federally endangered.

J.9.3 Water Management

There is no overall surface water management canal infrastructure in the Florida Keys. The C&SF canal system has very little influence on the Florida Keys except in the estuarine areas of Florida Bay, where it controls the amount and timing of freshwater releases into the estuaries.

J.9.4 Water Supply

Keys water is supplied almost entirely by a pipeline from the mainland that draws water from the West Miami Wellfield. This water supply is near capacity.

J.9.4.1 Groundwater

Because of the slight geographic relief and pervious nature of the Key Largo Limestone and Miami Oolite rock formations, most rainfall in the Keys infiltrates the surficial aquifer and forms shallow freshwater lenses. Groundwater in south Florida and the Keys is restricted to these shallow lenses and the deeper waters of the Floridan Aquifer (Schomer and Drew, 1982). The size of a freshwater lens is controlled by several factors, with the lens generally becoming thicker during the rainy season and thinner during the dry season. Permeability of the subsurface sediments, proximity to seawater and tidal fluctuations, and the rate of freshwater pumpage or seepage from these lenses are also significant (Schomer and Drew, 1982).

J.9.4.2 Floridan Aquifer

At the latitude of the Keys the Upper Floridan aquifer contains brackish groundwater, while the lower Floridan aquifer contains seawater. Groundwater movement in the upper aquifer is generally toward the Keys, from the area of highest head in central Florida, southward to the Straits of Florida, and westward to the Gulf of Mexico. Studies suggest saltwater upwelling occurs from the lower to upper aquifer (Meyer, 1989).

The aquifer system in the Keys is used by the public mainly for subsurface storage of liquid wastes, primarily injected treated municipal wastewater (Meyer, 1989).

J.9.4.3 Potable Water

South Florida's Biscayne Aquifer provides the Keys with its primary source of public potable water. Through this aquifer, the county extracts water from well fields in the Homestead area south of Miami. Ocean Reef Club, in North Key Largo, is the only area in the Keys that uses an alternative source of water (the Floridan Aquifer and a reverse-osmosis plant).

The Florida Keys Aqueduct Authority (FKAA) manages the distribution of potable water within the Keys. It is permitted by the South Florida Water Management District to withdraw up to 19.77 million gallons per day (mgd). About 15 mgd is currently being used. The total permitted yearly withdrawal is 5.56 billion gallons. The FKAA is currently operating at approximately 90 percent of capacity.

J.9.5 Socio-Economics

The Keys' economy is unique because of the area's location and geography. Monroe County's economy is dominated by the tourism industry, and the Keys attract both seasonal residents and short-term visitors because of their abundant recreational resources. The military and the commercial fishing industry are also important sectors of the region's economy. The Monroe County economic base expanded during the 1980s, with income and employment increasing at a faster rate than those of Florida or the nation did. In 1980, per capita income in Monroe County was $8,917, nearly nine percent below that of Florida and 10 percent below that of the nation for that year. By 1989, however, per capita income had increased to $17,896, higher than that of both the state and the nation.

J.9.5.1 Public Sector Employment

Public-sector employment makes up approximately 23 percent of the total work force in the Keys. About nine percent of these workers are State and county employees, seven percent are employed by the military, and seven percent are Federal employees. The number of State and local government employees increased substantially during the 1970s, but grew at a slower rate during the 1980s. The public-sector component of the work force has increased at a significant rate in recent years, but has yet to reach its previous level. There was a large decline in the number of military personnel employed in the Keys during the 1970s, but it appears that the military's strategy has been to hire additional civilian employees when possible.

J.9.5.2 Recreation/Tourism

In 1990, 16,691 jobs in Monroe County were dependent on the tourism/recreation industry. Recreation activities also had an indirect or induced effect, creating over 2,500 jobs (Kearny/Centaur, 1990). Consequently, outdoor recreation and tourism supported about half of all employment in the county, and half of all personal income by place of work came from these activities. Recreational activities include boating, camping, tourism, ecotourism, sport fishing, sport diving, and other activities associated with "vacationing."

J.9.5.3 Commercial Fishing

Commercial fisheries are among the Keys' most valuable natural resources. The area is one of the richest fishing grounds in the Gulf of Mexico (Phillips, 1990) and commercial fishing is the fourth-largest industry in the region, representing nine percent of Monroe County's private-sector employment (White, 1991).

The diversity of the Keys' aquatic habitats and communities (including coral reefs, seagrass beds, and softbottom and hardbottom areas) provides food and shelter for these invertebrates and fishes (Environmental Science and Engineering, Inc. et al., 1987; Comp and Seaman, 1985). Ninety percent of the region's commercially important species use these habitats for shelter, food, or nurseries during at least one stage of their life history (Comp and Seaman, 1985).

Population growth in Monroe County has raised management concerns about potential overfishing (Bohnsack, 1991). Commercial harvest is regulated by measures including annual catch quotas, closed seasons, gear restrictions, and guidelines setting minimum catch sizes. These regulations have been developed for most commercially important invertebrates, finfish, and corals through management plans written by the South Atlantic and Gulf of Mexico fishery management councils, the Florida Marine Fisheries Commission, and the Florida Cabinet (Bohnsack, 1991).

The State collects landings information on approximately 400 kinds of fish, invertebrates, and plants harvested in Monroe County. Information is collected from every commercial fishing trip (including those involving marine-life collecting). In 1990 commercial landings of food and bait species were 19.7 million pounds (approximately 10 percent of Florida’s total landings) (FDEP, unpublished data). Landings are impacted by the cyclical and migratory patterns of various species and quotas that have been imposed on certain commercial seafood.

Spiny lobster has recently surpassed pink shrimp, and leads the county in both landings and value. In 1990 spiny lobster landings totaled 5.3 million pounds, followed by pink shrimp (3.7 million pounds) and stone crab (2.6 million pounds). Of the finfish, yellowtail snapper accounted for the greatest landings (1.6 million pounds), followed by Spanish mackerel (1.1 million pounds).

Fishermen typically participate in a variety of fisheries during the year. A cycle may begin in August by fishing for spiny lobsters, adding or switching to stone crabs in mid- to late October, briefly switching to king and Spanish mackerel in January and February, and shifting to snapper, grouper, and dolphin in early summer (Muller, pers. comm.).

In 1989 over 1,700 fishermen regularly operated in association with wholesale fish houses, not including part-time or independent fishermen (White, 1991). In 1989 there were over 1,600 registered commercial fishing vessels in the county (White, 1991). Between 1980 and 1990, however, the number of commercial vessels declined by six percent, contributing to a 22 percent decline in total commercial landings during the period. Factors influencing the declining number of vessels included the high cost of living in the Key West (Stock Island) area, increased dock fees, a reduction in available dock space, the retirement of older fishermen, and a declining shrimp industry (Monroe County, 1992; Bohnsack, pers. comm.).

J.9.5.4 Marine Life Collecting

In addition to the commercial food and bait fish industries, a poorly documented fishery has recently been recognized as economically important. This "marine-life" fishery supplies small fishes, invertebrates, algae, and live rock to wholesalers, retailers, hobbyists, and public aquaria throughout the world (Feddern, pers. comm.).

Although the actual economic value of the marine-life fishery has not been determined due to its recently recognized significance, the wide variety of species involved, and the reluctance of fishermen to release financial data, it is estimated to be $30 million annually. About 260 species are harvested, including the juveniles of a small number of species managed in other fisheries (Feddern, pers. comm.). Overall harvest totals are not applicable because market categories are given as colonies, individuals, and pounds of material (e.g., live rock). Live rock is an important resource in the Key's coastal areas serving as a refuge and food source to many juvenile and cryptic species and serving as a substrate to filter feeders. However, rock beauty was the most frequently reported species collected in 1990 (on 1,913 trips). Angelfish and butterflyfish are the most frequently collected fish species in the county (Muller, pers. comm.).

J.9.5.5 Aquaculture

Aquaculture operations makeup a relatively minor portion of the Keys' commercial fisheries, and although various aquaculture attempts have been made, most have failed. There are currently several projects operating in the Keys involving shrimp, finfish, and conch (Little, pers. comm).

J.9.6 Land Use

In 1975 Florida designated Monroe County an Area of Critical State Concern under the authority of Chapter 380, F.S. This legislation was designed to preserve and protect the county's unique natural resources, which were being degraded by large development projects. It gave the State Department of Community Affairs (DCA) the responsibility of overseeing all development activities within the designated area. The legislation required both the drafting of a comprehensive plan and development regulations designed to set the county's growth-management standards, over which the State has final review and approval.

Significant features of the plan include the "down-zoning" of large natural areas (excluding Key West, Key Colony Beach, and Layton), and the establishment of the Monroe County Land Authority, which is responsible for purchasing these down-zoned areas. The plan was also designed to preserve the contiguous areas of habitat as biologically functional units, specifying that required open-space areas may not be altered. It also contained the rudiments of the concept of "concurrency," which requires that a project cannot be completed without the public infrastructure necessary to support it.

Monroe County and its sister municipalities are currently revising their comprehensive plans under Chapter 163, F.S. In general, Chapter 163 legislates more specific standards, significantly expands the concept of concurrency, and allows the local government to set a "level of service" for hurricane evacuation that cannot be exceeded as a result of new development. However, because the county is an Area of Critical State Concern, the County must still meet the standards of Chapter 380, F.S.

J.9.6.1 Existing Land Use

The inhabited Keys make up only five percent of Monroe County's total land area (65,500 of 1.2 million acres). The county also contains over 99,000 acres of the Everglades, but this area is almost entirely within Everglades National Park and Big Cypress National Preserve. The majority of the county, consequently, is classified as "conservation land."

Within the county, the unincorporated area is distinguished from the four incorporated areas of Key West, Key Colony Beach, Layton and Islamorada. Within the unincorporated area, land use is also apportioned differently between the Upper, Middle, and Lower Keys. The types of land use can be defined as residential, commercial, industrial, or public facilities and buildings; historical buildings and districts; military facilities; and recreation, conservation, and vacant land.

Residential Land

The portion of land used for residential purposes ranges from 12 percent in the Lower Keys to 58 percent in Key Colony Beach. The small percentage of residential use in the Lower Keys is due to the high proportion of conservation land, primarily in the National Key Deer Refuge. The relatively high proportion of residential development in Key Colony Beach reflects the city's reliance on Marathon for commercial and other use categories. Within the unincorporated area, the majority of residential development (78 percent) consists of single-family units. The unincorporated area also has the majority of the county's mobile homes, although the total area is relatively small. The cities of Key West and Key Colony Beach have substantial duplex development. In the City of Key West, the single-family/duplex zoning category accounts for 62 percent of all residential area. Key Colony Beach has similar percentages.

Commercial Land

The proportion of commercial land in each area is similar, although there are significant differences between the Upper, Middle, and Lower Keys. In general, commercially zoned land accounts for about four percent of land-use acreage within the Keys. The Middle Keys contain significantly higher proportions because of the large amount of commercial land in Marathon. The lower levels in the Lower Keys reflect the large amount of refuge conservation land.

Industrial Land

The cities of Key West, Key Colony Beach, and Layton contain no significant industrial development, and rely on the adjacent unincorporated areas for their industrial needs. Two industries, rock mining and marine repair and salvage define industrial use in the Keys. The majority of rock mining operations are in Stock Island and Marathon. Other small-scale industrial businesses are located in Stock Island, Big Pine Key, Marathon, and Key Largo.

Public Facilities and Buildings

As much as eight percent of Key West is allocated to public buildings and facilities (excluding recreational uses), while the unincorporated area, Key Colony Beach, and Layton provide one percent or less.

Historic Buildings and Districts

Within the cities of Key Colony Beach and Layton, and in the unincorporated areas of the Keys, virtually no acreage is allocated for historical lands. There are, however, historic structures and buildings outside Key West, including those on Pigeon Key and the Carysfort Light off North Key Largo, both of which are listed, in the National Register of Historic Places. The City of Key West also considers large areas of "old town" historic and, as a result, requires additional permits before allowing development. In addition, the City has established a Historic Architectural Review Commission to ensure that the traditional character and appearance of the area is maintained.

Military Facilities

Military facilities are located exclusively in Key West and the Lower Keys. About 25 percent of Key West’s land is used for military purposes. In the Lower Keys there are three military facilities that make up five percent of all land in the unincorporated area.

Recreational Facilities

The City of Key West provides about seven percent of its land area for recreational purposes, while the Lower and Upper Keys provide less than two percent each. The Middle Keys provide 11 percent, Key Colony Beach nine percent, and Layton none. These numbers may be somewhat misleading, however, as they are derived primarily from a list of publicly and privately owned lands that provide recreational activities. Many private owners of resort areas provide recreational facilities geared toward water activities that include swimming pools and/or tennis courts.

Conservation Land

Conservation land makes up about 34 percent of all unincorporated land use within the Keys. The largest proportion is in the Lower Keys, and is associated with the National Key Deer and Great White Heron refuges (28 percent). In the Upper Keys (51 percent), conservation land is located primarily in North Key Largo. The cities of Layton and Key Colony Beach have no conservation land. Within the City of Key West, conservation land is undeveloped and categorized as open water, freshwater islands, tidal wetlands, mangrove, and hammock. Some of the land is in private ownership and, therefore, could be subject to future development. However, substantial areas around the “Salt Ponds” area of Key West have been (and are currently being) acquired by the Monroe County Land Authority. A total of 550 acres remains undeveloped in Key West.

Vacant Land

About 210,000 acres of land are potentially available for development, representing just over 34 percent of the Keys' total land area. In the unincorporated area of the county, vacant land is the largest land-use category. Ten percent of the county's vacant land is divided into nearly 15,000 vacant lots. These lots represent the only reasonably buildable property remaining in the Keys, and make up a substantial proportion of the total potential single-family development area.

J.9.7 Recreation Resources

Recreation resources in the Florida Keys region are mostly water-based, with some upland shoreline activities. Boating, fishing, diving, and nature interpretation are some of the many recreation opportunities in the region. Five wildlife refuges and one of the busiest State Parks (Pennekamp) are located in the Keys. Several other state parks are also present (SCORP, 1994). Key Largo National Marine Sanctuary designates protection for the delicate reefs outside of Pennekamp. Divers and snorklers heavily visit these reefs. Fort Jefferson National Monument is the most southern point of the continental United States and is one of the most unique monuments in the world because of its setting. Recreation resources depend on the very fragile Florida Keys regional ecosystems. Diving is the most popular recreation activity followed by fishing, bird watching, etc. The overall region is a delicate natural resource that provides visitors with excellent recreation resources. Development pressures could adversely affect the regional water quality and recreation resources.

J.9.8 Aesthetic Resources

The Florida Keys visual landscape can be described in terms of expansive open water views, West Indian-style ("conch") architecture, coastal island beaches and small roadside developments. The Florida Keys and the offshore coral reefs and sea grasses are a threatened resource of international significance (DCA, 1996). The underwater aesthetics of the region are as significant as those above water. Many varieties of coral provide a seemingly limitless palette of textures, color, relief, and contrast beneath the sea. Reefs in the Gulf of Mexico and the Atlantic Ocean have been awarded preserve, refuge and sanctuary status due to their unique character and appearance. The trade winds ameliorate the temperatures in the region and provide a comfortable climate year round.

J.10 BIG CYPRESS REGION

The Big Cypress physiographic region is defined as that region bordered on the south by Everglades National Park, along the east by WCA-3A, the L-1, L-2, and L-3 levees, the northern boundary is State Road 832, and the west is bounded by the Gulf of Mexico. It includes all of the Big Cypress National Preserve (BCNP), including the Addition lands to the north (***Figure J.10-1***). Due to the nature and scope of the alternative plans for the Restudy, it is this area which has been identified as being the affected environment, and is primarily described below. The Big Cypress Swamp spans approximately 1,568,000 acres (Duever et al. 1986) from southwest of Lake Okeechobee to the Ten Thousand Islands in the Gulf of Mexico.

The 729,000 -acre BCNP was established by Public Law 93-440 in 1974 to protect natural and recreational values of the Big Cypress watershed and to allow for continued traditional uses such as hunting, fishing, and oil and gas production. It was also established to provide an ecological buffer zone and protect the Everglades National Park's water supply. The original designation of the Preserve encompassed a total of 582,000 acres. In 1988, Congress passed the Big Cypress National Preserve Addition Act which will add 147,000 acres to the BCNP.

J.10.1 Vegetation

The Big Cypress region is characterized by a variety of upland and wetland plant communities, including hardwood hammock, pine forests, low density pine woodlands, hardwood scrub, herbaceous prairie, cypress prairie, mixed-hardwood cypress strand, graminoid marsh, exotic vegetation assemblages, and others. Fire, as it modifies ecological succession and water as it affects hydroperiod, and seed germination, are major influences in determining the predominant vegetative community. Below are described the predominant upland and wetland vegetative community types.

J.10.1.1 Hardwood Hamock

Hardwood hammocks are climax communities found on rock outcrops at elevations between 10 and 12 feet above mean sea level (MSL). Inundation may occur only during extremely high water periods (Duever et al., 1986; Gunderson et al., 1982; Olmstead et al., 1980), although forests have been observed with hydroperiods of 10 to 45 days (Duever et al., 1986). Major canopy species include live oak (*Quercus virginiana*), wild tamarind (*Lysiloma latisliquum*) and gumbo limbo (*Bursea simaruba*) which are typically the largest and tallest trees in the hardwood hammocks (Gunderson and Loope, 1982c). A variety of understory vegetation is also present including several species of shrubs, vines, orchids, bromeliads, and other epiphytes. Hardwood hammocks support a great number of rare and threatened plants. The majority of these are epiphytes from the bromeliad, orchid, and fern families. Solution holes support some of the rare plant associations. Tropical hardwood hammocks have a high diversity of plant species, yet are one of the least frequently used of all the habitats by wildlife. Wildlife that are known to frequent this environment include wading birds, Florida tree snails, owls, lizards, skinks, and raccoons.

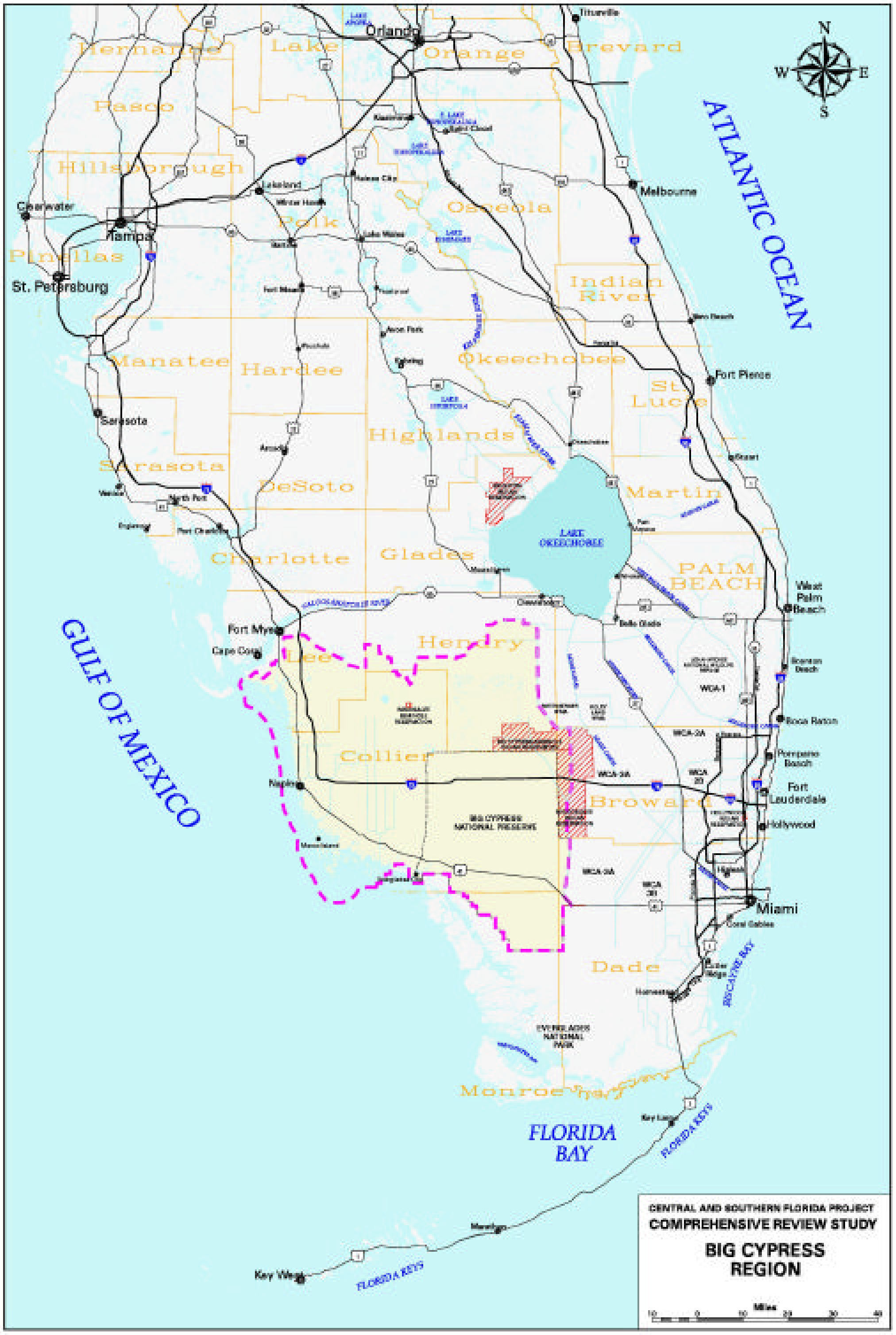


Figure J.10-1 Big Cypress Region

J.10.1.2 Pine Forest

The hydroperiod for the pine forest is 0 to 60 days (Duever et al., 1986; USACE, 1990). Pine forests are subclimax communities preceding the development of hardwood hammock. As such, fire is a major determinant of species composition. In the absence of fire for two or three decades, a pineland will take on the characteristics of a hammock in the process of succession (Lodge, 1994).

South Florida slash pine (*Pinus elliottii* var. *densa*) is the only species found in the canopy. Species found throughout the shrub layer include saw palmetto (*Serenoa repens*), cabbage palm (*Sabal palmetto*), varnish leaf (*Dodonaea viscosa*), wax myrtle (*Myrica cerifera),* bitter gallberry (*Chiococca alba*), and velvet seed (*Guettarda scabra*).

The pine rocklands of southern Florida are home to many endemic species, including several of the endangered plant species identified by the USFWS as likely to be effected by the Restudy. Examples include crenulate lead-plant (*Amorpha crenulata*), deltoid spurge (*Chamaesyce deltoidea*), and Small's milkpea (*Galactia smallii*).

J.10.1.3 Low Density Pine Woodland

Low density pine woodlands form in areas having longer hydroperiods, approximately 60 days, more than pine forests (Duever et al., 1986; Gunderson et al., 1982; USACE, 1990). Low density pine woodlands are successional communities maintained by water levels and periodic fires, and are among the most diverse plant associations in the Big Cypress region. South Florida slash pine is the dominant canopy species. The vegetation found in the understory contains many of the same species found in the herbaceous prairie, including maidencane (*Panicum hemitomon*), sand cordgrass (*Spartina bakeri*), beakrush (*Rhynchospora spp*.), muhly grass (*Muhlenbergia spp*.), spikerush (*Eleocharis spp*.), and sawgrass (*Cladium jamaicense*) (Duever et al. 1986; Olmstead et al., 1980)

J.10.1.4 Hardwood Scrub

This community is thought to be an early successional stage of the hardwood hammocks. The only common feature is that the vegetation is composed of hardwood species less than 5 meters tall. Some scrub areas can be recognized as disturbed oak/palm-Serenoa hammocks. Others, with saplings of gumbo limbo, and *Bumelia spp*., appear to be disturbed hardwood hammocks.

Common species observed in these scrub areas include cabbage palm, saw palmetto, Florida trema (*Trema micrantha*), false willow (*Baccharis glomeruliflora*), sweet bay, pond apple, red bay, cocoplum, dahoon, and poisonwood (Gunderson and Loope, 1982d).

J.10.1.5 Herbaceous Prairie

Herbaceous prairie is typically found on thin marl over limestone. Herbaceous prairies are one of the driest grass dominated communities with hydroperiods of 60 to 130 days (Gunderson et al., 1982; Gunderson and Loope 1982a; Olmstead et al., 1980; USACE, 1990). Herbaceous prairies have the most diverse flora of all the graminoid communities (Olmstead et al., 1980).

Muhly grass (*Muhlenbergia capillaris*) is typically the dominant species found in this community, and in pure stands may contribute 90-95 percent of the biomass. Sawgrass is always an associate of muhly grass and is favored at the wetter end of the hydrological gradient.

J.10.1.6 Cypress Prairie

Cypress prairie communities typically have a hydroperiod ranging from 90 to 270 days (Duever et al., 1978; Duever, 1980, Weakley et al., 1996), and are characterized by low densities of stunted cypress under 30 feet tall, interspersed in wet prairie. There are extensive areas within the BCNP which contain cypress prairie, throughout the BCNP north of Hwy 41, within the Loop Rd. area, and immediately south and west of Loop Road, west of Pinecrest.

J.10.1.7 Exotic Trees

Exotic trees found within the Big Cypress Region, include Melaleuca (*Melaleuca quinquenervia*), two species of Australian pine, (*Causuarina cunninghamia* and *C. glauca*), and Brazilian pepper (*Schinus terebinthifolius*). Exotic trees usually occur as individuals within natural communities and do not typically occur in large monotypic stands, exclusive of highly disturbed areas.

J.10.1.8 Mixed-Hardwood Cypress Strand

The hydroperiod of the mixed-hardwood cypress strand is 125 to 365 days (Gunderson and Loope, 1982a; USDI, 1991). The dominant species within this community type are pond cypress (*T. ascendens*), red maple (*Acer rubrum*), laurel oak and live oak.

J.10.1.9 Cypress Strand/Cypress Dome

Cypress strands and domes surround water filled centers. Strands are elongated depressions filled with deep peat, whereas domes are circular in shape, with similar peat deposits. Taller trees are found near the center with tree height decreasing toward the edge (Olmstead et al., 1980). Natural hydroperiods in cypress strands and domes are thought to be between 240 and 340 days (Duever et al., 1986; Olmstead et al., 1980; USDI, 1991). Pond cypress is the dominant species and often forms the entire canopy. Cypress strands and cypress domes are found in abundance within the BCNP, particularly north of Hwy 41 and west of the L-28 levee.

J.10.1.10 Graminoid Marsh

Graminoid marshes have a hydroperiod of 220 to 365 days (Gunderson and Loope, 1982b; Olmstead et al., 1980; Weakley et al., 1996; USACE, 1990). Species composition varies throughout the graminoid marsh and is strongly influenced by substrate. In areas with deep peat, sawgrass is the dominant species (Olmstead et al., 1980; USACE, 1990). In areas with shallow marl and sand, spikerush (*Eleocharis cellulosa*) is the dominant species (Gunderson and Loope, 1982b; USACE, 1990).

J.10.1.11 Inland Sloughs

Sloughs occur throughout the BCNP and are typically the deepest wetland community, with hydroperiods of about 11 months (Lodge 1994). Important sloughs which drain the Big Cypress region include the Okaloacoochee Slough in the extreme northwest BCNP, Mullet Slough in northeast BCNP, East Slough, and Lostmans Slough in southeast BCNP. The dominant vegetation occurring within the sloughs include submerged and floating aquatic plants such as water lily, pond lily, spatterdock, bladerwort, and maidencane. As sloughs may be continuously inundated for several years at a time, they provide valuable habitat for fishes, aquatic invertebrates, and as refugia for other animals during drought.

J.10.2 Fish and Wildlife

The following descriptions of wildlife habitats found in the project area have been adapted from the accounts of Duever et al., (1986). The pine forests and inland marshes, ponds and sloughs are heavily used by a large number of species. Some of the richest wildlife habitats in the project area are found in pine woodlands. These predominantly dry pine communities provide optimal conditions for burrowing, litter-dwelling, and ground-nesting species. In addition, the open nature of pine woodlands and the abundance of grassy forage are favorable to a diversity of wildlife. Frequent inhabitants of these habitats include the white-tail deer, gray fox, the Eastern meadowlark, and the Chuck-will's widow. In addition, the endangered Florida panther ranges extensively in pine woodland areas.

Inland ponds, marshes, and sloughs also support a multitude of wildlife species, and are particularly valuable to water-dependent species such as the gallinule, the snowy egret, and the American alligator. The endangered wood stork uses these ponded areas as foraging grounds, as does the endangered snail kite in the eastern BCNP.

Mixed swamp forests are used by substantially fewer wildlife species than the pine woodlands and the inland ponds, marshes, and sloughs. However, the lengthy hydroperiods often associated with these wet habitats are favorable to reptilian species such as the Florida cottonmouth, various turtles, and the alligator.

Wet prairies are not suitable as breeding grounds for most fauna due to the lack of adequate cover. However, several species such as the turkey vulture, snail kite, caracara, white ibis, and arctic falcon use these open expanses as foraging grounds. Muhly grass is often found in herbaceous prairies with shorter hydroperiods, and provides critical nesting habitat for the endangered Cape sable seaside sparrow.

Cypress dominated forests are often characterized by a sparsely vegetated understory, infertile soils, and fluctuating water levels. Few vertebrates in southwest Florida can tolerate such unfavorable conditions for extended periods, however the tall trees and surrounding water provide good nesting sites for wood storks, bald eagles, white ibis, snowy egrets, and little blue herons. The Florida Black bear, alligator, Everglades mink, and Florida panther may also use these habitats.

Hammock communities within wetland or water-dependent expanses, support a diversity of floral species, although wildlife sightings in such habitats are surprisingly scarce. The absence of wildlife in hammock areas may be due to the generally small size and isolation of the habitats. Hammock communities are extensively utilized by the Florida panther, most likely because they provide dense areas of dry cover. Important game species in these areas include white-tailed deer, hog, turkey, quail, gray squirrel and snipe.

Major freshwater fish species present within sloughs, canals, ephemeral and permanent ponds, and borrow pits, are listed below in table ***J-10.2-1***.

The Cyprinodontids such as the golden topminnow (*Fundulus chrysotus*), the least killifish (*Heterandria formosa*), and the Florida flagfish (*Jordanella floridae*) have been sampled and are known to be important food resources for wading birds, amphibians, and reptiles.

Table J-10.2-1 Common Freshwater Fish Species Found Within the Big Cypress Region	
Florida Gar	*Lepisosteus platyrhincus*
Bowfin	*Amia calva*
Gizzard Shad	*Dorosoma cepedianum*
Threadfin Shad	*D. petenense*
Yellow Bullhead Catfish	*Ictalurus natalis*
Channel Catfish	*I. punctatus*
Everglades Pygmy Sunfish	*Elassoma Evergladei*
Bluespotted Sunfish	*Enneacanthus gloriosus*
Largemouth Bass	*Micropterus salmoides*
Dollar Sunfish	*Lepomis marginatus*
Bluegill Sunfish	*L. macrochirus*
Spotted Sunfish	*L. punctatus*
Striped Mojarra	*Diapterus plumieri*
Mosquito fish	*Gambusia spp.*
least kilifish	*Heterandria formosa*
flagfish	*Jordanella floridae*
golden topminnow	*Fundulus chrysotus*

The USFWS has identified eighteen Federally listed plant and animal species as being present in the study area and likely to be affected by alternatives under the C&SF Restudy. Of these eighteen, seven animal species are known to occur or likely to occur within the area of the Big Cypress. These include the Florida panther, snail kite, wood stork, Cape Sable seaside sparrow, Red-cockaded woodpecker, bald eagle, and Eastern indigo snake. No Federally listed plant species within this region are expected to be affected by Restudy alternatives.

J.10.3 Water Management

The Big Cypress swamp is a recognized physiographic province in southwestern Florida. It is a source of recharge for the shallow aquifers of south Florida and is important to the integrity of the water resources in the western part of Everglades National Park. The hydrological features of the swamp were recognized by Congress when it established BCNP.

The water regimen of the area largely determines the patterns in which temperate and tropical vegetative communities and their related wildlife species occur. During the wet season (summer and fall) when heavy rains lead to widespread surface inundation, the almost imperceptible slope of the land creates an overland sheet flow. During the dry season (winter and spring) natural surface water flows are confined to the lower elevations of strands, swamps, and sloughs.

The BCNP has been mapped by the USFWS as part of the national wetlands inventory. The majority of BCNP lands are classified as wetlands; exceptions are scattered hardwood hammocks, some pinelands, and artificially filled areas.

The Big Cypress region is essentially a rain-driven hydrologic unit, and for the most part it is not dependent on adjacent land for water flow. Only three small areas (approximately 5 percent of the BCNP) receive flows from external drainages. These areas include less than 5 square miles in the Okaloacoochee Slough, about 30 square miles in the Mullet Slough component of the Everglades drainage, and approximately 40 square miles in the southeastern corner of the BCNP along the western boundary of the Shark River Slough.

J.10.3.1 Water Flows

Much of the BCNP is flooded during the rainy season, generally May through October, when nearly 80 percent of the rain falls. Rainfall averages 54 inches per year, but it has ranged from 35 inches to 80 inches per year. Summer rains are usually short, intense, and frequent. Winter rains are a result of frontal systems, and they last longer and have less intensity. Hurricanes occur most frequently in September and October and usually bring torrential rainfall.

During the rainy season shallow depressions fill with water. Because of the poor drainage, water stands on the land until it evaporates, infiltrates to the underlying aquifer, or slowly drains off through sloughs or strands. Thus, at the peak of the rainy season as much as 90 percent of the BCNP is inundated to depths ranging from a few inches to more than 3 feet. When the dry season begins, the water level starts to recede. The recession normally continues into May, when perhaps only 10 percent of the BCNP is covered by water in ponds, cypress domes, and sloughs.

Flows generally follow bedrock undulations, which run mostly to the northeast and range in relief from approximately 1 foot to as much as 10 feet. Marshy sloughs occupy the shallower undulations, and cypress stands and mixed hardwood swamps grow in the deeper ones. These relatively low channels control surface water flows because the water table is below the crests of the undulations most of the time; even during high water, the bedrock channels still carry a relatively large volume of water.

The BCNP is underlain by a shallow aquifer extending from the vicinity of Forty Mile Bend to the west coast of Florida and covering almost all of Collier County and the upper part of Monroe County. The aquifer is the prime source of freshwater for human use in Collier County and adjoining parts of Lee and Hendry counties. It is about 130 feet thick in western Collier County and becomes progressively thinner to the east, where it eventually disappears in the vicinity of

Forty Mile Bend. Throughout much of the BCNP, the limestone of this shallow aquifer is within 10 feet of the surface. The aquifer is replenished primarily by the infiltration of rainfall. During the rainy season groundwater levels are high. By April, the usual end of the dry season, water levels normally reach their annual lows.

J.10.4 Water Supply

The BCNP is considered wilderness and is primarily undeveloped. Throughout the BCNP are numerous inclusions of private properties and Native American lands that require potable water for consumption. Water supply needs in the area are minimal and are only related to these individually-owned lands. The need for additional water supply is not expected to significantly increase in the future. The source of the potable water are wells that extend into the surficial and Floridan aquifers. The interaction of the surface water with the surficial aquifer and the Floridan aquifer is a concern. The BCNP is not considered a water supply area although groundwater and surface water is critical in the operation of its existing ecosystem.

The area immediately east of the L-28 levee and the BCNP is WCA-3A, an important component of the water supply system for southern Florida. Any alterations to this area could impact the existing delivery of flows through the existing gaps and structures in the L-28 system. Conversely, any modifications to the gaps in the levee or the operation of the existing structures will need to be considered in terms of its potential impact on the water levels in WCA-3A.

J.10.5 Socio-Economics

South Florida has experienced tremendous growth since the end of World War II, particularly during the late 1950s and into the 1960s. Collier County, being one of the fastest growing counties in Florida, has seen its population increase by 126 percent from 1970 to 1980 (see table ***J-10.5-1***). The population of Miami-Dade County increased by 78 percent during this same decade, and Monroe County by 20 percent. The population increases suggest a growing potential visitor base for the Big Cypress region, as well as other parks in the south Florida region.

Population growth is primarily due to the rapid in-migration of retirees and people from the Caribbean and Latin America, not a high birthrate. One effect of this in-migration has been a disproportionate number of senior citizens. The median ages in the three counties increased from 1970 to 1980 in Collier from 35.2 to 38.2, in Miami-Dade from 34.2 to 34.8, and in Monroe from 27.3 to 35.5. These patterns are indicative of age changes occurring all across the Sunbelt, and they may represent a need for more programs aimed at senior citizens.

Table J-10.5-1
Area Population Statistics
Tri-County Area

	Miami-Dade County*	Monroe County	Collier County
Total Population			
1970	1,267,792	52,586	38,040
1980	1,625,781	63,180	85,971
% Change	+ 78	+ 20	+126
Total Minority Population			
1970	196,130	4,896	6,979
1980	363,506	5,254	11,310
% Change	+ 85	+ 7	+ 62
Median Age			
1970	34.2	27.3	35.2
1980	34.8	35.5	38.2

* only a minor portion of Miami-Dade Co. is within the Big Cypress Region

Another effect of this in-migration is the high percentage of minorities, particularly Spanish-speaking residents. Between 1970 and 1980 Miami-Dade County experienced an 85 percent increase in the number of minority residents, Collier County a 62 percent increase, and Monroe County a 7 percent increase. The growth in minority residents indicates a potential need for bilingual interpretive programs.

The median family income for Collier and Monroe counties for 1980 was slightly below the national average of $19,917, but higher than the state average of $17,280. The median family income in Collier County was $18,700 and in Monroe County $18,050. The Miami-Dade County median family income was $20,176, ahead of both the state and national averages.

The socio-economic data below were obtained from the 1990 Census of Population and Housing for Florida (U.S. Department of Commerce, 1992).

The region's employment consists of retail industry (19 percent), agriculture, forestry and fishery industries (13 percent) and construction (9 percent). Other industry includes finance, insurance, and real estate (7 percent), personal services (7 percent), business, repair services, other professional services, and public administration (6 percent each).

Fourteen percent of the labor force described themselves as administrative support. Another fourteen percent described themselves as service providers (excluding protective and household) and yet another fourteen percent described themselves as precision production, craft, and repair specialists. The overall unemployment rate for eligible workers in the vicinity of the project area was 4.5 percent.

About 12 percent of the families in the vicinity of the project area were classified as living below the poverty level. Although the definition of poverty varies depending upon the size of the size of the family, the number of children, and the age of the family householder, it is defined as $12,674 for a family of four in 1989.

The Census defines housing units as houses, apartments, mobile homes or trailers, or a group of rooms or a single room occupied as separate living quarters. There are 3,968 housing units in the vicinity of the project area. Of these units, four percent of the housing units lacked complete kitchens and three percent lacked indoor plumbing. Fifty-two percent of the units are part of public or private water systems. Forty-two percent have a drilled well. Sixty-eight percent of the housing units dispose of their waste in a septic tank or cess pool while thirty percent are hooked to a public sewer.

J.10.6 Land Use

Land use is organized into major public and private lands and their principal uses, including preservation, recreation, urban, agriculture and water supply.

J.10.6.1 Big Cypress National Preserve

Roadways in south Florida often obtain necessary roadfill from excavation of a parallel canal, resulting in both an elevated obstruction to natural drainage patterns and rerouting of flow in open canals. Such drainage alterations in the BCNP include the Tamiami Trail (U.S. Highway 41), Interstate 75 (Alligator Alley), County Route 839 (Turner River Road), County Route 841 (Birdon Road), County Route 94 (Loop Road) and numerous smaller roads. State Route 29, a north-south road, parallels the western boundary just outside of the BCNP, although its borrow canal is just within the boundary of the BCNP. Extending northward from the Tamiami Trail along the eastern boundary of the BCNP, the L-28 levee forms the boundary between the Everglades and Big Cypress drainage. Although the levee is located immediately outside of the BCNP boundary, it is significant to the hydrology of the BCNP. The L-28 Interceptor canal cuts through the extreme northeastern corner of the BCNP. This canal rapidly drains the agriculturally active lands north of the BCNP.

Oil and gas are currently produced from two active fields in the BCNP. A portion of the Bear Island field lies within the Okaloacoochee Slough in the northwestern corner of the BCNP. The Raccoon Point field is located in the northeastern corner of the original BCNP and north of the Jetport site.

The Miami-Dade-Collier Transition and Training Airport, popularly known as the Jetport, occupies a 32-square- mile site just north of the Tamiami Trail and adjacent to the eastern boundary of the BCNP. Although originally intended as an international airport, it is currently used only for limited training activities. Since all structures must be elevated above the seasonal high water levels, fill material must be excavated from borrow pits. Numerous such pits exist within the BCNP, ranging in size and depth, depending upon the extent of the development. One of the most significant borrow areas is associated with the construction of the Miami-Dade-Collier Training and Transition Airport just north of the Tamiami Trail and west of the eastern boundary of the BCNP. The Miami-Dade-Collier Transition and Training Airport, popularly known as the Jetport, occupies a 32-square-mile area. Construction required 3 million cubic yards of fill excavated from 7 pits, ranging from 30 to 40 feet deep and covering 65 acres of surface area just west and south of the Jetport runways.

Off-road vehicle (ORV) usage in the BCNP is regulated by the National Park Service and is permitted by the enabling legislation to the extent that it does not significantly harm the environment. About two-thirds of the original Preserve is currently open for ORV use. Permits are required, a maximum of 2,500 per year have been established, and areas open to use are designated. The Bear Island Unit, located in the northwestern corner of the BCNP, is restricted to designated trails. Other areas are open to either full or limited use, and two are closed to all ORV use. Airboat and swamp buggy use is mostly during October through March. There has been a general trend toward an increased number of permits annually since 1987.

Some 38,700 acres, totaling 6 percent of the BCNP's original boundary, are non-Federal lands. These non-Federal lands consist of 12,236 acres of School Board lands consisting of one section in each township set aside for schools, 23,488 acres of Jetport Authority lands, 1,514 acres of county roads, and 1,271 acres of private lands. Non-Federal lands within the Additions have not yet been completely defined.

Agriculture within the original boundary of the BCNP is minimal. Farming is known to be more extensive within the Additions, but until the lands are formally transferred to the Federal government, these agriculturally-impacted areas will not be completely defined.

Five active "life" leases, cover grazing rights on approximately 29,000 acres in the northwestern corner of the original Preserve. All leases are located north of

Alligator Alley. The leases can only be renewed by the permittee or spouse and are not transferable. These are gradually being phased out as lessees curtail operations or leases are relinquished.

Public Law 93-440 provides that members of the Miccosukee Tribe of Indians of Florida and members of the Seminole Tribe of Florida shall be permitted, subject to reasonable regulations established by the Secretary, to continue their usual and customary use and occupancy of Federal or Federally acquired lands and waters within the BCNP, including hunting, fishing, trapping on a subsistence basis and traditional tribal ceremonies.

J.10.6.2 Urban Areas

Naples, Marco Island, and Everglades City comprise the three largest urban areas within the Big Cypress region. All three cities are on the west coast, and Naples is among the fastest growing urban areas in the United States. It has developed into a significant retirement destination with extensive residential and business center construction. Water supply demands to meet this fast growing and developing urban area are rapidly increasing.

J.10.6.3 Fakahatchee Strand State Preserve

The Fakahatchee Strand, located just west of the BCNP, is included in the area designated by the State of Florida as an Area of Critical State Concern. It is the recipient of the flow of the Okaloacoochee Slough which cuts across the extreme northwestern corner of the BCNP and crosses under State Route 29 into the strand.

J.10.6.4 Southern Golden Gate Estates

West of the Fakahatchee Strand State Preserve and south of Interstate 75 is the Southern Golden Gate Estates. The area was planned as a large residential sub-division and construction began in the 1960's. The building of roads and several drainage canals in this 94 square-mile area has affected the areas environmental quality, by over-draining the watershed, sending harmful freshwater discharges to the estuaries, increasing frequency of forest fires, and reducing aquifer storage (SFWMD 1996).

J.10.6.5 Water Conservation Areas

The BCNP is bounded on the east by WCA-3A which, is managed by the South Florida Water Management District. Water is impounded in the Conservation Area and released to Everglades National Park and BCNP on predetermined schedules. The L-28 levee forms the boundary between WCA-3A and the BCNP.

J.10.6.6 Everglades National Park

The southern and portions of the eastern boundary of the BCNP abut Everglades National Park. The BCNP's southern boundary forms a "stair-step" pattern that distinguishes the wetland environment of the BCNP and the estuarine environment of the Everglades National Park. The Stair-Step area receives flows from the BCNP enroute to the estuarine environment of the Everglades National Park.

J.10.6.7 American Indian Reservations

Two American Indian reservations abut the BCNP. The Seminole Tribe along the eastern part of the BCNP's northern boundary, and the Miccosukee Tribe along the eastern boundary of the BCNP.

J.10.6.8 Agriculture

A persistent southward progression of agricultural development presents an external threat to the water quality and quantity of the Okaloacoochee Slough and Mullet Slough drainages. Expanding agricultural development is now located along the BCNP's northern boundary.

Hendry and Collier Counties are included in this region. More than 800,000 acres are farmed in the Big Cypress Region, and almost half of that area is pastureland. The region is characterized by moderate to large farms producing more than $600 per acre in market value (UFBEBR, 1995). Hendry County ranks third in the state of Florida for cattle production (FASS, 1996a). Approximately 70,000 acres of sugar were harvested in 1996 (FASS, 1996d). Hendry County ranks third in the state for acres of citrus with over 100,000 acres, while Collier County is ninth with over 36,000 acres (FASS, 1996b). Citrus production in the Big Cypress Region is currently increasing. The Big Cypress Seminole Indian Reservation is located in this region along the northern boundary of the BCNP. The reservation includes some citrus groves and row crops as well as pastureland.

More than 17,000 people are employed in agricultural production and services, and the payroll totals approximately $16 million. Agricultural products in this region have a total market value of more than $525 million. Hendry and Collier Counties rank third and fourth in Florida for market value of agricultural products (UFBEBR, 1995).

J.10.7 Recreation Resources

Recreation resources in the Big Cypress region are primarily wetland based with some upland access and facility use. Air boating, fishing, hunting, and nature interpretation are all very popular recreation activities in the region. Camping facilities are also found within the region. In the heart of the region, the BCNP and Wildlife Management Area is rivaled in size statewide only by the Everglades WMA. Five state parks and recreation areas are located in the region as is a state preserve. The Panther National Wildlife Refuge is also within the region. Artificial reefs are located in the region's coastal area (SCORP, 1994).

Major roadways in the region include Alligator Alley (I-75) and S.R. 41, which transect the region west to east. Several canals range north to south for many miles. Tamiami Canal runs east and west for many miles also. These represent pending concerns due to water quality issues and exotic species transport that could adversely affect recreation resources in the near future. Surrounding development pressures could also be critical to the natural and recreation resources. Substantially altered water deliveries to the Big Cypress Region could have a detrimental affect on many recreation resources in the region.

J.10.8 Aesthetic Resources

This region provides large expanses of undeveloped lands, expansive freshwater prairies and marshes, with cypress forest interspersed that create a patchwork of vertical elements that contrast with the flat panoramic views. The Big Cypress Region coastline contains a mosaic of vegetative communities that are diverse in their natural and aesthetic resources. These vegetative communities provide environmental interest, are a wildlife haven, and showcase unique aesthetic resource attributes. Contained within the Big Cypress Region are six national or state parks, sanctuaries, preserves, and refuges. It is a region of scenic and panoramic aesthetic resources.

Major infrastructures (I-75, S.R. 41, and miles of canals) have minimal background visual impact but act as corridors for the transport of exotic species. Development pressures are a growing factor in maintaining the aesthetic quality of the region.

J.10.9 Hazardous, Toxic, and Radioactive Wastes

The U.S. Army Corps of Engineers conducted an HTRW investigation of the Big Cypress Region in 1996 to facilitate early identification and appropriate consideration of HTRW problems. Due to the extensive size of the study area, the primarily undeveloped wilderness and budgetary limitations, a radial regulatory data base search was not conducted. The study area was investigated for possible HTRW contamination through the following means:

Visual inspection of the accessible regions of the study area

Interviews with personnel from the Florida Department of Environmental Protection, Collier and Miami-Dade Counties, and the BCNP.

Review of the history of the property from aerial photographs and available state, county and park records.

Review of other public documents.

The study area is primarily undeveloped, wetland wilderness with no grazing or agricultural uses. Several small areas of human habitation exist primarily along Tamiami Trail and the Loop Road in the form of permanent private residences, camps and Native American dwellings. A few other camps and less substantial dwellings exist in outlying areas away from the main roads that are only accessible by off-road vehicles or helicopter. Other than these features, the only other alteration in the study area is the Miami-Dade-Collier training and transition airport. This airport is managed by the Miami-Dade County Aviation Department as a training facility with no regular fleet maintained at the airport.

The findings from the review of the aerial photographs from the 1950's and the 1990's indicate that some changes in vegetation have occurred either from fires or timbering and does not appear to be the result of dumping or discharge of hazardous material on or adjacent to the study area.

The result of the personal interviews to collect information on possible HTRW issues revealed that only the Jetport is a possible point of concern. Although records for the Jetport are vague, they do indicate that two underground storage tanks (USTs) are located at the facility. These USTs were installed during the construction of the Jetport in the late 1960's and early 1970's and have a capacity of 4,000 and 5,000 gallons each. The USTs contain diesel fuel for generators and ground vehicles. Records show that they are past due for replacement and/or removal. Miami-Dade County Aviation Department indicated that the tanks would be removed during the early part of 1997. It is not now known whether or not these tanks have been removed/replaced. Since no groundwater monitoring is being performed in this area, it is unknown if leaking or soil/groundwater contamination exists. During replacement of the tanks, soil and groundwater conditions will be assessed and remediated if needed.

Visual inspection of the property was limited to areas accessible by Loop Road and the Tamiami Trail. This inspection indicated no signs of wastewater sources, hazardous waste, pits, solid waste disposal, chemical storage areas, storm drains, catch regions, fill pipes, pesticide storage areas, PCB-containing equipment or asbestos except as noted below:

The area known as the Corn Dance Ritual Site south of the airport has a large dumpster containing and surrounded by household trash, and other related debris.

Abandoned fuel pumps and an above ground storage tank (AST) are located on the south side of the Loop Road near parcel 72-36m Section 21, T54S, R34E.

Maintenance operations for equipment is performed at the Tamiami Range Station and Wildlife Check Station south of the eastern intersection of Loop Road and Tamiami Trail.

Fueling and storage of swamp buggy vehicles occurs at the Oasis Station along Tamiami Trail.

Storage of swamp buggy vehicles occurs at the Miami-Dade-Collier training and transition airport.

Maintenance operations are occurring at a private residence at or near parcel 508-45, Section 36, T53S, R34E.

Airport operations which may include refueling, vehicle maintenance and storage at the airport training facility.

Creosote Contamination at Jerome. Local contamination of the ground water, prior to 1956, by polynuclear aromatic hydrocarbons from a wood-treating facility at Jerome is currently undergoing remediation. The site is located on State Route 29, three miles north of the Tamiami Trail. The site is located within the western Additions and will be acquired under Public Law 100-301.

During the inspection, no evidence of soil staining or underground fuel tank vent pipes were observed at the AST fuel pump location, the Tamiami Range and Wildlife Check Stations or the private residence noted above to suggest possible leaks or contamination. No other records exist for these observed facilities in public records. Since access to the airport was not possible, a detailed inspection of the facility was not performed. The records noted above indicate the possibility of contamination in this area.

J.11 CALOOSAHATCHEE RIVER REGION

The Caloosahatchee River physiographic region extends approximately 70 miles from Lake Okeechobee to the lower Charlotte Harbor Basin at San Carlos Bay. The Caloosahatchee River Region is the northern portion of the South Florida Water Management District's Lower West Coast (LWC) Planning Area. This region primarily covers parts of Charlotte, Glades, Hendry, and Lee counties and dips slightly into Collier County (***Figure J.11-1***).

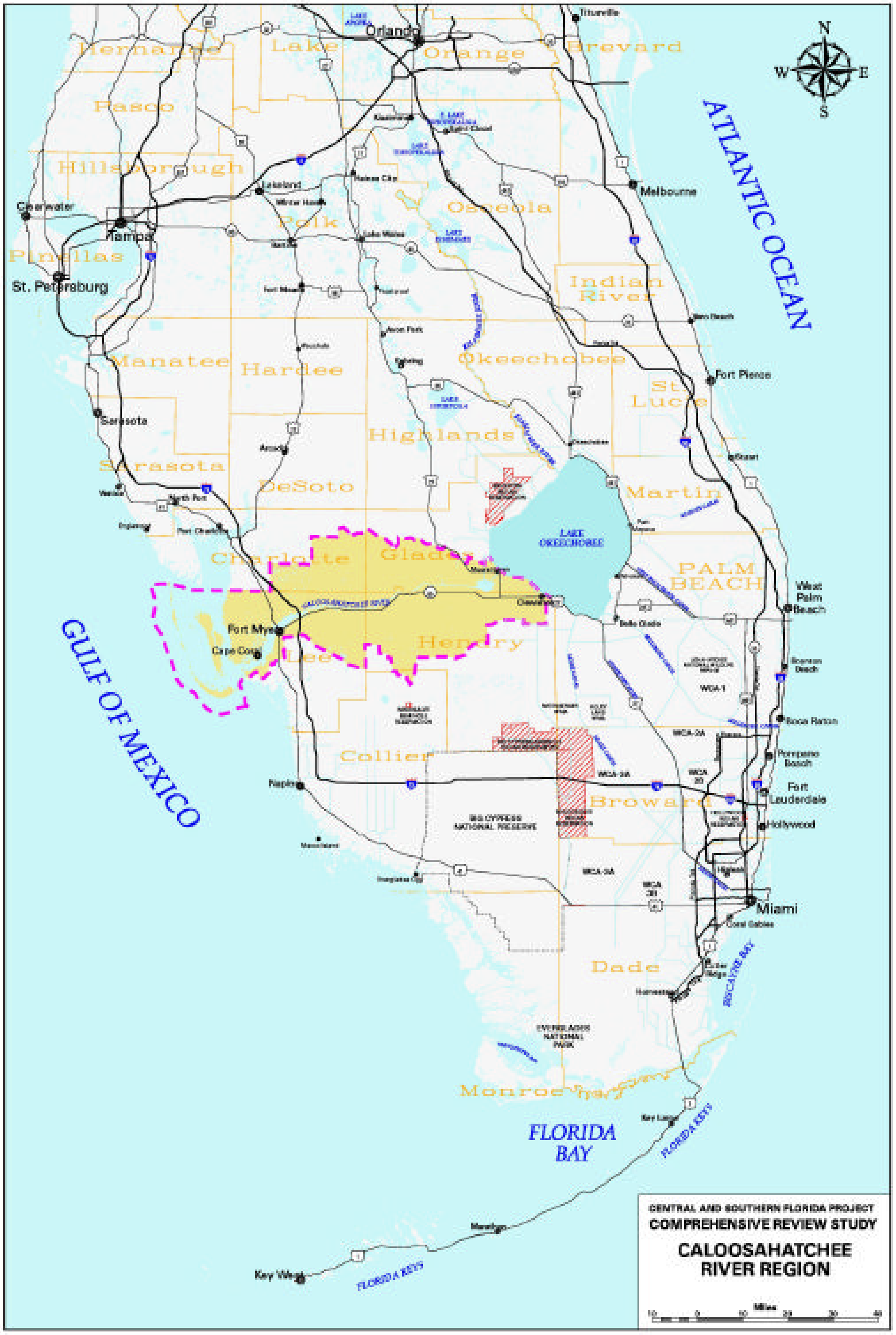


Figure J.11-1 Caloosahatchee River Region Map

The Caloosahatchee River, originally a blackwater river that drained low, flat mucklands located west of Lake Okeechobee, is now also a major navigation canal and flood control channel. It is the only flood-control outlet leading west from Lake Okeechobee, part of the Okeechobee Waterway, and the only navigable passage between the Gulf of Mexico and the Atlantic Ocean. From Olga to the Gulf, roughly 30 miles, the river broadens into a tidally influenced estuarine system. The river has a long history of human use. It flows past some of southern Florida's oldest settlements. The Indians used the river as a trade route before the Seminole Wars in the early 1800s. It later became more important as a steamboat waterway, especially after dredging and channeling in the early to mid-1900s (FDEP, 1996).

The Caloosahatchee River region is divided into major drainage basins according to their respective hydrologic characteristics. These basins are the North Coastal Basin, Tidal Caloosahatchee Basin, Telegraph Swamp Basin, the West and East Caloosahatchee basins, and the S-236 Basin (SFWMD, 1995).

J.11.1 Vegetation

The region contains a wide variety of cover types, ranging from coastal barrier islands, mangrove forests, bays, beaches, dunes and estuaries to an inland mosaic of forested uplands and forested, scrub/shrub and herbaceous wetlands. Many of these areas are public and private preserves, aquatic preserves, and lands proposed for public acquisition. The inland resources include lakes, rivers, canals, freshwater wetlands, and uplands. The coastal resources include estuaries, tidal wetlands, beaches, sand dunes, and barrier islands (SFWMD, 1994).

Vegetation in the Caloosahatchee River Region includes 174,850 acres of upland forest, largely pine flatwoods (107,633 acres). Wetlands total 173,159 acres including 50,102 acres of freshwater marshes, 30,261 acres of mangrove swamps, over 17,000 acres of wet prairie, and 23,513 acres of cypress/cypress mixed. There are 140,039 acres of water including streams, lakes, reservoirs, embayments, and slough waters.

Natural resources protected by public ownership within the Caloosahatchee River region include: J.N. Ding Darling National Wildlife Refuge, Matlacha Pass Aquatic Preserve, Matlacha Pass National Wildlife Refuge, Pine Island Sound Aquatic Preserve, Little Pine Island, Caloosahatchee National Wildlife Refuge, Caloosahatchee River State Park, Fred C. Babcock/Cecil M. Webb Wildlife ManagementArea, Nicodemus Slough, Charlotte Harbor State Aquatic Preserve, Pine Island Sound Aquatic Preserve, Matlacha Pass State Aquatic Preserve, Cayo Costa State Park.

The western portion of the region is dominated by large estuarine systems where the waters of the Gulf of Mexico mix with the freshwater inflow from numerous river systems, sloughs and overland sheetflow. These estuarine areas are characterized by low relief shorelines and islands separated by wide, shallow bays, extensive seagrass beds, and sand flats. To the north is the southern half of Charlotte Harbor, which is a large open water bay bounded on the east by the mainland, and on the west by barrier islands. Charlotte Harbor, Shell and Prairie creeks are considered important aquatic resources in the north. Pine Island Sound, San Carlos Bay, and Estero Bay comprise the southern element of this large estuarine network. Most of the uplands within or surrounding this area are buffered by extensive mangrove habitats that protect against erosion from storms and high tides, and also act as nursery and feeding grounds for Gulf of Mexico fisheries. Many of these estuaries are now designated as State Aquatic Preserves. Other associated habitats are high salt marshes and riparian fringing marshes. The Caloosahatchee River discharges into the estuarine system at Ft Myers. The river maintains an estuarine character up to the Franklin Lock and Dam (S-79) at Olga.

Over the past 50 years, the natural systems of the coastal sector have changed dramatically. Growth has altered the nature of these habitats, mainly through drainage, fragmentation, and conversion to residential and agricultural uses. In the west, the large peninsula now occupied by the City of Cape Coral was originally characterized by high marshes, seasonal ponds and sloughs, pine flatwoods, coastal scrub, and oak/cabbage palm hammocks. Most of these systems have now been lost to residential development. Lehigh Acres, a large-scale residential development project in the extreme eastern part of Lee County, south of the Caloosahatchee River, has also resulted in the ditching and draining of thousands of acres of the original wetland/upland mosaic.

Pine flatwoods or interior wetlands (including fresh marshes and ponds, wet flatwoods, wet prairies, swamps, sloughs and open water) dominate inland areas not converted to agriculture. In addition to major surface water features (Lake Okeechobee, the Caloosahatchee River and Lake Hicpochee) there are also numerous small tributary creeks, sloughs, marshes, and wet prairies. Isolated marshes and ponds are scattered throughout with higher concentrations in the north central parts of the region. Before the excavation of the C-43 canal, the area west and south of Moore Haven was a complex of emergent marshes and pond apple swamps. In this area today, only a remnant of Lake Hicpochee remains. It is a shallow open water body, covered by aquatic vegetation, bisected by the navigational channel for the Caloosahatchee River. Surrounding Lake Hicpochee is a large area of emergent marsh vegetation.

In addition to natural plant associations, large portions of the interior lands west of Lake Okeechobee are agricultural. Important uses include pasture (cattle ranching) and citrus.

J.11.2 Fish and Wildlife

The Caloosahatchee River region includes many outstanding wildlife and fish habitat areas. These include state and county parks, state Aquatic Preserves, several National Wildlife Refuges, and many sites on private lands. Wildlife species regularly sighted include most of the high-priority (threatened, endangered and State Special Concern) species. For example, manatees use the Okeechobee waterway and estuaries. Florida Panther habitat includes inland pine flatwoods, hardwood hammocks and swampy forest west of Lake Okeechobee. The American crocodile's range apparently extends up the cost as far north as Sanibel Island, where it is occasionally spotted. Inland species include the bobcat, river otter, gopher tortoise, eastern indigo snake, water birds such as the wood stork, and white ibis; and raptors including the snail kite (freshwater sloughs and wet prairies), bald eagle, and Audubon's crested caracara. Migratory seabirds and shorebirds frequent the coastal shorelands and beaches, along with waders such as the wood stork and roseate spoonbill. Pine flatwoods provide habitat for red-cockaded woodpecker. At least one nesting colony of this species occurs in the Cecil M. Webb Water Management Area. Upland game and non-game wildlife includes white-tailed deer, racoon, rabbit, gray squirrel, doves and pigeons, and migratory woodcock and snipe. J.N. 'Ding' Darling NWR, Charlotte Harbor State Aquatic Preserve, Cayo Costa State Park, and Fred C. Babcock/Cecil M. Webb Wildlife Management Area provide some of the most outstanding natural habitat for the above species. Addionally, the Orange River, a tributary entering the Caloosahatchee River estuary below the locks, is a favored wintering place for manatees, because a nearby power plant discharges warm water (FDEP, 1996).

Threatened and endangered species found in the Caloosahatchee region include the eastern indigo snake, bald eagle, red-cockaded woodpecker, Audubon's caracara, wood stork, snail kite, West Indian manatee and Florida panther.

The freshwater fishes of the Caloosahatchee River watershed are a mix of northern freshwater species, marine species, and exotics. Some principally marine species such as the tarpon, American eel, and mullet occasionally move far inland via canals and rivers. The freshwater fauna of south Florida consists of 108 species of fishes from 34 families. Small fish, including the golden topminnow, least killifish and Florida flagfish, inhabit the shallow emergent wetlands and sloughs, providing essential forage for wading birds. Freshwater game fish include largemouth bass, black crappie, sunfish and catfish. Significant freshwater invertebrates include the crayfish and apple snail.

Marine and estuarine fishes of southwest Florida are grouped by habitat into four types based on salinity, detritus, and substrate. These are a) black mangrove basin forest: *Rivulus*, mosquito fish, and marsh killifish; b) riverine fringing community: juvenile sheepshead, tidewater silverside, and sheepshead minnow; c) estuarine bay fringing community: silver perch, pig fish, and black cheek tonguefish; d) oceanic bay fringing community: lemon shark, gold spotted killifish, and southern stingray (Drew and Schomer, 1984). Many of the estuarine channels and open sounds are seasonal habitat for such inshore game fish as tarpon, redfish, and snook.

J.11.3 Water Management

Inflows from Lake Okeechobee and runoff from within its own basin supply the Caloosahatchee River. The freshwater portion of the river (C-43 Canal) extends westward from Moore Haven, on Lake Okeechobee, through La Belle, to the Franklin Lock and Dam (S-79). The C-43 Canal is part of the Lake Okeechobee Waterway, providing navigation between the east and west coasts of Florida. West of S-79, the river mixes freely with estuarine water as it empties into the Gulf of Mexico (SFWMD, 1995; SFWMD, 1997). C-43 is 45 miles long, averages 20 to 30 feet deep and ranges from 150 to 450 feet wide. The Ortona Lock and Dam (S-78), located approximately 27 miles upstream of S-79, separates the freshwater portion of the river into the east and west Caloosahatchee basins. Roughly 40 percent of the drainage area is in the east basin, and the remaining 60 percent is in the west basin. The total drainage area to the river between S-77 and S-79 is about 880 square miles (Camp, Dresser and Mckee, 1991).

The Caloosahatchee River region is part of the Lake Okeechobee Service Area. The Lake Okeechobee Service Area sub-basins lie at critical intermediary points in the water management system of south Florida. The needs of the Okeechobee sub-basin for flood protection and drainage services affect inflows to the Caloosahatchee Estuary. Excessive discharges of fresh water to the Caloosahatchee Estuary are caused by regulatory releases from Lake Okeechobee and runoff from each local watershed (SFWMD, 1997).

The Lake Okeechobee regulation schedule determines the timing and quantity of water that is released from the lake into the Caloosahatchee river, depending on lake water surface elevation and season. The current lake regulation schedule allows the lake to peak at 16.75 ft. on September 30th. The stored water is intended for water supply during the dry season. The lake regulation schedule is often called a 15.65 to 16.75 ft. regulation schedule because of these key low and high lake stages. When lake levels exceed the highest allowable elevation (generally during flooding rainfall events), rapid releases of large volumes of water occur down both the Caloosahatchee and St. Lucie canals. At intermediate elevations, lower continuous releases of water occur. Timing and duration of releases are set by a targeted discharge volume from Lake Okeechobee, which in turn is set according to the lake level. Maximum water releases through the Caloosahatchee may be up to 9,300 cfs. Lake Okeechobee regulatory releases are made after the peak of the local inflow has passed. Lower, but continuous flows occur under "Zone B" or "Zone C" conditions. Minor rainfall events lead to smaller, pulsed discharges, intended to mimic natural rainfall events.

Continuous discharges to the Caloosahatchee and St. Lucie estuaries have caused documented negative effects on estuarine ecology (Chamberlain et al. 1995, Haunert and Startzman 1985, Chamberlain and Hayward 1996). Research has shown that prolonged releases, even at the modest Zone C rates, transform the estuarine systems into freshwater habitats within three to four weeks. The dramatic and rapid changes in salinity, and associated siltation caused by the release of suspended solids and precipitation of dissolved organic matter at the fresh/salt interface, can produce long-term negative effects on these estuaries. In addition, continuous flow releases at these levels tend to create critically low benthic oxygen concentrations at the transitional zone between fresh water and the Ocean or Gulf. High, continuous releases generate even more problems, because of greater potential for environmental disruption and associated public concern. Even with a thorough understanding of these major environmental concerns, flood control remains a major purpose of the man-made structures, and regulatory discharges are sometimes necessary because of the high risk of loss of life and property associated with high lake stages and hurricane generated waves and tides.

J.11.3.1 Problems related to Water Management

During the annual November to April dry season, little water is released into the river from the lake, resulting in low flows and low water levels in the upper Caloosahatchee. Two problems may develop as a consequence: First, low flow may lead to development of an occasional severe algal bloom in the river above Franklin Lock (S-79) and Dam. The City of Ft. Myers and Lee County both have municipal water intakes in this area. Short term high rates of discharge from Lake Okeechobee are used to break up the blooms by the U.S Army Corps of Engineers whenever requested by the South Florida Water Management District (SFWMD) (USACE, 1991). During the extreme driest months (April-May) river flow may drop to near zero. When this occurs, navigation lockages through the W. P. Franklin Lock (S-79) allow a salt-water wedge to move upstream. If salt intrusion is too severe, South Florida Water Management District requests the Corps of Engineers to flush out the salt water with a short-term high rate of discharge from Lake Okeechobee. During a declared water shortage period, the South Florida Water Management District requests the U.S. Army Corps of Engineers to go to reduced hours of lockages (USACE, 1991).

J.11.4 Water Supply

The Lower West Coast is one of the fastest growing regions in the state. Rapid population growth is projected to continue, accompanied by an increase in water demand. In addition, the area is experiencing growing and changing agricultural activity. Citrus has begun moving into this area following a series of freezes in central Florida, and it is displacing more traditional agricultural activities, including cattle ranching. This trend will increase agricultural water demands (SFWMD, 1995).

The major issues influencing water availability in the lower west coast include: dependency upon rainfall, limited and regulated surface water sources, protection of water resources and associated natural systems, and pressure on these resources from increasing urban and agricultural demands.

J.11.4.1 Surface Water Resources

Two utilities, Ft. Myers and Lee County (Olga) take surface water from the Caloosahatchee River to meet some or all of their water demands. Other utilities in the basin use ground water as their source (SFWMD, 1997). The river (C-43) is the only major surface water body used for water supply. It is maintained by releases from Lake Okeechobee. Lake Hicpochee, in the East Caloosahatchee Basin, is not considered a good source of water supply (SFWMD, 1994). Three structures (S-77, S-78 and S-79) provide navigation and water control in the C-43 Canal. The S-79 structure also serves as a saltwater barrier. The operation schedule for these structures is dependent on rainfall conditions, agricultural practices, the need for regulatory releases from Lake Okeechobee, and the need to provide water quality control for the public water supply facilities (SFWMD, 1987; SFWMD, 1992).

J.11.4.2 Ground Water Resources

Three major aquifer systems have been recognized within the region: the Floridan Aquifer System (FAS), Intermediate Aquifer System (IAS), and Surficial Aquifer System (SAS). Ground water is the predominant source of supply to public utilities and agricultural users not adjacent to the Caloosahatchee River. Although the deep Floridan Aquifer System is capable of high yields, it produces poor quality to nonpotable water throughout this region, except for the northern part of Glades County. Salinity also increases as a function of depth, making the deeper producing zones less suitable for development than those zones near the top of the system. Nearer the coast (Charlotte and Lee Counties) Floridan water requires desalination treatment to be acceptable for potable uses and some other uses. Currently, only four utilities (the City of Cape Coral, Florida Cities, Greater Pine Island, and Sanibel Island Water Association) obtain water from the FAS. In Glades County, the Floridan aquifer is a major source of irrigation and potable water. Elsewhere it supplies only a few agricultural irrigation wells.

The IAS yields moderate quantities of water in certain parts of the region. The sandstone aquifer sub-unit provides large quantities of water for both potable and irrigation uses in the south central portion of Lee County. The aquifer provides all of the water withdrawn by the Lehigh Acres public water supply wellfield and a portion of the water withdrawn by the Corkscrew and Green Meadows wellfields. Other communities and areas using the IAS include domestic self-supply in Cape Coral, and small water utilities north of the Caloosahatchee River. It is also a major potable and irrigation water source in southern Charlotte County.

The surficial aquifer is used for potable supply and irrigation in many areas, although it may suffer from salt intrusion near the coast. Five major public water suppliers, Lee County Utilities (Corkscrew wellfield), Gulf Utilities, Florida Cities (Green Meadows wellfield), the City of Fort Myers, and Bonita Springs, all pump water from the Surficial Aquifer System. The system also furnishes irrigation water for many uses, including vegetables, nurseries, and landscaping (SFWMD, 1998). It is also a significant water source in inland southern Charlotte County. In Hendry County, most users depend primarily on water from the surficial and intermediate aquifer systems as a primary water source for domestic and agricultural use. The water table aquifer and the sandstone aquifer (part of the IAS) supply most potable water demands.

J.11.5 Socio-Economics

The human population in the Caloosahatchee River region is concentrated along the coast, as in most of Florida. The coast is rapidly becoming highly urbanized. The southwest subregion has the highest growth rate in Florida over the past ten years, and the highest projected growth rate from now to 2010. The Cape Coral, Ft. Myers and Naples metropolitan areas are among the seven fastest growing in the United States. In the 1980s, Lee County population grew by 63 percent (SFWMD 1992). Projected population increases for Lee county from 1990 to 2010 is 90 percent (SFWMD 1992).

A somewhat unique aspect of this subregion is large scale "planned" residential development projects, which date from the late 1950s to the early 1970s. Cape Coral, Lehigh Acres, and Golden Gates are the largest of these developments. Cape Coral is the second largest Florida city in area (285 km2). The natural habitats in over 90 percent of this area were destroyed. Wetlands were filled; terrestrial forests were cleared of vegetation. Over 2000 km of roads and 650 km of freshwater and estuarine residential canals were constructed. During this process most of the land was platted and sold as residential home sites. The projected build out population of Cape Coral is 400,000 people. Population today is 80,000-100,000. Many areas of the city are sparsely populated, however Cape Coral is one of the five fastest growing cities in the country.

Agriculture is a major activity in the interior of this region. It probably has the highest rate of land conversion to agriculture, primarily citrus. In the 1980's, irrigated agricultural acreage in Lee County grew by 35 percent. Recently, land conversion to citrus has increased substantially. From 1985 to 1990, citrus acreage in Hendry and Lee counties increased 83 percent and 46 percent, respectively (SFWMD 1992). This boom in acreage is the result of interregional movement of citrus from central to southwest Florida following several severe freezes in the mid-1980's. The projected increases in citrus acreage for Hendry, Glades, and Lee counties from 1990 to 2010 are 100 percent, 90 percent, and 50 percent (SFWMD 1992).

Through 1988, industrial earnings were concentrated in services (30 percent, retail trade (19 percent) and government(14 percent). In Charlotte and Lee counties, the service industry provided the main economic activity, while agriculture and associated products are the dominant industrial activities. In Glades and Hendry counties, agriculture and service industries represent 72.5 and 54.7 percent of total earnings, respectively (SFWMD, 1992).

J.11.6 Land Use

The Caloosahatchee River Region has 169,660 acres of urban land, largely fixed single family units (69,172 acres) and an almost equal number of acres in some stage of construction. There are 355,125 acres of agriculture with improved and unimproved pastures (163,348 acres), citrus groves (92,410 acres) and sugar cane (67,628 acres) predominant. Various types of rangeland make up 51,663 acres of land use. The category of barren land has 10,000 acres. This includes spoil and borrow areas (7,090 acres) and rural land in transition (2,377 acres). Transportation, communication and utilities comprise 16,280 acres.

Rangeland and agriculture dominate land use in the basin, particularly the upper portion (FDEP, 1996). The freshwater portion of the Caloosahatchee River Region is mostly agricultural in nature. The only urban areas are the cities of LaBelle, Alva, and Moore Haven (Camp, Dresser and Mckee, 1991).

Land use adjacent to the Caloosahatchee River Estuary is largely residential and urban with the city of Cape Coral on its northern bank and the highly urbanized city of Fort Myers on its south bank. Both of these communities have experienced rapid growth with even more growth anticipated in the near future (SFWMD, 1997).

J.11.6.1 Agriculture

Glades and Lee Counties are included in this region. Almost one half million acres are farmed in the Caloosahatchee River Basin, and approximately three-fourths of that area is pastureland (UFBEBR, 1995). The region is characterized by large farms averaging 1800 acres, with relatively low productivity per acre (UFBEBR, 1995). Glades County ranks eighth in the state of Florida for cattle production (FASS, 1996a). Citrus production in the Caloosahatchee River Basin covers more than 20,000 acres (FASS, 1996b) and is currently increasing. Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value citrus crops.

Almost 5,000 people are employed in agricultural production and services, and the payroll totals approximately $5 million (UFBEBR, 1995). Agricultural products in this region have a total market value of more than $135 million (UFBEBR, 1995).

More than 77,000 acres of farmland are irrigated in the Caloosahatchee River Basin (UFBEBR, 1995). Reliable water supply is a big concern in this region which has traditionally relied upon water deliveries through the Caloosahatchee River from Lake Okeechobee. Irrigation demands can be expected to increase as additional land is used for citrus production.

J.11.7 Recreation Resources

Recreation resources in the Caloosahatchee Basin and West Coast Region are diverse, consist of good quality and include coastal, inland water and land based resources. The Caloosahatchee River provides approximately 67 miles of navigable waterway with ten U.S. Army Corps of Engineers recreation facilities that include boating, fishing, picnicking, and camping. Several other river bodies also offer recreational opportunities in the region.

The Caloosahatchee River provides approximately 67 miles of navigable waterway with ten Corps recreation facilities that include boating, fishing, picnicking, and camping. The J.N.”Ding” Darling NWR, a popular birding area, administers Caloosahatchee, Matlacha Pass, Island Bay National Wilderness area and Pine Island National Wildlife Refuge, all located near the region’s western edge. Boca Grande Pass is world renowned for record tarpon, Sanibel Island is reported among the top shelling destinations in the Western Hemisphere. The Fred C. Babcock/Cecil M. Webb Wildlife Management Area and CREW Wildlife and Environmental Area also provide recreational ammenities in this region.

Caloosahatchee State Park and Recreation Area is located near Alva on the Caloosahatchee River. Estero River and Hickory Creek State Canoe Trails are within the region and provide excellent recreation resources. Cayo Costa State Park, Sanibel Island State Park, and State Aquatic Preserves are located in the Lower West Coast region. The region’s boating, diving and fishing are very popular recreational activities. Surrounding development pressures could adversely affect the region’s natural and recreational resources. Substantially altered water deliveries to this region have had detrimental affect on natural and recreation resources in the region. The region's recreation resource use is substantial and anticipated to increase.

J.11.8 Aesthetic Resources

The Caloosahatchee Basin and Lower West Coast regional aesthetic overview is characterized by the Caloosahatchee River corridor, the Gulf of Mexico coastal plain, and surrounding uplands. The Caloosahatchee River is a linear body of water whose width allows observation of shoreline vegetation that includes texture, color, and wildlife varieties of interest and beauty. Minor urban impacts exist along the Caloosahatchee until the Fort Myers area where impacts increase noticeably.

The coastal segments of the region possess a higher degree of aesthetic quality within the visual environment. State Parks, Wildlife Management Areas, and Wilderness Areas secure natural resources of prominent aesthetics.

Much of the region's interior aesthetics are comprised of forested wetlands and irrigated pasturelands of moderate aesthetic quality. Many of the regional rural areas possess scenic quality on a small scale. Rural areas are largely pine forested with some oak, hickory and gum associations. Air traffic noise is an increasing adverse aesthetic impact. Development pressures are an increasing concern to natural and aesthetic resources.

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APPENDIX K

ENVIRONMENTAL EFFECTS
OF THE
INITIAL DRAFT PLAN

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APPENDIX K
ENVIRONMENTAL EFFECTS
OF THE
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K.1 INTRODUCTION

The following describes the expected beneficial and adverse physical, ecological, and socio-economic affects to resources of regional concern within the study area. In all instances the assessment of effects in this appendix is based on a comparison between Alternative D-13R (henceforth called the "Initial Draft Plan") and the Without Plan Condition (2050 base). In a few instances a comparison to the 1995 base (existing conditions) was also documented, as it may have lent additional relevant evidence to the impact analysis. This appendix is organized to discuss impacts to the regional system first on a comprehensive basis. A finer resolution of environmental effects, based on the ten physiographic regions (described in ***Appendix J***), which comprise the entire study area, is presented afterwards.

Detailed analyses of affects to water quality are available in ***Appendix H***, to air quality in ***Appendix I***, and to Socio-economics in ***Appendix E***. Summary discussions of these effects only are included in this appendix. This analysis includes the approximately fifty project features included in the Initial Draft Plan. It does not attempt to assess impacts associated with the Other Project Elements (OPEs) as the OPEs included in the recommended Comprehensive Plan had not yet been decided on until late in the preparation of the draft document and several others were being re-organized under the Restudy during preparation of the final Programmatic EIS. More detailed analysis of environmental impacts, including the full range of OPEs, will be conducted in future National Environmental Policy Act documents which will be "tiered" from this Programmatic EIS as per guidance in 40 CFR, Parts 1502.2 and 1508.8. Supporting information, including Fish and Wildlife Coordination Act Reports, supplied by Department of Interior and the Florida Game and Fresh Water Fish Commission (GFC), and a final programmatic biological opinion on affects to threatened and endangered species, supplied by the U.S. Fish and Wildlife Service, are provided in Annexes A and B, respectively.

K.2 REGIONAL SYSTEM

While this section's organization is similar to traditional National Environmental Policy Act documentation of environmental effects, it includes a preliminary discussion of the overall changes thought necessary to restore the C&SF Project area to a more natural and sustainable ecological system. These remarks include brief summaries on key Everglades (for the purposes of this report defined as the Water Conservation Area and Everglades National Park regions) essential characteristics that have helped shape the Restudy planning efforts to date.

This report reviews the impacts of the Initial Draft Plan on the essential characteristics of the south Florida ecosystem that operate on a landscape scale. These characteristics include spatial extent, heterogeneity of habitat, and sheet flow. Because they affect both the abundance and distribution of wide-ranging fish and wildlife species and the success of more localized species at an ecosystem scale (See Chapter 2), the extent to which these essential characteristics will be recovered has bearing on the ecological sustainability of the future, restored system.

This section also discusses trade-offs that involve the region-wide balance of benefits and the sharing of adversity. Because different alternatives tend to favor different parts of the system at the expense of others, one strength of the Initial Draft Plan is that it tends to balance benefits and impacts across the south Florida ecosystem.

Spatial extent of the interior marshes has been reduced by nearly half in comparison to their original size. This reduced the storage and affected the timing of water delivered through the central Everglades marshes. Recent studies suggest that the deepest marshes were once located east of the Miami-Dade-Broward levee in areas now developed. To restore historic flows and depths to the southern Everglades and Florida Bay, alternatives either needed to pass more water through the small, remaining Everglades, which would continue the flooding of tree islands, or find other ways to move water.

The alternative plans contained four strategies to store and transport water around and through the Everglades in a timely manner. First, extensive storage facilities substitute for the lost marsh area. Second, interior levees that impeded flow were removed. Third, remaining levees and canals were used to direct and speed flow south. Fourth, a Central Lake Belt conveyance system was designed to route water around the WCAs to compensate somewhat for the lost eastern portion of deeper Everglades that once fed Shark River Slough and Everglades National Park. Only the Initial Draft Plan, using all four strategies, came close to replicating natural flows throughout the northern, central, and southern Everglades. The alternative also meets or comes close to meeting the goals for reducing dependence on Lake Okeechobee for storage, and provides appropriate fresh water flows to the St. Lucie and Caloosahatchee estuaries, Florida Bay, and Biscayne Bay to maintain proper salinities.

Natural patterns of habitat heterogeneity in the interior Everglades marshes have been compromised by the network of canals and levees that deeply pond water upstream and overly dry areas downstream of man-made barriers. The hydrologically disjunct areas these features create disrupt the natural continuity of the landscape. When the differences in water surface elevations across existing levees were compared with the differences predicted by the Natural Systems Model (NSM), the Initial Draft Plan greatly improved connectivity over the 2050 base. Removing levees and canals or installing weirs will eliminate abrupt differences in water depths on either side of a given levee and restore hydrologic connectivity within interior Everglades marshes. As a result, free movement of fish and smaller animals can occur. Foraging habitat for wading birds will be more consistent over the landscape as drydown patterns that concentrate fish for them to harvest become reestablished. The natural heterogeneity of the marsh will replace the pattern of discrete pools the current system supports.

Canals and levees physically fragment habitat by interjecting strands of deep water and dry land where they should not occur. The Initial Draft Plan reduces the number of miles of interior canals, within the natural system by 40 percent and levees by 20 percent, compared to the 2050 base. Removing levees reduces the ability of land-based predators and exotic plants to spread to the interior of the marsh. Similarly, removing the canals adjacent to levees is expected to benefit smaller native fishes, by removing habitat for larger-bodied predators, exotic fishes, and invasive waterborne plants.

A relative value for improvement in sheetflow in the Everglades marshes was obtained by comparing flow volumes across a number of transects in the north, central and southern Everglades and Big Cypress National Preserve with NSM and 2050 base flow volumes. Sheetflow throughout the system in the Initial Draft Plan closely resembled NSM flows and was a vast improvement over the 2050 base condition. Restoring sheetflow to large areas of the freshwater marshes will allow the system to naturally shape tree islands, take up nutrients, precipitate phosphorus and calcium carbonate into the substrate, and retain water into the dry season. The implications for fish and wildlife are implicit and deserve additional study.

In the natural system, 62 percent of the water that crossed from WCA-3 into Everglades National Park flowed east of the L-67 levee, while 38 percent flowed to the west of it. That pattern of flow, coupled with sufficient volumes, ensured that northeast Shark River Slough received a majority of the water flowing into Everglades National Park. Only 11 percent of the reduced flows in the 2050 base condition crossed the eastern portion of the Tamiami Trail. In the Initial Draft Plan, 110 percent of the predicted NSM volume crosses from WCA-3 to the Park and 55 percent of that water flows east of L-67. Only this alternative came close to recapturing the natural pattern, which would ensure that a most of the water crossing into the Park supplies Shark River Slough, and, by implication, Taylor

Slough. With sufficient water in Shark River Slough, the Marl Prairies and Florida Bay are highly likely to receive the water they require for restoration.

Trade-offs at the regional scale cannot be avoided. In theory, no portion of the system should bear a disproportionate share of the cost of ecosystem restoration. Careful evaluation of negative impacts to local areas must be balanced against the benefits gained by the system as a whole. Three issues that have already emerged are: 1) the trade-offs inherent in creating vast storage areas, 2) the trade off between further decompartmentalizing the system and keeping structures that allow flexible water management, and 3) the potential trade-off of increasing hydroperiods in portions of the WCAs in order to restore Shark River Slough.

System-wide, the most important feature of all of the alternatives has been the vast amount of water storage that has been created in the system. Storage facilities, including aquifer storage and recovery, reduce the dependence of the urban areas on Lake Okeechobee for water supply, allowing Lake Okeechobee to fluctuate more naturally for its own benefit. Protecting the littoral zone of Lake Okeechobee from damaging high lake stages will support healthy emergent aquatic vegetation and its function as a reliable nursery for the fish populations. Capturing flood waters in storage areas will diminish the need for damaging regulatory releases to the St. Lucie and Caloosahatchee estuaries, benefiting seagrass beds and oysters, among other species. Water from the storage areas will become available during dry seasons to support minimum flows to the estuaries, to enhance dry season flows to the central and southern Everglades, and to supplement water supply in developed areas.

The problem with creating vast storage areas is that the land on which they are built will be permanently altered. None of these storage areas has been located yet, so impacts are conceptual at this time. Whether they are eventually built on uplands or wetlands, they must be carefully located and designed to minimize potential impacts to threatened or endangered species and to avoid environmentally sensitive areas. Care must be take to ensure that the regional benefits gained will exceed the local habitat values lost. In addition, because these storage areas are of considerable size, care should be taken in their design and operation to take advantage of any opportunity to benefit fish and wildlife.

The second tradeoff is that despite the ecological values of decompartmentalizing the system, some canals and levees will be needed to perform the functions once performed by the missing parts of the system. WCA-3B, for example, is one of the healthier parts of the current Everglades system and biologists want to avoid degrading it if possible. However, in an effort to increase flows to Shark River Slough, it has been nearly impossible to do so without increasing high water events and lengthened hydroperiods in WCA-3B. Since the former deep marshes east of the WCAs have been developed, WCA-3B has become the new headwaters of the Shark River Slough. In the Initial Draft Plan, instead of removing the L-67 levee and the adjacent canal, which would increase sheetflow, increase connectivity, and reduce fragmentation, a modified L-67 was kept in place to protect WCA-3B from excessive flooding seen in earlier scenarios. This tradeoff appears to be entirely justified, given the many obvious benefits of protecting a pristine portion of the Everglades. Using the levee and canal to route flows around this valuable area justifies their existence and modeling results appear to prove the effort was successful.

The Initial Draft Plan succeeds in moving large volumes of water through the northern and central Everglades to the southern Everglades without causing as many extreme high and low water events as earlier plans. Unfortunately, increased hydroperiods are still a potential problem in parts of the WCAs. In some places, WCA-3B for example, hydroperiods are longer than the NSM predicts for Shark River Slough. Although ecologists are fairly open to allowing portions of the Everglades to transform from one healthy freshwater marsh type to another, it is unknown whether a pristine area like WCA-3B will become a more slough-like system or simply become degraded. As more detailed studies continue, there needs to be a duel path of seeking ways to reduce excessive hydroperiod lengths and to reach a better understanding of what is likely to occur in WCA-3B if it is subjected to lengthened hydroperiods.

K.2.1 Geology and Soils

Implementing the Initial Draft Plan will not affect regional geology. Soil effects should be largely beneficial, and lead to a reversal or retarding of peat soil subsidence. Extensive monitoring should assist in more accurately assessing beneficial or other impacts to relatively long-term processes such as soil formation and subsidence.

K.2.1.1 Soils

The peat soils of the Everglades were formed under anaerobic conditions when, due to insufficient oxygen because of flooding, microorganisms were unable to completely decompose plant remains to carbon dioxide, water and mineral constituents. Therefore, partially decomposed organic matter accumulated, forming peat soils, which in some places were 12 feet thick. When the soils were drained, the land surface began falling (subsiding) for a number of reasons: (1) loss of buoyancy; (2) peat shrinkage; (3) fires; (4) wind erosion; and, most importantly, (5) aerobic microbiological decomposition (oxidation). This is not a condition unique to the Everglades; all organic soils subside when drained. In the Everglades, the rate of subsidence averages about 1 inch per year, the exact rate being directly related to the depth of the water table. The lower the water table, the more rapid the rate of subsidence (Snyder and Davidson, 1994).

For any area within the limits of the Restudy that contains peat soils, an increase in hydroperiod will help retard subsidence. For areas that contain peat soils, a decrease in hydroperiod will increase the magnitude of oxidation, rate of subsidence and frequency of peat fires. Immediate effects of this decrease in hydroperiod will result in decreased volume of peat that can be exploited as a resource, alteration of vegetation types, and reduction in productivity of current agriculture. On a regional scale, the Initial Draft Plan results in generally longer hydroperiods throughout the affected area of the natural system relative to both base conditions. The long-term average rate of peat deposition was estimated by McDowell et al. (1969) at 8.4 centimeters per century, with a maximum rate of 16 centimeters of peat deposited per 100 years. Therefore it is reasonable to conclude that the rate of soil subsidence and the frequency of peat fires will be reduced and peat may begin to accrue again. Protecting peat soils will improve the sustainability of natural vegetative cover and agriculture.

K.2.1.2 Geology

For any area within the limits of the Restudy that is underlain by limestone, an increase or decrease in hydroperiod should not result in subsidence. For any area underlain by quartz sands of the Pamlico Sand, a decrease in hydroperiod could produce relatively very minor subsidence and increase susceptibility to erosion as the sands are drained. Increase in hydroperiod should not effect elevation of the upper bounding surface of the Pamlico Sand. No significant effect is anticipated to the geology of the project area as a result of implementation of the Initial Draft Plan.

K.2.2 Climate

Overall, climate is not expected to be directly or indirectly affected, in the short or long-term, by implementation of the Initial Draft Plan. Air circulation patterns (wind, storms), evapotranspiration, and rainfall patterns, distribution and abundance (all factors of climate) should not be affected. Local microclimates may be affected on a modest scale, and to a moderate extent, in the vicinity of particularly large (>5,000 acres) storm water treatment areas, and above ground reservoirs, where uplands have been converted to open water systems with differential effects on local air circulation patterns, ET, and humidification.

K.2.3 Air Quality

The implementation of the Initial Draft Plan is not expected to have an impact on existing air quality. Overall, the air quality for the region is considered good, or to be in attainment with all National Ambient Air Quality Standards (NAAQS), as established by the Clean Air Act (CAA). Air quality is expected to remain the same as under the 2050 base, and will not affect the region's attainment status as described above. Limited, minor, and localized impacts may occur within construction zones due to earth moving equipment and transportation of fill and materials. Fugitive dust and hydrocarbon emissions from heavy equipment and construction vehicles may have moderate, temporary impacts on air quality, but this should be restricted to those areas currently under construction. There will be no effect on air quality due to the operation and maintenance of the project, once construction is completed. For further information on air quality impacts, reference ***Appendix I***.

K.2.4 Noise

Overall implementation, operation and maintenance of the proposed project, will cause little effect on ambient noise levels. Within the natural areas, the site will retain its wilderness characteristics, and noise emissions will be limited in source and of low occurrence. No new transportation corridors, which are significant noise emission sources, are proposed under the Initial Draft Plan. Urban and agricultural areas will retain their land use functions and will not be significantly affected by the Initial Draft Plan.

Noise levels due to construction of the proposed project will be moderate in both scope and scale and limited to areas where construction activities are currently ongoing. Construction equipment would be expected to include bulldozers, backhoes, tractors, graders, front-end loaders, trucks, and other heavy equipment. This earth-moving equipment has noise levels at 50 feet in the range of 70 decibels to about 95 decibels. Continuous exposure above about 86 decibels is likely to degrade the hearing of most people (U.S. Environmental Protection Agency 1972). At these times, noise effects may be locally bothersome, but will likely affect few individuals as most project features are planned to take place in natural or rural areas, and away from areas normally frequented by people. These localized impacts would likely occur for relatively brief periods at any one location. On a regional basis however, impacts may occur for an extended period of time, as the schedule for construction activities may last up to 20-30 years prior to project completion.

K.2.5 Vegetation

The Initial Draft Plan reduces dependence on Lake Okeechobee for storage by increasing artificial water storage in the system. The consistent need for extreme high lake water levels that damage the littoral zone is reduced, maintaining a more healthy plant community around the lake margin. Alternative storage areas also improve the timing of water releases to the Caloosahatchee estuary, the St. Lucie estuary, and into the Everglades Protection Area. Regulatory releases will no longer be a constant threat to seagrass beds in the estuaries, and extreme high and low water events in the central Everglades will no longer be as pervasive or as damaging to freshwater marsh vegetation. Although lengthy hydroperiods and extreme low and high water events still remain a concern in portions of the central

Everglades, their impact is less understood, and the problems are more likely to be solved by improved operations during detailed studies.

The northern and central Everglades (Holey Land and Rotenberger Wildlife Management Areas, A.R.M. Loxahatchee National Wildlife Refuge (WCA-1), and the Everglades and Francis S. Taylor Water Management Area) constitute roughly 900,000 acres of Everglades landscape. The managed system caused widespread loss of peat soils from over-drainage, followed by microbial oxidation and muck fires. Tree island vegetation was lost due to muck fires in over-drained regions and prolonged high water in deeply ponded areas. The Initial Draft Plan appears to make major steps toward solving these two critical problems. Although all of the final alternatives developed by the Restudy team help relieve drought conditions that damage peat soils, the Initial Draft Plan provides the best reduction in extreme high-water conditions that would flood tree island vegetation communities.

K.2.6 Fish and Wildlife

Allowing Lake Okeechobee to function more as a natural lake, rather than as a reservoir should enhance fish populations. Juvenile fish and other small aquatic species depend on a healthy, vegetated littoral zone for food and cover. If the Initial Draft Plan is implemented and Lake Okeechobee's stages act more normally, the littoral zone would be less subject to excessive flooding and drying.

Increasing the geographical extent of the Everglades marshes is unlikely, given the extensive urban and agricultural development in south Florida. None of the alternatives addressed this issue directly except to attempt to increase the acres of wetlands restored. However, operations within the planned storage areas and the water preserve areas may be able to serve as fish and wildlife habitat to some degree.

Many of the effects of compartmentalization and fragmentation on fish and wildlife are hypothetical and need further study. Water appears to flow more evenly through the system in the Initial Draft Plan than the 2050 base. As pooling effects disappear and as physical barriers to native fish and other aquatic species are removed, the flow of genetic material may be enhanced and the ability of aquatic species to repopulate the WCAs following dryouts may be improved. Unnaturally deep areas within canals and upstream of levees should no longer favor large predatory fish, allowing smaller native species to increase in abundance. Removal of canals may also slow the spread of exotic fish into the interior of the Everglades. Removal of levees is expected to slow the spread of exotic plants and reduce easy access to the marshes by predatory mammals.

In the Water Conservation Areas the Initial Draft Plan tends to reduce extreme high and low water events at the expense of increasing inundation period in several areas. Compared to the 2050 base, the plan improves conditions in southern WCA-3A by reducing high water and in northern WCA-3A by reducing drydowns, but worsens conditions in northeastern WCA-3A and WCA-3B by increasing high water. The potential long-term biological effect of longer inundation periods and greater depths than NSM predicts are unknown. While peat soils may be better protected by reducing the number of drydown events, wading birds depend on the seasonal drying pattern to concentrate their prey in shallow pools, and the depth at which they can fish is limited by their leg length. A system that is deeply flooded year after year may increase fish populations, yet the water may be too deep or the fish too dispersed to be harvested by wading birds.

Localized and short-term impacts on wading bird nesting and foraging within eastern WCA-3A are likely to occur, but they are expected to be offset at the regional scale if the plan is implemented with an adaptive management strategy and regional monitoring programs. It will be necessary, for example, to develop sufficient breeding and foraging sites in other areas before existing sites are impacted. Specifically, the Initial Draft Plan predicts increased hydroperiods and a 2-foot increase in depths in northeastern WCA-3A. On the other hand, the area south of the 3A-3 gage and east of the Miami Canal will remain deeper than NSM values, but have far fewer high-water events. Both of these areas support important wading bird rookeries. The Initial Draft Plan, therefore, is likely to improve breeding habitat in eastern WCA-3A, possibly damage it in northeastern WCA-3A, and alter the distribution of suitable foraging areas as well. Although restoration of the Everglades watershed is expected to improve habitat for nesting wading birds at a system-wide scale, significant short-term and/or localized effects on particularly rookeries are probably unavoidable. Suitable breeding and foraging sites must exist and be reliably in use to offset any expected negative impacts to current sites. Careful system-wide research, development of better performance measures, additional modeling, careful monitoring of wading bird responses to changes in hydrologic conditions, and a flexible implementation plan will be critical to protecting the remaining wading bird populations in the Everglades.

Higher average fish abundances than the 2050 base should be produced by the hydrologic conditions created by the Initial Draft Plan. In particular, increased hydroperiods in northeast Shark River Slough, Taylor Slough, WCA-3B, northeast WCA-3A, and Loxahatchee NWR should increase fish abundance. Increased abundance of prey-sized fish will enhance wading bird survival if seasonal drydown patterns can be optimized to concentrate them.

For white-tailed deer, the reduction of excessive high water conditions in many portions of the WCAs should provide slightly better foraging conditions and reduced drowning losses. Overall, however, increased hydroperiods in most of the WCAs and northeastern Big Cypress compared to the 2050 base are likely to decrease the quality of these marginal deer habitats slightly except for small areas of northeastern and southern WCA-3A and the Big Cypress-Everglades National Park border. In Everglades National Park where deer habitat is already poor, the NSM-like conditions in the plan would reduce quality further. For those few areas with high deer breeding potential (Long Pine Key and surrounding short hydroperiod marsh and northwest Big Cypress), there will be no impact.

For the southern Everglades and for Florida Bay, the Initial Draft Plan greatly improves hydropatterns. Improved timing and duration of freshwater flows to Florida Bay estuaries and improved timing of fish-concentrating drydowns should lead to better wading bird foraging and breeding conditions in the southern Everglades than both base cases. Greater fish abundances suggest improved foraging conditions for wading birds and fish-eating raptors.

K.2.7 Threatened and Endangered Species

Within the regional system, improved habitat conditions and benefits for overall populations are anticipated for the West Indian manatee, American crocodile, snail kite, wood stork, Cape Sable seaside sparrow, and the Okeechobee gourd. In the case of the manatee and crocodile, this is due to substantially enhanced freshwater flows to Florida Bay, and decreased salinities in the Florida Bay and Shark River Slough estuarine habitats relative to the 2050 base. For the snail kite, wood stork, and Cape Sable seaside sparrow, restoring hydroperiod to NSM like conditions throughout much of their habitat, leads to an overall regional improvement in their populations. In some instances there may be local, minor negative impacts to habitat, by vegetation shifts over time, or increased ponding depths in relatively small areas currently serving as functional foraging or breeding grounds.

The endangered Okeechobee gourd is also expected to benefit due to a reduced occurrence of high water events and flooding of its habitat on the south shore of Lake Okeechobee.

The development of new water storage reservoirs on the scale proposed under the Initial Draft Plan is a concern in that they may create "attractive nuisance" conditions for wading birds, or nesting raptors such as the wood stork, bald eagle and caracara. These reservoirs are expected to operate primarily for flood water retention, storage and later release. Therefore, should birds and other wildlife become attracted to them, possibly becoming dependent upon them for foraging during a breeding cycle, significant mortality or breeding collapse may result should operational criteria demand a significant release of floodwaters downstream.

As a whole, the scrub jay, bald eagle, caracara and eastern indigo snake may be negatively impacted by the Initial Draft Plan, primarily through the construction and operation of water storage and treatment areas, mostly within the Kissimmee

River and Caloosahatchee River regions. Filling in of canals is also likely to negatively impact some eastern indigo snake habitat, and may cause direct mortality of snakes. The impacts to these animals are not likely to jeopardize their continued existence.

According to the United States Fish and Wildlife Service, Preliminary Programmatic biological opinion, received by the Corps on August 7, 1998 and later certified as the final biological opinion (Annex B) implementation of the Initial Draft Plan is not likely to affect the following species found within the project area: 1) Florida panther, 2) Florida grasshopper sparrow, 3) red-cockaded woodpecker, 4) crenulate lead-plant, 5) deltoid spurge, 6) Small's milkpea, 7) tiny polygala and, 8) Garber's spurge. Moreover the Initial Draft Plan is not expected to adversely modify Critical Habitat for the American crocodile, West Indian manatee, snail kite, and Cape Sable seaside sparrow.

Comments received from the Florida Game and Fresh Water Fish Commission in a letter dated December 14, 1998 state that the following state listed species may also be affected (positively or negatively) by the Comprehensive Plan. Specific impacts to these species will be discussed in future National Environmental Policy Act documents resulting from detailed planning. Miami black-headed snake, southeastern snowy plover, white-crowned pigeon, resident subspecies of the southeastern American kestrel, Florida sandhill crane, Everglades mink, Big Cypress fox squirrel, and Florida black bear (all threatened); common snook, gopher frog, gopher tortoise, Florida pine snake, roseate spoonbill, limpkin, little blue heron, reddish egret, snowy egret, tricolored heron, white ibis, American oystercatcher, brown pelican, black skimmer, whooping crane, burrowing owl, Sherman’s short-tailed shrew, Sherman’s fox squirrel, and Florida tree snail (all species of special concern).

K.2.8 Water Management

The Lower East Coast Regional Water Supply planning process demonstrated that, by taking advantage of the seasonal availability of surplus water throughout the regional system, a major portion of future needs can be met with increased storage. Modeling results show that increasing storage capabilities within the system will enable users to be less affected by dry seasons and droughts and at the same time save excess freshwater that would otherwise be discharged to tide and lost. Increasing the storage capabilities throughout the system will help the regional system meet increasing agricultural, environmental, and urban demands. The regional system will continue to experience significant fluctuations in water availability depending on the natural cycles of flood and drought. Alternative sources can help provide stable supplies during dry cycles.

One method of storing surplus water in the system is through the use of Aquifer Storage and Recovery wells. These Aquifer Storage and Recovery wells are associated with some type of reservoir to store water to feed the wells. These Aquifer Storage and Recovery wells make the reservoir more effective by steadily drawing it down and creating storage, enabling the next rainfall event to be captured within the reservoir.

For the Kissimmee Basin, water managers will use a climate based inflow forecasting model, in conjunction with operational rules, which will help them in deciding when to pump water to the storage facilities outside Lake Okeechobee. Climate based inflow forecasting, reservoir storage north of Lake Okeechobee, lakeside Aquifer Storage and Recovery wells, and other project features located in the C-43 and C-44 basins are expected to reduce the occurrence of peak lake stage events and harmful flood control discharges to the estuaries. Under the Initial Draft Plan, most of the water previously stored in the lake at prolonged and even extreme lake stages and/or sent to tide via the estuaries, is pumped to storage north of the lake (127,000 acre-feet on a mean annual basis) or to other storage facilities in the Everglades Agricultural Area, Caloosahatchee River (C-43) Basin or the St. Lucie (C-44) Basin.

Changes to the existing Lake Okeechobee operation schedule (Run-25) include operational changes only, except for the project features designed to enhance water storage outside of the lake. All flood releases to the St. Lucie and Caloosahatchee River estuaries are expected to be eliminated except pulse releases in Zone A of the regulation schedule. These water storage facilities will reduce the frequency and duration of flood control releases to the estuaries. Water from Lake Okeechobee will be pumped into Aquifer Storage and Recovery wells when the climate-based inflow forecasting model projects that the lake water level will rise significantly above those levels that are desirable for the littoral zone. Water management of the lake will rely on existing structures that will not require structural modification. In order to meet capacity requirements for water conveyance to Aquifer Storage and Recovery facilities, stormwater treatment area's and storage reservoirs, additional canals, resizing existing canals, pumps and conveyance structures will be constructed outside of the immediate lake area.

Lake Okeechobee operators have traditionally considered input from meteorologists, biologists, hydrologists, and engineers in making real-time release decisions. Modifying discharges based on weather and/or climate forecasts is not a new concept and was specifically stated as part of the operational rules on many of the historical regulation schedules. The new schedules are designed to increase operational flexibility. It appears desirable to design flexible operating rules that give water managers some latitude to utilize best available multi-disciplinary information, and adjust operations as necessary to achieve a better balance of the competing objectives. Considering the potential benefits from recent lake inflow forecasting tools, and the rapid increase in the state-of-the-art in forecasting technology, it makes good sense to establish more flexible rules which allow lake managers to utilize supplementary information and apply their sound judgement in making operational decisions.

The Caloosahatchee Basin storage reservoir and Aquifer Storage and Recovery system will capture local basin runoff and releases from Lake Okeechobee. Water from the reservoir will be used to provide environmental deliveries to the Caloosahatchee estuary, to meet demands in the Caloosahatchee Basin, and to inject water into the Aquifer Storage and Recovery wellfield for long-term (multi-seasonal) storage. Water from the Aquifer Storage and Recovery facilities will be used to meet the environmental demands of the estuary and local basin demands. Any estuarine demands not met by basin runoff, the reservoir and the Aquifer Storage and Recovery system, will be met by Lake Okeechobee, as long as lake stages are above 11.5 feet NGVD. Lake Okeechobee water will also be used to meet any remaining local basin demands subject to supply-side management. The Caloosahatchee Basin storage reservoir and Aquifer Storage and Recovery system will be operated in conjunction with the Caloosahatchee backpumping facilities, which include a stormwater treatment area for water quality treatment. This component operates after estuary and agricultural/urban demands have been met in the basin and when the level of water in the storage reservoir exceeds 6.5 feet and Lake Okeechobee is below the pulse release zone. When this situation occurs, water is released from the reservoir and delivered to the stormwater treatment area at the capacity of the backpumping/treatment system of 2000 cfs. The stormwater treatment area water is then backpumped to Lake Okeechobee. The operation of project components in the Caloosahatchee Basin will significantly improve regional water managers' abilities to meet local basin agricultural/urban demands as well as the environmental needs of the downstream estuary.

The Initial Draft Plan introduced operational changes in Water Conservation Area 2A that improved inundation patterns in the north, but in so doing increased the frequency of extreme drought conditions in the south. It appears that water management in Water Conservation Area 2A imposes tradeoffs between providing improved marsh conditions in some areas but worse conditions in others. It is also possible that restoration of a more natural hydropattern to this portion of the Everglades is hampered by constraints imposed by water management elsewhere, notably the fixed regulation schedule in Water Conservation Area 1 that may be amplifying high and low water conditions in Water Conservation Area 2A. If rainfall based operational rules are adopted for Water Conservation Area 1 in the future, such unnatural fluctuations in depth in Water Conservation Area 2A may be alleviated. Overall, the most significant component affecting performance in Water Conservation Areas 2A and 2B is the Central Lake Belt storage facility, which takes water from southern Water Conservation Area 2B (as well as from eastern Water Conservation Area 3A and 3B) and routes it to the Central Lake Belt reservoir for later delivery to Everglades National Park or other areas. Rather than exhibiting high water in the south combined with over-drainage in the north, as is currently the case in all of the Water Conservation Areas, the Initial Draft Plan predicts longer hydroperiods near Stormwater Treatment Area-2 input in the north, increased drying in the south, and accumulation of water at the “bottom” in Water Conservation Area 2B. As a result, those areas that most closely match hydrologic performance targets are those nearest to the location of gages that trigger inflow/outflow operations. A more detailed study of the effects of different operational rules will be needed in order to identify the most ecologically beneficial method of water management for this region.

A number of components in the Initial Draft Plan lead to significant predicted changes in hydrologic conditions in Water Conservation Area 3A. Those components having the most direct effects on the Water Conservation Area are (1) the changes in the location and magnitude of water deliveries along the northern and western boundaries; (2) the Central Lake Belt reservoir and its operation; (3) the L-67A canal and levee changes; and (4) the removal of the L-28, L-28 tieback, and L-29 levees.

The Initial Draft Plan succeeded in holding the frequency of extreme high water events within the overall bounds defined for the natural system by the NSM. This performance can clearly be credited to the barrier provided by the L-67 levee, which prevents excess build up of water within the northern and central sections of the Water Conservation Areas. The Initial Draft Plan avoided excessive flooding in Water Conservation Area 3B. In addition, the Initial Draft Plan predicts a lower frequency of extreme high water events than that predicted for the 2050 base, although 2050 base conditions in Northeast Shark River Slough are drier than their ideal restoration targets.

The proposed storage areas under the Initial Draft Plan will significantly improve water management on the Upper East Coast relative to the 2050 base. Water storage sites will allow localized rainfall runoff to be captured and used for flow augmentation to the St. Lucie estuary when needed during the dry season. The greatest benefit will come from storage of peak rainfall inside the basins, and reduced loss of this turbid, nutrient-laden water to tide. The Initial Draft Plan reduced the frequency of high-flow discharges to the estuary by nearly 80 percent.

The principal changes in water management will be an increase of structures (levees, pumps, weirs, and canals) associated with the storage areas and their operation. A fairly complex operation schedule will have to be designed and implemented to maximize the benefits of these storage sites. Water will be pumped into and out of the storage areas, requiring fuel and causing additional noise to nearby areas.

Under the Initial Draft Plan, all flood control releases to the St. Lucie and Caloosahatchee River estuaries are expected to be eliminated except pulse releases in Zone A of the regulation schedule. The Indian River Lagoon Issue Paper (1999) stated that the Indian River Lagoon feasibility study will review this problem in much greater detail. Water managers will use a climate based inflow forecasting model, in conjunction with operational rules, which will help them decide when to pump water to the storage facilities outside the lake. When the model shows that lake water levels may rise above desirable levels for the littoral zone, water will be pumped to the storage facilities in the Everglades Agriculture Area with increased conveyance from Lake Okeechobee to the reservoir. The purposes are to improve timing of environmental deliveries to the Water Conservation Areas, including reducing damaging flood releases from the Everglades Agriculture Area to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands, and increase flood protection within the Everglades Agriculture Area. Conveyance capacity of the Miami, North New River, Bolles, and Cross Canals between Lake Okeechobee and the storage reservoirs would be increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries.

The proposed structural changes in water management associated with Biscayne Bay will be due to structures associated with the water reuse plants and transport of recycled water to the Bay. Any reuse water going to Biscayne Bay will be treated with superior technology and will meet the stringent low nutrient levels of the main bay and the coral communities of the National Park. No adverse impacts on flood protection are expected as a result of any of the seepage barrier or seepage control methods employed. Components will be designed to function so that the rise in groundwater elevation will not cause a loss of storage in the affected area. Alternatively, seepage impacts will be mitigated through the addition of seepage pumps and improved or new secondary collection systems. Excess water, when available, will be sent to the South Miami-Dade Conveyance System, Northeast Shark River Slough and deep injection wells. Saltwater intrusion benefits to the southern part of Miami-Dade County are anticipated under the Initial Draft Plan. The effects of above ground storage on flood protection will be positive. The western C-4, C-9, and Hillsboro basins are currently flood prone basins. Available above ground storage areas should greatly reduce flooding in those areas during storm events.

Further evaluation of large scale regional Aquifer Storage and Recovery facilities utilizing surficial aquifer ground water in association with C&SF Project canals and proposed storage facilities are recommended. Computer simulations of certain regional groundwater Aquifer Storage and Recovery facilities indicate the potential for using large scale Aquifer Storage and Recovery as a regional storage mechanism. Regional groundwater Aquifer Storage and Recovery systems have great potential to be highly effective in meeting local demands during the dry season and reducing excessive discharges of freshwater to tide during the rainy periods.

Overall, the remaining Everglades should be managed as a whole, not as individual subcomponents of the regional system. A number of hydrologic benefits will be gained by construction of the Everglades Construction Project and implementation of rainfall-driven hydropattern targets within the Everglades. Rainfall-based delivery plans for Water Conservation Areas 2A and 3A based on antecedent rainfall and natural system hydropatterns should be developed. In addition, modifications should be made to the Everglades National Park's current rainfall-based delivery plans in a manner that replicates natural system-like conditions. Model results showed that using the rainfall-driven targets significantly improve the quantity, timing, and distribution of water delivered to Water Conservation Area 2A, Water Conservation Area 3A, and Everglades National Park to more closely resemble natural, pre-drainage patterns.

A recommendation for future water management of the C&SF Project is that the application of recent advances in the field of climatology be applied for increasing the flexibility and efficiency of managing the C&SF Project water control system. The ability to forecast changes in water availability associated with climate fluctuations would be a valuable asset to regional water management authorities. These forecasts may provide advanced warnings of extended periods of deficits or surpluses of water availability, allowing better regional water management for flood protection, water supply, and environmental enhancement.

K.2.9 Water Quality

Viewed from a regional perspective, the Initial Draft Plan is expected to greatly improve water quality conditions in the Restudy area. The Initial Draft Plan creates approximately 181,270 acres of surface water storage area, totaling approximately 1.5 million-acre feet of additional storage volume compared to existing and future base conditions (***Table K.2-1***). Minimally, this proposed tremendous increase in surface water storage volume is expected to result in a reduction in pollution loading into downstream receiving water bodies, simply through the attenuation of surface flows and settling of attendant pollution loads prior to discharge. Aquifer storage and recovery components in the Initial Draft Plan provide additional deep aquifer storage capacity totaling approximately 1,665 MGD (***Table K.2-2***). This additional storage capacity will also improve regional water quality conditions through aquifer storage of existing flood discharges.

Table K.2-1 **Storage Areas/Volume in the Initial Draft Plan**	
Name of Component	**Storage Area/Volume**
North of Lake Okeechobee	20,000 acres @ 10 feet (200,000 AF)
Upper East Coast C-23	8,400 acres @ 8 feet (67,200 AF)
Upper East Coast C-24	6,000 acres @ 8 feet (48,000 AF)
Upper East Coast C-25	12,800 acres @ 8 feet (102,400 AF)
Upper East Coast St. Lucie River, N. Fork	11,800 acres @ 8 feet (94,400 AF)
Upper East Coast St. Lucie River, S. Fork	9,350 acres @ 4 feet (37,400 AF)
St Lucie (C-44)	10,000 acres @ 4 feet (40,000 AF)
Caloosahatchee (C-43)	20,000 acres @ 8 feet (160,000 AF)
EAA	60,000 acres @ 6 feet (360,000 AF)
Taylor Creek/Nubbin Slough	5,000 acres @ 10 feet (50,000 AF)
Southern L-8	1,200 acres @ 40 foot depth (48,000 AF)
Central Palm Beach (Ag Reserve)	1,660 acres @ 12 feet (19,920 AF)
Site 1	2,460 acres @ 6 feet (14,760 AF)
C-9	2,500 acres @ 4 feet (10,000 AF)
North Lake Belt	4,500 acres @ 20 foot depth (90,000 AF)
Central Lake Belt	5,200 acres @ 36 foot depth (187,200 AF)
Bird Drive Basin	2,900 acres @ 4 feet (11,600 AF)
TOTAL	***181,270 acres (1,530,870 AF)***

Table K.2-2 **Aquifer Storage And Recovery Facilities in the Initial Draft Plan**	
Name of Component	**Storage Capacity**
Caloosahatchee Storage Reservoir	220 MGD (44 @ 5MGD)
Site 1 Impoundment	150 MGD (30 @ 5MGD
Lake Okeechobee	1,000 MGD (200 @ 5MGD)
C-51	170 MGD (34 @ 5MGD)
Palm Beach County Ag Reserve	75 MGD (15@5MGD)
L-8	50 MGD (10 @ 5 MGD)
TOTAL CAPACITY	***1,665 MGD***

Additionally, several components of the Initial Draft Plan include treatment features to assure that water quality conditions are improved or not degraded as a result of the operation of those components. Specifically, the Initial Draft Plan includes nineteen stormwater treatment areas totaling approximately 35,550 acres, providing approximately 126,370 acre feet of treatment volume (including other project elements; see ***Table K.2-3***). These stormwater treatment areas represent additional storage volume beyond that provided by the storage areas. Furthermore, those components of the Initial Draft Plan involving aquifer storage and recovery and wastewater reuse include treatment facilities to meet applicable State of Florida water quality standards.

For further information and details on the anticipated effects of the Initial Draft Plan on regional water quality as well as water quality within the ten physiographic regions, refer to ***Appendix H*** and this Appendix.

Table K.2-3
Stormwater Treatment Areas/Volume in the Initial Draft Plan

Name of Component	Storage Area/Volume
Caloosahatchee River (C-43)	5,000 acres @ 4 feet (20,000 AF)
North of Lake Okeechobee	2,500 acres @ 4 feet (10,000 AF)
Taylor Creek/Nubbin Slough	5,000 acres @ 4 feet (20,000 AF)
Western C-11	1,600 acres @ 4 feet (6,400 AF)
C-9	2,500 acres @ 4 feet (10,000 AF)
Central Lake Belt	640 acres @ 4 feet (2,560 AF)
L-28I	1,100 acres @ 4 feet (4,400 AF)
L-28I	800 acres @ 4 feet (3,200 AF)
C-17 Backpumping	550 acres @ 4 feet (2,200 AF)
C-111 North	3,200 acres @ 4 feet (12,800 AF)
L-8 Project	Undetermined acreage
North Lake Belt	1,200 acres @ 4 feet (4,800 AF)
C-51 Backpumping	600 acres @ 4 feet (2,400 AF)
Miccosukee Tribe Water Management Plan (OPE)	900 acres @ 4 feet (3,600 AF)
Acme Basin B (OPE)	310 acres @ 4 feet (1,240 AF)
Seminole Tribe Big Cypress (OPE)	5,270 acres @ 1 foot (5,270 AF)3,835 AF)
South Biscayne Bay Coastal Wetlands (OPE)	Undetermined acreage
S-154 Basin (OPE)	1,775 acres @ 4 feet (7,100 AF)
S65-D Basin (OPE)	2,600 acres @ 4 feet (10,400 AF)
TOTAL	35,550 + acres; 126,370 + AF

K.2.10 Water Supply

The Initial Draft Plan substantially improves water supplies for the Lower East Coast Service Area (LECSA) compared to the 2050 base. The Initial Draft Plan meets public water demands, minimizes the duration of cutbacks, and maintains saltwater intrusion stages in the primary coastal canals. Compared to the 2050 base, it greatly improves the ability to meet public water supply demands and prevent saltwater intrusion. All of the alternative plans reduce the dependence of users on Lake Okeechobee and the Water Conservation Areas. In the Initial Draft Plan, there is 23 percent less water delivered from Lake Okeechobee and the Water Conservation Areas through the structures to the Lower East Coast than in the 2050 base case. The future for urban water supply looks significantly worse in the 2050 base without the C&SF Restudy, even if the health of the environment were not a consideration. The urban areas are expected to benefit from a sustainable system that supports their future water supply demands and restores the Everglades ecosystem. In addition, as expensive as these projects are, they are likely to be even more expensive if delayed farther into the future.

In its effort to control flood waters and provide water supply, the C&SF Project created miles of canals, levees, and water control structures with associated deep pools. In the Initial Draft Plan, the miles of canals and levees fragmenting the remaining natural system was reduced. In the natural area, the number of miles of canals was reduced by 40 percent and levees by 20 percent from the 2050 base. In the Initial Draft Plan, flows across the Tamiami Trail not only increased 92 percent over 2050 base but the proportion flowing east of the L-67 vs. west of L-67 improved from only 11 percent in 2050 base to 55 percent in the Initial Draft Plan. Flows through southern WCA-3A increased from only 62 percent of NSM volumes in the 2050 base to 110 percent of NSM in the Initial Draft Plan without causing excessive high water events. Flows in western WCA-3A were spread more evenly into the dry season in the Initial Draft Plan, preventing the premature dry season drydowns seen in the 2050 base.

In the Lake Okeechobee Service Area (Everglades Agricultural Area, Caloosahatchee and St. Lucie basins, S-4 and L-8 basins, and Seminole Indian reservations), the performance measures are based on frequency, duration and severity of water supply cutback events. Water restriction events vary according to how often they occur (frequency), how long an event lasts (duration), and how much of the water that would normally be demanded is not delivered (severity). Scores were developed for each of these characteristics. The principal goal for the alternatives was that they should be able to meet all demands in a 1-in-10 year drought. The best indicator for this goal is the number of years with water shortage restrictions that does not exceed three in the 31-year simulation period. The Initial Draft Plan comes closest to the goal, with just 5 events. By comparison, the 2050 base has 16 events.

Low ground water levels near the coast increase the vulnerability of the Biscayne Aquifer to saltwater intrusion. Continuing to meet urban water demands may exacerbate lowering of ground water levels and therefore cutbacks are necessary when there is a threat to the resource. Low storage levels in Lake

Okeechobee at the beginning of the dry season are indicative of a prolonged storage problem that dictates when the cutbacks can be removed, while low ground water levels indicate immediate problems within the LECSA. Either of these triggers, Lake Okeechobee or local ground water levels can initiate a water supply cutback and are reflected in the ability to meet the 1-in-10 level of service water supply goal. Although regional water supplies or local ground water levels may rebound during the dry season, cutbacks are continued through the end of the dry season, May, to ensure protection of the Biscayne Aquifer.

K.2.11 Socio-Economics

The economic impact evaluation of the alternative restoration plans includes four principal elements.

1. Anticipated Effects of Alternative Plans on the National Economic Development (NED) Account: Alternative plans could result in positive or negative effects on net national economic efficiency due to project-induced impacts on the following economic activities in south Florida:

- Agricultural water supply,
- Municipal and industrial (M&I) water supply,
- Flooding potential,
- Commercial navigation,
- Recreation (Everglades-related), and
- Commercial and recreational fishing.

2. Evaluation of Project Costs: Project costs include all expenditures required to implement the alternative plans. These costs would be shared by the Federal government and the State of Florida. Project costs include initial construction costs; lands; relocations; rights of way; rehabilitation, replacement, and repair costs; and operations and maintenance (O&M) costs (including the costs of post-construction monitoring and adaptive management).

3. Regional Economic Development (RED) Effects: The potential RED effects of the alternative plans include changes in income, employment, or economic output of the region.

4. Other Social Effects (OSE): The potential social effects of the alternative restoration plans include effects on minority, elderly, and disadvantaged groups, population displacement, and community cohesion.

The economic analysis for the C&SF Restudy was conducted consistent with Federal statutes and Corps policy. Procedures for estimating NED and RED effects are specified in the <u>Economic and Environmental Principles and Guidelines for</u>

Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 10 May 1983), Engineering Regulation (ER) 1105-2-100, and other Corps guidance.

The South Florida Water Management Model (SFWMM), the principal analytical tool used in this study, was not designed to conduct economic analysis, but does include many indicators of hydrologic change, which can have economic consequences. To assist in estimating the economic effects of water management decisions, the South Florida Water Management District developed the Economic Post-Processor (EPP) to estimate the economic effects of cutbacks in agricultural and urban water supply during drought periods. The EPP was used in the Restudy economic analysis to estimate the impacts of alternative restoration plans on the frequency and duration of drought-induced changes in agricultural and urban water supply. Other categories of economic effects were estimated by conducting “outside-the-model” analyses of various SFWMM-generated hydrologic performance indicators.

Using SFWMM as the principal tool for evaluating the economic effects of alternative restoration plans requires some practical modifications to the traditional with and without-project analysis procedures typically used in Corps of Engineers water resource planning studies. In a traditional feasibility investigation, a probabilistic analysis is conducted to project conditions expected to occur throughout the planning period (typically 50 years), both with and without implementation of a project. Average annual expected value of economic impacts are estimated by evaluating a range of possible future conditions, weighting the likelihood (i.e., probability) of these conditions by their economic effects, and then statistically combining them. The difference between this average annual value under with vs. without-project conditions constitutes the net annual economic impacts (positive or negative) of the alternative plans.

This type of with and without-project analysis had to be modified during the C&SF Restudy to account for the limitations imposed by SFWMM. As stated previously, the SFWMM is a simulation model, which equally weighs each of the days in the 31-year simulation period. As a result, it is not possible to use SFWMM to determine the likelihood of occurrence of any given hydrologic event. While the 31 years of past climate data are considered representative of future climatic conditions, they are of insufficient duration to assign frequencies of occurrence to specific simulated hydrologic events (e.g., 25-, 50-, or 100-year return period events). Therefore, the economic effects of the alternative restoration plans were estimated by comparing two “snapshots” of study area conditions that are expected to exist in the future, with and without each alternative plan.

The potential economic impacts of the alternative restoration plans are a secondary consequence of the hydrologic changes, which are expected to result from the proposed structural and operational modifications to the C&SF system. The figure on the following page traces the causal linkages between the structural and operational modifications to the C&SF system and the different categories of economic effects.

Some categories of economic impact, such as urban and agricultural water supply effects, can be estimated directly from SFWMM-simulated hydrologic changes associated with each alternative restoration plan. Other economic effects, such as commercial and recreational fishing impacts in the St. Lucie and Caloosahatchee estuaries and in Biscayne and Florida bays, are less directly linked to the hydrologic changes resulting from the alternative restoration plans. In this latter case, the chain of cause and effect includes: the impacts of project-induced changes in water release rates, the impacts of changes in release rates on the productivity of the fisheries, and the impacts of changes in the fisheries on the net income of commercial fishing operations and the quality of recreational fishing experiences. These chains of cause and effect have important consequences for our ability to quantify the economic effects of the alternative plans. Economic analyses cannot be applied to estimate the value of physical or ecological impacts of the alternative plans if those impacts cannot first be defined and quantified.

The principal challenge of ecosystem restoration economics is estimating the value of restoration benefits. The benefits of ecosystem restoration are usually expressed by ecologists in non-monetary units, such as acres of specific habitat created or enhanced, indices of biological productivity associated with habitat improvement, or increased abundance and/or diversity of particular species of plants or animals. Environmental amenities are public goods that are generally not exchanged in the marketplace. For marketable commodities (i.e., items that people buy and sell), the demand, and prices paid, for these goods can be used as “proxies” for determining their value to consumers. In the absence of data on consumers’ expenditures for environmental amenities, resource economists have attempted to develop techniques that can be used to estimate their value using indirect indicators of consumers’ “willingness to pay” for ecosystem restoration. There are a number of surrogate-market techniques, such as contingent value methodology (CVM), which can be used to estimate these willingness to pay values.

Unfortunately, these methods, including CVM, have significant shortcomings that lead to concerns about their reliability and validity. Therefore, Corps of Engineers ecosystem restoration policy has been formulated in recognition of the practical limits of available economic tools to value environmental resources. Corps of Engineers ecosystem restoration policy is such that ecosystem restoration projects are not subject to traditional benefit-cost analyses. Economic justification of ecosystem restoration is not required in the traditional sense of ensuring that the monetary benefits of the alternative plans exceed their monetary costs

The focus of the economic impact evaluation studies has been on: (1) the NED costs (in monetary terms), (2) the positive and adverse NED effects expected to occur in the following economic impact categories: agricultural water supply, municipal and industrial water supply, commercial navigation, recreation, and commercial fishing (in monetary and non-monetary terms) and (3) the positive and adverse regional economic effects (RED) resulting from project implementation. The development of this information can be found in ***Appendix E*** of this report.

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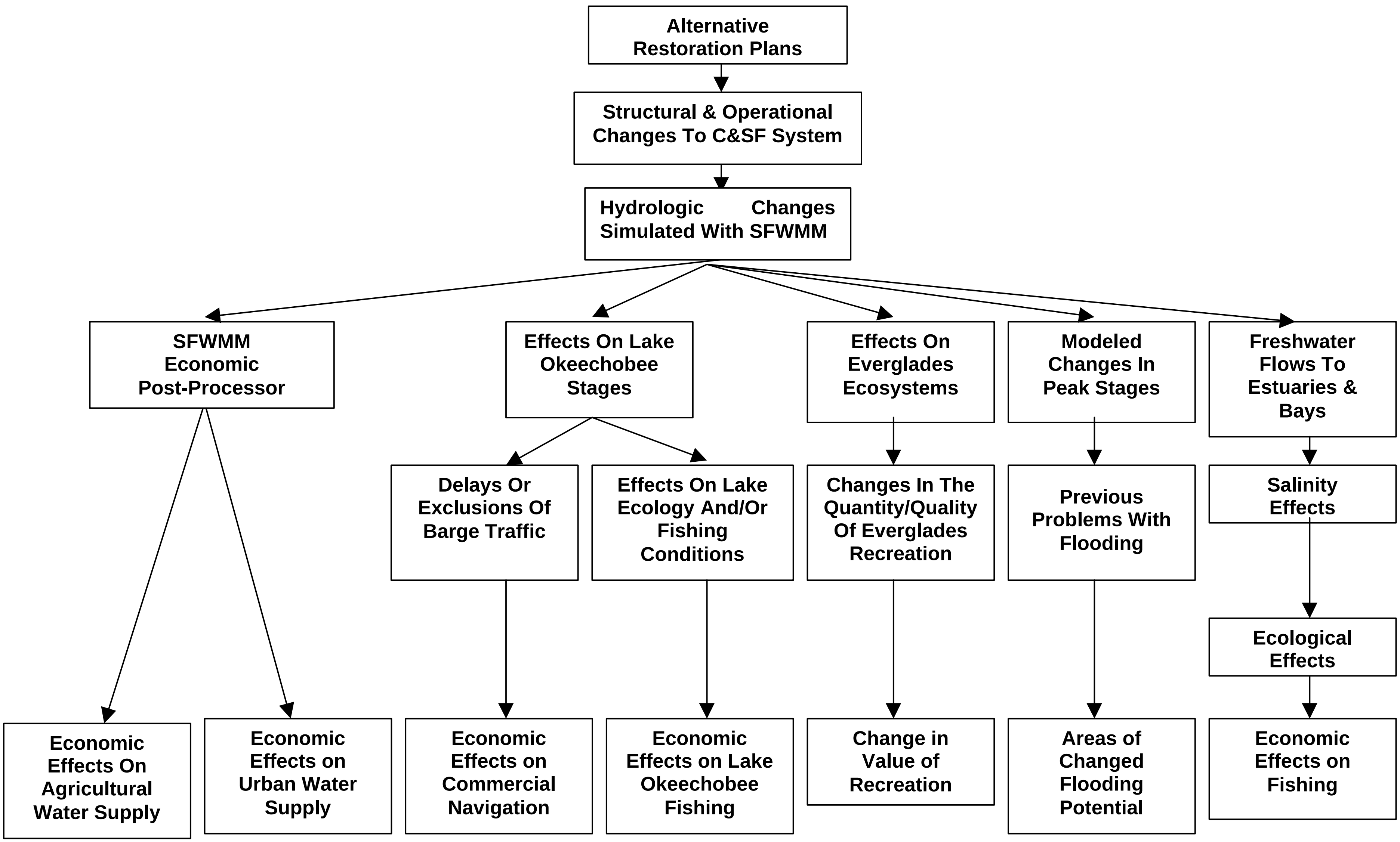
SOURCES OF ECONOMIC EFFECTS



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K.2.11.1 NED Effects

The NED effects are the changes in the economic value of the National output of goods and services from a plan. The following discussion outlines the NED effects estimated to result from the alternatives.

K.2.11.1.1 Agricultural Water Supply

Effects on agricultural water supply are based on simulated water shortages under the different alternatives compared against the without-project condition. Water shortages are translated into plant growth and crop harvest effects, which are in turn translated into estimated net farm income differences between alternative plans and the without-project condition. Water shortage reductions are reduced with all of the plans, with estimated average annual positive NED effects ranging from about $1.7 million to $2.0 million. The effect for the Initial Draft Plan is $1.9 million per year.

K.2.11.1.2 Municipal And Industrial Water Supply

Effects on M&I water supply are based on consumers' willingness to pay to avoid water shortages. This represents the economic value to consumers of water not received during shortages. The difference between the without-project condition and the alternatives ranges from an average annual positive effect of $21.5 million to $27.2 million (for the Initial Draft Plan).

K.2.11.1.3 Flood Control

Studies to estimate the flooding implications of the alternative plans were limited by the spatial resolution of the SFWMM. This model was not designed for flood studies, and the relatively coarse spatial resolution of this regional model limits its utility in assessing the flood impacts of the alternative restoration plans. Recognizing these limitations, the flooding studies conducted for the Restudy employed a four-part methodology. First, using secondary information and professional judgement, flood problem areas in the region were identified. Second, the SFWMM was used to assess whether these areas would be expected to have higher or lower peak stages as a result of the implementation of the alternative plans. Third, other areas with potential adverse and beneficial effects from the alternative plans were identified. Finally, for those existing problem areas that are expected to be adversely affected, further studies were recommended.

K.2.11.1.4 Commercial Navigation

As discussed in Chapter 7, the alternative regulation schedules are expected to alter average lake stages on Lake Okeechobee, which is a critical link in the Lake Okeechobee Waterway connecting the Atlantic Ocean with the Gulf of Mexico via the Caloosahatchee River and the St. Lucie Canal. There has been a small but relatively stable level of commercial navigation on this waterway over the past ten years. The Lake Okeechobee Waterway was used to transport 430,000 tons of freight in 1995. Based upon field research and database searches regarding commercial navigation on the Lake Okeechobee Waterway, it can be concluded that the effects of the alternative restoration plans on the NED account would be very small. All of the alternative restoration plans are expected to lead to significant reductions in the frequency of low lake stages. However, the economic effects of these improvements for commercial navigation are expected to be minimal to negligible.

K.2.11.1.5 Recreation

Tourism is Florida's largest industry. Many Florida residents and visitors recreate in the Everglades-related recreation resources of south Florida. The economic value of resource-based recreation is determined by the users' willingness to pay for a recreation occasion. The interaction of demand with the quantity and quality of recreation resources available determines the recreation use or "participation" levels for that resource-based activity. When the quantity or quality of recreation resources is modified by a project, such as the alternative restoration plans, the change in value of resource-based recreation is based on the difference in the willingness of users to pay under the with- and without-project conditions. The restoration of the Everglades ecosystems could potentially have significant impacts on the value of outdoor recreation in south Florida. If the alternative restoration plans improve the ecology of the Everglades, the quality of the Everglades-related recreation and/or the number of people who participate in Everglades-related recreation could increase significantly. Consequently, the value of outdoor recreation in south Florida could increase as well. Estimating the future value of Everglades-related recreation in south Florida is problematic, and anticipating the incremental changes in value associated with Everglades restoration is even more challenging. There are three principal uncertainties, which limit the ability to anticipate the future quantity and quality of outdoor recreation under with- and without project conditions:

- <u>Timing and character of the ecological changes from restoration</u>: If the results of the restoration effort can not be predicted, secondary effects on recreation are even more uncertain.

- <u>Marketing of tourism and Everglades-related recreation</u>: Tourism is particularly sensitive to marketing efforts. Restoration may or may not be accompanied by promotion of the enhanced recreation opportunities.

- <u>Development of recreational facilities and recreational access</u>: Facilities and access are critical determinants of recreation participation. Restoration may or may not be accompanied by development of additional recreation facilities and access.

Given these uncertainties, it is beyond the scope of this analysis to quantify the value of Everglades-related recreation under the with- and without-project future conditions through the 50-year planning period. However, the alternative plan that is expected to be most effective in terms of restoration can be expected to also be most effective in terms of positive recreation effects.

Although recreation benefits have not been estimated, current expenditures have been estimated for Everglades-related recreation in order to help frame the issues surrounding the recreation effects of the alternative restoration plans. There are approximately 6.3 million visitors annually to the principal Everglades parks and preserves. At the regional scale, there are approximately 16.6 million wildlife watching participants in south Florida. It is estimated that the current annual expenditures associated with visitation to the Everglades parks and preserves is approximately $404 million, and expenditures for wildlife watching in south Florida are approximately $598 million. These provide insight into the value of the Everglades-related recreation resources, and the potential for increases brought about by improved conditions with implementation of a plan.

K.2.11.1.6 Commercial and Recreational Fishing

The alternative plans have the potential to affect recreational and commercial fishing throughout south Florida by modifying the hydrologic regime in the region's waterways and estuaries. There are five principal fishing impact zones that would experience the majority of the potential economic effects on fishing in the region: Lake Okeechobee, the Caloosahatchee and St. Lucie estuaries, and Biscayne and Florida bays. Total annual revenues associated with recreational sportfishing, guided sportfishing, and commercial fishing are significant.

The hydrologic changes that are expected to result from the alternative restoration plans may have economic implications for commercial and recreational fishing in the study area. Estimating the actual extent of such effects has been beyond the scope of this study. Economic effects on commercial fishing would be based on changes in net income for commercial fishing, and changes in the quality and quantity of recreational fishing experiences. Not enough is known about the linkages between hydrological changes which would be brought about by plan implementation, nor is enough known about the timing of the linkages between these changes, the resulting ecological changes, and ultimately the changes in the value of fishing, to estimate the economic effects on fishing in this study.

Appendix E discusses the economic fishing activity in the major five impact zones of Lake Okeechobee, St. Lucie and Caloosahatchee estuaries, Biscayne Bay, and Florida Bay. All of the plans are expected to positively impact fishing, with the exception of Biscayne Bay, whose fishery would likely be slightly positively affected only with Alternative D and the Initial Draft Plan.

K.2.11.1.7 NED Costs

The initial costs for construction and real estate range from $5.2 billion to $7.8 billion for the Comprehensive Plan. Recurring annual costs for operation and maintenance, and monitoring, ranges from $70 million to $165 million per year. These costs translate into a uniform annual equivalent cost alternatives ranging from $254 million to $402 million for the Comprehensive Plan.

K.2.11.2 Regional Economic Effects

The effects of the alternative plans on the regional economy include such primary effects as the economic activities stimulated by the purchases of materials and services required in the construction of the project, the purchases of real estate, operation and maintenance of the system, and monitoring costs. They also include secondary consequences, such as changes in agricultural land use and changes in agricultural water supply. The types of regional economic impacts that a new project can have on output, earnings, and jobs in a region are known as “direct,” “indirect,” and “induced.” Direct impacts are caused by first round of expenditures associated with the project. The indirect impacts count only the inputs that are purchased as a result of the first round expenditures. The importance of these “indirect” effects will vary with the complexity of production in the study area and the degree to which required materials are supplied by local producers. Induced effects are the multiplier effects of the project expenditures as that spending circulates in the regional economy.

Total regional impacts are a net positive for all alternatives, and though large in absolute terms, they are small relative to the study area’s regional economy. Average annual effects on total sales are estimated to range from +$173 million to +$307 million, close to 1/10th of one percent of the study area’s total output of over $220 billion per year. Employment effects range from about +1,700 to +3,165 jobs; the regional economy’s total employment exceeds 2.9 million. Impacts on earnings ranges from $59 million per year to $108 million per year; annual earnings for the regional economy exceed $78 billion.

K.2.11.3 Other Social Effects

The categories of potential effects include:

- Urban and community impacts,
- Life, health, and safety factors,
- Displacement,

- Long-term productivity, and
- Energy requirements and energy conservation.

The most potentially significant OSE consideration for the alternative restoration plans concerns the development of new storage reservoirs in the rural areas surrounding Lake Okeechobee, and the consequences for urban and community impacts and displacement of people. These project features would convert farmland to reservoirs. Their development could eliminate the jobs of the individuals who depend on those lands for their employment and have adverse effects on local communities and economies. The potential locations of the new reservoirs are not known at this time. However, the resilience of local economies and the cohesion of local communities to agricultural land conversion depend on a variety of factors, including the age, ethnic, and racial composition of the community and income, unemployment, and poverty levels. A social vulnerability index was developed using county-scale socioeconomic characteristics, and this type of analysis could be replicated in more detail when and if new reservoir sites are proposed.

K.2.12 Land Use

The following section discusses the effects of the Initial Draft Plan on land use within the region. The most significant effect upon land use will be the proposed construction of approximately 171,000 acres of above ground water storage. It is anticipated that the majority of the water storage areas will be located over land that is currently in some form of agricultural production.

In the immediate vicinity of Lake Okeechobee, agricultural lands are not expected to be affected by implementation of the lake regulation schedule proposed under the Initial Draft Plan. Storage reservoirs designed to augment Lake Okeechobee will occupy 30,000 acres in the Kissimmee River region and 60,000 acres in the Everglades Agricultural Area. Proposed aquifer storage and recovery facilities include 200 wells located near the Lake Okeechobee levee. These wells will require some land for construction, operation, and maintenance. Agricultural production may be compatible with aquifer storage and recovery wells, as the structures are expected to take up minimal land above ground. It appears likely, however, that more than 90,000 acres of land in the regions surrounding Lake Okeechobee will be taken out of agricultural production. Conversion of 60,000 acres of agricultural land in the Everglades Agricultural Area to reservoirs would be an approximate 9 percent reduction of the area farmed in this region. Everglades Agricultural Area lands are designated as unique farmland. Implementation of the Initial Draft Plan should have no negative effect on future urban land use around Lake Okeechobee. Urban lands surrounding the lake should benefit through a greater, more consistent source of water for urban and industrial use, including continued flood protection, beyond that projected in the 2050 base.

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SUMMARY OF ECONOMIC EFFECTS OF ALTERNATIVE RESTORATION PLANS
(all dollar values in $ millions)

IMPACT CATEGORY	WITH- AND WITHOUT-PROJECT CONDITIONS					
	2050 Base Condition	**Alternative A**	**Alternative B**	**Alternative C**	**Alternative D**	**Comprehensive Plan**
NED EFFECTS						
Agricultural Water Supply: Avg. annual value of unmet demand*	$2.6	$0.6 (+$2.0)	$0.9 (+$1.7)	$0.7 (+$1.9)	$0.8 (+$1.8)	$0.7 (+$1.9)
M&I Water Supply: Avg. annual value of unmet demand*	$31.8	$10.2 (+$21.7)	$10.3 (+$21.5)	$6.4 (+$25.4)	$4.6 (+$27.2)	$4.6 (+$27.2)
Flood Control	• Limited evaluation of impacts, since SFWMM not designed for flood studies.					
Commercial Navigation	• No significant difference expected between with- and without-project conditions.					
Recreation	• Problematic to quantify effects of alternative plans. • Current Expenditures: $404 million (parks/preserves); $598 million (region). • Current Consumer Surplus: $290 million (parks/preserves); $764 million (region).					
Commercial/Recreational Fishing	• Annual revenues estimated for commercial and guided & recreational sportfishing in five areas: Lake Okeechobee, St. Lucie & Caloosahatchee estuaries, and Biscayne & Florida bays. • Significant positive economic impacts are expected to result from hydrologic modifications and consequent ecological impacts to all five areas with the exception of Biscayne Bay.					
NED COSTS						
Total Construction & Real Estate Costs		$5,229	$6,023	$6,725	$7,335	$7,789
Total Operations & Maintenance Costs		$70	$72	$126	$162	$165
Total Monitoring Costs		$10	$10	$10	$10	$10
Annualized Costs		$254	$286	$341	$383	$402
REGIONAL EFFECTS						
Average annual effects (% of regional economy)						
Output		$173 (.08%)	$195 (.09%)	$192 (.09%)	$277 (.12%)	$307 (.14%)
Employment (jobs)		1,707 (.06%)	1,934 (.07%)	2,057 (.07%)	2,903 (.10%)	3,165 (.11%)
Earnings		$59 (.08%)	$65 (.08%)	$78 (.10%)	$103 (.13%)	$108 (.14%)
OTHER SOCIAL EFFECTS	• Potential community disruption from conversion of agricultural land to reservoirs.					

* A "+" indicates a reduction in unmet water demand.

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Implementation of storage sites in the upper East Coast will cause land use changes in the area. About 46,000 acres of mostly agricultural lands are being targeted for siting surface water storage areas. Some of the agricultural activity in the area, especially citrus, has been on the decline and the land use could possibly have changed with or without the Restudy. However, lands acquired for surface water storage will be removed from the agricultural land base of St. Lucie and Martin Counties.

The Initial Draft Plan would alter agricultural land use within the Caloosahatchee River region. A 20,000 acre storage reservoir is proposed for the C-43 Basin to capture basin runoff and water releases from Lake Okeechobee for eventual use for water supply and environmental demands. Conversion of 20,000 acres from agriculture to reservoir would be an approximately 4 percent reduction of agricultural acreage, in a region that has experienced recent expansion of agricultural production.

Several thousand acres of land will be needed for above ground storage facilities in the lower East Coast region. The lands proposed for the Water Preserve Areas in the lower East Coast are generally vacant or are in agricultural production. It is assumed that the majority of these lands would eventually be designated urban land, especially low density residential. These urban land uses can in general be accommodated on other vacant lands or by increases in density of development. The lake belt reservoirs, which are in-ground facilities, are not expected to diminish the land use of rock mining or impinge on productive agricultural land. Seepage management should not cause changes to existing land use; minimal land is required for the wells and physical barrier methods. Seepage control components along eastern Water Conservation Areas 3A and B are located on wetlands; these components will lengthen the hydroperiods of the wetlands involved.

Land use within the Big Cypress basin will not likely be significantly affected by implementation of the Initial Draft Plan. Residential development and future Miccosukee Indian residences along Loop Road will not be affected by flow modifications to southeast Big Cypress. Traditional use of lands within the preserve, guaranteed to the Miccosukee Tribe of Indians of Florida and members of the Seminole Tribe of Florida under Public Law 93-440, would not be affected by implementation of the Initial Draft Plan. The urban areas along the coast, including the municipalities of Naples, Everglades City, and Marco Island are outside the area of hydrologic influence of the plan and land use will be unaffected by the project.

No land use changes in the Florida Keys are contemplated by the Initial Draft Plan, as no construction is proposed for this region.

K.2.13 Recreation Resources

Overall, hydroperiods resulting from implementation of the Initial Draft Plan within the Kissimmee River region will not be substantially affected by or adversely affect recreation resources in the region. The proposed construction of above ground water storage reservoirs north of Lake Okeechobee, in the Caloosahatchee and St. Lucie basins, within the Everglades Agricultural Area, and along the eastern perimeter levees (Water Preserve Areas) could provide important recreation benefits depending on specific resource function and future design. These reservoirs could provide opportunities for fishing, bike riding, bird watching, hunting, and environmental interpretive recreation activities. Reservoirs sited near urban areas such as the Water Preserve Areas would probably have a greater beneficial impact on the area recreation resource potential, due to the larger potential user community located close by.

The Initial Draft Plan will modify the existing hydrologic cycle of Lake Okeechobee, producing more natural lake level fluctuations. This should improve the general health of the lake's recreational fishing resources. A reduction in the frequency of extreme and prolonged low water events should further provide a benefit both for fish habitat and access for recreational fisherman to backwater and littoral zone areas.

The following discussion on impacts to recreation resources within the Water Conservation Area and Big Cypress regions is excerpted in part from the Florida Game and Fresh Water Fish Commission Fish and Wildlife Coordination Act Report, Attachment B, dated August 6, 1998. This report is available in entirety in Annex A.

Under the Initial Draft Plan, WCA-3B and northern WCA-3A will be wet for a greater proportion of the year; thus airboat access would probably be increased in these areas. The increased accessibility of tree islands in this area may lead to an increase in privately constructed camps, which function primarily as a base for recreational pursuits.

Although airboat activity may increase as a result of the longer hydroperiods predicted by the Initial Draft Plan, the use of vehicles that require relatively little or no surface water for operation (tracks, swamp buggies, ATVs, etc) would be expected to decline. Although tracked vehicle use may continue to decline, hydrological conditions in Holey Land Wildlife Management Area and perhaps the northern portion of WCA-3A in drier years would probably still be suitable for tracked vehicle operation. Rehydration of Rotenberger Wildlife Management Area will probably result in a decrease in use by tracked vehicles and walk hunting. The use of swamp buggies is currently minimal on Everglades mucky soils, and would likely disappear altogether under the elevated water table proposed under the 2050 base. Thus, the use of swamp buggies is not expected to be affected under the Initial Draft Plan. In the Everglades Wildlife Management Area increased water levels will likely reduce opportunities for hunting deer.

The adoption of the Initial Draft Plan may result in an initial, localized decline in the mileage of canals available to fishermen. According to Corps design and costs estimates for the Initial Draft Plan, approximately 72 miles of canals are scheduled to be filled, while 74 miles of new canals will be constructed, and 100 miles of existing canals will be widened. The planned addition of 6,977 acres of water preserve areas with maximum water depths of 4 feet; 9,700 acres of water-storage areas with variable depths in the Lakebelt region; and 1,600-acres of stormwater treatment areas of an unspecified depth in Broward and Miami-Dade counties offer an important potential for new water based recreational areas.

Of particular concern to the GFC is the L-67A canal. The Initial Draft Plan proposes to backfill approximately six miles of the southern end of this canal. The “three pines” area, located near the proposed end of the canal, has been a particularly productive fishing spot, and may be eliminated if this portion of the canal is backfilled. In general, the southern half of the L-67A canal receives the most fishing pressure, probably due in part to the prolonged hydroperiod that normally exists in the southern portion of WCA-3A (Jon Fury, pers. com.) Fisherman would still be able to access the remaining L-67A from the Holiday Park area. GFC records indicate that over 75 percent of fisherman currently launch their boats from this boat landing as opposed to the boat landing at Tamiami Trail. Regardless of what access problems may exist, modeled hydrological conditions for the WCA-3A marsh adjacent to the L-67A canal predict somewhat lower mean water depths than would exist under the 2050 base, and considerably lower mean depths (> 1 ft.) than would occur under the 1995 base. With implementation of Modified Water Deliveries in the 2050 base, the size of the flooded area, with flooding duration in WCA-3A sufficient to maintain a productive marsh/canal bass fishery, is expected to decline dramatically. The reduction in flooding depth and duration would be even greater under the Initial Draft Plan. At this time, it is not clear how the weir design and operations across the L-67A levee will affect the fishery of the L-67A canal.

The L-67C canal, although not as popular a fishing area as the L-67A canal, also receives fishing pressure, especially when marsh water levels recede during the dry season. A count of the boat trailers parked at the L-67C boat ramp during the 6-month period extending from December 1996 through May 1997 yielded a total count of 2,900 boats using this canal, with an average of two persons per boat (Jon Fury, GFC, pers. com.). This canal would be backfilled entirely in the Initial Draft Plan, and this fishery would be lost as well.

Under the Initial Draft Plan, the area of upland refugia in the form of tree islands and levees is expected to decline in WCA-3B. The removal of the entire length of the L-67C levee and portions of the L-67A levee would significantly reduce the area of upland habitats in this portion of the Everglades.

Due to increased water levels in WCA-3B, deer hunting opportunities and huntable deer populations may decline in this area, where tree islands occur at lower densities and many are at relatively low elevations. Conversely, the area and duration of emergence of tree islands above ambient water levels is expected to increase in the southern portion of WCA-3A after removal of the impounding effects of the L-28, L-29, and partial removal of the L-67 levees. This would allow a relatively large number of tree islands to remain above ambient water levels for much longer periods of time. The greater density of tree islands in southern WCA-3A and a considerable reduction in the length of time that slough water levels remain above 30 inches deep in the Initial Draft Plan may provide a more stable environment for upland game animals. Hence, deer hunting opportunities should improve in the southern portion of WCA-3A. Although the removal of the L-28 levee would result in the loss of dry habitat that has served as relief for deer and other upland dependent wildlife in the past, lower water levels and reduction in prolonged high water events predicted by the Initial Draft Plan would make this levee less critical as an upland refugium.

The removal of the L-29 levee and canal by the Initial Draft Plan could have negative impacts on recreational access into WCA-3A and WCA-3B from U.S. 41, since the roadway would have to be elevated in some way. There are three public boat ramps providing airboat access into WCA-3B and three public boat ramps providing airboat and jon boat access into the L-29 canal and marsh of WCA-3A. One of the boat ramps for WCA-3B also provides jon boat access into the L-67C canal, which would be backfilled in the Initial Draft Plan. Therefore, it will be necessary to construct on and off ramps to these recreational areas and provide ample parking space for vehicles and boat trailers.

Within the Big Cypress region, the Stairsteps and Loop Road units of BCNP would most closely approach NSM conditions under the Initial Draft Plan. Under the ATLSS Cape Sable Seaside Sparrow Model and Index output for the Initial Draft Plan versus the 2050 base, the hydroperiod length was shown to decrease somewhat in the Stairsteps and Loop Road units. Ponding depths in the eastern portion of the Stairsteps unit also appeared to be slightly less in the Initial Draft Plan than under the 2050 base. Although no ATLSS output for the White-tailed Deer Breeding Potential Index was generated for the Initial Draft Plan, output was available for Alternative B, which was structurally similar to the Initial Draft Plan in that both the L-28 and L-29 levees were removed. Under this modeled output, the overall deer breeding potential mean was slightly higher in the Stairsteps and Loop Road units than under the 2050 base, but remained relatively unchanged in the Corn Dance unit. In conclusion, these evaluations suggest that more favorable hydrological conditions will exist for deer and upland game animals in the Stairsteps and Loop Road units of the Big Cypress Water Management Area with the adoption of the Initial Draft Plan than would occur in the 2050 base. Deer populations in the Corn Dance unit will probably remain relatively stable.

The proposed improved water deliveries to Northeast Shark River Slough in Everglades National Park, based on seepage control and redirecting outfall from L-31, will provide water for environmental purposes. Water structures will be removed and others will be added, L-31N will be rerouted and L-31N borrow canal will be backfilled. A five-foot high levee will be constructed along the west side of the existing lake. Bank fishing along L-31N borrow canal could be adversely affected. An associated action (L-31N Levee improvements for seepage management) will reduce groundflows to Everglades National Park 100 percent during the wet season and will help to restore hydropatterns in Everglades National Park. These proposals could produce temporary interruption of recreation resources that would cease once construction had been completed. The 2050 base plan would propose no such component.

The economy of the Florida Keys is very water resources oriented and depends upon healthy water-based ecosystems. Over 36 percent of Monroe County's annual gross earnings are generated from tourism and recreation activities (USDC, 1995). Proposed C&SF Restudy Components do not directly affect the Keys, but are expected to improve water quality in Florida Bay that could improve shrimp and fishery habitats, which would enhance the sustainability of the recreation and tourism industry in the Keys.

K.2.14 Aesthetic Resources

Restoration of the south Florida ecosystem is expected to result in a healthy ecosystem that will support vigorous plant communities, large fish and aquatic animal populations, large numbers of wading birds, alligators, and sustainable populations of wide-ranging mammals in a natural setting, in perpetuity. Viewing wildlife, wetlands and open, relatively pristine spaces is important to people. Recent studies are discovering that recognizing our connection with nature brings peace of mind and respect for life.

Reducing high stages in Lake Okeechobee will improve water clarity and fish production in the littoral zone. Reducing damaging freshwater releases into the Caloosahatchee and St. Lucie estuaries will improve water clarity, restore seagrass beds, oyster beds, attract more wading birds and increase densities of fish, shrimp and crabs among other species.

Decompartmentalization of the Everglades, which removes many miles of structures, improves the wilderness character of the Everglades by removing some of the human ability to control it. While levees provide human access to the Everglades interior, the exotic vegetation that covers them is visible at a distance, marring the view of the landscape. Levee removal, therefore, will restore the visual impact of the Everglades as well as remove a source of invasive exotic species.

K.2.15 Cultural Resources

Component features at this stage of planning are conceptual and feature locations are not precisely determined. Under the tiering concept of the National Environmental Policy Act, specific effects to historic properties will be addressed and coordinated with the State Historic Preservation Officer under Section 106 of the National Historic Preservation Act. A separate Environmental Assessment or supplemental EIS will be prepared for each project feature, and cultural resources assessments will be conducted in support of those documents, when necessary. Specific effects to historic period and pre-Columbian period archeological sites and standing structures, engineering structures and architectural features will be evaluated after individual project feature sites are determined. Effects from the proposed project are anticipated to come from project feature construction, operational changes, erosion, human disturbance, and changes in the hydrologic regime of the flood plain.

Early in the planning stage of each project feature, appropriate cultural resources investigations will be conducted to locate and identify potentially significant historic properties that will be affected by the project. Initially, a comprehensive archival and background review will be completed, and an historical overview will be compiled. Archival research should culminate in the formulation of specific research question that will direct future field studies, guide analysis of collected data, and most importantly, give the resource managers a basis against which to measure site significance and National Register eligibility.

An architectural assessment will be made of structures and architectural features that may be affected. An archeological sample survey, stratified by culturally meaningful environmental variables, will be undertaken. A geomorphologic investigation designed to identify landforms that could contain significant resources may be completed.

Based on the results of the archival and background review, the archeological sample survey and the geomorphologic investigation, a predictive model will be developed to identify areas with a high probability to contain significant resources. Additional archeological investigations are expected to be necessary, in order to adequately assess the National Register of Historic Places eligibility of all potentially significant historic properties.

In consultation with the State Historic Preservation Officer, the Corps will apply the criteria of effect and adverse effect (36 CFR 800.9) for historic properties that meet the criteria of eligibility to the National Register of Historic Places. For those historic properties that will be adversely affected, mitigation plans will be developed by the Corps, in consultation with the State Historic Preservation Officer and the Advisory Council on Historic Preservation. The Corps will implement the mitigation plans prior to any ground disturbing activities or reinundation being initiated. Collections from cultural resources investigations will be curated in repositories meeting the standards established by the Corps and the National Park Service.

Water control structures that will be removed or altered will be assessed to determine if they meet the criteria for eligibility to the National Register. Assessments will consider the age, integrity and design of the structures, and evaluate if they contribute to the history of the C&SF project. Based on a preliminary assessment, the proposed project is expected to have no adverse effect on standing structures, engineering structures or architectural features that are National Register eligible.

Construction of water storage areas, stormwater treatment areas and aquifer storage and recovery wells may affect significant archeological sites. The footprints of constructed portions of these features will be surveyed for archeological sites. If significant archeological sites are found to be affected by construction of these features, efforts will be made to modify the construction footprint to reduce or eliminate those effects. If effects can not be avoided, a mitigation plan will be developed and implemented, in consultation with the Florida State Historic Preservation Officer, to mitigate those effects.

Storage of water within the water storage areas and stormwater treatment areas will not in itself create an effect on archeological sites within the basins of the storage areas or stormwater treatment areas. Efforts will be made to identify archeological sites within the storage and stormwater treatment area basins for future historic resource management needs, but no mitigation will be necessary if water is stored on lands containing archeological sites.

Operational changes to water regulation schedules may also effect historic properties through erosion and changes in the hydrology of the sites. These effects will be considered during cultural resources investigations in support of operational changes.

The State Historic Preservation Officer, in a letter dated August 14, 1998, reaffirmed the archeological and historical potential of the C&SF project area. They also acknowledged our commitment to adhere to the procedures outlined in 36 CFR

Part 800, and concurred that, at this stage of project planning, the Restudy will have no adverse effect on historic properties listed or eligible for listing on the National Register.

K.2.16 Hazardous, Toxic, and Radioactive Wastes

Phase I Hazardous, Toxic and Radioactive Waste (HTRW) Site Assessments were conducted in all subregions in conformance with the scope and limitations of ASTM Practice E 1527 and Engineer Regulation ER-1165-2-132 The findings and conclusions provided below reflect existing HTRW conditions based on database searches, aerial photography, review of available records, site inspections and interviews. These findings and conclusions are of existing conditions at this time. The project conditions assume that any HTRW found during any phase of the project would be remediated in accordance with local, state and federal laws. Therefore, it can be assumed that conditions at future construction sites will be contamination free or of low levels, which would include de minimis conditions that generally do not present a material risk of harm to public health or the environment. This assessment of environmental effects is not intended to be site specific in that definitive sites for the placement of most project features have not been decided. In some instances, tasking involved assessment of a certain area, or areas which were identified as possible conceptual locations for a project feature, subject to change, pending future detailed planning.

The assessment covered all Restudy regions, within the general vicinity of proposed project features or existing features proposed for significant modification. Several site visits were conducted over the past few years, with the most recent survey having been performed during the week of 12 August 1998. The HTRW database search was performed on the entire area and it indicated that overall, the majority of the selected sites investigated are free of hazardous and toxic waste. Most of these general features are proposed for remote and rural areas, and were farms, vacant land, or wildlife management areas. The most common type of HTRW, hydrocarbons, was found along state highways in which the majority of the gasoline stations had leaking underground storage tanks.

Databases also revealed that several locations are National Priority Listed (NPL). Most of these NPL sites are due to past landfill operations. These sites are located in Palm Beach County, the Lower East Coast Lakebelt area in the vicinity of the S-9 Structures and in Broward County south of Alligator Alley. Contaminated sites located on the perimeter of any proposed water storage area may have migrating or expanding pollution plumes into the project area. Any such sites would require further survey and specific evaluation prior to detailed design for Restudy features. Another feature of concern is the numerous landfills and waste handling facilities existing in the Lower East Coast sub-region. To the extent feasible, water storage areas should not be sited immediately adjacent to these known sites.

There are, in addition to identified sites, numerous undocumented tanks and landfills that may be present in future project areas that were not included in the database. These HTRW locations may be due to undocumented dumping or other HTRW operations. Within the agricultural areas there are numerous temporary pump sites and fuel storage areas. These makeshift portable tanks are not reported, and therefore are not presented in the HTRW database. In addition, pesticide/chemical-mixing areas may also exist. Project implementation requires that any HTRW problems revealed during the real estate acquisition or actual project construction require full remediation.

The database and Phase-1 assessment results are maintained at the U.S. Army Corps of Engineers, Planning Division, as a series of maps and GIS overlays. It is not appropriate to include detailed information in this Programmatic report and EIS. However, the data will be available to planners for consultation during development of specific project features, and is expected to aid in avoiding sites with major remediation needs.

K.2.17 Unavoidable Adverse Environmental Effects

Land Use (Agriculture). A significant number of acres within a given hydrologic basin and cumulatively throughout the project area, and an even larger number of acres of agricultural lands will be permanently removed from production due to the construction of large above ground storage reservoirs, and stormwater treatment areas north of Lake Okeechobee, in the Caloosahatchee River and St. Lucie basins, and within the Everglades Agricultural Area. Further agricultural land use will be permanently removed from Palm Beach, Broward and Miami-Dade Counties due to the construction of the Water Preserve Areas.

Wetlands. A limited number of acres of wetlands will be permanently altered within the boundaries of the large above ground storage reservoirs and stormwater treatment areas, and within the Water Preserve Areas.

Water quality. Temporary increases in turbidity of local waters are expected from the removal of canals and levees and by the construction of raised roadways and other structures.

Air quality. Fugitive dust from vehicular traffic and earth moving will be unavoidable but insignificant.

Wildlife. Significant short-term disruption of wading bird colonies is expected from altering hydroperiods in the WCAs. Localized disturbances to fish and wildlife are expected from removal of canals and levees and from the elevation of roadways and construction of other structures.

Recreation. Increased depths in WCA-3B will increase airboat access, encouraging illegal camping on tree islands. Campers often use trees for firewood and occasionally allow campfires to get out of control. Alteration of the L-67 canal will reduce access to important and popular fishing areas.

Cultural Resources. An unknown number of historic and archeological sites may be affected. Studies will identify significant sites and necessary mitigation will be implemented.

K.2.18 Relationship Between Short Term Uses and Long Term Productivity

In the process of improving conditions regionally, short-term or localized problems will undoubtedly occur. For example, in the process of improving wading bird nesting and foraging areas regionally, current rookeries may be affected. The changed conditions may improve breeding habitat in the Andytown rookery, on one hand, but possibly damage the Rescue Strand rookery on the other. Although overall restoration of the Everglades watershed is expected to improve habitat for nesting wading birds regionally over time, the transition period could have significant effects on regional wading bird populations. Further study and close monitoring will be critical to maintaining viable wading bird populations in the Everglades as the system transforms.

K.2.19 Irreversible and Irretrievable Commitments of Resources

Construction of the proposed project will include many features considered permanent, or modifications to existing C&SF Project features that may be deemed irreversible. This would include, among others, such things as construction of a large reservoir, degradation of levees and filling in of canals. Funding, labor, equipment, and supplies necessary for these features, as well as building regional aquifer storage and recovery facilities, large storage reservoirs, stormwater treatment area, water preserve area's, and waste water reuse facilities, all necessary for the restoration of the natural ecosystem and maintenance of the urban and agricultural system, on the scale proposed in the Restudy, are probably of such a magnitude that this would represent an irreversible and irretrievable commitment of resources. These resources would include state and Federal funding to purchase lands and labor, energy and project materials to build, operate, and maintain the project.

Fish and wildlife habitat, located within the project footprint, particularly in the case of storage reservoirs, and stormwater treatment area facilities which would likely be inundated for much of the year, may be permanently altered and could represent a irreversible commitment of land and/or wetland resources.

K.2.20 Cumulative Effects

Important areas north of Lake Okeechobee, within the Everglades Agricultural Area, around the lake, in the Caloosahatchee River basin, and the upper east coast will be committed to providing storage for the overall gain and long-term benefit of the regional system. These project features, by providing important storage functions, are intrinsic to the overall restoration of the study area downstream and in the east-west estuaries. Project features may cause some adverse consequences locally, however the overall benefit to the regional system will be far greater than the localized adverse effects. As these features occur disparately across the landscape, within different hydrologic basins, and as distinct units rather than multiple features within a single watershed, they likely will not result in a detrimental cumulative effect.

Overall, the Restudy project elements in the Water Preserve Areas may cumulatively slow or stop expansion of lower east coast cities toward the west, and may make other residential or potentially residential lands more valuable. Restudy project components are not expected to result in a cumulative negative effect to the environment of the Lower East Coast. Project components in the area, especially storage, seepage control, and water reuse plants, will act to restore more natural freshwater flows to Biscayne Bay, and should result in other beneficial environmental effects. The Florida Keys are the subject of a separately funded, cooperative carrying capacity study. All identified indirect effects of the Initial Draft Plan recommended by the Restudy on the Keys would be positive (i.e., increased freshwater flows to Florida Bay).

K.3 KISSIMMEE RIVER REGION

This assessment will cover only those consequences realized within the Kissimmee River geographic planning region, which includes the Taylor Creek and Nubbin Slough drainage. The primary project features of the Initial Draft Plan in the Kissimmee River region are large scale above ground storage reservoirs in two locations north of Lake Okeechobee. These changes will provide a substantial net increase in regional storage capacity, which Lake Okeechobee has provided in the past. Features include: 1) an approximately 20,000 acre above ground storage reservoir, located north of the lake at a location to be determined, with a maximum design depth of 10 feet, inflow pump capacity of 4,800 cfs, and outflow structure sized at 4,800 cfs; 2) an approximately 5,000 acre above ground storage reservoir, 10 feet deep, with an inflow pump capacity of 2,500 cfs, and outflow structure sized at 1,000 cfs, linked to a 5,000 acre stormwater treatment area, at 4 foot depth, with inflow pump capacity of 1,000 cfs, and outflow structure sized at 1,000 cfs located in the Taylor Creek / Nubbin Slough drainage basin at a location to be determined. In aggregate, these features will provide 250,000 acre-feet of storage.

Taylor Creek and Nubbin Slough were identified as a priority location for these project features, as they are two of the largest sources of phosphorous loading to the Lake Okeechobee (SWIM Plan 1997). The reservoir and stormwater treatment area are designed for 10 feet and 4 feet maximum depth respectively. They will be operated with inflow and outflow pumps, and are expected to reduce phosphorous concentrations in the basin runoff from about 528 ppb to 107 ppb.

The report below will address potential effects (beneficial or harmful) of the Initial Draft Plan compared to the 2050 base, on several key physical, ecological and socio-economic resources of the Kissimmee River region.

K.3.1 Vegetation

The above ground storage reservoirs and stormwater treatment area located north of Lake Okeechobee and in the Taylor Creek / Nubbin Slough area will cover approximately 30,000 acres total. The existing plant cover is predominantly agricultural in nature, i.e., row crops, rangeland, upland forest, and barren lands. Isolated emergent wetlands are scattered throughout this area, representing approximately 5 percent of land cover. Converting 30,000 acres of lands into reservoirs and a stormwater treatment area could potentially impact approximately 1,500 acres of emergent freshwater wetlands. These wetlands and the adjoining uplands, i.e., agricultural lands, would be directly converted to an open water system. The 4-foot deep areas will function as emergent marsh and probably will become dominated by cattails. The deep reservoirs will become colonized by floating and rooted aquatic vegetation. During detailed planning of these components, every effort will be made to minimize impacts to wetlands or habitats determined to be critical to threatened or endangered species.

K.3.2 Fish and Wildlife

The wildlife now occupying the lands that would become water storage areas would be completely displaced to adjacent sites and face an increased risk of mortality. No adverse effects on endangered, threatened or state special concern species are anticipated. It is expected that unknown numbers of common wildlife species will be displaced into adjoining areas when wetlands or uplands are flooded to provide surface water storage. This will unavoidably cause some mortality. Affected species likely would include white-tailed deer, opossum, raccoon, native mice, rats and rabbits, as well as many species of songbirds. This fauna would be replaced by fish, reptiles (alligator, turtles) and water birds. Siting of water storage areas over altered or agricultural lands will minimize adverse impacts on native wildlife. However, even agricultural lands provide some minimal terrestrial wildlife habitat, habitat that will be irretrievably converted to marsh or open water habitat. Foraging habitat will be created for some fish-eating birds in the shallow (4' deep) storage areas, including osprey, snail kite, and kingfisher.

K.3.3 Threatened and Endangered Species

Of the eighteen listed plant and animal species submitted by the USFWS as likely to be affected by the C&SF Restudy, seven are thought to occur within the affected area of the Kissimmee River region. A brief description of effects to these state and federally listed threatened and endangered species follows.

K.3.3.1 Florida Scrub-jay

The Florida scrub-jay (*Aphelocoma coerulescens*) is known to inhabit well drained, sandy uplands, typical of a xeric oak scrub habitat. A "core population" of scrub-jays is also located within the Lake Wales Ridge sub-region, northwest of Lake Okeechobee. An essential feature of the Initial Draft Plan is the construction of a 20,000-acre above ground storage reservoir and a 5,000 acre storage reservoir and 5,000-acre stormwater treatment area. All are to be built at sites to be determined, north of Lake Okeechobee. Although no definitive site has been selected for these project features, preliminary sites identified are outside of the Lake Wales Ridge sub-region. No effect on the scrub-jay is anticipated at this conceptual level of planning, until definitive sites are identified and selected for the project features it is impossible to determine precise impacts to scrub-jays or scrub-jay habitat. The scrub-jay is listed by both the USFWS and GFC as a threatened species.

K.3.3.2 Eastern Indigo Snake

The eastern indigo snake (*Drymarchon corais couperi*) could potentially be affected by construction of storage reservoirs, the stormwater treatment areas and their associated facilities. No effect is anticipated at this conceptual level of planning. When definitive sites are identified and selected, it will be possible to determine precise impacts. The USFWS and the GFC classify the eastern indigo snake as a threatened species.

K.3.3.3 Snail Kite

The snail kite (*Rostrhamus sociabilis plumbeus*) is wide ranging raptor, listed as endangered by the USFWS and GFC. Within the study area, critical habitat includes the WCA's, portions of Everglades National Park and western portions of Lake Okeechobee. Lake Okeechobee and surrounding wetlands are major nesting and foraging habitats, particularly the large marsh in the southwestern portion of the lake. No adverse effect on the snail kite is anticipated due to construction of water storage facilities in this region. Under some conditions the water storage areas may provide suitable habitat for foraging snail kites. However, the USFWS is concerned that these areas would become "attractive nuisances" when temporarily favorable conditions are created, drawing in opportunistic wildlife species.

Temporary favorable conditions could induce species such as wood storks, snail kites, bald eagles and others to nest nearby; but nesting success would depend on continued favorable foraging conditions. Short term success could produce artificially inflated populations of some species. When reservoir operations then cause a rapid change in conditions, widespread nesting failures and direct mortality of adult individuals could result due to loss of foraging resources.

K.3.3.4 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) should benefit by implementation of the Initial Draft Plan water storage components north of Lake Okeechobee due to the reduction of lake level fluctuations. Lake Okeechobee levels, with fewer occurrences of lake stages in the vicinity of 11-12 feet NGVD and below should benefit the bald eagle by providing for a more sustainable and reliable foraging ground within the shallow littoral areas. The regular occurrence of lake level recessions would concentrate prey fish over an extended period of time, which may further benefit the eagle. Both the USFWS and GFC currently list the bald eagle as a threatened species.

K.3.3.5 Wood Stork

The wood stork (*Mycteria americana*) is listed as an endangered species by the USFWS and the GFC. Wood storks forage in freshwater marshes, seasonally flooded roadside or agricultural ditches, narrow tidal creeks, shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. No adverse effect on the wood stork is anticipated due to construction of water storage facilities in this region. Under some conditions the water storage areas may provide suitable habitat for foraging wood storks. However, the USFWS is concerned that these areas would become “attractive nuisances” when temporarily favorable conditions are created, drawing in opportunistic wildlife species. Temporary favorable conditions could induce species such as wood storks, snail kites, bald eagles and others to nest nearby; but nesting success would depend on continued favorable foraging conditions. Short term success could produce artificially inflated populations of some species. When reservoir operations then cause a rapid change in conditions, widespread nesting failures and direct mortality of adult individuals could result due to loss of foraging resources.

K.3.3.6 Audubon’s Crested Caracara

The Florida population of this resident, non-migratory raptor is listed as threatened by the USFWS and GFC. The caracara (*Polyborus plancus*) commonly occurs in dry or wet prairie areas, as well as improved or semi-improved pasture. The region of greatest abundance is a five county area north and west of Lake Okeechobee, including Glades, DeSoto, Highlands, Okeechobee, and Osceola counties (Kissimmee River and Caloosahatchee River regions). Their numbers continue to decline throughout their range due largely to loss of habitat. Implementation of the Initial Draft Plan components in this region could impact this species through loss of habitat. No effect on the caracara is anticipated at this conceptual level of planning, until definitive sites are identified and selected for the project features it is impossible to determine precise impacts to caracara or caracara habitat.

K.3.3.7 Florida Grasshopper Sparrow

The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) was listed by the USFWS as endangered in 1986 because of habitat loss and degradation resulting from conversion of native vegetation to improved pasture (USFWS 1998). It is also listed as endangered by the GFC. No critical habitat has been designated for this sub-species. The Florida grasshopper sparrow is non-migratory, and is limited to the prairie region of south-central Florida. Within the study area, it is known to inhabit Glades, Highlands, Okeechobee, Osceola, and Polk Counties, in habitat consisting primarily of tree-less, relatively poorly drained grasslands that have a history of frequent fires. Implementation of the Initial Draft Plan components in this region could impact this species through loss of habitat. No effect on the Florida grasshopper sparrow is anticipated at this conceptual level of planning, until definitive sites are identified and selected for the project features it is impossible to determine precise impacts to Florida grasshopper sparrow or Florida grasshopper sparrow habitat.

K.3.4 Water Management

Under the Initial Draft Plan all flood control releases to the St. Lucie and Caloosahatchee River estuaries are expected to be eliminated except pulse releases in zone A of the regulation schedule. Water managers will use a climate based in-flow forecasting model, in conjunction with operational rules, which will help them in deciding when to pump water to the storage facilities outside the lake. Use of climate based in-flow forecasting, reservoir storage north of Lake Okeechobee, lakeside aquifer storage and recovery's, and other project features located in the C-43 and C-44 basins, is expected to reduce the occurrence of peak lake stage events and harmful flood control discharges to the estuaries. When the model shows that Lake Okeechobee water may rise above desirable levels for the littoral zone (14.35 feet to 14.75 feet,), water will be pumped to the storage facilities in the Everglades Agricultural Area, and north of the lake. In the dry season, flows will be allowed back to the lake, when the lake is predicted to fall back to within 0.75 feet of the supply side management line within the same dry season or below 11.75 feet NGVD in the upcoming wet season. During the wet season, flow is allowed from the storage facilities to Lake Okeechobee when the model projects less than 1.5 million acre-feet of inflow during the next 6 months and the lake water level is either below 11.75 feet or projected to be in supply side management during the upcoming dry season. Most of the water previously stored in the lake, at prolonged and even extreme lake stages and/or sent to tide via the estuaries, under the Initial Draft Plan, is pumped to storage north of Lake Okeechobee (127,000 acre-feet on a mean annual basis) or other storage facilities in the Everglades Agricultural Area, Caloosahatchee River (C-43) Basin or the St. Lucie (C-44) Basin.

K.3.5 Water Quality

Water quality conditions in the Kissimmee River region are expected to improve compared to both the 1995 and 2050 base conditions through implementation of the Initial Draft Plan. The Initial Draft Plan calls for two water storage/treatment components in the Kissimmee River region: one 20,000 acre, 10 foot deep storage reservoir (200,000 acre-feet of storage) and one, 5,000 acre, 10 foot deep storage area connected to a shallow stormwater treatment area. The larger, deeper storage reservoir would be at an unspecified site north of Lake Okeechobee, and the two smaller areas would be sited in the Taylor Creek and Nubbin Slough drainage.

Construction and operation of water storage areas north of Lake Okeechobee would result in an aggregate 30,000 acres and 250,000 acre-feet of off-Lake Okeechobee storage in the subregion. The north of Lake Okeechobee components would be operated to receive backpumped water from Lake Okeechobee, or receive high drainage flows from Kissimmee and Taylor/Nubbin Slough sub-basins and retain them for later release downstream, depending on lake stage and predicted weather conditions. Under the first scenario, the water storage areas would serve to prevent overly high stages in Lake Okeechobee. Under the second scenario the storage areas would retain a portion of flood flows and reduce pollutant loading from the Kissimmee and Taylor/Nubbin sub-basins to Lake Okeechobee. From a water quality enhancement perspective, the second operation scenario would be preferred over the first, since the second operating scenario would maximize reduction in pollutant loading from the Kissimmee River to Lake Okeechobee. Total phosphorus (TP) loading data provided in the Lake Okeechobee SWIM Plan (SFWMD, 1997) indicates that average TP concentrations in the lower Kissimmee River, i.e., Pools S-65D and S-65E, during 1990-94, were 0.77mg/l and 0.36 mg/l respectively.

These average TP concentrations in the lower Kissimmee River are some of the highest TP average concentrations in the entire Kissimmee River drainage basin. The associated average TP loading from Pools S-65 D&E, during 1990-94, were 29.1 and 43.0 tons/year, respectively. These TP loading rates were some of the highest in the entire Kissimmee River basin with the exception of the TP loading to Lake Okeechobee coming from the Taylor Creek/Nubbin Slough area (91.4 tons/year).

The South Florida Water Management District 1997 Lake Okeechobee SWIM Plan identifies four critical upstream drainage basins where TP loading to Lake Okeechobee must be significantly reduced to enable long-term recovery and restoration of Lake Okeechobee water quality conditions and ecological health.

Those four critical basins which produce high TP loads to the downstream Lake Okeechobee are: the S-65 D basin, the S-65-E basin, the TCNS basin and the S-154 basin. Water quality degradation in the lower Kissimmee River region south of Lake Kissimmee is mainly attributable to agricultural non-point pollution consisting primarily of elevated nutrients and bacteriological contamination and increased turbidity and sedimentation in watercourses of the region.

Construction of one or more water storage areas in the Kissimmee River region consistent with north of Lake Okeechobee storage would result in removal of particulate and dissolved nutrients and other pollutants in the water storage area through sedimentation and biological uptake processes. Maximizing the retention time of surface runoff waters captured in the water storage area would increase the pollutant reduction benefits provided by the water storage area.

In addition to phosphorus loading, other key water quality parameters of concern in the Kissimmee River region are dissolved oxygen (DO) and nitrogen compounds (NOx). Construction of water storage areas north of Lake Okeechobee would result in reduction of NOx loading to the surface water bodies in the basin as well as to Lake Okeechobee.

In terms of maximizing future water quality benefits provided by water storage area construction and operation in the lower Kissimmee River area, it is likely that water quality benefits could be increased by siting multiple water storage areas totaling 20,000 acres at strategic locations, optimized for reducing nutrient loading to downstream surface water bodies, as opposed to the construction of one large contiguous 20,000 acre water storage area in the basin. Existing and ongoing water quality monitoring in the Kissimmee river region being conducted by the South Florida Water Management District could be used to optimally site several water storage areas totaling 20,000 acres while realizing the primary hydrologic water storage purpose of the Kissimmee River basin water storage areas.

Construction and operation of the recommended plan features in the Taylor Creek/Nubbin Slough area includes a combined 5,000 acre water storage area coupled with a 5,000 acre stormwater treatment area. This component will result in substantial reduction of nutrient loads entering the Taylor Creek/Nubbin Slough watercourses and Lake Okeechobee. The purpose of this component is to provide flood protection, water quality treatment, water supply benefits and enhancement of the St. Lucie and Caloosahatchee River estuaries. This water storage area combination is sized to capture and treat stormwater runoff from the Taylor Creek /

Nubbin Slough basin, the highest nutrient loading basin flowing to the eutrophic Lake Okeechobee. The design of the combination water storage area/stormwater treatment area is intended to reduce TP concentrations in TCNS runoff to Lake Okeechobee by 80 percent from 0.528 mg/l down to 0.107 mg/l. This reduction in nutrient loading to Lake Okeechobee would contribute toward the Lake Okeechobee SWIM Plan target for reducing TP loading to Lake Okeechobee and ultimately restoring its ecological health.

Another water quality related Initial Draft Plan component that will improve water quality conditions in tributary basins flowing to Lake Okeechobee is the Other Project Element (OPE) entitled "Water Treatment Facilities for Pollutant Load Reduction: Lake Okeechobee". This project is a logical extension of the WRDA '96 Critical Project entitled Lake Okeechobee Water Retention/Phosphorus Removal" that is not associated with the Initial Draft Plan. The OPE Lake Okeechobee watershed water quality treatment facilities project would entail re-isolation of previously drained wetlands (ditch plugging) in the four previously identified critical phosphorus loading basins north of Lake Okeechobee, (S-65 D&E, S-154 and TCNS) as well as construction of stormwater treatment areas at key locations within the four drainage basins. The main purpose of this OPE would be nutrient load reduction within the basins and to Lake Okeechobee downstream.

K.3.6 Water Supply

Utilization of the revised Lake Okeechobee operation schedule, coupled with the climate based in-flow forecasting model, and in conjunction with the reservoir storage features described above, will allow greater retention and storage of regional water, greater flexibility in operations, and more opportunities to store water during wet periods for use in dry periods. This new regional water supply system, proposed under the Initial Draft Plan, will markedly enhance water supply to all water users in the Lake Okeechobee Service Area (LOSA), and the Everglades Agricultural Area, as well as the Service Areas of the lower east coast, above and beyond that provided by the 2050 base.

K.3.7 Land Use

The C&SF Comprehensive Restudy recommends land use changes within the Kissimmee River region, north of Lake Okeechobee, by construction and operation of water storage areas and a stormwater treatment area. Existing land uses include agriculture, ranching, and forestry. The below discussion of impacts to agriculture will include all existing land uses except urban.

The two proposed above ground storage reservoirs and stormwater treatment area would have a combined surface area of 30,000 acres. The proposed action would convert the existing land uses into open water (water storage areas) or emergent marsh (stormwater treatment area).

K.3.7.1 Agriculture

A 20,000 acre storage reservoir is proposed in the Initial Draft Plan for this region to help shorten the duration and frequency of high water levels in Lake Okeechobee, as well as reduce discharges from the lake to downstream estuaries. An additional 5,000 acres of storage and 5,000 acres for stormwater treatment area is planned in the Taylor Creek/Nubbin Slough area for flood protection, estuary protection, water quality treatment, and water supply benefits. It is likely that these reservoirs will be located in an area currently being used for agricultural production and designated as unique farmland. Conversion of 30,000 acres from agriculture to storage reservoirs would represent a 1.5 percent reduction in total farm acreage in this four county area.

K.3.8 Recreation Resources

The proposed components (water storage areas and stormwater treatment areas recommended under the Initial Draft Plan in the Kissimmee River region are not anticipated to impact any existing recreational facilities. Due to their large size every effort will be made during the detail design phase of the project to minimize any future impacts. The reservoirs and stormwater treatment area may provide future recreational opportunities compatible with their primary restoration purpose.

K.3.9 Aesthetic Resources

The main visual components of the Initial Draft Plan features in the Kissimmee River region are the low levees of the reservoirs and stormwater treatment area, water control structures, and pump stations. These features are not unlike existing features in the region. The stormwater treatment area would appear from a distance as areas similar to agricultural fields or marsh. The project components do not include any tall structures that would interrupt the existing landscape profile.

K.3.10 Unavoidable Adverse Environmental Effects

The following unavoidable adverse effects are expected to occur with implementation of the project features described above, which are expected to have an affect on the Kissimmee River physiographic region.

Construction of above ground storage reservoirs, and stormwater treatment areas, will take large tracts of agricultural lands out of production, and possibly remove the functional values of lesser amounts of wetlands, prairie, forested lands, or other natural areas. There will be a change in the dominant plant cover (from emergent or crop to floating aquatic) and dominant animal groups (common terrestrial wildlife to aquatic birds, reptiles, amphibians, fish and invertebrates).

K.3.11 Relationship Between Short Term Uses and Long Term Productivity

Construction of the reservoir storage and stormwater treatment area facilities represents a significant short-term disruption to the environment, and possible unintentional direct and indirect environmental consequences. Short-term effects due to construction activities (clearing, grubbing, levee building, installation of structures, equipment noise, etc.) may be visually unpleasant and annoying to adjacent landowners. However, the storage areas will be sited in rural zones. Grading and restoration will improve the visual quality of the landscape when construction is finished, and adverse effects will be minimized wherever possible.

Once completed, vegetation would be expected to recolonize the levee slopes and crest and the reservoirs. In addition, these modifications to the water management system will have a beneficial long-term and permanent effect on the Lake Okeechobee and ultimately downstream throughout the Everglades Protection Area

K.3.12 Irreversible and Irretrievable Commitments of Resources

The proposed construction of reservoir storage sites and stormwater treatment area, represents, in all likelihood, an irreversible and irretrievable commitment of land and monetary resources. These resources would include, in addition to the lands themselves, state and Federal funding, labor, energy and project materials and equipment to build the storage sites and the structures associated with the operation of these storage sites. Fish and wildlife habitat, located within the proposed component footprint, particularly in the case of storage reservoirs and stormwater treatment areas, which would likely be inundated for much of the year, may be permanently altered and could represent a irreversible commitment of land and/or wetland resources.

K.3.13 Cumulative Effects

Restudy project components are not expected to result in a cumulative negative effect on the environment of the Kissimmee River region. Project components in the Kissimmee River region, especially reservoir storage and stormwater treatment area water quality treatment, will act cumulatively to restore more natural freshwater flows to Lake Okeechobee. The restoration of Lake Okeechobee will lead to the restoration of the estuaries and eventually downstream to the Everglades. To achieve restoration will require substantially more storage in the headwaters of the system in order to provide for the correct quantity, quality, timing, and duration of flows. The land spatially occupying these headwater areas once provided these important functions to the regional system. Today, they are largely developed, drained, and ditched. The restoration of these important natural functions will require some reversal of the current trend in order to provide the retention area for holding, storing and treating water prior to being discharged downstream. The proposed project features, along with a restored Lake Okeechobee, able to provide important storage functions, is intrinsic to the overall restoration of the study area downstream. The commitment of tens of thousands of acres of land represents a huge investment in funding and land resources. It may also cause some adverse consequences locally, however the overall benefit to the regional system will be far greater than the localized adverse effects. The localized adverse effects will not result in a detrimental cumulative effect within the region.

K.4 LAKE OKEECHOBEE

This assessment will cover only those consequences realized within Lake Okeechobee proper and those communities immediately surrounding Lake Okeechobee. Effects incurred downstream in the WCA's, estuaries or within the Everglades Agricultural Area, as a result of flood control discharges or water supply issues, will be addressed in sections of the report dealing with those physiographic regions. The primary project features of the Initial Draft Plan affecting the hydrology and ecological sustainability of Lake Okeechobee are the introduction of large scale above ground storage reservoirs and a belt of aquifer storage and recovery wells. These changes will provide a substantial net increase in regional storage capacity, which the lake heretofore has provided. Features include: 1) an approximate 20,000 acre above ground storage reservoir, located north of the lake at a location to be determined, with a maximum design depth of 10 feet, inflow pump capacity of 4800 cfs, and outflow structure sized at 4800 cfs; 2) an approximate 60,000 acre above ground storage reservoir (comprised of 3 separate 20,000 acre cells), located within the Everglades Agricultural Area, at a location to be determined (conceptually between the Miami and North New River canals), and with a maximum design depth of 6 feet for all 3 cells. This reservoir would be operated by inflow and outflow pumps and structures of various capacity.

Another feature that will affect Lake Okeechobee is the construction of a 5,000 acre above ground storage reservoir and 5,000 acre stormwater treatment area to control and treat runoff from the Taylor Creek and Nubbin Slough area north of Lake Okeechobee. Taylor Creek and Nubbin Slough were identified as a priority location for these project features as they remain two of the largest sources of phosphorous loading to Lake Okeechobee (SWIM Plan 1997). The reservoir and stormwater treatment area are designed for 10 feet and 4 feet maximum depths respectively, will be operated with inflow and outflow pumps, and are expected to reduce phosphorous concentrations in the basin runoff from about 528 ppb to 107 ppb.

Lake Okeechobee aquifer storage and recovery is being proposed under the Initial Draft Plan, to provide additional storage while reducing ET loss, and to reduce the amount of land removed from current land use compared to an above ground reservoir. Two hundred 5-MGD (million gallons per day) aquifer storage and recovery wells and associated infrastructure are proposed outside Lake Okeechobee, near the Herbert Hoover Dike, at a location(s) to be determined. Water from Lake Okeechobee to be injected into the aquifer storage and recovery wells will need to meet coliform standards as specified by the U.S. Environmental Protection Agency, before injection. Efficiency of aquifer storage and recovery is estimated for planning purposes to be about 70 percent, although there is considerable uncertainty associated with this estimate, and recovery rates may vary depending on area geology and other factors. More detailed information on design and operation of reservoirs, stormwater treatment areas, and Lake Okeechobee aquifer storage and recovery is included in Section 9.

The report below will address potential effects (beneficial or harmful) of the Initial Draft Plan compared to the 2050 base, on several key physical, ecological and socio-economic resources of the Lake Okeechobee ecosystem. Ecological evaluations will consider first, a suite of priority performance measures as discussed in Havens et al. (1998). They include: 1) frequency of extreme low lake stage events <11 feet NGVD; 2) frequency of prolonged low lake stage events <12 feet NGVD for >12 continuous months; 3) frequency of extreme high lake stage events >17 feet NGVD; 4) frequency of prolonged high lake stage events >15 feet NGVD for >12 continuous months; and 5) number of years in which spring lake level recessions occur (defined as a lake level decline from near 15 feet to 12 feet NGVD without reversals greater than 0.5 feet from January to May). These performance measures were developed through scientific research and interagency consensus over a period of several years. Other hydrologic performance measures and model output from the SFWMM posted on the Restudy web site at http://www.sfwmd.gov/org/pld/restudy/hpm/index.html was considered as well. This information was used primarily to supplement conclusions based on the priority performance measures, or to evaluate non-ecological resources such as socio-economics, water supply etc.

K.4.1 Vegetation

Modeling results indicate that hydrologic conditions within Lake Okeechobee under the Initial Draft Plan are substantially improved relative to both 1995 base conditions and the 2050 base. The changes in hydroperiod observed under the Initial Draft Plan, are considered by experts to be more conducive to a healthy littoral plant community (Havens et al. 1998). Under the Initial Draft Plan, occurrence of extreme low lake stage events (<11 feet) are reduced relative to both base conditions, which should enhance conditions within the littoral zone and marsh for natural vegetation assemblages, and reduce the spread of exotics, and suppress less desirable cattail. Richardson and Harris (1995) showed that melaleuca and cattail, both problematic species, were increasing in abundance in the marsh. Panicum (torpedograss) is also commonly thought to be expanding within the marsh (Hanlon, pers. comm.). Richardson et al. (1995) found that vegetation distribution in Lake Okeechobee is largely controlled by hydroperiod. For example, the hydroperiods of melaleuca and torpedo grass are 78 and 81 percent, respectively, while the hydroperiod of spike rush (the native plant that dominates Moonshine Bay) is 96 percent. Richardson et al. concluded "higher elevation areas of the marsh which now have melaleuca and torpedo grass on them may expand if hydroperiods are shortened." Lockhart (1995) showed that Melaleuca seedlings could not germinate effectively under water, and D. Thayer (pers. comm.) observed a dramatic increase in the areal extent of Melaleuca seedlings in the marsh following the 1989 drought, when lake stage fell below 11 feet NGVD and over 95 percent of the marsh was exposed.

The performance of the Initial Draft Plan, with fewer extreme and prolonged (<12 feet >1 year) low lake stage events, should indirectly inhibit the expansion of these exotic and less desirable species relative to conditions under the 2050 base. These effects, which may require a few to several years to fully manifest themselves, will lead to more sustainable populations of native vegetation, and heterogeneous communities, as they affect the ability of exotic plant seeds and cattail to germinate, or spread through the extension of rhizomes. Evaluations done by the Alternative Evaluation Team (Havens et.al. 1998) showed the 2050 base experienced 13 events in which lake levels fell below 11 feet over the 31 year simulation period, while the 1995 base showed nine events, and the Initial Draft Plan, three events. This represents a marked improvement by the Initial Draft Plan over the 2050 base, and should lead to hydrologic conditions considered by experts to be more favorable for supporting native plant communities than conditions under the 1995 and 2050 base (Havens et al. 1998).

Occurrence of extreme high lake stages (>17 feet) and prolonged high lake stages (>15 feet >1 year) are about the same under the Initial Draft Plan as in the 2050 base. Both the Initial Draft Plan and the 2050 base represent a moderate improvement over the existing 1995 base in reducing prolonged high lake stage events. Prolonged high stages can cause wind and wave damage to near shore plant communities, and facilitate the resuspension and transport of phosphorous laden waters into the lake water column, which facilitate algae blooms. Conditions under both the 2050 base and the Initial Draft Plan may help to protect and reinvigorate willow trees, whose loss has been documented to be connected to higher lake levels (Aumen, 1995; Richardson and Harris, 1995). Prolonged moderately high lake levels (> 15 ft NGVD) also can be harmful because they bring about changes in the extent of nutrient transport within the lake, as well as losses of benthic plants due to light limitation. A Lake Okeechobee hydrodynamic model indicated that at high lake levels, P-rich pelagic water is mixed into the littoral zone (Sheng and Lee 1991), where it may impact the pristine, nutrient-poor littoral communities. If such events persist over a long period of time, there may be eutrophication trends in the littoral zone similar to those observed in the Everglades Water Conservation Areas

(Koch and Reddy 1992, McCormick et al. 1996), and in recent experimental studies in Lake Okeechobee (Havens et al. 1997). It is possible that the dense growth of cattails at the pelagic / littoral interface in Lake Okeechobee is attributable to advection of nutrient-rich water from the pelagic zone. During periods of extreme high lake levels (>17 ft NGVD), wind and erosion cause emergent and submerged plants to be torn loose from their substrates, resulting in a loss of important fish and wildlife habitat. When lake levels exceeded 17 ft NGVD in 1995, large sections of bulrush (*Scirpus californicus* and *S. validus*) were lost. These plants, which occur at the interface between the pelagic and littoral zone, where they are exposed to wave action, are a prime habitat for largemouth bass and black crappie, two of the most important recreational fishes in the lake (Furse and Fox 1996).

Conditions under the Initial Draft Plan also show the greatest number of spring lake level recessions (January to May lake level declines from near 15 feet to 12 feet, without any reversals greater than 0.5 feet), which may prove favorable in reinvigorating willow habitat and in reducing cattail thatch through a more natural fire periodicity (Smith et al. 1995).

K.4.2 Fish and Wildlife

There has not been research to explicitly link water level variations in Lake Okeechobee with fisheries status. However, a general understanding of how fisheries respond to changes in habitat structure and resource availability leads to a consensus among experts that Lake Okeechobee's fishery may be harmed by extreme high and low lake stage events (Havens et al. 1998). When lake stage declines below 11 ft NGVD for instance, the stage considered to be extreme, 95 percent of the littoral zone is exposed land without standing water. In that condition, it no longer can function as a habitat for fish or wildlife that depend on local fish populations as a food resource. Spike rush and bulrush are almost completely dry at this lake level, and can no longer support the fish and bird communities that depend on them for foraging and nesting (Havens et al. 1998). Fish stocks may improve, under conditions brought about by the Initial Draft Plan, in terms of reproductive success and overall production, both directly, through the initiation of more natural hydrologic conditions. Particularly a marked reduction in the occurrence of extreme and prolonged low lake stage events, and indirectly through the promotion of native submergent vegetation, which provides quality fish habitat. Given the critical importance of the littoral zone to the reproductive success of native fish species. Maintaining minimum water level conditions necessary for optimum reproduction, as well as improving the overall nesting and foraging habitat for fishes within the littoral zone, conditions under the Initial Draft Plan should lead to an improvement in the fishery resource over conditions predicted under the 2050 base.

Both the Initial Draft Plan, and the 2050 base, show a slight improvement over existing conditions in reducing prolonged high lake stages which has been shown to limit light penetration to bottom dwelling benthic plants, algae and invertebrates (Havens et al. 1998). These resources provide habitat and food for fry and fingerling populations in the first weeks of their existence. Actually, extreme and prolonged high lake stage events occur infrequently under the 2050 base, due to the high demands put on Lake Okeechobee in future, so the Initial Draft Plan and the 2050 base represent a substantial improvement over the 1995 base. Although there is a perception among many resource users that high lake stages negatively affect the fishery, there is little hard data to substantiate this. A key benefit of the Initial Draft Plan is to protect the existing fishery resource from the harm that may be caused by 2050 demands on Lake Okeechobee (K. Havens pers. comm.). During a Corps study on Lake Okeechobee (1998), coincident with high lake stages (16 to 18 feet NGVD), reptiles and amphibians were not captured at several littoral sites where previously they had been sampled in high numbers. There are several possible explanations for this: 1) high water levels caused animals to seek out more favorable habitat; 2) traps may have failed in deep water; and 3) seasonal effects such as cold water effects on animal movement. With additional data collected over another hydro-cycle, relationships between lake stage and animal densities may become clearer.

Spring lake level recessions appear to be an important dynamic in providing optimal foraging conditions for wading birds during critical nesting periods. Smith et. al. (1995) observed that most wading birds were attracted to the lake during periods of protracted surface water recession, when the lake stage was below about 15.4 feet NGVD (4.7 m). This may mean that Lake Okeechobee functions as a regional habitat of "last resort" when all the other aquatic habitats are dry (K. Havens, pers. comm.). Smith et al. (1995) also noted that birds enjoyed particularly good nesting success in years when a regular and pronounced spring recession occurred. Under the Initial Draft Plan, performance measure results, as modeled by the SFWMM, indicate a distinct improvement in the occurrence of these events (once in three years) over the 2050 base, or the 1995 base (once in five years for 2050 and 1995). Lake Okeechobee stages under the Initial Draft Plan are also more representative of the historical target than are the 2050 base. Assuming that spring lake level recessions were a part of a more historical condition, then this result, would tend to support the implication that the Initial Draft Plan will produce more conditions indicative of a springtime water level recession and support and sustain a more productive foraging habitat for wading birds.

It is less clear what, if any, benefits may be accrued under the Initial Draft Plan in terms of macroinvertebrate abundance, species composition, and/or diversity. Warren et. al. (1995) documented a shift towards macroinvertebrate dominance in the sub-littoral sediments by species known to be tolerant of organically enriched sediments and highly eutrophic waters. Oligochaeta (segmented worms), larval Chironimidae (true midges), and Nematodes (roundworms) dominated samples where caddisfly (Trichoptera) and mayfly

(Ephemeroptera) had once been abundant. Conditions under the Initial Draft Plan are not likely to affect the hyper-eutrophic status of the sub-littoral sediments, or reverse, in a meaningful way, the current species composition. Benthic invertebrate fauna, within the littoral zone, dominated by fairly intolerant species (Warren et. al. 1995), and high quality as fish prey, will likely be maintained and protected as a critical element in the food chain due to the improved conditions under the Initial Draft Plan.

Apple snail populations, which are the primary food source of the endangered snail kite, may improve due to less prolonged low and extreme low lake stage events. Any improvement in their food source, coupled with optimum water depths, a healthy spike rush community, and suitable perches for surveying prey, may lead to locally improved foraging conditions for the snail kite as well.

It is uncertain what, if any, benefits or effects may be felt by resident mammal populations. Water levels in rim canals are not expected to recede to the point of affecting the habitat for manatees, river otters, bobcat or other mammals that feed or hunt along the canals or within the marsh. These populations may, in fact, benefit indirectly, over the long term, by improved habitat conditions under the Initial Draft Plan, relative to the 2050 base. Creating conditions less favorable for dense monotypic stands of melaleuca, cattail and torpedograss, and more favorable for a heterogeneous habitat with a multitude of niche space for both predator and prey. Conditions for alligators, who use the interior marsh canals, airboat trails, and rim canal may improve slightly under the Initial Draft Plan relative to the 2050 base, given a reduction in prolonged low and extreme low lake stage events, which could impede their mobility, reduce availability of quality nesting areas, and reduce spatial habitat. The alligator may further benefit from a more abundant food base made available by improved conditions for spawning fish, and other animals linked to improved conditions for primary and secondary productivity through predator/prey relationships.

K.4.3 Threatened and Endangered Species

Of the eighteen listed plant and animal species submitted by the USFWS as likely to be affected by the C&SF Restudy, seven are thought to occur within the affected area of Lake Okeechobee. A brief description of effects to these state and federally listed threatened and endangered species follows.

K.4.3.1 American Alligator

The american alligator (*Alligator mississippiensis*), although not identified as a species likely to be affected by Restudy alternatives by USFWS, is a keystone species, and an important component in the ecology of Lake Okeechobee. The american alligator is currently listed as threatened by the USFWS, due to its similarity to the american crocodile (*Crocodylus acutus*). It is currently listed as a species of special concern by the GFC. Hydrologic conditions for the american alligator may improve slightly from an improved hydroperiod for Lake Okeechobee due to the Initial Draft Plan. A reduction in the frequency of occurrence of prolonged low and extreme low lake stage events, and associated enhancements to the fishery resource and overall quality of habitat for wildlife in the littoral zone of Lake Okeechobee, may prove moderately beneficial to the alligator population. The alligator may also benefit by expanding its range into newly created habitat, made available by thousands of new acres of wetlands (reservoirs) proposed under the Initial Draft Plan.

K.4.3.2 Eastern Indigo Snake

The eastern indigo snake (*Drymarchon corais couperi*) would not likely be affected, as lake stages will not be sufficiently altered in depth or duration such that they would impact adjacent uplands where Indigo snakes are known to exist. The USFWS and the GFC classify the eastern indigo snake as a threatened species.

K.4.3.3 Bald Eagle

Lake Okeechobee levels, with fewer occurrences of lake stages in the vicinity of 11-12 feet NGVD and below should benefit the bald eagle (*Haliaeetus leucocephalus*) by providing for a more sustainable and reliable foraging ground within the shallow littoral areas. The regular occurrence of lake level recessions, would concentrate prey fish over an extended period of time, which may further benefit the eagle. Both the USFWS and GFC currently list the bald eagle as a threatened species.

K.4.3.4 Wood Stork

Impacts to the wood stork (*Mycteria americana*) would be moderately beneficial due primarily to the greater frequency of occurrence of spring Lake Okeechobee level recessions under the Initial Draft Plan. The wood stork is a long-legged wading bird which fishes with tactile probing of its beak and attains greatest success when water levels are receding, which concentrates prey species (Smith et al. 1995). More dynamic Lake Okeechobee level fluctuations, with minimal occurrence of extremely low lake levels, which may be harmful to stork prey species such as fish, may result in greater foraging habitat, and nesting success around Lake Okeechobee. Both the USFWS and GFC currently list wood storks as an endangered species.

K.4.3.5 Snail Kite

The hydrologic conditions expected to occur long term as a result of the Initial Draft Plan may be moderately beneficial for the snail kite (*Rosthrhamus sociabilis* *plumbeus*) on a local, and possibly regional scale. Water levels, with fewer dry downs, are expected to benefit the apple snail, long term. The apple snail is the primary food source of the snail kite. Water levels must be sufficiently stable to prevent loss of the apple snail through drying out of the surface. Dr. Robert Bennetts (pers. comm.) expressed the opinion that impacts to snail kites due to the Restudy would be moderated due to the kites' relatively high mobility, and critically important habitat, outside of the sphere of Restudy influence, within the Kissimmee River and St. Johns River watersheds. The Initial Draft Plan, which nearly succeeds in preventing the occurrence of lake stage events <11 feet NGVD, will be able to provide habitat within the Moonshine Bay area to kites from other areas when those areas are dry. The 2050 and 1995 bases will be able to provide this habitat of last resort much less frequently, as these dry out events occur much more frequently (four out of ten years for 2050 base and three out of ten years for 1995 base). Both the USFWS and GFC currently list the snail kite as an endangered species.

K.4.3.6 Audubon's Crested Caracara

The Florida population of this resident, non-migratory raptor is listed as threatened by the USFWS and GFC. The caracara (*Polyborus plancus*) commonly occurs in dry or wet prairie areas, as well as improved or semi-improved pasture. The region of greatest abundance is a five county area north and west of Lake Okeechobee, including Glades, DeSoto, Highlands, Okeechobee, and Osceola counties (Kissimmee River and Caloosahatchee River regions). Their numbers continue to decline throughout their range due largely to loss of habitat. Implementation of the Initial Draft Plan components in this region could impact this species through loss of habitat. No effect on the caracara is anticipated at this conceptual level of planning, until definitive sites are identified and selected for the project features it is impossible to determine precise impacts to caracara or caracara habitat.

K.4.3.7 West Indian Manatee

No appreciable impact would be expected to occur to the West Indian manatee (*Trichechus manatus*) as a result of the Initial Draft Plan. No effects on water levels within boat canals, the rim canal, at structures or navigation locks would expose this animal to boat traffic or result in a die-off of food supplies. Both the USFWS and GFC currently list the West Indian manatee as an endangered species.

K.4.3.8 Okeechobee Gourd

Okeechobee gourd (*Curbita okeechobeensis okeechobeensis*) sites currently known to exist in the Lake Okeechobee region are limited to the shores of Lake Okeechobee inside of the Herbert Hoover Dike. Given its limited range and habitat requirements, any alteration in the hydrology where this plant currently exists could potentially damage the population. Since lake levels under the Initial Draft Plan will not result in a greater occurrence of prolonged high or extreme high lake stage events compared to the 2050 base conditions, the gourd is not flooded and, therefore, it is reasonable to conclude that no appreciable effects are anticipated to the Okeechobee Gourd. Both the USFWS and the Florida Department of Agriculture and Consumer Services currently list the Okeechobee gourd as an endangered species.

K.4.4 Water Management

Under the Initial Draft Plan, Lake Okeechobee will retain all of its authorized project purposes, including the ability to provide flood control, water supply to the urban areas, agriculture, and the natural system, navigation, protection of estuarine resources, and recreation. Changes to the existing lake operation schedule (Run 25-3) include operational changes only, except for the project features designed to enhance water storage outside of the lake. This includes the storage reservoirs north of Lake Okeechobee, the storage and stormwater treatment area facilities in Taylor Creek and Nubbin Slough, the storage facilities in the Everglades Agricultural Area, and the aquifer storage and recovery facilities outside of the Herbert Hoover Dike. All flood control releases to the St. Lucie and Caloosahatchee River estuaries are expected to be eliminated except pulse releases in zone A of the regulation schedule. These water retention facilities are expected to provide an overall net environmental benefit to the lake by increasing storage capacity, and reducing both the duration and frequency of high lake stage events, which are documented to be stressful to the littoral zone. Furthermore, these water storage facilities will reduce the frequency and duration of flood control releases to the estuaries from about a mean annual 206,000 acre-feet to the Caloosahatchee River under 2050 base conditions to 15,000 acre-feet under the Initial Draft Plan and from a mean annual 88,000 acre-feet (2050 base) to 13,000 acre-feet (the Initial Draft Plan) in the St. Lucie estuary. Most of the water previously stored in the lake, at prolonged and even extreme lake stages and/or sent to tide via the estuaries, under the Initial Draft Plan, is pumped to storage north of Lake Okeechobee (127,000 acre-feet on a mean annual basis), to the Everglades Agricultural Area storage facilities (mean annual 278,000 acre-feet), sent to aquifer storage and recovery injection wells outside Lake Okeechobee (mean annual 264,000 acre-feet), or discharged to the WCA's (mean annual 102,000 acre-feet).

Water managers will use a climate based in-flow forecasting model, in conjunction with operational rules, which will help them in deciding when to pump water to the storage facilities outside the lake. Use of this system, along with other project features in the C-43 and C-44 basins, is expected to reduce the occurrence of peak lake stage events and harmful flood control discharges to the estuaries. When the model shows that lake water levels may rise above desirable levels for the littoral zone (14.35 feet to 14.75 feet), water will be pumped to the storage facilities in the Everglades Agricultural Area, and north of the lake (***Figure 4.4-1***). In the dry season, flows will be allowed back to the lake, when the lake is predicted to fall back to within 0.75 feet of the supply side management line within the same dry season or below 11.75 feet NGVD in the upcoming wet season. During the wet season, flow is allowed from the storage facilities to Lake Okeechobee when the model projects less than 1.5 million acre-feet of inflow during the next 6 months and Lake Okeechobee water level is either below 11.75 feet or projected to be in supply side management during the upcoming dry season.

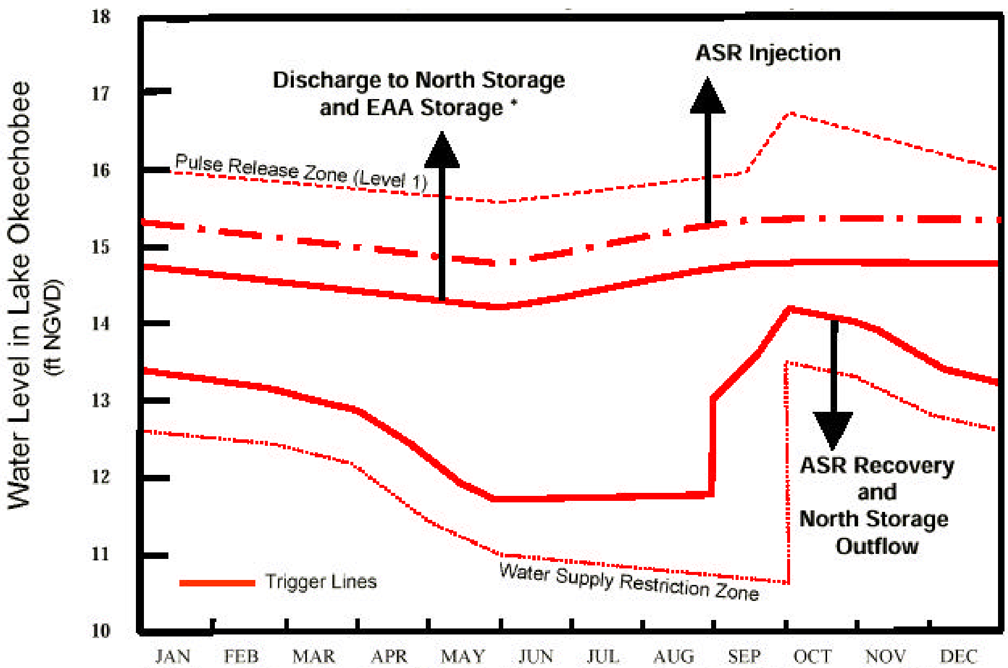
Water from Lake Okeechobee will be pumped into aquifer storage and recovery wells when the climate-based inflow forecast projects that Lake Okeechobee water level will rise significantly above those levels that are desirable for the Lake Okeechobee littoral zone (14.5 - 15.0 feet NGVD; Figure 4.4-1). During the dry season, flow may be moved back to Lake Okeechobee from the aquifer storage and recovery wells either when Lake Okeechobee water level is projected to fall to within three-quarters of a foot of the supply side management line during the same dry season, or below 11.75 feet NGVD during the upcoming wet season. During the wet season, flow is allowed from the aquifer storage and recovery wells to Lake Okeechobee when climate-based inflow forecast projects less than 1.5 million acre-feet of inflow during the next 6 months, and Lake Okeechobee water level is either below 11.75 feet NGVD during the current wet season, or is projected to be in supply side management during the upcoming dry season.

Water management will rely on existing structures, which will not require structural modification. In order to meet capacity requirements for water conveyance to aquifer storage and recovery facilities, stormwater treatment area and storage reservoirs, additional canals, resizing existing canals, pumps and conveyance structures will be constructed outside of the immediate Lake Okeechobee area. Potential effects associated with construction and operation of these project features are discussed under their respective physiographic sections.

K.4.5 Water Quality

Water quality conditions in Lake Okeechobee are expected to be slightly improved relative to the 1995 base and the 2050 base conditions as a result of implementation of several components of the Initial Draft Plan. Water quality improvements in water inflows to Lake Okeechobee will be more marked then in-lake water quality improvements. The discussed Initial Draft Plan related water quality improvements in watersheds north of Lake Okeechobee will result in reduction of agricultural non-point source pollutants (nutrients, bacteriological contamination, turbidity/sedimentation) entering Lake Okeechobee relative to the 1995 and 2050 base conditions.

Figure 4.4-1: Trigger Lines for Storage Reservoirs and Aquifer Storage and Recovery Water Management.



* Discharge to North and EAA Storage if Lake Okeechobee stage is forecasted to be above "Discharge to …Storage" line, or if stage is above Pulse Release Zone (level 1) line.

The key water quality parameters of concern in Lake Okeechobee waters are TP, NOX, chlorophyll a and turbidity. Currently, water quality can be characterized as eutrophic, with in-lake TP concentrations averaging 90-100 ppb TP. Pollutant loading, primarily nutrients, over the past several decades has significantly degraded Lake Okeechobee water quality and resulted in massive loading of nutrients to Lake Okeechobee sediments. Average TP concentrations have increased from 40 to 100 ppb TP since the early 1970s. Resuspension of nutrient laden lake sediments during strong wind events dominate pollutant loading in the lake (Reddy et al., 1995).

Initial Draft Plan components in the Lake Okeechobee area are expected to result in incremental improvement for in-lake water quality conditions. The Lake Okeechobee aquifer storage and recovery project component would result in the construction and operation of 200 aquifer storage and recovery wells located on Lake Okeechobee's peripheral levee (Herbert Hoover Dike) with each aquifer storage and recovery pump having a maximum capacity of 5 million gallons per day (MGD), for a total Lake Okeechobee aquifer storage and recovery, maximum capacity of 1 billion gallons per day. The multiple purposes of Lake Okeechobee aquifer storage and recovery include: providing additional regional water storage while reducing evapotranspiration losses and minimizing the acreage of regional above ground storage reservoirs; improving the Lake Okeechobee's water supply capacity for downstream environmental/urban/ agricultural users; and, reducing harmful regulatory discharges to the St. Lucie and Caloosahatchee estuaries and maintaining existing flood protection.

Although implementation of aquifer storage and recovery facilities on the scale is unprecedented, preliminary data (Pyne, personal communication) indicates that nutrient levels in aquifer storage and recovery waters stored and recovered from the upper Floridan aquifer may be significantly decreased from concentrations in well injectate. If future pilot project associated with this component prove this nutrient reduction feature of aquifer storage and recovery to be present in large scale aquifer storage and recovery projects, then some water quality benefits may be realized in Lake Okeechobee waters (at least localized) as a result of large scale aquifer storage and recovery implementation. The aquifer storage and recovery will be designed and operated to meet the requirements of regulating agencies (U.S. Environmental Protection Agency and Florida Department of Environmental Protection) that all recovered aquifer storage and recovery waters will be treated to meet the Class I Water Quality Standards applicable to Lake Okeechobee waters.

The Initial Draft Plan calls for the construction and operation of a 5,000 acre stormwater treatment area in the vicinity of structure S-77, where the Caloosahatchee River flows from Lake Okeechobee. The stormwater treatment area would be coupled with a backpumping facility to backpump excess Caloosahatchee basin water to Lake Okeechobee. Backpumping would only occur when Lake Okeechobee water levels and storage capacity was appropriate. Based on the design of the 5,000 acre stormwater treatment area and the performance of the Everglades Nutrient Removal (ENR) Project, it is anticipated that backpumped water from the stormwater treatment area to the lake would be below 50 ppb TP. Since average TP concentrations in Lake Okeechobee are 100 ppb TP, it is anticipated that the backpumped waters would reduce in-lake nutrient conditions.

Although implementation of Lake Okeechobee watershed Initial Draft Plan components along with the Lake Okeechobee Aquifer Storage and Recovery system, and the Caloosahatchee Backpumping with stormwater treatment area facilities are anticipated to reduce nutrient and pollutant loading to Lake Okeechobee, the Restudy Water Quality Team's analysis of the overall effect of the Initial Draft Plan on Lake Okeechobee waters concluded that only minor improvements would result to Lake Okeechobee water quality. This conclusion was based on several analyses, including extensive water quality modeling of the 1995 and 2050 base conditions and all evaluated Restudy alternatives using the Lake Okeechobee Water Quality Model (LOWQM) (James et al., 1997). The LOWQM analysis concluded that when comparing the Initial Draft Plan to the 1995 and 2050 base conditions using six Lake Okeechobee water quality performance indicators: TP Inload; TP Outload;

Median Lake Okeechobee TP; Median Lake Okeechobee chlorophyll; Maximum Lake Okeechobee TP and Maximum Lake Okeechobee chlorophyll A, that the Initial Draft Plan would result in slightly better cumulative water quality conditions then either the 1995 or the 2050 base conditions. However, the slight water quality benefits of Initial Draft Plan components, the Lake Okeechobee Aquifer Storage and Recovery system, and the Caloosahatchee Backpumping with stormwater treatment area facilities, on in-lake water quality conditions are overwhelmed by the effects of lake resuspension of nutrient rich sediments as well as by nutrient enriched inflows from the watersheds flowing into Lake Okeechobee.

Supporting this general conclusion is recent work (Havens and James, 1998) indicating that due to the dominant effect of Lake Okeechobee sediment resuspension with the associated release of nutrients into the lake water column, even if all nutrient inflows to the lake were eliminated, it would be several decades before lake-wide TP concentrations and other associated lake water column parameters would show significant improvement.

K.4.6 Water Supply

Lake Okeechobee will continue to function as a multipurpose regional reservoir. The prolonged staging of relatively high lake levels as is the case under the 1995 base, will largely be replaced, under the Initial Draft Plan, with more hydrologically dynamic lake stage fluctuations, including fewer prolonged low and extreme low lake level events and greater spring recession events as was believed to be the case historically. Utilization of the revised lake operation schedule, coupled with the climate based in-flow forecasting model, and in conjunction with the other project features described above, will allow greater retention and storage of regional water, greater flexibility in operations, and more opportunities to store water during wet periods for use in dry periods. This new regional water supply system, proposed under the Initial Draft Plan, will markedly enhance water supply to all water users in the Lake Okeechobee Service Area (LOSA), and the Everglades Agricultural Area, as well as the Service Areas of the lower east coast, above and beyond that provided by the 2050 base.

While water supply targets are largely met in these areas, and a distinct improvement is demonstrated by modeling results over the 2050 base, there is a marked improvement to the lake and the littoral zone as well. As discussed above, the lake receives adequate amounts of water to prevent prolonged low, and extreme low lake stage events under the Initial Draft Plan, relative to both the 1995 and 2050 base. For example, model results predict that the Lake Okeechobee stage will fall below 12 feet NGVD 30 percent of the time (during the 31 year simulation period) under the 2050 base, and 18 percent of the time under the existing conditions (1995 base). This is harmful to the lake littoral zone as over 90 percent of the littoral zone is dry under these conditions, removing spawning habitat, available wildlife habitat, and encouraging the spread of exotic plants such as melaleuca and possibly torpedograss. Under the Initial Draft Plan, lake stages fall below 12 feet NGVD only 9 percent of the time, and below 12 feet for a year or more only once in 30 years.

The Initial Draft Plan and the 2050 base both predict similar positive results for reducing the frequency of prolonged high and extreme high lake stage events which can be harmful to Lake Okeechobee, particularly in allowing the transport of nutrient rich limnetic waters into the relatively pristine littoral zone. Both the Initial Draft Plan and 2050 base model results forecast a one in ten year return frequency of extreme high lake stage events (>17 feet), which is an improvement over the one in five year return frequency predicted by the 1995 base. The Initial Draft Plan performs slightly better than the 2050 base in reducing the frequency of prolonged high lake stage events (>15 feet >1 year), which occur about 18 percent of the time over the simulation period, 7 percent less than the 2050 base, and 14 percent less than the 1995 base. It is reasonable to conclude that implementation of a new regional water supply system within and around the Lake Okeechobee basin, including the use of additional water storage reservoirs, stormwater treatment area, and lake aquifer storage and recovery, will result in noticeable hydrologic changes, and indirectly, in long-term ecological benefits to Lake Okeechobee beyond those demonstrated by both the 2050 and 1995 base conditions.

K.4.7 Socio-Economics

The following discussion will address affects on commercial navigation, agriculture production, urban areas around Lake Okeechobee, recreation and sport fishing, and commercial fishing. These are the principal socio-economic activities on and around Lake Okeechobee that may be affected by the project.

K.4.7.1 Commercial Navigation

According to a U.S. Army Corps of Engineers socio-economics report (1998), the Lake Okeechobee Waterway has an authorized project depth of eight feet based upon a lake stage of 12.56 feet NGVD. Lake Okeechobee levels above (or below) 12.56 feet NGVD will result in a corresponding increase (or decrease) in channel depths. Daily stage hydrographs for Lake Okeechobee indicate that lake stages, under the Initial Draft Plan, are usually higher than the 2050 base and with fewer extreme low lake stages, at or below the 12 foot and 11 foot thresholds, relative to the 2050 base, where one may begin to observe moderate effects to commercial navigation. In this sense then, the Initial Draft Plan is an improvement over the 2050 base, in reducing the occurrence of reduced waterway stages which could prevent ship passage, delay passage or induce reductions in average loads.

Stage duration curves for Lake Okeechobee support the premise that lake stages under the Initial Draft Plan are actually higher than under the 2050 base nearly 75 percent of the time, and higher than existing lake stage conditions about half the time. Moreover, when model results predict that lake stages, under the Initial Draft Plan, will be lower than the 2050 base, it occurs at high lake stages, generally at 14.75 feet NGVD and above, which would not affect commercial navigation. It is therefore reasonable to conclude that the Initial Draft Plan will not result in any negative effects to commercial navigation, and may result in intermittent benefits to navigation through a dampened frequency of extremely low lake stages where effects to navigation may be realized.

K.4.7.2 Agriculture Production

The agriculture community immediately surrounding Lake Okeechobee is a critical industry to the local and regional economy. Agriculture is dependent on Lake Okeechobee for irrigation water, particularly during dry periods and during drought. Farmers also back pump excess waters to Lake Okeechobee in order to maintain canals at adequate levels for flood protection and to provide drainage for their fields. Under the Restudy Initial Draft Plan, the new regional water supply system proposed under the Initial Draft Plan demonstrates a much improved ability to meet the agricultural community's needs in terms of water supply. Under the 2050 base case, model results predict 16 years, over the 31-year simulation, in which the LOSA will experience water restrictions of some magnitude. Usually this is defined as being under supply side management with cutbacks of at least 10 percent for a minimum of 7 days. The Initial Draft Plan improves this scenario substantially to just 5 years, over the 31-year simulation period, with the above described water restrictions. This is just 2 years over the target.

The use of 200 5-MGD aquifer storage and recovery facilities outside Lake Okeechobee is expected to provide a substantial amount of additional storage for lake water for use by the regional system. These facilities present several possible benefits in that they can store considerable amounts of water without taking large contiguous areas of valuable and expensive land out of production. Storage of water in a deep aquifer is not subject to evapotranspiration losses, although only a percentage of the stored water may be recoverable (estimated to be approximately 70 percent). Depending on the ultimate location and design of the proposed aquifer storage and recovery field, an unknown quantity of land would need to be purchased and committed to the building, operation and maintenance of these facilities. This is expected to permanently remove some land from agricultural production. However the benefits accrued by agriculture in terms of meeting future and increasing water supply needs, with a minimum of agricultural lands being directly effected, probably far outweigh the costs of permanently losing these lands from cultivation or other agricultural purposes.

Agriculture will also benefit from the enhanced flexibility in being able to draw supplemental irrigation water from the Everglades Agricultural Area storage facilities. No water supply shortage effects on agriculture are expected. The ability of the proposed regional water supply system to meet the water supply demand of agriculture, now and in the future, is nearly assured under the Initial Draft Plan, assuming all project features prove to be technically feasible and permittable by state and Federal agencies. The agricultural community perceives the conversion of existing water supply from Lake Okeechobee, to a combination of Lake Okeechobee, aquifer storage and recovery, and above ground storage reservoirs, as uncertain. It is reasonable to conclude, however, that no detrimental short or long term effect will be incurred by the agriculture community as a result of the inability of the project to function as a water supply and flood control facility.

K.4.7.3 Urban

The residential and commercial water users of the urban areas around Lake Okeechobee depend on lake water for wellfield recharge, drinking water, and industrial processes. As was discussed above, the Initial Draft Plan model results predict that Lake Okeechobee will far exceed the 2050 base (with its increased population and associated demand), in meeting water supply demands around Lake Okeechobee and among the service areas. This includes demands of the urbanized and municipal areas for drinking water, commercial, private and industrial uses. Flood protection is also maintained around Lake Okeechobee under the Initial Draft Plan. Flood protection criteria, described as the number of days, over the entire simulation period, the lake stage exceeds 16.5 feet during the August 1 to September 15 time period, is improved under the Initial Draft Plan (19 days), compared to the 2050 base (32 days) or the 1995 base (47 days). Also, the structural integrity of the Herbert Hoover Dike should not be compromised under the lake stages proposed in the Initial Draft Plan (as assessed from Lake Okeechobee stage duration curves). The residence time of high Lake Okeechobee levels (about 15 feet NGVD and above) predicted under the Initial Draft Plan, will actually be less as a percent of time equaled or exceeded at a given lake stage, than the 2050 and 1995 base conditions. The urban landscape surrounding Lake Okeechobee should therefore not be appreciably affected by either reduced water supply or a reduced level of flood protection as a result of the Initial Draft Plan.

K.4.7.4 Recreation and Sport Fishing

Recreation and sport fishing may indirectly benefit as a result of implementation of the Initial Draft Plan. Under the 2050 base, increased development pressure, and an increasing demand on the water supply, would have affected Lake Okeechobee by increasing the frequency of prolonged low and extreme low lake stage events. This alone would effect the recreation potential of Lake Okeechobee in the short term by reducing access to many areas of Lake Okeechobee, which are normally available by boat, air boat, canoe etc. In the long term, extreme low lake levels, and related ecological stress imposed on Lake Okeechobee by 2050 base demands, may have reduced available fish spawning habitat, spatially available wildlife habitat, as well as habitat quality due to encroachment by exotic plant species.

As discussed above, the Initial Draft Plan, substantially reduces the frequency of both prolonged low, and extreme low lake stages that cause the kinds of ecological stress described above. Furthermore, the Initial Draft Plan predicts a greater frequency of occurrence, relative to the 2050 base, of spring lake level recessions which have been documented to be productive for wading birds, and the overall quality, health and vigor of the native vegetation communities in the littoral zone. Thus, the ecosystem upon which much of the recreation and sport fishing is dependent, should be substantially restored under the Initial Draft Plan, as well as maintaining lake level conditions conducive to user access by recreation enthusiasts.

K.4.7.5 Commercial Fishing

No negative effects on the commercial fishing industry are expected as a result of the Initial Draft Plan. Lake Okeechobee levels predicted under the Initial Draft Plan, as described above, will not impede navigation of fishing boats, trawls, use of seines, or placement of traps. It is probable that the commercial fishing industry on the whole, and over the long term, are expected to benefit through a healthier, more sustainable commercial fishery as a result of improved fish spawning and reproductive success, greater available littoral habitat for forage production, and possibly enhanced food resources for commercial species.

K.4.8 Land Use

Up to three-quarters of the land area immediately around Lake Okeechobee, is used for agricultural production. In the immediate vicinity of Lake Okeechobee, agricultural lands are not expected to be negatively effected by implementation of the lake regulation schedule implemented under the Initial Draft Plan. Development and operation of 200 5-MGD aquifer storage and recovery facilities will remove some amount of land from future agricultural production purposes. No precise acreage figure is known at this time, as a location, or locations for the project, design features and specifications are not addressed under this conceptual comprehensive plan. Some agricultural production may be compatible with aquifer storage and recovery wells, as the structural components of the aquifer storage and recovery wells are expected to take up minimal lands above ground. Additional facilities required such as holding reservoirs, inflow-outflow conduits, and associated plumbing infrastructure etc. are not known at this time. Specific impacts relative to aquifer storage and recovery and its effects on agricultural land use will be addressed in future; tiered National Environmental Policy Act documents will be prepared specifically for this project feature. Above ground storage reservoirs to be located north of Lake Okeechobee and in the Everglades Agricultural Area, and their effects on agricultural land use, will be discussed in their respective physiographic regions (Kissimmee River and Everglades Agricultural Area regions).

K.4.8.1 Agricultural Land Use

There is no agricultural production in Lake Okeechobee. However, Lake Okeechobee has traditionally been the water supply source for surrounding agricultural areas including the Everglades Agricultural Area, Caloosahatchee Basin, St. Lucie Basin, and Big Cypress Reservation. Changes in the distribution of Lake Okeechobee water to supply the storage reservoirs and aquifer storage and recovery facilities will reduce the volume of lake water delivered directly to agricultural areas for supplemental irrigation by approximately 50 percent. Although the total supplemental irrigation supply for the agricultural areas will be increased through deliveries from storage reservoirs and aquifer storage and recovery facilities, this represents a major shift in water supply source.

Improvements to the ecology of Lake Okeechobee are achieved in the Initial Draft Plan by preventing extremely low lake levels. Storage reservoirs and aquifer storage and recovery wells proposed for locations near the lake provide the capacity to store excess water when it is available. These facilities then provide a water source to be pumped into Lake Okeechobee when the lake stage falls below a minimum level. Specific locations for the storage reservoirs and aquifer storage and recovery wells have not been determined, but they will most likely be placed on land now used for agricultural production. The storage reservoirs designed to supply Lake Okeechobee will occupy 30,000 acres in the Kissimmee River region and 60,000 acres in the Everglades Agricultural Area. The proposed aquifer storage and recovery facilities include 200 wells located near the Lake Okeechobee levee. These wells will require some land for construction, operation, and maintenance. It appears likely that more than 90,000 acres of land in the regions surrounding Lake Okeechobee will be taken out of agricultural production to improve conditions in Lake Okeechobee. In addition, the majority of this acreage will likely come from lands designated as unique farmland based upon their location, growing season, high value crops, and other factors (UFIFAS, 1982).

K.4.8.2 Urban Land

Implementation of the Initial Draft Plan should have no negative affect on the existing or future urban land use around Lake Okeechobee. As noted earlier, water supply to the LOSA is substantially improved over and above the 2050 base with its associated increased urban population, and user demand. Flood protection for the urban areas is also maintained into the future. It is reasonable to conclude, that urban lands surrounding Lake Okeechobee, including their future use, will benefit as a result of the Initial Draft Plan through a greater, more consistent source of water for urban and industrial use, including continued flood protection, beyond that projected in the 2050 base.

K.4.9 Recreation Resources

Lake Okeechobee hydroperiods under the Initial Draft Plan will modify the existing lake levels towards a more natural water level cycle as depicted by the daily stage hydrographs for Lake Okeechobee. The more natural and seasonal fluctuations, generally forecasted, should improve conditions for the lake's recreational fishing resources. The proposed construction of 200, 5-MGD aquifer storage and recovery wells and associated infrastructure will be located adjacent to the outside levee toe. The proposal will not affect recreation resources within the Lake Okeechobee region. Construction impacts would most likely be temporary and are not anticipated to adversely affect recreation resources in the region.

K.4.10 Aesthetic Resources

General forecasts of increasing public water supply demands under the 2050 base result in lower lake levels for longer duration throughout the year (K. Havens, 1998). These developments could expose more of the lake shoreline and result in the growth of successional or exotic species, nearshore erosion, and exposed mud and nearshore banks. Accessible, nearshore aesthetic resources could be negatively affected while panoramic aesthetics would remain largely unaffected. Water levels predicted under the Initial Draft Plan would maintain more natural lake levels most of the time, decrease prolonged low and extreme low lake stage events, and maintain the existing visual appeal of Lake Okeechobee.

The proposed construction of 200, 5-MGD aquifer storage and recovery wells and associated infrastructure located on the peripheral levee could affect aesthetic resources locally, depending on well and infrastructure siting. Local residents and visitors to the area could experience some temporary adverse aesthetic impacts during construction of aquifer storage and recovery wells. Long term, the aquifer storage and recovery facilities may pose a moderate detrimental effect on the overall aesthetics of the surrounding remnant natural areas behind the levee.

K.4.11 Unavoidable Adverse Environmental Effects

The following unavoidable adverse effects are expected to occur with implementation of the project features described above, which are expected to have an effect on the Lake Okeechobee physiographic region.

Land Use - The construction, operation and maintenance of 200 5-MGD Lake Okeechobee aquifer storage and recovery facilities will likely remove significant acreage of existing land from agriculture production, and possibly convert remnant wetlands around the outside of the Herbert Hoover Dike. While the exact extent, and nature of this land use impact is unknown, and some level of agricultural production may be compatible with aquifer storage and recovery facilities, some lands are expected to be permanently removed from their existing land use in order to accommodate these facilities. Likewise, with the construction of above ground storage reservoirs, and stormwater treatment areas, these facilities will take large tracts of agricultural lands out of production, and possibly remove the functional values of lesser amounts of wetlands, prairie, forested lands, or other natural areas.

K.4.12 Relationship Between Short Term Uses and Long Term Productivity

There is no project construction planned to take place within Lake Okeechobee proper, atop the Herbert Hoover Dike, or at any of the associated water control structures along the Herbert Hoover Dike. Construction of all 200 5-MGD aquifer storage and recovery well facilities may require several years to complete. This construction would involve a comparatively short-term use of resources within the project area, which has, as yet, not been sited. Several unavoidable effects such as disruption and dislocation of agricultural lands, wildlife habitat, wetlands and other resources are likely. Such adverse effects associated with these storage facilities will be minimized wherever possible, and aquifer storage and recovery facilities will be located and sited so as to cause the least adverse effect to the natural and social environment. Placement of the aquifer storage and recovery facilities near to the back toe of the Herbert Hoover Dike should minimize effects to agricultural lands as well as socio-economic impacts to urban areas and infrastructure. Above ground reservoirs will remove large areas of land from their current land use. Factors such as location of urban areas, regional and local infrastructure, wetlands, critical habitat for threatened and endangered species, and other unique or pristine natural areas will be avoided to the maximum extent possible. In the longer term, restoration of the dynamic water storage capacity of the region, without adversely affecting Lake Okeechobee's natural characteristics, are expected to enable the regional water supply system to restore and sustain the ecological values of Lake Okeechobee, and estuaries, including valuable commercial and sport fisheries, and wetlands resources critical to native fish and wildlife.

K.4.13 Irreversible and Irretrievable Commitment of Resources

Construction of the Lake Okeechobee aquifer storage and recovery facilities, and above ground storage reservoirs, necessary for the restoration of Lake Okeechobee and downstream estuaries, is such an expensive undertaking that full implementation of these project features would represent an irreversible and irretrievable commitment of resources. These resources would include state and Federal funding to purchase lands and labor, energy and project materials to build, operate, and maintain the project. Fish and wildlife habitat, located within the project footprint, particularly in the case of storage reservoirs, which would likely be inundated for much of the year, may be permanently altered and could represent a irreversible commitment of land and/or wetland resources.

K.4.14 Cumulative Effects

The restoration of Lake Okeechobee, the estuaries, the Everglades and the developed lands downstream, require substantially more storage in the headwaters of the system in order to provide for the correct quantity, quality, timing, and duration of flows. The land spatially occupying these headwater areas once provided these important functions to the regional system. Today, they are largely developed, drained, and ditched. The restoration of these important natural functions will require some reversal of the current trend in order to provide the retention area for holding, storing and treating water prior to being discharged downstream. Important areas north of Lake Okeechobee, within the Everglades Agricultural Area, within and around Lake Okeechobee will be committed to providing this lost storage for the overall gain and long-term benefit of the regional system. These project features, along with a restored Lake Okeechobee, able to provide important storage functions, is intrinsic to the overall restoration of the study area downstream. The commitment of tens of thousands of acres of land represents a huge investment in funding and land resources. It may also cause some adverse consequences locally, however the overall benefit to the regional system will be far greater than the localized adverse effects. As these features occur disparately across the landscape, within different hydrologic basins, and as distinct units rather than multiple features within a single watershed, they likely will not result in a detrimental cumulative effect.

K.5 UPPER EAST COAST AND INDIAN RIVER LAGOON

The Initial Draft Plan would add six surface water storage areas to the Upper East Coast subregion. Individual areas would range from 8,000-12,000 acres in size. These storage areas are conceptually planned for siting in the western parts of St. Lucie and Martin Counties, over mostly agricultural lands. The storage areas would capture local runoff from C-25, North Fork (St. Lucie River), C-24, C-23, C-44 and South Fork (St. Lucie River) catchment basins. The C-44 storage basin would capture local runoff and store it in a reservoir of about 10,000 acres, at 4 feet maximum depth. It would be operated to reduce flood flow to the estuary from this basin and provide fresh water during the dry season. The C25, North Fork, C-24, and C-23 storage areas would be located in each sub-basin. Storage requirements were 39,000 acres (total) at 8 foot depth. Water storage areas should improve water quality by inducing sedimentation and deposition of phosphorus out of the water column. The South Fork storage area would be about 10,000 acres at 4 foot depth. The exact location of these features is not known; however, they would be most beneficial if sited in the western part of Martin and St. Lucie counties (one in each drainage).

K.5.1 Vegetation

Nearly 50,000 acres of agricultural lands, with included wetlands and upland, would be converted to water storage areas under the Initial Draft Plan. Small amounts of upland forest (pine flatwoods) and wetlands might be included in the total acreage. These lands will be permanently removed from agricultural production, and are expected to develop emergent or floating vegetation, depending on depth. The 4 foot deep areas will function as emergent marsh and probably become dominated by cattails. The deep (8') reservoirs will become colonized by floating and rooted aquatic vegetation. Many of these sites are located near marginal wetlands that could be enhanced through active management or passively through seepage from the storage facility. The storage sites will remove sediments and some nutrients, particularly phosphorus. The shallower areas are expected to provide additional wildlife habitat and recreational values, as do the created marshes and water management areas in the headwaters of the adjoining St. John's River drainage (Indian River and Brevard Counties).

The Initial Draft Plan is expected to benefit the St. Lucie estuary and the southern Indian River Lagoon. It will nearly eliminate excessive and prolonged freshwater releases to the estuary that now occur after regionally heavy rainfall. It will increase desirable fresh water deliveries during the dry season. Reduction of sediment-laden, freshwater runoff will decrease the turbidity of estuarine water during the rainy season. In contrast, increased freshwater deliveries during the dry season will reduce the wide annual swings in water salinity that are believed responsible for sea grass die-offs. Clearer water and more stable salinity is expected to foster re-colonization of the bottom by benthic plants, especially shoal grass. In the southern Indian River lagoon (IRL), submerged aquatic vegetation (SAV) is also expected to benefit. The St. Lucie estuary is the most important source of fresh water into the IRL. Less frequent and extreme salinity fluctuations and a potential decrease in flocculent material should cause an increase in the cover and health of SAV in the area.

K.5.2 Fish and Wildlife

The wildlife now occupying the lands that would become water storage areas would be completely displaced to adjacent sites. No adverse effects on endangered, threatened or state special concern species are anticipated. It is expected that unknown numbers of common wildlife species will be displaced into adjoining areas when wetlands or uplands are flooded to provide surface water storage. This will unavoidably cause some mortality. Affected species likely would include white-tailed deer, opossum, raccoon, native mice, rats and rabbits, as well as many species of songbirds. This fauna would be replaced by fish, reptiles (alligator, turtles) and water birds. Siting of inland water storage areas over altered or agricultural lands will minimize adverse impacts on native wildlife. However, even agricultural lands provide some minimal wildlife habitat, which will be irretrievably converted to marsh or open water habitat. Foraging habitat will be created for some fish-eating birds in the shallow (4' deep) storage areas, including osprey, snail kite, and kingfisher.

If, as expected, the Initial Draft Plan restores estuarine conditions and permits the return of oysters and seagrass, substantial fish and wildlife benefits will occur. Both oysters and seagrass have a number of invertebrate and fish species associated with them that are either absent from the estuary or present in very low numbers. Once the habitats are restored fish and invertebrates that depend on these substrates should recolonize the area quickly. Past high discharge events have caused fish kills, fish lesions, invertebrate kills, and probably impacted spawning of a number of species. By reducing freshwater flow events outside the natural salinity envelope, the Initial Draft Plan should reduce stress on fish and wildlife of the estuary. A number of species utilize the area as a spawning, nursery, or juvenile area. Restoring the St. Lucie to estuarine conditions should re-create favorable spawning and nursery grounds for a number of important commercial and recreational species, including snook, red drum, spotted seatrout, tarpon, mangrove snapper and mullet.

As the health of the St. Lucie estuary increases as a result of plan implementation, a number of endangered species may benefit. Restored seagrasses will provide additional forage area for the manatee. Improved fisheries will be particularly beneficial to the wood stork and bald eagle.

K.5.3 Threatened and Endangered Species

Of the eighteen listed plant and animal species submitted by letter from the USFWS as likely to be affected by the C&SF Restudy, five are thought to occur within the affected area of the Upper East Coast and Indian River Lagoon. A brief description of affects to these Federally listed threatened and endangered species follows.

K.5.3.1 West Indian Manatee

Manatees, an endangered species, are known to frequent the Indian River Lagoon and migrate up major tributaries such as the St. Lucie canal. Within the Indian River Lagoon, they are highly dependent on seagrass beds for foraging. Implementations of the Initial Draft Plan will likely benefit seagrasses through improved overall water quality conditions, improved timing of deliveries and fewer high volume discharges, as is the case under the existing conditions. Under the 2050 base regulatory discharges from Lake Okeechobee and the Upper East Coast basin carry high loads of sediment and nutrients, producing turbid conditions within the lagoon, colors the water column, limiting light penetration to benthic biota, physically smothers some benthic organisms and seagrasses, and renders the estuarine waters fresh. Model results show that the frequency of regulatory discharges is drastically reduced under the Initial Draft Plan, and no discharges are made from Lake Okeechobee. Benefits to seagrass, coupled with the above hydrologic and biological improvements to water deliveries to the Indian River Lagoon and throughout the St. Lucie estuary is expected to benefit manatees.

K.5.3.2 Sea Turtles

Although not identified by the USFWS as likely to be affected by the Restudy, sea turtles, including the green turtle (*Chelonia mydas*) and the loggerhead turtle (*Caretta caretta*) may also be present along the Atlantic coast and near the mouth of the Indian River Lagoon. The green turtle is listed as endangered and the loggerhead as threatened by the USFWS. Both species are known to nest along Florida beaches, with highest nesting densities for green turtles occurring at Melbourne Beach, Hutchinson Island, and Jupiter Island, and for loggerheads between Brevard and Broward Counties (Moler 1992). It is doubtful that the Initial Draft Plan will have any real affect on foraging or nesting sea turtles which rarely frequent the inner lagoon waters and no effect on sea turtles or their habitat is anticipated.

K.5.3.3 Florida Scrub-jay

The Florida scrub jay is known to inhabit coastal upland areas with well-drained soils within the Upper East Coast. Their range extends inland from the coast to include about on quarter of the two county area. This area consists of the Atlantic Coast sub-region, an area of particular importance to scrub jays due to the presence of major sand deposits, which is an important habitat requirement. Since final siting of storage reservoirs has not yet been decided for the 10,000 acres of proposed storage under the Initial Draft Plan there is no definitive means of assessing impacts to this species at this time. It is anticipated however, that most of the reservoirs sites will be on agricultural lands, already developed for citrus groves and other crops which in all likelihood would have removed the necessary scrub jay habitat from these areas. No negative impact to this species is anticipated at this time. In any event, final siting of storage reservoirs within the Upper East Coast will need to consider potential impacts to this threatened species.

K.5.3.4 Eastern Indigo Snake

Indigo snakes, a threatened species are known to inhabit this region and often reside within burrows of gopher tortoises, which also inhabit sandy uplands within the region. Indigo snakes are also known to inhabit canal banks where they use crab holes as refuge. Some negative impacts to indigo snakes is probable due to the construction of storage reservoirs but the total impact will probably not be a significant.

K.5.3.5 Bald Eagle

The threatened southern bald eagle is known to inhabit and breeds within large areas of the Upper East Coast, particularly along the Indian River Lagoon. No negative affects to bald eagles or their habitat is expected at this time. However, final siting of storage reservoirs within the Upper East Coast will need to consider nest locations and possible affects to bald eagles due to the possible creation of "nuisance habitats". That is, the creation of open water habitat, which may attract foraging and/or nesting eagles, and due to water management priorities and downstream discharges, not be able to sustain them throughout the year.

K.5.3.6 Wood Stork

Endangered wood storks are also known to frequent and breed throughout the Upper East Coast. Two breeding sites are known in western St. Lucie County and one in western Martin County (Moler 1992). Some limited and localized negative affects to wood storks may occur (such as construction activities, blasting, earth moving equipment, noise etc.), but overall, significant improvements to wood stork habitat should result under the Initial Draft Plan. As with bald eagles, final siting of storage reservoirs within the Upper East Coast will need to consider wood stork rookery locations and possible affects to storks due to the possible creation of "nuisance habitats". That is, the creation of open water habitat, which may attract foraging and/or nesting storks, and due to water management priorities and downstream discharges, not be able to sustain them throughout the year.

K.5.4 Water Management

The proposed storage areas will significantly improve water management on the Upper East Coast. Water storage sites will allow localized rainfall runoff to be captured and used for flow augmentation to the St. Lucie estuary when needed during the dry season. The greatest benefit will come from storage of peak rainfall inside the basins, and reduced loss of this turbid, nutrient-laden water to tide. The Initial Draft Plan model output predicted that this alternative could significantly reduce basin high flow events (>1600 cfs over a 14-day period) as compared with the 2050 base. In fact, while the Initial Draft Plan did not completely meet the performance target, it reduced the frequency of high-flow discharges to the estuary by nearly 80 percent.

The principal changes in water management will be an increase of structures (levees, pumps, weirs and canals) associated with the storage areas and their operation. A fairly complex operation schedule will have to be designed and implemented to maximize the benefits of these storage sites. Movement of water into and out of the storage areas will be by pumps, which will require fuel to run and will be an additional source of noise to nearby areas.

K.5.5 Water Quality

The Initial Draft Plan includes several components specifically addressing ecological conditions in the Upper East Coast/Indian River Lagoon sub-region, including the St. Lucie River estuary. Furthermore, other regional storage features (e.g., North of Lake Okeechobee Storage reservoir, Caloosahatchee Basin Storage reservoir(s) with Aquifer Storage and Recovery System, Everglades Agricultural Area Storage Reservoir, Taylor Creek/Nubbin Slough Storage and Treatment Area, and Lake Okeechobee Aquifer Storage and Recovery System, see below) are expected to improve water quality conditions in the sub-region by contributing to the attenuation of flood discharges via the C & SF Project. Additionally, an “Other Project Element” (OPE) involves attenuation of C-25 Canal flows to improve water quality in the Indian River Lagoon.

Water quality conditions in the St. Lucie River and Indian River Lagoon estuaries are expected to be significantly improved as a result of the implementation of the following components:

North Storage reservoir, Kissimmee River watershed; regional system storage reduces flood discharges from Lake Okeechobee into St. Lucie (C-44) Canal;

C-44 (St. Lucie) Canal reservoir; attenuates C-44 basin runoff, reduces flood discharges into C-44 Canal;

Environmental water supplies to St. Lucie River estuary to achieve optimal salinity;

Caloosahatchee (C-43) Canal regional system storage reduces flood discharges into St. Lucie and Caloosahatchee Canals;

modified regulation schedule for Lake Okeechobee to provide increased environmental deliveries to the WCAs/Everglades National Park and reduce flood discharges to St. Lucie and Caloosahatchee estuaries;

Everglades Agricultural Area reservoir; regional system storage reduces Lake Okeechobee flood discharges into C-44 Canal;

Taylor Creek/Nubbins Slough storage and treatment; regional system storage reduces flood discharges from Lake Okeechobee into C-44 Canal; long-term net improvement of Lake Okeechobee water quality discharged into C-44 Canal;

Regional-scale aquifer storage of Lake Okeechobee water reduces flood discharges into C-44 Canal; water supply to St. Lucie River estuary upon recovery;

Surface water storage reservoirs totaling 27,200 acres in C-23, C-24 and C-25 Canal basins and 21,150 acres of storage in North Fork and South Fork basins of the St. Lucie River. The reservoirs provide regional storage volume totaling 349,400 acre-feet and are designed to prevent undesirable flood discharges to the St. Lucie River estuary.

Key water quality parameters of concern in this sub-region include nutrients, mercury, dissolved oxygen, pesticides, salinity, turbidity, coliform bacteria, and heavy metals. A substantial amount of the surface water storage area in the Initial Draft Plan (St. Lucie/C-44 Basin Storage Reservoir and C-23, C-24, C-25, North and Southfork Basins Storage Reservoirs, was developed specifically to prevent fresh water inundation of the St. Lucie River estuary consistent with salinity targets. It is expected that these surface water storage areas can be optimized to reduce nutrient and heavy metals concentrations and turbidity levels in inflows to the estuary. Nutrient reductions may also improve dissolved oxygen conditions by reducing biochemical oxygen demand (BOD). Attenuation of runoff should also reduce coliform bacteria concentrations in the estuary. Certain pesticide concentrations may also be reduced, depending upon pesticide forms (dissolved or particulate) and pesticide application practices in the watershed. It is not expected that increased surface water storage will affect mercury concentrations.

K.5.6 Water Supply

Of all the alternatives evaluated, the Initial Draft Plan came closest to attaining performance targets. The Initial Draft Plan components greatly decrease the amount of agricultural irrigation demands not met when compared with the 2050 base condition. The storage reservoir in the C44 basin accounts for a portion percentage of the decrease in the demand not met. The project elements will have no effect on urban demands.

K.5.7 Socio-Economics

Implementation of the Initial Draft Plan could provide minor economic benefits related to the boating and fishing industry. The restored St. Lucie Estuarine System should bring in an increase in recreation, thus causing an increase in revenue for the area, through increased use of boat ramps, bait and tackle sales, guide services and rentals.

K.5.8 Land Use

Implementation of the storage sites will cause direct land use changes in the Upper East Coast. About 60,000 acres of mostly agricultural lands, whose specific location is not known yet, are being targeted for siting surface water storage areas. Some of the agricultural activity in the area, especially citrus, has been on the decline and the land use could possibly have changed with or without the Restudy. However, lands acquired for surface water storage will be removed from the agricultural land base of St. Lucie and Martin Counties.

K.5.8.1 Agriculture

A 10,000 acre storage reservoir is proposed in this region to capture local runoff from the C-44 basin. An additional 48,350 acres of storage are proposed for the C-23, C-24, C-25, North Fork, and South Fork basins. These reservoirs are designed to attenuate flood flows to the St. Lucie estuary and provide water supply and water quality benefits. This represents a potential conversion of almost 60,000 acres from productive agriculture to storage reservoirs in an area designated as unique farmland. This total is approximately 12 percent of the area currently used for agriculture in the Upper East Coast region.

These reservoirs should, however, offer water supply benefits for agriculture in this region. Results of the South Florida Water Management Model indicate that irrigation demands not met would be reduced from 31.6 percent in the future without-project condition to 6.7 percent in the Initial Draft Plan. This would be a substantial improvement in water supply.

K.5.9 Recreational Resources

The proposed elimination of fresh water discharges to the St. Lucie and the Caloosahatchee Estuary except for emergencies would more closely resemble "natural conditions" prior to the existence of the canal system. The 2050 base would propose no such component. This component could improve seagrass cover and fisheries in estuarine areas, ultimately improving recreational fishing, boating, diving and bird watching.

The proposed construction of water storage reservoirs could potentially improve recreation resources in those locations, depending on several factors. The construction of gentle sideslopes could produce high quality fish and wildlife habitat. Water depths potentially occurring in some of these water storage reservoirs are known to sustain breeding, feeding, and growth for various fish. The stockpiling of some excavated material adjacent to the WSRs could provide access for bank fishing, bike riding, bird watching, and hunting or environmental interpretive recreation opportunities. The 2050 base plan would propose no such component.

K.5.10 Aesthetic Resources

The proposed construction of Water Storage Reservoirs in Martin and St. Lucie Counties could have an adverse affect on aesthetic resources depending on WSR design, location, construction and proximity to visual corridors and populated areas. Local residents and visitors could experience some temporary adverse aesthetic impacts during construction of the reservoirs. Temporary construction impacts would most likely return to pre construction conditions upon construction completion. The stockpiling of excavated material adjacent to the reservoirs could adversely affect visual resources within the component area. However, the reservoirs themselves would resemble natural marsh and lake areas, as observed from boundary levees. The marshy areas (4' deep) will undoubtedly attract waterfowl and provide many visual benefits. The deeper areas may develop game fisheries (bass and crappie) as other such water management areas have done. The 2050 base plan would propose no such benefit.

The proposed operational water delivery change to the St. Lucie Estuary via S-80 and C-44 could potentially improve aesthetic resources in the estuarine area by more closely duplicating historical salinity levels. This plan could improve underwater views of seagrass beds and associated wildlife for improved aesthetics.

K.5.11 Unavoidable Adverse Environmental Effects

The Initial Draft Plan, the Initial Draft Plan, has not quite reached the proposed salinity envelope targets for reduction of high flow, either from regulatory releases from Lake Okeechobee or from high flow basin runoff. These flows above the salinity envelope targets could have potential unavoidable adverse impacts to the St. Lucie and Indian River Lagoon estuaries, but these are reduced in comparison to existing (base 1995) or future (base 2050) conditions.

Storage areas will modify land use by converting land (agricultural land, wetland or upland forest) to open water. There will be a change in the dominant plant cover (from emergent or crop to floating aquatic) and dominant animal groups (common terrestrial wildlife to aquatic birds, reptiles, amphibians, fish and invertebrates).

K.5.12 Relationship Between Short Term Uses and Long Term Productivity

Construction of the storage facilities represents a significant short-term disruption to the environment, and possible unintentional direct and indirect environmental consequences. Short-term effects due to construction activities (clearing, grubbing, levee building, installation of structures, equipment noise, etc.) may be visually unpleasant and annoying to adjacent landowners. However, the storage areas will be sited in rural zones. Grading and restoration will improve the visual quality of the landscape when construction is finished, and adverse effects will be minimized wherever possible.

Once completed, vegetation would be expected to colonize over the levees and in the reservoirs. In addition, these modifications to the water management system will have a beneficial long-term and permanent effect on the St. Lucie Estuary and some of the wetlands in the associated watersheds.

K.5.13 Irreversible and Irretrievable Commitments of Resources

The proposed construction of storage sites, as described above, represents, in all likelihood, an irreversible and irretrievable commitment of land and monetary resources. These resources would include, in addition to the lands themselves, state and Federal funding, labor, energy and project materials and equipment to build the storage sites and the structures associated with the operation of these storage sites.

K.5.14 Cumulative Effects

Restudy project components are not expected to result in a cumulative negative effect on the environment of the Upper East Coast. Project components in the Upper East Coast, especially storage and on-site retention/detention, will act cumulatively to restore more natural freshwater flows to the St. Lucie Estuary, but should not result in negative environmental effects or effects unfavorable to the restoration of the natural environment.

K.6 EVERGLADES AGRICULTURAL AREA

This assessment will cover only those consequences realized within the Everglades Agricultural Area geographic planning region. The primary project feature of the Initial Draft Plan that would affect the hydrology and ecological sustainability of the Everglades Agricultural Area region is the introduction of a large above ground storage reservoir. This change will provide a substantial net increase in regional storage capacity, and reduce demands on Lake Okeechobee water. Features include an approximately 60,000-acre above ground storage reservoir, at a location to be determined. The reservoir will be divided into three compartments. Compartment 1 will cover 20,000 acres, with inlet capacities for excess runoff of 2,700 and 2,300 cfs, for the Miami Canal Basin and the North New River Basin, respectively. It will have outlet capacities of 3000 and 4400 cfs, for the Miami Canal Basin and the North New River Basin, respectively, to meet Everglades Agricultural Area water demands. Compartment 2A covers 20,000 acres and will be operated as a dry storage reservoir. Compartment 2B, also covering 20,000 acres, will be operated as a dry storage reservoir. Both compartments 2A & B will have inlet and outlet facilities.

K.6.1 Vegetation

Approximately 60,000 acres of agricultural lands would be converted to a water storage reservoir under the Initial Draft Plan. These lands will be permanently removed from agricultural production. It is difficult to predict what vegetative communities will be present in the individual cells of the new water storage areas, due to the unusual hydrologic patterns they will experience. These areas will act primarily as “surge tanks”, storing large amounts of excess water during wet periods and drying out completely during dry times. Alternating wet and dry conditions may last only a few days or may last for many months to more than a year, and water depth will vary widely, from 6 feet to only a few inches, depending on rainfall conditions and operational demands. These irregular hydrological patterns will certainly cause profound and widespread changes in wildlife habitats existing in these areas at the time of construction. Long periods of flooding would be expected to kill trees used as nesting sites by bald eagles, caracara and many other species, eventually destroying the nests and reducing available nesting substrates.

Under some conditions, large areas of habitat suitable for foraging wood storks, snail kites, bald eagles, and Audubon’s crested caracaras may be created. However, the USFWS is concerned that these areas would become “attractive nuisances” when temporarily favorable conditions are created, drawing in opportunistic wildlife species. Temporary favorable conditions could induce species such as wood storks, snail kites, bald eagles and others to nest nearby; but nesting success would depend on continued favorable foraging conditions. Short term success could produce artificially inflated populations of some species. When reservoir operations then cause a rapid change in conditions, widespread nesting failures and direct mortality of adult individuals could result due to loss of foraging resources. In addition, the rapid filling of storage areas that have been dry for extended periods would likely result in direct mortality due to drowning of less mobile species such as the eastern indigo snake.

K.6.2 Fish and Wildlife

Fish and wildlife resources inside the 60,000 acres water storage area would be directly affected by construction of the features recommended by the Initial Draft Plan. The wildlife now occupying the lands that would become a water storage reservoir would be completely displaced, exposing them to increased risk of mortality. No adverse effects on endangered, threatened or state special concern species are anticipated. It is expected that unknown numbers of common wildlife species will be displaced when wetlands or uplands are flooded to provide surface water storage. This will unavoidably cause some mortality. Affected species likely would include opossum, raccoon, native mice, rats and rabbits, as well as many species of songbirds. This fauna would be replaced by fish, reptiles (alligator, turtles) and water birds. Siting of the Everglades Agricultural Area water storage reservoir over altered or agricultural lands will minimize adverse impacts on native wildlife. However, even agricultural lands provide some minimal wildlife cover, which will be irretrievably converted to marsh or open water habitat. Foraging habitat will be created for some fish-eating birds in the reservoir cells as water levels recede to shallow (<4' deep) stages, including osprey, snail kite, and kingfisher.

K.6.3 Threatened and Endangered Species

Of the eighteen listed plant and animal species submitted by the USFWS as likely to be affected by the C&SF Restudy, two are thought to occur within the affected area of the Everglades Agricultural Area region. A brief description of effects to these state and federally listed threatened and endangered species follows.

K.6.3.1 Eastern Indigo Snake

The eastern indigo snake (*Drymarchon corais couperi*) could potentially be affected by construction of storage reservoirs and their associated facilities. No effect is anticipated at this conceptual level of planning. When definitive sites are identified and selected, it will be possible to determine precise impacts. The USFWS and the GFC classify the eastern indigo snake as a threatened species.

K.6.3.2 Wood Stork

The wood stork (*Mycteria americana*) is listed as an endangered species by the USFWS and the GFC. Wood storks forage in freshwater marshes, seasonally flooded roadside or agricultural ditches, narrow tidal creeks, shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. No adverse effect on the wood stork is anticipated due to construction of water storage facilities in this region. Under some conditions the water storage areas may provide suitable habitat for foraging wood stork. However, the USFWS is concerned that these areas would become “attractive nuisances” when temporarily favorable conditions are created, drawing in opportunistic wildlife species. Temporary favorable conditions could induce species such as wood storks, snail kites, bald eagles and others to nest nearby; but nesting success would depend on continued favorable foraging conditions. Short term success could produce artificially inflated populations of some species. When reservoir operations then cause a rapid change in conditions, widespread nesting failures and direct mortality of adult individuals could result due to loss of foraging resources.

K.6.4 Water Management

Under the Initial Draft Plan, all flood control releases to the St. Lucie and Caloosahatchee River estuaries are expected to be eliminated except pulse releases in zone A of the regulation schedule. Water managers will use a climate based inflow forecasting model, in conjunction with operational rules, which will help them decide when to pump water to the storage facilities outside the lake. When the model shows that lake water levels may rise above desirable levels for the littoral zone (14.35 feet to 14.75 feet), water will be pumped to the storage facilities in the Everglades Agricultural Area (one 20,000 acre compartment at 6 ft. maximum depth for supplying Everglades Agricultural Area irrigation demands and two 20,000 acre compartments at 6 ft. maximum depth for supplying environmental demands) with increased conveyance from Lake Okeechobee to the reservoir. The purposes are to improve timing of environmental deliveries to the Water Conservation Areas, including reducing damaging flood releases from the Everglades Agricultural Area to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands, and increase flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami, North New River, Bolles and Cross Canals between Lake Okeechobee and the Storage Reservoirs would be increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries. The two compartments (2A&B) are to be operated as dry storage areas with withdrawals being made down to 18" below ground level. They were also subdivided to allow for more efficient use of the reservoir and to facilitate alternative uses of the compartments during dry times (i.e., agriculture).

K.6.5 Water Quality

The Initial Draft Plan is expected to improve water quality conditions in the Everglades Agricultural Area. This conclusion is based on the premise that the existing Everglades Agricultural Area regulatory program (Florida Administrative Code Rule 40E-63), which has resulted in significant phosphorus load reductions in runoff from Everglades Agricultural Area farmland, will continue to be effectively implemented.

Phosphorus is the primary pollutant of concern in the Everglades Agricultural Area, especially as it affects ecological conditions in the downstream WCAs. The phosphorus load reduction target for the regulatory program is 25 percent. The three-year trend (for the period ending April 30, 1997) in total phosphorus loads originating from Everglades Agricultural Area farms indicates a 51 percent reduction compared to the 1979–1988 baseline period (SFWMD, 1998). Other pollutants of concern in the Everglades Agricultural Area include mercury, nitrogen compounds (NOx), dissolved oxygen, and pesticides.

The principal water quality benefit to the Everglades Agricultural Area resulting from the Initial Draft Plan is the conversion of approximately 60,000 acres of farmland, and concomitant elimination of attendant non-point source pollution loads to surface water storage. Water column mercury concentrations in the Everglades Agricultural Area are not expected to be affected by construction and operation of storage reservoirs.

Combined with the existing Everglades Agricultural Area regulatory program, the increase in storage volume on former farmland in the Everglades Agricultural Area will result in a net reduction of phosphorus and other non-point source pollutants in surface waters of the Everglades Agricultural Area compared to existing and future base conditions.

K.6.5.1 Effects of Initial Draft Plan on the Everglades Construction Project

Increasing hydraulic and phosphorus loads are predicted to affect the performance efficacy of the Everglades Construction Project. The Everglades Construction Project and Best Management Practices (BMPs) in the Everglades Agricultural Area comprise the primary water quality improvement strategy for the downstream WCAs.

For purposes of evaluating the future (2050) base condition and alternative plans, “Phase 2” treatment technologies necessary to meet water quality criteria adopted pursuant to the Everglades Forever Act, were assumed to be implemented. However, since the numeric treatment targets are not yet known, nor has the most appropriate supplemental treatment technology been selected, the potential impact of the future base and restudy alternatives on the design and operation of the Everglades Construction Project was evaluated in the context of the interim treatment targets defined in the conceptual plan for the Everglades Construction Project (Burns & McDonnell, 1994) and current design criteria for the Everglades Construction Project.

An evaluation of the effect of the future base condition and Restudy alternatives on the Everglades Construction Project was conducted by William W. Walker, Jr. (Walker, 1998). Walker’s evaluation indicates that, utilizing existing water quality data and the phosphorus settling rate constant and Everglades Agricultural Area BMP phosphorus load reduction assumptions used in the conceptual design for the Everglades Construction Project (Burns & McDonnell, 1994), the 31-year average hydraulic and phosphorus loads in the Initial Draft Plan cause the interim phosphorus concentration target (50 ppb) to not be met at Stormwater Treatment Areas 1W, 2, 5, and 6. This potential problem also exists for all of the stormwater treatment areas except Stormwater Treatment Area 1E in the 2050 base condition.

On the other hand, using the 51% observed average phosphorus reduction rate from 1995 to 1997 for the EAA BMP significantly changes the outcome. Walker observes that all STAs with the exception of STA 5, meet or exceed the interim phosphorus concentration target. STA 5 is the sole exception due to the hydrologic model not including the nearly 2,000 acre treatment area of STA 6 Section 2. Design of STA 6 Section 2 was not completed at the time this analysis was done. Changing other criteria such as the settling rate constant or the target outflow phosphorus concentration to that observed in the Everglades Nutrient Removal project over the 1995 to 1997 period would also significantly improve the STA performance models.

When compared to projected 2050 base conditions, the Initial Draft Plan is not predicted to worsen performance deficiencies predicted for the Everglades Construction Project. Significantly, the Initial Draft Plan improves the predicted performance at Stormwater Treatment Area 3\4. Stormwater Treatment Area 3\4 benefits from the proposed 60,000 acre Everglades Agricultural Area reservoir, acting as a net sink for phosphorus. Stormwater Treatment Area 1E is not predicted to be adversely affected by the future base or Initial Draft Plan flows.

The predicted performance deficiency at Stormwater Treatment Area 5 is caused by not including Stormwater Treatment Area 6, Section 2 as a future base condition or in any of the Restudy alternatives. Excluding Stormwater Treatment Area 6 Section 2 requires all of the C-139 basin runoff to be routed through Stormwater Treatment Area 5, thereby increasing the average hydraulic and phosphorus loads above the amounts for which it was designed.

The Everglades Construction Project is designed to treat one hundred percent of the runoff originating within the Everglades Agricultural Area for the 1979-1988 baseline period to an interim phosphorus concentration target of 50 ppb. The conceptual design for the Everglades Construction Project does not provide for any bypasses of 1979-1988 flows. The period of record utilized for evaluating alternatives during the Restudy was 1965-1995, a much longer and, on average, wetter period than the baseline period utilized to design the Everglades Construction Project. In addition, different operational rules (Rain-Driven Operational Rules,) were used to evaluate the effects of Restudy alternatives, including the Initial Draft Plan, on the Everglades Construction Project.

Nevertheless, using 1979-1988 hydrologic conditions, Walker's evaluation indicates that bypasses of the stormwater treatment areas are predicted to occur in the 2050 base condition. Furthermore, the amount of bypassing is predicted to increase over the 2050 base with implementation of the Initial Draft Plan. Bypass phosphorus loads to the WCAs are further increased when considering 1965-1995 average hydrologic conditions.

One preliminary conclusion is that if the Everglades Agricultural Area reservoir is constructed and operated as modeled in the Initial Draft Plan, the size of Stormwater Treatment Area 3\4 (the costs for construction and operation of that would be fully paid for by the state funding as provided for in the Everglades Forever Act) could be reduced. The interim phosphorus concentration target could still be achieved.

Furthermore, the beneficial effect of reservoir storage on stormwater treatment area function illustrated by Walker's evaluation suggests that splitting the 60,000 acres of storage area into other basins or delivering water from other basins would similarly benefit other stormwater treatment areas.

Third, supplemental treatment technologies designed to achieve low phosphorus concentrations (Phase 2) in discharges from the stormwater treatment areas consistent with the requirements of the Everglades Forever Act should be designed consistent with the average hydraulic and phosphorus loads inherent in the Initial Draft Plan. It should be noted that this conclusion is based on Walker's modeling results utilizing existing water quality data, operational rules (lake regulation schedule, etc.) for the 2050 base condition and the Initial Draft Plan, and the phosphorus settling rate (10.2 m/yr.) and the BMP load reduction (25 percent) assumptions used to develop the conceptual plan for the Everglades Construction Project (Burns & McDonnell, 1994).

However, the observed three-year trend in actual phosphorus load reduction resulting from implementation of Best Management Practices in the Everglades Agricultural Area is 51 percent (SFWMD, 1997), not the 25 percent assumed for the conceptual design of the Everglades Construction Project. Walker's evaluation further indicates that a 51 percent load reduction resulting from Best Management Practices enhances the performance of the stormwater treatment areas. Furthermore, observed performance at the Everglades Nutrient Removal stormwater treatment area demonstration project indicates that under certain conditions, vegetated stormwater treatment areas can be operated to achieve a higher settling rate and lower concentrations of phosphorus than the interim concentration target of 50 ppb (SFWMD, 1998). Increased phosphorus load reduction and an increased settling rate consistent with that observed at the ENR Project may negate the need to modify the size and/or operation of the stormwater treatment areas.

There are many uncertainties to be evaluated before more reliable predictions can be made about the impact of the recommended plan on phosphorus loading. They include the following: (1) how great a reduction in phosphorus loading will result from adoption of Best Management Practices in the Everglades Agricultural Area; (2) future Lake Okeechobee phosphorus concentrations; (3) net phosphorus settling rates in stormwater treatment areas; the effects of supplemental (Phase 2) stormwater treatment technologies; (4) the effects of bypasses of the stormwater treatment areas, and (5) the effects of operation schedules on the distribution of phosphorus loads. These issues will need further evaluation as the appropriate components of the Initial Draft Plan progress toward detailed design.

K.6.6 Water Supply

Under the Initial Draft Plan, large-scale storage would augment the regional water supply budget. The storage reservoir would improve the timing of environmental deliveries to the Water Conservation Areas. It would reduce damaging flood releases from the Everglades Agricultural Area, with their high nutrient loads, to the WCA's. The reservoirs would be used to meet supplemental agricultural irrigation demands within the Everglades Agricultural Area. Modifications to flow volume, timing and duration due to implementation of the Initial Draft Plan with its storage reservoirs in the Everglades Agricultural Area, will have significant positive benefits downstream through the Everglades Protection Area by contributing to a healthier Everglades system.

Water supply for supplemental irrigation to the Everglades Agricultural Area is substantially improved in the Initial Draft Plan over both the future without-project condition and the existing condition. The demands not met are reduced from 24 percent in the future without-project condition and 12 percent in the existing condition to 5 percent in the Initial Draft Plan. State of Florida House bill 715 specifies that the planning goal for water supply needs shall be based upon meeting the needs for a 1-in-10 year drought event. The South Florida Water Management Model shows the frequency of water restrictions would be cut from 16 years (restricted) out of 31, under the 2050 base (future without-project) condition to 5 years out of 31 in the Initial Draft Plan. Five years with restrictions is closer to the 1-in-10 year goal of 3 years of water restrictions over the 31-year model simulation period.

The change in water supply source, however, is a concern. This region has historically relied upon Lake Okeechobee for its supplemental irrigation water. Approximately 25 percent of the Everglades Agricultural Area irrigation supply will come from storage reservoirs in the Initial Draft Plan. The agricultural community is reluctant to rely upon reservoir technology that is new to this region for their water supply. The reservoirs will have to be completed and functioning before the Everglades Agricultural Area water supply from Lake Okeechobee is reduced, in order to prevent a potential water shortage.

The Initial Draft Plan does not address the soil subsidence issue in the Everglades Agricultural Area. Research is currently underway to develop sugarcane varieties and management practices to control subsidence (Glaz, 1995).

Higher water tables are a key factor in controlling subsidence. When more water-tolerant sugarcane varieties become available, the water supply needs within the Everglades Agricultural Area will increase, in an effort to maintain higher water tables. Adaptive management should enable modifications to the Initial Draft Plan to raise Everglades Agricultural Area water tables in order to preserve the valuable soil resource.

K.6.7 Land Use

Under the Initial Draft Plan the main existing land use to be impacted would be agriculture. The proposed above ground storage reservoirs would have a combined surface area of 60,000 acres. The proposed action would convert an undetermined, but significant amount of land currently in agricultural acreage or vacant, into open water.

K.6.7.1 Agriculture

Conversion of 60,000 acres of agricultural land to reservoirs would be an approximate 9 percent reduction of the area farmed in this region, which is designated as unique farmland. The first two 20,000 acre components are filled approximately 20 percent and 35 percent of the time, respectively; and they hold at least four feet of water approximately 50 percent and 40 percent of the time, respectively. The third compartment, however, is full only about 8 percent of the time, and holds at least four feet of water approximately 10 percent of the time. This is rather limited use to justify conversion of 20,000 acres of farmland. Options for continued agricultural production during dry periods in these reservoir compartments, particularly the third, should be pursued.

K.6.8 Recreation Resources

Overall, existing recreation resources in the Everglades Agricultural Area region would not be significantly adversely affected under the Initial Draft Plan. The proposed construction of 60,000 acre reservoirs to the depth of six feet should not adversely affect either existing or future recreation resources forecast under the 2050 base conditions in the Everglades Agricultural Area Region. The three-compartment reservoir, depending on the reservoir construction and placement of the excavated material, could enhance fishery resources in the region. If public access is permitted, recreational fishing, bird watching, and environmental interpretation could be developed. The 2050 base plan proposed no such component.

The proposed reduction of dryout periods in the northwest corner of the WCA 3A by increasing the capacity of pump station G-404 in the Everglades Agricultural Area Region should not adversely affect recreational resources in the region. The proposal should enhance water-dependent recreation resources in the WCA 3A area.

K.6.9 Aesthetic Resources

The main visual components of the C&SF Restudy in the Everglades Agricultural Area region are the low levees of the reservoirs, water control structures, and pump stations. These features are not unlike existing features in the region. The storage reservoirs would appear from a distance as areas similar to flooded agricultural fields or marsh. The project components do not include any tall structures that would interrupt the existing landscape profile. The Initial Draft Plan would not significantly affect aesthetic resources within the Everglades Agricultural Area.

K.6.10 Unavoidable Adverse Environmental Effects

The following unavoidable adverse effects are expected to occur with implementation of the project features described above, which are expected to have an affect within the Everglades Agricultural Area physiographic region.

Construction of a 60,000 acre above ground storage reservoir will take large tracts of agricultural lands out of production, and possibly remove the functional values of lesser amounts of wetlands, prairie, or other natural areas. There will be a change in the dominant plant cover (from emergent or crop to floating aquatic) and dominant animal groups (common terrestrial wildlife to aquatic birds, reptiles, amphibians, fish and invertebrates).

K.6.11 Relationship Between Short Term Uses and Long Term Productivity

Construction of the reservoir storage facilities represents a significant short-term disruption to the environment, and possible unintentional direct and indirect environmental consequences. Short-term effects due to construction activities (clearing, grubbing, levee building, installation of structures, equipment noise, etc.) may be visually unpleasant and annoying to adjacent landowners. However, the storage areas will be sited in rural zones. Grading and restoration will improve the visual quality of the landscape when construction is finished, and adverse effects will be minimized wherever possible.

Once completed, vegetation would be expected to colonize over the levees and in the reservoirs. In addition, these modifications to the water management system will have a beneficial long-term and permanent effect downstream throughout the Everglades Protection Area.

K.6.12 Irreversible and Irretrievable Commitments of Resources

The proposed construction of a 60,000 acre reservoir storage site represents, in all likelihood, an irreversible and irretrievable commitment of land and monetary resources. These resources would include, in addition to the lands themselves, state and Federal funding, labor, energy and project materials and equipment to build the storage site and the structures associated with the operation of these facilities. Fish and wildlife habitat, located within the proposed component footprint, would likely be inundated for much of the year, would be permanently altered and could represent a irreversible commitment of land and/or wetland resources.

K.6.13 Cumulative Effects

Restudy project components are not expected to result in a cumulative negative effect on the environment of the Everglades Agricultural Area physiographic region. Project components in the Everglades Agricultural Area region, especially reservoir storage, will act cumulatively to restore more natural freshwater flows to the Water Conservation Areas, Everglades National Park and ultimately to Florida Bay. To achieve restoration will require substantially more storage in the Everglades Agricultural Area region of the system, in order to provide for the correct quantity, quality, timing, and duration of flows. The land spatially occupying these Everglades Agricultural Area areas once provided these important functions to the regional system. Today, they are largely developed, drained, and ditched agricultural lands. The restoration of these important natural functions will require some reversal of the current trend in order to provide the retention area for holding, storing and treating water prior to its discharge downstream. The proposed project features, along with a restored Lake Okeechobee, able to provide important storage functions, are necessary to the overall restoration of the study area downstream. The commitment of 60,000 acres of land represents a huge investment in funding and land resources. It may also cause some adverse consequences locally, however the overall benefit to the regional system will be far greater than the localized adverse effects. The localized adverse effects will not result in a detrimental cumulative effect within the region.

K.7 WATER CONSERVATION AREAS

Within this physiographic region are contained the Arthur R. Marshall Loxahatchee National Wildlife Refuge (WCA 1), Water Conservation Areas 2 A, 2B, 3A, and 3B (collectively managed by the Florida Game and Fresh Water Fish Commission as the Everglades Wildlife Management Area), as well as the Holey Land Wildlife Management Area and Rotenberger Wildlife Management Area. Although the latter two areas are not, strictly speaking, a part of the Water Conservation Area system, for the purposes of organization of this report only, they have been included within the overall Water Conservation Area region.

The following is a discussion of affects to the largest contiguous area of historic Everglades outside Everglades National Park. The C&SF Project has compartmentalized the WCA's into several water conservation areas and water management areas through a large system of levees and canals. The assessment of effects to this region, presented below, is drawn largely from the Florida Game and Fresh Water Fish Commission, Fish and Wildlife Coordination Act Report, Part I, submitted to the Corps on August 6, 1998. This Coordination Act Report, and two additional Coordination Act Reports (Parts II-III) dated January 19, 1999 and February 19, 1999 respectively, are available in their entirety in Annex A.

K.7.1 Vegetation

The discussion of affects to existing vegetation is organized by the several different Water Conservation Areas, beginning with Water Conservation Area 1 in Palm Beach County, and proceeding southwards. Holey Land and Rotenberger Wildlife Management Areas are discussed last.

K.7.1.1 Water Conservation Area 1 (Arthur R. Marshall Loxahatchee NWR)

Current refuge management goals are to maintain present conditions, comparable to the 1995 base. Therefore, the Initial Draft Plan was formulated with the current water regulation schedule. Overall, Water Conservation Area 1 would be expected under the Initial Draft Plan to maintain marsh conditions favoring deeper water species such as snail kites and waterfowl, as well as substantial populations of marsh fishes. However, it is possible that a continuation of the existing schedule, which maintains deeper water in the southern part of the refuge, could lead to adverse effects on tree island communities and the wildlife that depend on them.

In Water Conservation Area 1 the number and duration of extreme low water conditions is reduced in the Initial Draft Plan, an improvement over the drier conditions predicted for the 2050 base. The number and duration of high water events are also reduced compared to the 2050 base, and meet the performance targets for extreme high water. There is some uncertainty about the effect of high water on tree islands in southern Water Conservation Area 1, however, overall, the proposed alternative conforms to current hydrologic management objectives for the refuge.

K.7.1.2 Water Conservation Area 2A

The marsh ecosystem in Water Conservation Area 2A has suffered substantial damage as a result of past water management. In the south, most of its tree islands have been lost to prolonged high waters (Dineen 1974), while many acres of northeastern Water Conservation Area 2A have been overtaken by cattails. The highest quality marsh occurs in central Water Conservation Area 2A in the vicinity of the 2-17 gage and to the northwest of the gage, where a small number of intact tree islands persist. Principal hydrological restoration needs are a reduction in over-drainage in the north and in extreme high-water events that have drowned tree islands in the south.

The Initial Draft Plan introduced operational changes that improved inundation patterns in the north, but in so doing increased the frequency of extreme drought conditions in the south. It appears that water management in Water Conservation Area 2A imposes tradeoffs between providing improved marsh conditions in some areas, but worse conditions in others. It is also possible that restoration of a more natural hydropattern in this portion of the Everglades is hampered by constraints imposed by water management elsewhere, notably the fixed regulation schedule in Water Conservation Area 1, that may be amplifying high and low water conditions in Water Conservation Area 2A. If Water Conservation Area 1 adopts rainfall based operational rules in the future, such unnatural fluctuations in depth may be alleviated.

In general, the Initial Draft Plan exhibited problematic performance in Water Conservation Area 2A compared to the 2050 base and it is uncertain whether these conditions would lead to a sustainable healthy marsh in the future. Generally, model results are poor in northern Water Conservation Area 2A and mixed in southern Water Conservation Area 2A. Inundation patterns in northern Water Conservation Area 2A were much longer. NSM predicts that northern Water Conservation Area 2A dried out approximately every year, yet the Initial Draft Plan predicted dry-outs to occur less than once every three years on average. In southern Water Conservation Area 2A, conditions were similar to NSM. Both southern and northern Water Conservation Area 2A failed to meet target values for extreme high water conditions. High water conditions in the north were similar to the 2050 base, but in the south, conditions were slightly worse. Although extreme high water events occurred only 1 percent of the time, the duration of those events was greater than NSMv.4.5 predictions. Extreme low water events were also reduced in the Initial Draft Plan compared to the 2050 base. The Initial Draft Plan showed four additional low water events over the period of record in the southern part of Water Conservation Area 2A, a situation that would not protect peat soils. Overall, northern Water Conservation Area 2A would have a very non-NSM-like hydropattern and southern Water Conservation Area 2A would have exaggerated extreme high water conditions and lengthy hydroperiods. Together, they create uncertainty about projected future marsh conditions in this area. It appears that there would be trade-offs between the northern and southern parts of Water Conservation Area 2A that may be solvable by operations. More detailed design is needed to determine if a balance can be achieved that promotes sustainable marsh conditions in both the north and the south.

K.7.1.3 Water Conservation Area 2B

Water Conservation Area 2B was one of the two most problematic regions in the northern and central Everglades from the standpoint of restoration to more natural hydrologic conditions. Although the overall hydroperiod in this area is similar to that in the NSM, all the alternatives exhibit too frequent extremes of high water, low water, or both. In the Initial Draft Plan, the occurrence of extreme high-water events is substantially less than it is in the 2050 base; however, there still remains a combination of frequent drought conditions and frequent extreme high-water events that occupy 16 percent of the total simulation period. Such frequent extremes imply that this area will not be able to function sustainably as either a shorter or a longer hydroperiod Everglades wetland.

Although Water Conservation Area 2B had good NSM-like inundation patterns as a result of the Initial Draft Plan, problems with extreme high water, extreme low water, or both, caused it to fail to meet the targets. The Initial Draft Plan reduced high water extremes over the 2050 base, but depths greater than 2.5 ft still occurred 10-11 percent of the time, far from the NSM value of 1 percent. Although the Initial Draft Plan shows significant improvement relative to the 2050 base, the frequent occurrence and long duration of extreme high and low water makes it unlikely that this area would function in a sustainable manner as either a shorter or longer hydroperiod Everglades wetland. More attention needs to be given to this area during detailed design.

K.7.1.4 Water Conservation Area 3A

The most dramatic improvement is in the southernmost part of Water Conservation Area 3A. Here the occurrence of extreme high-water events is reduced from 6 percent of time in the 2050 base, to only 1 percent of time in the Initial Draft Plan. These benefits are clearly owing to the removal of the L-29 levee along the southern boundary of Water Conservation Area 3A, since significant reduction in the intensity of flooding occurs only in the Initial Draft Plan and B, the two alternatives in which this levee is removed. On the other hand, although extreme depths are largely eliminated from southern Water Conservation Area 3A, the overall hydroperiod of the area is increased, with periods of inundation that are much longer than those predicted by the NSM. These extended hydroperiods are most pronounced in the area immediately to the south of Alligator Alley. Here the model predicts only 11 marsh dryouts during the 31-year simulation, as compared with 18 events in the 1995 base and 24 events in the NSM. This lengthening of hydroperiods is a result of the relocation and increased operational capacity of the S-140 structure, which leads to greatly increased discharges directly northwest and upstream of south-central Water Conservation Area 3A (near to Alligator Alley). Hence, although the reduction in predicted tree island flooding would be a dramatic step toward ecological restoration of southern Water Conservation Area 3A, the ecological effects of a general shift toward longer hydroperiods is uncertain.

In the region to the east of the Miami Canal, the performance of the Initial Draft Plan is problematic. In addition to uncertainty about the effect of hydrologic changes on rookery vegetation in this region, the Initial Draft Plan also predicts that northeastern Water Conservation Area 3A will continue to experience drought conditions frequently enough to raise concern about continued impacts to peat soils.

The Initial Draft Plan makes substantial progress toward remedying the two most significant causes of habitat degradation in Water Conservation Area 3A. The first of these is flood damage to tree islands, with attendant loss of upland tree species, willow strands in northeastern Water Conservation Area 3A, and tropical hardwood hammocks in southwestern Water Conservation Area 3A. The second major cause of habitat degradation has been the destruction of peat soils, marsh vegetation, and tree islands as a result of wildfires brought on by drought conditions in the north. Together, the reduction in the frequency and intensity of these two sources of environmental damage should be expected to lead to substantial restoration within this large portion of the remnant Everglades ecosystem.

Nevertheless, there continues to be uncertainty about several aspects of the predicted hydrologic change. First, the ecological effect of prolonged inundation periods on the overall functioning of the Everglades ecosystem is not known. Comparison of predicted hydroperiods for the overall Water Conservation Area 3A region indicates that the entire landscape will, on average, be shifted toward inundation duration's that are longer than those predicted by the NSM. Second, it is uncertain whether hydropattern restoration will lead to cattail proliferation in the north, as a possibly inevitable consequence of antecedent soil conditions and changed topography.

Northwestern Water Conservation Area 3A performed better under the Initial Draft Plan than the 2050 base on all performance measures. In the Initial Draft Plan, inundation patterns match NSM planning targets, high water extremes are minimal and low water extreme events are much improved over the 2050 base. There remains some concern that the area just north of Alligator Alley, and west of the Miami Canal, within north Water Conservation Area 3A may still be likely to experience more extreme low water than will be sufficient to protect peat soils. However, it may not be possible to further reduce low water events without causing trade-offs such as increased risk of cattail proliferation in ponded areas.

Northeastern Water Conservation Area 3A would have a problem with a tendency toward both too frequent high and low water conditions that would not be completely solved by the Initial Draft Plan. For inundation pattern, the Initial

Draft Plan was close to NSM target values. The frequency of high water events is greater than in the 2050 base. This increase raises concerns about potential negative effects on wading bird nesting habitat in this region. Changes in stormwater treatment area operations, additional storage, or re-routing of floodwaters might alleviate or reverse this negative impact for some rookery sites. Low water events are a problem whenever protection of peat soils is desired and the best target for this area is the one with the fewest extreme low water events. For extreme low water events, the 2050 base had fewer events than NSM, although the duration of the events is same. The Initial Draft Plan did better than NSM targets, but had a few more events than the 2050 base. While the Initial Draft Plan performed the best of the alternatives in reducing low water extremes relative to 2050 base case, the predicted frequency and duration of low water events still seems large and may not ensure protection of peat soils.

None of the alternatives approached NSM targets in eastern Water Conservation Area 3A (just north of Holiday Park). The area east of the Miami Canal and south of Alligator Alley is deeply ponded in the 2050 base. High water extremes are most notable in this area. High water extremes in the Initial Draft Plan are still far from matching the NSM target of 0 percent high water. This may be the result of changes in operations and retention of a portion of the L-67A Canal, which allows more rapid removal of water from this area. Overall, the eastern Water Conservation Area 3A is far from reaching its target values. However, unlike the predictions for Water Conservation Area 2B, extreme high water is not combined with an increased frequency of extreme low water events.

In central and southern Water Conservation Area 3A, the Initial Draft Plan performed reasonably well by reducing the frequency of high water events, thereby eliminating flooding of tree islands during high rainfall years. While the Initial Draft Plan showed increased inundation duration's, with fewer marsh dryouts than NSM, especially within central 3A, it meets the important target for tree island communities because of the greatly reduced frequency of extreme high water events.

K.7.1.5 Water Conservation Area 3B

Water Conservation Area 3B is the second of two remaining high quality marsh areas within the northern and central Everglades, the other being central Water Conservation Area 3A. Although generally drier than it was prior to construction of the C&SF Project, the area is characterized by good water quality and intact wet prairie and sawgrass communities and hardwood hammock and bayhead tree islands. Southeastern Water Conservation Area 3B is part of the pre-drainage channel of Shark River Slough. Although it is substantially drier, at least in its southeastern reaches, than in pre-drainage estimates, and has suffered significant soil loss in this area, tree islands have been largely unimpacted by flood, drought, or human activity. Overall, the Initial Draft Plan leads to an inundation and depth pattern in Water Conservation Area 3B that more closely matches NSM predictions for mid-Shark River Slough than it does for Water Conservation Area 3B itself. This pattern represents a substantial deviation from both current conditions in Water Conservation Area 3B and from NSM predictions of the predrainage hydrology. Hence, although the Initial Draft Plan appears likely to prevent damage to higher hammock tree islands in Water Conservation Area 3B, impacts on less elevated tree islands still may occur.

In the central region of Water Conservation Area 3B, the Initial Draft Plan predicts fewer drydowns and longer periods of inundation than the 2050 base. The effect of very lengthy periods of inundation on Water Conservation Area 3B is uncertain. The Initial Draft Plan significantly reduced the frequency of events enough to prevent damage to higher hammock tree islands, but impacts on less-elevated tree islands may still occur. For extreme low water events, the Initial Draft Plan had either a few more events or events of slightly longer duration than the NSM targets. Given the removal of the eastern portion of L-29, combined with the restoration of long hydroperiods and deeper water in Northeast Shark River Slough, it appears inevitable that water depths and inundation duration's in Water Conservation Area 3B would increase.

K.7.1.6 Holey Land Wildlife Management Area

Comparison of the Initial Draft Plan to the revised 1995 and 2050 bases is not realistic, because the revised bases modeled a 0 to 2-foot regulation schedule that has been abandoned and is unlikely ever to be reimplemented in the future within the Holey Land Wildlife Management Area. For this reason, the interpretation of the Initial Draft Plan for Holey Land Wildlife Management Area must be made by comparing performance to the unrevised 1995 base, which assumed a 0 to 1-foot regulation schedule more like that which is currently in use. When this comparison is made, the performance of Holey Land Wildlife Management Area in the Initial Draft Plan is overall similar to the revised 1995 base. Advantages of using the rainfall based operations, as opposed to the fixed schedule in the 1995 base, cannot be discerned at the level of resolution of the SFWMM. Drought conditions still occur during about 3 to 4 percent of the simulation period in the Initial Draft Plan. The minimum depths and durations needed to protect peat soils are still not well understood, but as long as the plan provides for dry season deliveries of adequately treated water via the stormwater treatment areas, it should be possible to adjust operational details so as to avoid further soil loss.

K.7.1.7 Rotenberger Wildlife Management Area

Predicted conditions are largely consistent with overall current management goals for Rotenberger Wildlife Management Area. These goals are the restoration of natural hydropatterns; the avoidance of extreme high-water events that would drown remaining tree islands and promotes cattail proliferation; and the prevention of extreme drought conditions that cause soil oxidation and risk of muck fires. The model results show a reduced frequency of drought conditions (when the water table drops to more than one foot below the ground surface) relative to the 2050 base. However, drought conditions still occur during about 3 to 4 percent of the simulation period in the Initial Draft Plan. The minimum depths and duration's needed to protect peat soils are still not well understood, but, so long as the plan provides for dry season deliveries of adequately treated water via the stormwater treatment areas, it should be possible to adjust operational details so as to avoid further soil loss.

K.7.2 Fish and Wildlife

Presented below is a discussion of affects to fish and wildlife resources within the Water Conservation Area region where they are expected to occur under the Initial Draft Plan.

K.7.2.1 Water Conservation Area 2A

The ability of the Initial Draft Plan to support appropriate densities of Everglades fish and wildlife within Water Conservation Areas 2A and 2B will depend strongly on the results of detailed project design and the operational rules that accompany it. On the one hand, it is possible that water management could promote protection of remaining tree islands in northern Water Conservation Area 2A along with recovery of previously damaged islands in southern Water Conservation Area 2A. Such protection would provide nesting areas for wading birds and reptiles, as well as improved wading bird foraging habitat. On the other hand, it is also plausible that extremes of high and low water could result in soil loss in southern Water Conservation Area 2A, deterioration of remaining tree islands, and spread of cattails throughout the north.

K.7.2.2 Water Conservation Area 2B

Similarly, the deep water in Water Conservation Area 2B might support fish and apple snail populations and provide refuges for aquatic organisms during all but the most extreme dry periods. However, if water management in this area allows Water Conservation Area 2B to dry out for extended periods, it will not be able to serve such ecological functions.

K.7.2.3 Water Conservation Area 3A

Based on ATLSS fish model results, the Initial Draft Plan hydrologic conditions should produce higher average fish abundance compared with the 2050 base, as expected hydroperiods increase consistent with NSM. In particular, increased hydroperiods in northeast Water Conservation Area 3A should lead to greater fish abundance. This should also be true when only prey-sized fish at appropriate wading bird foraging depths are counted.

The region to the east of the Miami Canal is the area that has had the most successful wading bird nesting in recent years, although rookery vegetation was substantially damaged by the high water event of 1994-95 (T. Towles, GFC, pers. comm.). The performance of the Initial Draft Plan is problematic in this area. In the northeastern region, north of Alligator Alley, the frequency of extreme high water events is higher than it is in the 2050 base, and simulated depths and duration's during the high rainfall years of 1994-95 are worse than in the 1995 base. This increase in predicted flooding raises concerns about potential negative effects on wading bird nesting habitat in this region, which already suffered damage during the 1995-96 high water event. The problem in the Initial Draft Plan appears to be caused by excess discharges from Stormwater Treatment Area-3/4 during high rainfall years. In contrast, to the south of the 3A-3 gage, northeastern and eastern Water Conservation Area 3A are predicted to experience reduced depths and flooding compared to the 1995 base. Since eastern Water Conservation Area 3A has suffered from extreme high water events in recent years, rookery sites in eastern Water Conservation Area 3A might be expected to do better under the Initial Draft Plan than under current conditions. The Initial Draft Plan makes substantial progress toward remedying flood damage to willow strands that serve as wading bird nesting sites in northeastern Water Conservation Area 3A. Tropical hardwood hammocks in southwestern Water Conservation Area 3A, and habitat throughout the Water Conservation Area for island dependent organisms such as nesting reptiles, white-tailed deer, and migratory and nesting songbirds.

Since ATLSS wading bird results are not available for the Initial Draft Plan, predicted effects to wading birds must be inferred from the ATLSS high resolution hydrology results and other sources. A review of performance measures for Water Conservation Area 3A shows that the Initial Draft Plan, compared to the 2050 base, provides mixed results for wading birds in Water Conservation Area 3, with improvements in southern Water Conservation Area 3A (due to reduced high water) and in northern Water Conservation Area 3A (due to reduced drydowns), and losses in northeastern Water Conservation Area 3B (due to increased high water).

However, it is difficult to predict how wading bird nesting and foraging will be affected by changes in depth patterns in northeastern Water Conservation Area 3A. The more northerly parts of this area (represented by model output for the 3A-4 gage) are predicted to become wetter, while to the south, areas east of the Miami Canal will remain deeper than the NSM values, but will have much reduced high water frequencies compared to the 1995 base. These conditions could be expected to improve suitable rookery sites in some areas, but could possibly damage others; and the distribution of suitable foraging areas will undoubtedly be changed. Although overall restoration of the Everglades watershed is expected to improve nesting habitat for wading birds regionally, the timing of development of suitable breeding sites to the south, relative to changes in current nesting sites, could have significant effects on regional wading bird populations. A more detailed analysis of anticipated effects of the Initial Draft Plan on wading bird breeding and foraging habitat, combined with a plan for system-wide monitoring, will be important components in implementing the plan.

ATLSS white-tailed deer results are also not available for the Initial Draft Plan, so predicted effects on deer must be inferred from the ATLSS high resolution hydrology results and other sources. A review of performance measures for Water Conservation Area 3A indicator regions shows that the Initial Draft Plan reduces many of the excessive high water conditions and excessive inundation duration's that had caused concern for eastern Water Conservation Area 3A and southern Water Conservation Area-3A in several previous alternatives. Overall, increased hydroperiods in most of the Water Conservation Areas under the Initial Draft Plan as compared to the 2050 base would likely slightly decrease habitat quality in these marginal deer habitats. Small areas of northeastern and southern Water Conservation Area-3A are exceptions.

K.7.2.4 Water Conservation Area 3B

Under the Initial Draft Plan, Water Conservation Area 3B is neither restored in an historical sense, nor is its current ecological value conserved. Overall, the Initial Draft Plan makes flooding in Water Conservation Area 3B deeper and longer lasting than predicted by the NSM. This pattern represents a substantial deviation from both current conditions in Water Conservation Area 3B and from NSM predictions of the predrainage hydrology. It is doubtful that Water Conservation Area 3B could tolerate much deeper conditions than those seen in the Initial Draft Plan without causing a net degradation in fish and wildlife resources in this area.

Based on the ATLSS fish model results, the Initial Draft Plan hydrologic conditions should produce higher average fish abundances compared with the 2050 base, as expected hydroperiods increase consistent with NSM. In particular, increased hydroperiods in Water Conservation Area 3B should lead to greater fish abundance. This should also be true when only prey-sized fish at appropriate wading bird foraging depths are counted, except for the deepest parts of Water Conservation Area 3B.

Since ATLSS wading bird results are not available for the Initial Draft Plan, predicted effects to wading birds must be inferred from the ATLSS high resolution hydrology results and other sources. A review of performance measures for Water Conservation Area 3B shows that the Initial Draft Plan reduces many of the excessive high water conditions and excessive inundation duration's that had caused concern for Water Conservation Area 3B in several previous alternatives. When compared to the 2050 base, the Initial Draft Plan provides mixed results for wading birds in Water Conservation Area 3, with losses in Water Conservation Area 3B due to increased high water.

ATLSS white-tailed deer results are also not available for the Initial Draft Plan, so predicted effects on deer must be inferred from the ATLSS high resolution hydrology results and other sources. A review of performance measures for Water Conservation Area 3B indicator regions shows that the Initial Draft Plan reduces many of the excessive high water conditions and excessive inundation duration's that had caused concern for Water Conservation Area 3B in several previous alternatives. Overall, increased hydroperiods in most of the Water Conservation Areas under the Initial Draft Plan as compared to the 2050 base would likely slightly decrease habitat quality in these marginal deer habitats.

K.7.3 Threatened and Endangered Species

The preliminary biological opinion of the USFWS transmitted by letter dated August 7, 1998, and certified as the final biological opinion on March 1, 1999 under provisions of the Endangered Species Act included the following determinations concerning effects of the Initial Draft Plan on listed species occurring in the Water Conservation Areas.

K.7.3.1 Effects on Listed Species

The snail kite would likely be slightly benefited overall by the proposed action through improved quality in foraging habitat and a reduction in high water damage to nesting substrate. Although these beneficial effects would slightly improve the species' chances for recovery, the proposed changes are not beneficial in all areas; some areas will likely be improved, while others will be degraded. Therefore, sequencing of project elements will be crucial in ensuring that improved habitat quality is already available to offset anticipated losses in other areas. This will give the species time to adjust to the changing landscape with a low level of risk. The wood stork should be benefited overall due to improved timing and volume of water flow that should substantially increase nesting success, particularly in the estuarine areas of Everglades National Park, adjacent to Florida Bay. The proposed action may adversely affect the bald eagle and indigo snake, but the level of adverse effect is not likely to jeopardize the continued existence of these species.

K.7.3.2 Effects on Critical Habitat

The action would not likely adversely modify designated Critical Habitat for the snail kite. There is no other designated Critical Habitat in the Water Conservation Areas.

K.7.4 Water Management

Water management within the Water Conservation Area region has been substantially modified under the Initial Draft Plan, particularly in Water Conservation Areas 2 and 3. Management of flows to and from the Arthur R. Marshall Loxahatchee NWR (WCA 1) will remain unchanged from existing water management operations.

K.7.4.1 Water Conservation Area 2

The Initial Draft Plan introduced operational changes in Water Conservation Area 2A that improved inundation patterns in the north, but in so doing increased the frequency of extreme drought conditions in the south. It appears that water management in Water Conservation Area 2A imposes tradeoffs between providing improved marsh conditions in some areas but worse conditions in others. It is also possible that restoration of a more natural hydropattern to this portion of the Everglades is hampered by constraints imposed by water management elsewhere, notably the fixed regulation schedule in Water Conservation Area 1 that may be amplifying high and low water conditions in Water Conservation Area 2A. If rainfall based operational rules are adopted for Water Conservation Area-1 in the future, such unnatural fluctuations in depth in Water Conservation Area 2A may be alleviated.

The overall most significant component affecting performance in Water Conservation Areas 2A and 2B is the Central Lake Belt storage facility, which takes water from southern Water Conservation Area 2B (as well as from eastern Water Conservation Area 3A and 3B) and routes it to the Central Lake Belt reservoir for later delivery to Everglades National Park or other areas. This design leads to continued flow through and a very different set of water management issues than those of the present C&SF Project. Rather than exhibiting high water in the south combined with over-drainage in the north, as is currently the case in all of the Water Conservation Areas, the Initial Draft Plan predicts longer hydroperiods near the Stormwater Treatment Area 2 input in the north, increased drying in the south, and accumulation of water at the "bottom" in Water Conservation Area 2B. As a result, those areas that most closely match hydrologic performance targets are those nearest to the locations of gages that trigger inflow/outflow operations. A more detailed study of the effects of different operational rules will be needed in order to identify the ecologically most beneficial method of water management for this region.

K.7.4.2 Water Conservation Area 3

A number of components in the Initial Draft Plan lead to significant predicted changes in hydrologic conditions in Water Conservation Area 3A. Those components having the most direct effects on the conservation area are: (1) the changes in the location and magnitude of water deliveries along the northern and western boundaries; (2) the Central Lake Belt reservoir and its operation; (3) the L67-A canal and levee changes; and (4) the removal of the L-28, L-28 tieback, and L-29 levees.

The Initial Draft Plan came closest to providing conditions that are more NSM-like throughout WCA 3. The natural slope of the land directs water toward the eastern boundary of Water Consesrvation Area 3A and Water Conservation Area 3B. A persistant problem in all the alternatives was that water tended to pond on the eastern sidees. Only D-13R came close to solving this problem. It did so by using a combination of 1) using the L-67A canal to speed flows south, 2) removing the L-28, L-28 Tieback, and L-29 to restore flows, and 3) developing a conveyance system east of the L-30 and L-33 levees (including the Central Lake Belt) to compensate somewhat for loss of the eastern Everglades. While depths and inundations increase in the eastern Everglades in the Inditial Draft Plan, conditions are not as extreme as earlier plans and hydropatterns resemble an Everglades slough system. In addition, the Initial Draft Plan predicts a lower frequency of extreme high water events than that predicted for the 2050 base, although 2050 base conditions in Northeast Shark River Slough are far drier than their restoration targets.

K.7.4.3 Holey Land Wildlife Management Area

The principle hydrological restoration needs for the Holey Land Wildlife Management Area are: the provision of clean water during both wet and dry seasons, in quantities suitable to provide natural hydropatterns; the avoidance of extreme high water events that would drown remaining tree islands and promote cattail proliferation; the gradual increase in hydroperiods and water levels over time until a final hydrologic regime is implemented and; the prevention of extreme drought conditions that cause soil oxidation and risk of muck fires. Although the Restudy alternatives do not include significant structural alterations to the Holey Land Wildlife Management Area, the Initial Draft Plan contains some potentially beneficial components, including: (1) an inflow/outflow operational schedule that would deliver water to the Holey Land Wildlife Management Area during dry as well as wet seasons; and (2) rainfall based operational rules that provide for natural depth variations, but with high and low limits imposed to prevent extreme flood or drought conditions; and (3) improvement of additional outflow structures in Holey Land Wildlife Management Area as needed to support the outflow operations. The overall performance of the Initial Draft Plan appears to be largely satisfactory in the Holey Land Wildlife Management Area.

K.7.4.4 Rotenberger Wildlife Management Area

The principle hydrological restoration needs for this area are: the provision of clean water during both wet and dry seasons, in quantities suitable to provide natural hydropatterns; the avoidance of extreme high water events that would drown remaining tree islands and promote cattail proliferation; and the prevention of extreme drought conditions that cause soil oxidation and risk of muck fires. Although the Restudy alternatives do not include significant structural alterations to this Wildlife Management Area, the Initial Draft Plan contains some potentially beneficial components, including: (1) an inflow/outflow operational schedule that would deliver water to the Rotenberger Wildlife Management Area during dry as well as wet seasons; and (2) rainfall based operational rules that provide for natural depth variations, but with high and low limits imposed to prevent extreme flood or drought conditions. The overall performance of the Initial Draft Plan appears to be largely satisfactory in the Rotenberger Wildlife Management Area.

K.7.5 Water Quality

The below discussion is excerpted from an analysis of water quality affects on the Water Conservation Area region conducted by the U.S. Environmental Protection Agency, and Florida Department of Environmental Protection (FDEP).

K.7.5.1 Water Conservation Areas

The primary pollutant of concern in the Water Conservation Areas and Rotenberger and Holeyland Wildlife Management Areas is phosphorus. A principal assumption for purposes of evaluating the effect of the Initial Draft Plan on water quality in the Water Conservation Areas is that the Everglades Forever Act is fully implemented, and that all discharges into Everglades Protection Area comply with all water quality criteria, including the yet-to-be-established phosphorus criterion. Accordingly, the evaluation focused upon projected increases and decreases of structural flows into the Water Conservation Areas.

Other pollutants/constituents of concern in the Water Conservation Areas and Rotenberger and Holeyland Wildlife Management Areas include nitrogen compounds (NOx), dissolved oxygen, conductivity, and mercury.

Many of the components of the Initial Draft Plan are designed to achieve hydrologic targets in Loxahatchee National Wildlife Refuge (Water Conservation Area 1) and Water Conservation Areas 2 and 3 and downstream in Everglades National Park and Florida Bay. Generally, these components are to be operated to increase the volume of water delivered into and retained in the Water Conservation Areas and to optimize the timing of those deliveries. The following components are expected to affect hydrologic conditions in the Water Conservation Areas and downstream in Everglades National Park/Florida Bay:

Modified regulation schedule for Lake Okeechobee to provide increased environmental deliveries to the Water Conservation Areas and Everglades National Park;

Rain-driven operations in Water Conservation Areas 2 and 3 to improve hydropatterns and hydroperiods in the Water Conservation Areas and Everglades National Park;

Water Conservation Area 3A/3B levee seepage management;

Western C-11 basin diversion (eliminates discharges of urban runoff to eastern Water Conservation Area 3A via S-9 pump station);

Central Lake Belt Storage Area, operated to improve hydropatterns and hydroperiods in Water Conservation Area 3B;

Additional water control structures between Water Conservation Area 3A & 3B;

Lake Okeechobee aquifer storage and recovery to increase storage of lake water for environmental and water supply deliveries;

Increased capacity of Everglades Construction Project pump station G-404 to improve hydropatterns and hydroperiods in Water Conservation Area 3A;

Internal L-7 and L-40 canal structures to improve hydropatterns and hydroperiods in Water Conservation Area1 (LNWR);

Decompartmentalization of Water Conservation Area 3 to reestablish ecological and hydrologic connection between Water Conservation Area-3A and 3B and NESRS;

Relocation and increase in capacity of pump station S-140 to improve hydropatterns and hydroperiods in central Water Conservation Area 3A;

Increasing capacity of S-150 to discharge Lower East Coast water supply deliveries to US 27 borrow canal (potential adverse impact in Water Conservation Area-3A associated with relocation of Miami canal water supply deliveries to North New River Canal);

Storage of excess flows in Water Conservation Area 3A and 3B in Central Lake Belt storage area, to be returned to Water Conservation Area 3A to achieve preferred hydropatterns and hydroperiods;

Conservation of water use in Lower East Coast; expected to benefit Water Conservation Areas through reducing water supply demand from Water Conservation Areas/regional system;

L-28I levee modifications;

Storage of excess flows from Water Conservation Area 2A & 2B in Central Lake Belt storage area, to be returned to Water Conservation Area 3B to achieve preferred hydropatterns and hydroperiods.

Collectively, these components will result in an increase in the average annual volume of water (and phosphorus and nitrogen loads) delivered to the Water Conservation Areas compared to current (1995) and future (2050) base conditions. Utilizing the water budget data generated from the SFWMM simulations of the base conditions and the alternatives, 31-year average structural flows into the Everglades Protection Area are projected to increase from approximately 2,092,000 acre-feet per year (2050 base condition) to 2,181,000 acre-feet per year in the Initial Draft Plan (SFWMD, 1998).

The projected increase in average annual volume is not, however, simply an accumulated incremental increase for all of the existing and proposed water control structures discharging into the Everglades Protection Area. For example, the volume of water delivered by some of the structures contained in the Initial Draft Plan discharging water into the Water Conservation Areas is predicted to increase greatly (e.g., S-140 pump station, 31-year average increase in volume is approximately 285,000 acre-feet; S-150 pump station, 31-year average increase in volume is approximately 32,000 acre-feet), whereas other structures will be significantly decreased (e.g., S-9 pump station, 31-year average decrease in volume is 185,000 acre-feet; S-190 water control structure, 31-year average decrease in volume is 89,000 acre-feet, 2050 base flows from S-190 eliminated.

Decreases in average annual structural flows containing significant pollution loads (e.g. S-9, S-190) would be expected to improve water quality conditions in those areas within the Water Conservation Areas impacted by those discharges. Conversely, increases in structural discharges (e.g., S-140, S-150) may create potential water quality problems if treatment strategies are not included in the Initial Draft Plan. For modified pump station S-140 in particular, the majority of the projected increase in volume is flow out of Stormwater Treatment Area-3\4 directed west along the L-5 and L-4 borrow canals via modified pump station G-404. However, a portion of the water discharged via S-140 would include runoff from cattle pasture on the Seminole and Miccosukee tribal reservation lands adjacent to northwest Water Conservation Area-3A. The Seminole Tribe has identified treatment facilities for discharges from the Big Cypress Reservation.

The affect of in flows and attendant pollution loads into the WCAs resulting from the implementation of IDP components will be evaluated in future detailed design studies and may affect the final design of treatment facilities. Implementation of the IDP is not expected to alter mercury concentrations (which is primarily atmospheric in origin), or conductivity within the canals and marsh areas. Similarly, dissolved oxygen levels are not expected to be affected by IDP components.

Even with such modifications in place, the net phosphorus load delivered into the Everglades Protection Area may increase compared to projected 2050 base conditions as a result of the Initial Draft Plan. However, any increase in the net phosphorus load delivered to the Water Conservation Areas and Everglades National Park would be delivered at a concentration which would not cause the numeric phosphorus criterion to be exceeded.

K.7.6 Water Supply

With the removal of the southern confining levees of Water Conservation Area 3A and 3B, their present water supply function as a project purpose through water management would be replaced by a water supply function that is incidental to the water levels maintained for ecosystem restoration purposes. There is no specific water supply function served by the Holey Land and Rotenberger Wildlife Management Areas.

K.7.7 Socio-Economics

The Water Conservation Area region generates indirect income to neighboring counties through tourism (including private and Tribal airboat concessions) fishing, hunting and other recreational activities that occur in this area. The Water Conservation Areas, do not support residential development, other than that which exists outside of the perimeter levees, and about two dozen private camps, based mostly on tree islands within the Water Conservation Areas. The Initial Draft Plan is expected to lead to significant improvement in fish and wildlife habitat, and has been predicted to improve habitat for alligators, increases in forage fish populations, and improved foraging and nesting success for colonial wading birds, among other wildlife. These improvements may cause an increase in visitation and possibly prolonged stays in and near the Water Conservation Areas by these visitors. Therefore, the indirect income generated by Water Conservation Area regional visits by sportsman, tourists and day visitors can be expected to increase, relative to 1995 and 2050 base conditions.

K.7.8 Land Use

There will be no impacts on land-use within the Water Conservation Areas or within the Holey Land and Rotenberger Wildlife Management Areas. They will remain as undeveloped wetland areas.

K.7.8.1 Agriculture

There are no active agricultural practices within the Water Conservation Areas or within the Holey Land and Rotenberger Wildlife Management Areas.

K.7.9 Recreation Resources

If native wildlife populations, especially large consumers (alligators and raptors) and wading bird colonies, increase substantially under the Initial Draft Plan as predicted, there will be a greater abundance of "watchable wildlife" within the Water Conservation Area region. This should increase visits to the region for bird watching, photography and other wildlife-related recreation. The removal of certain levees and filling in of canals will result in a certain adverse impact to recreational fisheries and boater and possibly bicycle or pedestrian access. The removal of the L-29 borrow canal will affect fishermen from the area who fish this popular canal by boat and fish along the bank. Several boat launches are also expected to be removed as a result of implementation of the Initial Draft Plan. Filling in 6 miles of the southern end of the L-67A canal, of the 72 total miles of canal anticipated to be filled-in under the Initial Draft Plan, will reduce the size and accessibility of this important state fishery. It will directly impact boater access from several boat launches along Tamiami Trail, although access from Holiday Park, at the north end of the L-67 will still be possible. This fishery, of statewide importance (GFC, pers. comm.) is both a popular and important one, particularly for large-mouth bass fisherman. The construction of several in-ground and above ground storage reservoirs and new canals (413 total miles of new levees/borrow canals is planned for the Initial Draft Plan), several within the Lower East Coast are being proposed under the Initial Draft Plan. Depending on the ultimate purposes of these facilities, they represent a potential significant fishery and recreational resource, which could offset or even surpass that, lost through the degradation of existing open water bodies used for boating and fishing. For a detailed discussion of recreation resource affects, reference Annex A, GFC, Fish and Wildlife Coordination Act Report.

K.7.10 Aesthetic Resources

Removal of the L-29 levee and bridging of part of Tamiami Trail should lead to an improvement in the visual aesthetics along the southern Water Conservation Area boundary. This is a busy highway, and travelers should now be able to appreciate the viewscape of the Everglades with greater ease with removal of the L-29 levee. More NSM like flows and water stages within the Water Conservation Area region is expected to lead to enhanced conditions for wildlife. Greater numbers of animals, including wading birds and raptors, may enhance the wilderness aesthetic to the casual observer. Also, the viewer who penetrates into the marsh and slough system of the central Everglades, would be expected to observe a healthier, sustainable and more vibrant native plant community among the marsh, slough, and tree island communities. Signs of stressed and dead trees on tree islands, as was evidenced during recent high water events, would be expected to be reduced under the Initial Draft Plan.

K.7.11 Unavoidable Adverse Environmental Effects

Implementation of the Initial Draft Plan should not result in any net ecologically adverse effects within the Water Conservation Areas or the Holey Land and Rotenberger Wildlife Management Areas in excess of that expected under the 2050 base condition.

K.7.12 Relationship Between Short-Term Uses and Long-term Productivity

Construction of the structural features of the Initial Draft Plan and the physical removal of the existing structural features called for in the plan would cause minor short-term environmental impacts on wetland habitats, aesthetics, and air and water quality. These would be immeasurably offset by the long-term beneficial effects of ecosystem restoration that would subsequently occur.

K.7.13 Irreversible and Irretrievable Commitments of Resources

There would be no irreversible and irretrievable commitments of resources other than the human and economic resources utilized in constructing the plan. All of the physical changes that would be implemented could be decommissioned just as those constructed in the original C&SF Project are now proposed to be.

K.7.14 Cumulative Effects

The proposed action in the Water Conservation Areas and Holey Land and Rotenberger Wildlife Management Areas would act cumulatively with other elements in the Initial Draft Plan to provide significant ecosystem restoration in the Everglades. No cumulative adverse effects are anticipated.

K.8 LOWER EAST COAST AND BISCAYNE BAY

The following presents a discussion of affects to the various resources within the Lower East Coast region, including the developed areas east of the Everglades

Protection Area, within Broward, Miami-Dade, and Palm Beach Counties. The Lower East Coast region also includes Biscayne Bay.

K.8.1 Vegetation

The Initial Draft Plan includes deep water (depth > 4 feet) and shallow water (depth < 4 feet) above ground storage reservoirs. Both types of reservoirs will provide habitats different from existing natural wetlands in the area. Any deep-water reservoir sited over an existing wetland system will convert wetland to open water habitat. Shallow water, above ground impoundments used as Storm Water Treatment Areas will create wetland habitat for the portion of the year they are flooded. This wetland will be different in character than existing vegetation (it will flood more deeply and have a longer hydroperiod).

All proposed below ground reservoirs are sited in the vicinity of existing rock mining operations and in areas deemed suitable for rockmining by the Miami-Dade County Lake Belt Plan Implementation Committee. Existing rock mines were former wetlands. Areas permitted for future mining are currently wetlands or converted wetlands. Wetland losses resulting from previously permitted mining operations will be mitigated for under a Lake Belt Plan currently being developed. The C-51 and southern L-8 Reservoir, composed of 1,200 acres and 40 feet of working storage depth is sited in Palm Beach County. This site was upland that has been converted to farmland. Building this reservoir will not impact existing wetlands.

The western half-mile of the proposed C-9 stormwater treatment area is currently a wetland system. This wetland will be converted to an above ground impoundment (stormwater treatment area), reducing the acreage of short hydroperiod natural wetland in the subregion. The stormwater treatment area will also provide improvements to surface water discharges to WCA 3A by reducing pollutants and high flow events.

No adverse effects on wetlands or other sensitive natural lands are expected as a consequence of siting aquifer storage and recovery facilities, including wells, pumps and reservoirs. Many of the aquifer storage and recovery facilities will be sited in areas considered having less potential for wetland and natural resource value. Siting will be adjacent to existing canals or associated with reservoirs and will not cause additional impacts to existing wetlands.

The impacts of the use of seepage barriers on adjacent and eastern (down gradient) wetlands must be evaluated. In addition, the impoundment effects of these structures upgradient must be more thoroughly investigated. The costs and technical feasibility of removing these structures are unknown. These structures would constitute irretrievable and irreversible commitment of resources and further analysis of the impacts of these structures is necessary.

Interim targets for Biscayne Bay were used in the alternative evaluation process. Models are currently being developed to better identify the water quantity and quality needs of Biscayne Bay. Except for flows out of North Biscayne Bay (G-58, S-28, S-27), existing surface flows to Biscayne Bay were modified by the Initial Draft Plan. Flows out of Snake Creek (S-29) exceed the wet season target by 15 percent and dry season flows are short of the target by 72 percent. Annual surface flows out of the Miami River (S26, S-25B, S-25) were reduced by 69 percent when compared to the 1995 base flows. Both wet and dry season flows to Central Bay (G-97, S-22, S-123) are below targeted flows. Wet and dry season flows to South Biscayne Bay exceed the targets by 13 percent and 27 percent, respectively.

In general, maintaining existing flows are expected to continue to support existing seagrass and coastal communities. Decreasing existing flows or failing to meet targets may result in increased salinity thereby depressing productivity and/or seagrass cover. Until further studies are conducted, it is unclear as to the effects of significantly reduced flows from the Miami River. However, due to the amount of channelization which has occurred over the past 100 years including Government Cut, decreases in flows from the Miami River may have little deleterious impact upon vegetation in Biscayne Bay.

Additional dry season flow to Biscayne Bay in south Miami-Dade County, coupled with the overland flow distribution network Other Project Element, the Biscayne Bay Coastal Wetlands Project should benefit the coastal areas and may maintain a more stable coastal estuarine community nearshore. While algal and seagrass communities currently dominate the estuarine zone in this area, redistributing the pulse, high flow discharge events across the mangrove wetlands are expected to benefit coastal and submerged plant communities. Until further modeling is conducted, the effects of “more estuarine” conditions upon existing sea grass communities remains unclear.

The additional flows in south Miami-Dade are from treated wastewater provided by the proposed south Miami-Dade County Reuse Facility. The potential exists to increase nutrients, particularly phosphorus, loading to southern Biscayne Bay as a result of this component. If water quality is not consistent with ambient water quality of the mid-portion of South Biscayne Bay, then the wastewater reuse component could have a negative impact on submerged aquatic vegetation. Sea grasses would potentially become overgrown with epiphytes and in some areas undesirable planktonic or benthic algae may encroach.

Severely decreased freshwater to north Biscayne Bay from Snake Creek may negatively impact this extremely restricted area, and decrease the extent of seagrass cover due to stress. It may also depress productivity of this area due to decreased inflow and restricted circulation. Projected discharges from Snake Creek would be expected to cause significant fluctuations in salinity, which may adversely affect existing vegetation.

K.8.2 Fish and Wildlife

The Initial Draft Plan will restore estuarine and marine conditions in Lake Worth Lagoon and enhance estuarine conditions in Biscayne Bay. Substantial fish and wildlife benefits will be provided to both systems. Restored seagrass and desirable algal communities in Lake Worth Lagoon should be recolonized. Many important fishery species including spotted seatrout, mangrove snapper and others should benefit. Establishing more estuarine conditions in southern Biscayne Bay by improving the timing and distribution of flows and increasing dry season flows should provide improved habitat for juvenile fish and fish that spawn under estuarine conditions. In southern Biscayne Bay, if more estuarine conditions are achieved using freshwater with water quality that constitutes a nutrient loading, there may be impacts to water clarity and some hardbottom communities. However, if water used to achieve more estuarine conditions is comparable in quality to that of the main portion of southern Biscayne Bay, then fish nursery habitat within the bay will improve.

In the terrestrial sections of the Lower East Coast, improved hydroperiods should improve wetlands and conditions for the organisms associated with them. Some of the water storage areas with long (twelve-month) hydroperiods should support a viable freshwater fish population. These areas could become forage areas for a number of piscivorous animals including birds, reptiles, and mammals.

Significant benefits to wildlife are anticipated if the Bird Drive Recharge Area is operated to enhance wetlands. Additionally, the increased freshwater to the North Fork of the New River and Pond Apple Slough in Broward County should enhance the wildlife in those areas.

K.8.3 Threatened and Endangered Species

Increasing estuarine conditions in the nearshore environment of southern Biscayne Bay should provide suitable habitat for the American Crocodile. Increasing freshwater flow, compared to the 2050 base, should decrease salinity in the nearshore environment and provide nursery habitats for crocodile hatchlings. If the salinity is low enough, favorable habitat for the reproduction by adult crocodiles will be restored. Additionally, the manatee is expected to benefit from increased freshwater flow to southern Biscayne Bay. Greater freshwater input should favor colonization of the bay bottom by seagrasses, an important food source for manatees.

Generally, threatened and endangered plants in the Lower East Coast will not be affected by the Restudy components. Threatened and endangered fish and wildlife should benefit. Longer hydroperiods in the western sections of the Lower East Coast should produce greater numbers of forage fish for wading birds, wood storks and bald eagles. In addition, the US Fish and Wildlife Service noted in its biological opinion on the Initial Draft Plan, that the endangered Eastern Indigo snake may be present in one or more areas proposed for water storage, and that some mortality of this species may be expected. The Cape Sable seaside sparrow, known to exist in the Southern Glades Wildlife Management Area, is expected to benefit due to increased hydroperiods and reduced fire periodicity of essential breeding habitat.

K.8.4 Water Management

The proposed changes in water management associated with Biscayne Bay will be due to structures associated with the overland flow distribution of discharges and the addition of reuse water to Biscayne Bay's water budget. Reuse water discharged to Biscayne Bay will be treated with superior technology and will meet the stringent low nutrient levels of the main bay and the coral communities of the Biscayne National Park.

No adverse impacts on flood protection are expected as a result of any of the seepage barrier or seepage control methods proposed by the Initial Draft Plan. However, further analysis is needed to assess impacts to adjacent agricultural areas and to verify that components are designed to function so that the rise in groundwater elevation will not cause a loss of storage in the affected area. Alternatively, seepage impacts will be mitigated through the addition of seepage pumps and improved or new secondary collection systems. In addition, the effects of these barriers on prevailing groundwater movement and gradients must be evaluated with respect to their impacts on existing groundwater contamination sites, landfill leachate plumes, and well field drawdown zones.

Excess water from the South Miami-Dade Wastewater Treatment Plant (SDRWTP) with superior treatment technology will be sent to deep injection wells to avoid impacting flood protection. Since the overland flow aspect of this component was not modeled, further analysis is needed to assess effects upon neighboring agricultural lands. The future West Miami-Dade Wastewater Treatment Plant (WDWTP) with superior treatment technology will send reclaimed water to the Bird Drive Recharge Area. Excess water, when available, will be sent to the South Miami-Dade Conveyance System, and Northeast Shark River Slough, to offset regional supplies, and lastly, deep injection wells.

The effects of above ground storage on flood protection will be positive. Creating storage areas within a drainage basin and pumping surface water into storage areas during storm events will reduce the occurrence of flooding in that basin and reduce the volumes of runoff reaching canals during storm peaks. This will allocate larger shares of the canal's capacity to the remaining drainage basin and allow faster drainage of flooded lands. The storage areas will discharge off peak, when the canal capacity is restored, or retain the peak flow to meet future demands on the regional system. The western C-4, C-9 and Hillsboro basins are currently flood prone basins. Above ground storage areas should greatly reduce flooding in those areas during storm events. However, improvements to the C-9 and the local stormwater infrastructure may be required due to increased stages at S-29 over existing conditions.

The effects on flood protection by in ground storage areas will be positive. In ground storage, and pumping to this storage during storm events, will reduce the occurrence of flooding, and reduce the volumes of runoff reaching canals during storm peaks. This will allocate larger shares of the drainage canal's capacity to other parts of the basin, and allow improved rapid flood drainage on these lands. The storage areas will discharge off peak when the canal capacity is restored or retain the peak flow to meet demands later. The difference in flood protection between above and below ground storage is that the below ground storage area will not require seepage collection and control because water is not stored above existing groundwater table elevations.

The below ground storage area adjacent to the L-8 Canal, in the southern L-8 basin and the Indian Trail Improvement District, will provide flood protection currently not provided to this area by the regional system. The North Lake Belt Storage Area (NLBSA) will provide a greater level of flood protection to the flood prone western C-9 basin. Runoff from the western C-11 basin is currently discharged to WCA 3A via the S-9 pump station. The construction of the NLBSA will allow the runoff currently discharged from the S-9 to be redirected, reducing pollutant loads to the Everglades Protection Area. The western reach of the C-6 Canal will also be back-pumped to NLBSA. This will require a water control structure in the C-6 Canal holding the water table higher in the area. This is likely to require improvements and/or creation of a secondary drainage system between NLBSA and the C-6 Canal to maintain flood protection in that area.

Aquifer storage and recovery wells in the Lower East Coast are usually associated with a reservoir to store water to feed the wells. These aquifer storage and recovery wells increase the effectiveness of the reservoirs by steadily drawing down the reservoir and creating storage in the reservoir, enabling the next rainfall event to be captured within the reservoir. The Site 1 storage area will be more effective with the addition of aquifer storage and recovery. The use of aquifer storage and recovery results in an additional 78 percent of water captured that was lost to tide under the 2050 base case.

K.8.5 Water Quality

Water quality conditions in portions of the Lower East Coast and Biscayne Bay are currently degraded. Florida Department of Environmental Protection, listed approximately 90 water bodies or segments of water bodies within the Lower East Coast sub-region as not presently meeting water quality standards (FDEP, 1998). Pollutants and constituents of concern include phosphorus, nitrogen compounds (NOx), dissolved oxygen, mercury, coliform bacteria, volatile organic compounds, heavy metals, pesticides, tri-butyl tin (TBT), and salinity.

There are several components in the Initial Draft Plan designed to achieve public water supply and salinity control objectives in the Lower East Coast sub-region (Palm Beach, Broward, and Miami-Dade Counties), and to meet environmental targets in Lake Worth Lagoon and Biscayne Bay. The following components are expected to affect hydrologic conditions in the Lower East Coast:

Southern L-8 basin improvements to enhance water supply function in Palm Beach County Water Catchment Area;

Relocate coastal wellfield operations to minimize threat of saltwater intrusion;

Site 1 reservoir adjacent to Hillsboro Canal; supplemental storage for Lower East Coast water supply;

C-9 Canal impoundment/diversion canal for treatment of water supply deliveries from North Lake Belt Storage Area;

Central Lake Belt storage area; provides regional storage for public and environmental water supply, and salinity control;

C-4 Canal divide structures for seepage control and coastal wellfield recharge;

Bird Drive basin reservoir; seepage control, flood attenuation, and water supply deliveries to South Miami-Dade Conveyance System;

Backpumping of urban runoff from C-17 Canal and C-51 Canal watersheds to supplement water storage/supply in West Palm Beach Water Catchment Area;

Improvements to Miami-Dade-Broward Levee to reduce seepage losses, enhancing Miami-Dade County Northwest Wellfield;

Improve Broward County secondary canal system to enhance wellfield recharge and salinity control functions;

C-51 Canal aquifer storage and recovery water supply and salinity control;

Palm Beach County Agricultural Reserve reservoir to increase water supply storage in central and southern Palm Beach County;

C-111N Spreader Canal; improve flows to Model Lands/ southern Biscayne Bay;

North Lake Belt storage area to provide public water supply, canal stage (salinity) control, and to achieve salinity targets in Biscayne Bay;

Diversion of excess flows out of WCA 3A & 3B to enhance function of Central Lakebelt storage area;

Increased conservation of regional system water delivered to Lower East Coast public water supply/distribution systems;

Reuse of treated wastewater to meet salinity targets in Biscayne Bay;

Higher stages in C-102 and C-103 Canals for urban and environmental (Biscayne Bay) water supply;

C-51 Canal/Southern L-8 basin reservoir to achieve salinity targets in Lake Worth Lagoon, control flooding, and provide additional water supply to Lake Worth Drainage District;

West Miami-Dade County wastewater reuse to enhance ground water recharge and provide additional water supply for salinity control and to meet environmental targets in Everglades National Park.

Construction and operation of these components is expected to result in a net improvement in water quality conditions in the Lower East Coast. Water quality improvements are expected simply through the attenuation function (and attendant pollutant load reduction, particularly nutrients and heavy metals) of the storage components for those surface waters presently discharged to coastal canals and estuaries. Storage and attenuation facilities may also improve bacteriological quality through attenuation of surface waters containing coliform bacteria and will improve dissolved oxygen conditions where existing conditions have been adversely affected by increases in biochemical oxygen demand (BOD) loading. Salinity regimes are also expected to improve consistent with ecological targets.

Additionally, water quality conditions are expected to improve as a result of the incorporation of treatment features into the design and operation of several components. Where the design and operation of a component could increase pollution loads in groundwater or downstream receiving waters through aquifer injection or diversion of surface waters, treatment facilities necessary to meet water quality standards have been included in the design and cost estimates for those components (e.g., chlorination treatment prior to aquifer injection, stormwater treatment areas associated with diverting runoff into reservoirs/storage areas, treatment works at wastewater reuse facilities to produce effluent meeting water quality standards). These facilities, depending upon location and further detailed design (volumes, attenuation times, discharge points), could result in a net reduction of pollutants in receiving water bodies compared to existing and future base conditions.

The beneficial effect of such facilities is not quantifiable at the feasibility investigation stage, for several reasons. First, exact locations of the components and volumes of water added to downstream receiving waters have not been determined. This information will be determined at the detailed design stage of project implementation. Second, and most importantly, existing and projected pollution loads and total maximum daily loads (TMDLs) in receiving waters affected by the operation of the components of the Initial Draft Plan necessary to achieve ecologically sustainable conditions have not been determined, particularly for nutrients. According to Florida Department of Environmental Protection's draft 1998 303(d) list, 90 of the 169 listed water bodies and/or segments of water bodies designated by the Florida Department of Environmental Protection as not meeting water quality standards criteria in the Restudy area are within the Lower East Coast sub-region (FDEP, 1998). TMDLs have not been established for any of these water bodies.

There is a concern that the water from the reuse plant must be as clean as the water naturally found within the main portion of south Bay. With the volume of reuse water to be supplied, a slight increase in nutrients or contaminants from background levels could generate a huge nutrient or contaminant load for Biscayne Bay. The reuse facilities will utilize superior technology and provide suitable water quality. The facilities should, at a minimum, remove total phosphorus and nitrogen to background levels of the main portion of southern Biscayne Bay and should not increase pollutant loading to the bay. Data analysis conducted to date by the Biscayne Bay Water Quality Group has identified main bay background levels for total phosphorus of 5ppb, nitrite/nitrate of 10 ppb, and dissolved total nitrogen of 20 ppb.

While it is expected that components of the Initial Draft Plan would improve water quality for Lake Worth Lagoon and Biscayne Bay compared to existing and projected future conditions additional analysis is needed to fully quantify the water quality objectives for these areas. Construction and operation of those components of the Initial Draft Plan affecting hydrologic conditions in the Lower East Coast are not expected to affect mercury concentrations and loads, the primary source of which is atmospheric deposition.

Some of the seepage management proposed for west of Biscayne Bay may impact the groundwater resources feeding into Biscayne Bay. Groundwater recharge is a natural cleaning process and much of the water entering the bay through the groundwater is very clean.

K.8.6 Water Supply

The SFWMM's predicted frequency of water restrictions over the 31 year period of record indicate that North Palm Beach County and Lower East Coast Service Area 1 have exceeded their targets under the Initial Draft Plan, with one year less of water restrictions than the target. The model output for Lower East Coast Service area 2 and Lower East Coast Service area 3 display 2 and 1 additional years of restrictions above the target, respectively. In the Lower East Coast, water supply should be improved due to deliveries from the regional system in general, holding stages higher in secondary canals and the West Palm Beach Water Catchment Area, and directing regional water deliveries to wellfields.

Canal stages for the primary coastal canals are maintained and meet their respective saltwater intrusion criteria. The C-51, C-17, C-16, C-15, C-14, C-9, C-6, C-4, C-2, and Hillsboro Canal will prevent saltwater intrusion into the Biscayne Aquifer by maintaining regional groundwater levels. There is a reduced potential for localized saltwater intrusion due to increased well field demands

In general, the control of saltwater intrusion into the Biscayne Aquifer in Miami-Dade County improves as a result of the Initial Draft Plan in that the majority of canal stages at the salinity control structures are being held at or above saltwater intrusion criteria. However, saltwater intrusion criteria have not yet been developed for the southern portions of the Biscayne Aquifer in Miami-Dade County and, therefore, the adequacy of the Plan in controlling salt encroachment in that area needs further assessment.

Above ground impoundments are designed to capture stormwater being lost to tide during a rainfall event. The stormwater directed to an impoundment will be stored and then used to meet demands during a drier time. It is anticipated that storage within the above ground impoundments will not be available over extended dry periods due to evapotranspiration (ET) and seepage losses.

The below ground impoundments work much the same as above ground impoundments, only more effectively. Whereas building the above ground impoundments will increase seepage and evapotranspiration losses over base conditions, the in-ground storage areas will be rock mines. ET will not increase beyond what is expected. Seepage barriers are proposed for these areas to eliminate water infiltrating into the surrounding ground water table.

Stormwater treatment areas in the Everglades Agricultural Area require maintenance of water six inches above the surface to prevent drying out, otherwise stormwater treatment areas lose their water cleansing function if they dry out. During dry periods, these stormwater treatment areas are water consumers. The stormwater treatment areas proposed along the Lower East Coast do not need to be wet at all times. However, to maintain a viable wetland for treatment, certain minimum criteria for water levels below ground surface must be met. Under dry conditions, water levels must not be less than 1.0 - 1.5 feet (depending on soil type) below ground surface for 30 days or less with a frequency of not more than one in four years (SFWMD, 1998).

The positive effects of regional aquifer storage and recovery on water supply are due to their use in conjunction with above ground reservoirs. Aquifer storage and recovery increases the efficiency of above ground reservoirs more efficiently by providing long-term storage and efficiently capturing stormwater that would otherwise be lost to tide. Long-term storage under ground eliminates losses to ET. In addition, pumping stored water out of the impoundment and into the regional canal system regains storage capacity within the impoundment that will be used to capture flows from the next storm.

K.8.7 Socio-Economics

Many significant socio-economic effects can be expected from the implementation of a plan as large and complex as the Initial Draft Plan. Three potential areas of impacts have been identified. One area of impact within the Lower East Coast would be the effects of the taxing and spending needed to implement the alternative. The second will reflect the economic impacts due to the utilization of resources to meet project purposes instead of the economic purposes they would be used for without the project. The third will consider the potential impacts due to project output. All these impacts will be the result of complicated economic interactions that can be identified, but not be quantified within the scope of the Programmatic Environmental Impact Statement.

Some of the potential impacts and factors influencing the significance of the impacts that are related to the taxing and spending associated with project implementation are: Federal funds used to implement the Initial Draft Plan will almost entirely be additional expenditures and will increase economic activity throughout the project area. State funds used to implement the Initial Draft Plan will to a significant extent represent additional expenditures and will also increase the economic activity throughout the project area. Taxes raised by the local sponsor, the South Florida Water Management District, will come largely from the Lower East Coast, while a portion of the expenditures will be on projects outside this area. This will tend to decrease economic activity within the Lower East Coast. Because of the economic dominance within the study area, businesses in the Lower East Coast will capture some of the additional business generated by the project and the operations and maintenance of the projects outside the Lower East Coast. If the local funds are raised by the issuance of a bond, the increase in economic activity will occur when these bond funds are spent. On the other hand, the decrease in economic activity caused by the taxes to pay off the bonds will occur gradually over an extended period of time. A significant portion of the funds will be used for land purchases, and land purchase only represents a change in wealth form, and does not directly effect economic activity. These transactions will diminish the significance of the spending on the economy of the Lower East Coast area.

Other impacts are those due to the utilization of resources to meet project purposes instead of the economic purposes they would be used for without the project. This would occur, for instance, if land that was in agriculture is purchased for a project reservoir and there were no economically feasible sites to transfer the agricultural production. Some of the lands proposed for the water preserve area and reservoirs in the Lower East Coast area would probably have had an urban land use, especially low density residence, as the alternative land use. These urban land uses can generally be accommodated on other vacant lands, or by increased density elsewhere. Furthermore, the Lake Belt reservoirs are not expected to diminish the land use for rock mining or impinge on productive agriculture land since permitted rock mines will complete their desired excavations. One exception to this is the Palm Beach County reservoir; it is proposed for location in the agriculture reserve in Palm Beach County. Thus, the implementation of the Initial Draft Plan will remove a substantial amount of this Palm Beach agricultural reserve land out of production and represent a loss of revenue.

The third type of impact is the impacts of project outputs. Flood control and water supply improvements provided by the project are not expected to alter the nature or intensity of agriculture or urban development in the Lower East Coast. However, impacts to urban and landscape due to public water supply shortages are expected to be reduced as a result of the project. Larger economic impacts might result from the environmental improvements expected. Potential areas of increased economic activity could include additional recreation in the ecologically restored areas due to increases in wildlife populations, improved fishing or other related characteristics. The environmental improvements will be beneficial to both residents and visitors from outside the study area. The tourists will help to increase the economic activity and are expected to spend a good portion of their vacation expenditures in the Lower East Coast, even when visiting Everglades

National Park or other parts of the project area. Additionally, commercial fishing may improve as a result of improved fish habitat and fish nursery functions in Biscayne Bay and Lake Worth Lagoon.

K.8.8 Land Use

Seepage management should not cause changes to existing land use. Minimal land is required for the wells and physical barrier methods. Where groundwater recharge is proposed by raising groundwater controls, limited development has occurred. The State of Florida will acquire lands where groundwater controls would be raised. Therefore, no changes in the existing land uses are expected as a result of the seepage barrier/control method selected. The seepage control component along eastern Water Conservation Areas 3A and B is located on wetlands. This feature will lengthen the hydroperiods of the adjacent wetlands.

Several thousand acres of land will be needed for above ground storage facilities in the Lower East Coast area on lands deemed suitable, according to the Land Use Suitability Analysis completed in 1997. The in ground storage areas will be located in existing rock mines/borrow pits. Therefore, a land use change from rock mining to storage will occur. The stormwater treatment areas will be located on uplands or impacted wetlands.

K.8.8.1 Agriculture

Agricultural producers in South Miami-Dade County are concerned about the continuation of flood control benefits in their region. As a result of urban sprawl from the city of Miami, agricultural production has shifted westward over the last several years until it now abuts the eastern boundary of Everglades National Park. The close proximity of the park and farming activities has created ongoing water management conflicts between the water needs of the Everglades ecosystem and flood control for the neighboring farmland. The problem is exacerbated by high seepage rates from the park to the east, which tend to dry the park and raise ground water levels and compromise flood control on farmland. The Initial Draft Plan includes levee improvements to L-31N for seepage management to address this issue and help restore hydropatterns in Everglades National Park. The features are intended to eliminate levee seepage throughout the year and eliminate ground water seepage during the wet season. Another component of the Initial Draft Plan is modified C-111 canal operations intended to both improve water deliveries to the Park and decrease potential flood risk to nearby farmland.

The flood control benefits of these components east of L-31N are uncertain. The South Florida Water Management Model (SFWMM) is not intended for use in flooding and flood control estimation due to its coarse spatial scale, and, therefore, only limited conclusions can be drawn regarding flooding impacts to agriculture in this region. Model outputs include simulated ground water levels for specified cells that may indicate if ground water might occur within the crop root zone. Of the seven model cells in this region for which ground water stages were reported, six had stages comparable to or slightly higher than the future without-project condition. These results indicate a level of flood protection comparable to the future without-project condition. Three of the seven model cells do not meet performance targets indicating a possible risk of flood damages in these areas.

The future without-project condition includes the federally authorized C-111 Project and Modified Water Deliveries to Everglades National Park Project. These projects are intended to maintain existing flood control in agricultural areas while restoring specific elements of the park ecosystem. However, due to the limitations of the modeling tools currently available, it is very difficult to determine flooding effects in agricultural areas. Research is now underway to develop field scale modeling applicable to South Miami-Dade County agriculture (Savabi, 1998). When the results of this research become available, flood control in South Miami-Dade County can be more accurately assessed. The effects of the Initial Draft Plan together with the C-111 and Modified Water Deliveries Projects can then be determined. Adverse effects to flood control in this region would compromise the sustainability of agriculture on this unique farmland.

K.8.9 Recreation Resources

The proposed C-111N spreader canal, associated culverts, and backfilling of C-111 (south of C-111N to S-197), C-110, removal of S-197, S-18C, and the construction of an stormwater treatment area is planned to supply Southern Glades and Model Lands. These proposals could produce temporary interruption of use of recreation resources that would cease once construction had been completed. The stormwater treatment area could provide increased recreational fishery resources and subsequent recreation fishing if access is provided.

Other components in the Lower East Coast should provide additional recreational opportunities. The water preserve areas and perimeter canals will be suitable habitat for many of the important recreational fish including bass and sunfish. However, the filling in or degrading various canals could remove these areas from being viable fishing sites.

Overall, the proposed construction of storage reservoirs, seepage control systems, reuse plants, and aquifer storage and recovery, should not adversely affect the total amount of recreation resources in the Lower East Coast. Some temporary interruption of recreation resources could be experienced during project construction but would cease once construction is completed.

K.8.10 Aesthetic Resources

The proposed construction of storage reservoirs, seepage control systems, reuse plants, and aquifer storage and recovery should not adversely affect aesthetic resources. The stormwater treatment areas and storage reservoirs will be similar in appearance to other artificial impoundments in the subregion. Conveyance canals and surrounding levees will be similar in appearance to existing canals and levees. During construction, site preparation will include such typical activities as removal of vegetation, grading by means of heavy machinery, earth-movement, construction of temporary roads, removal and off-site or on-site disposal of excess material, import of fill materials for levees, movements of heavy dump trucks through public roads, etc. These activities will last during the construction phase only, and operations would be planned to minimize disruption to surrounding urban and residential uses. Most adverse visual effects would not persist after construction is complete. Appropriate finishing procedures should be completed to blend the disturbed areas into the landscape.

The proposed C-111N spreader canal, associated culverts, and the backfilling of C-111 (south of C-111N to S-197) and C-110, removal of S-197, S-18C, and the construction of a stormwater treatment area is planned to supply Southern Glades and Model Lands water. These proposals could produce temporary impacts to aesthetic resources that would cease once construction had been completed. Construction of the stormwater treatment area could adversely affect aesthetic resources depending on stormwater treatment area size, design, disposal of excavated material, and proximity to visual corridors and populated areas.

The proposed West Miami-Dade Wastewater Treatment Plant will be located south of Bird Drive and treat wastewater for supply to the Bird Drive Recharge area. Excess water will be directed to the South Miami-Dade Conveyance System, NESRS, or deep injection wells. Adverse effects on aesthetic resources could occur depending on treatment plant size, design, disposal of excavated material, and proximity to visual corridors and populated areas.

K.8.11 Unavoidable Adverse Environmental Effects

Storage areas will modify land use by converting an unspecified amount of upland habitat or natural wetland areas to open water. These land use and habitat modifications represent an unavoidable effect upon the environment whether they are in existing upland or wetlands. Most of the wildlife of the Lower East Coast consists of common species that are tolerant of the dense human population. However, the water storage structures will convert all the area inside their perimeter into open water habitat. The terrestrial wildlife will be displaced to adjoining lands, and some mortality is likely as a result. These impacts will depend on future project development, and site-specific environmental documentation would be prepared at that stage of design.

K.8.12 Relationship Between Short Term Uses and Long Term Productivity

Storage sites, seepage control structures, and water reuse plants represent a significant short-term disruption to the environment, and possible unintentional direct and indirect environmental consequences. Short-term effects due to construction activities (vehicular access, creation of staging and turnaround areas, etc.) such as impacts to wildlife habitat, aesthetics, wetlands, noise, air and water quality will be minimized wherever possible. BMP's to control erosion from construction sites will be implemented to minimize impacts to water quality and sedimentation. It is not possible to predict the type or magnitude of these short-term losses at this stage of the Restudy. However, all the recommended modifications to the water supply and water management system will have an overall beneficial long-term and permanent effect on the Lower East Coast and some of the high quality wetlands in the associated watersheds. The Initial Draft Plan provides the best combination of improvements to water supply and improvements to sensitive regional ecosystems, including the southeastern glades, Biscayne Bay, Lake Worth and other Lower East Coast estuaries.

K.8.13 Irreversible and Irretrievable Commitments of Resources

The proposed construction of storage sites, seepage control structures, and wastewater reuse plants, canals, pumps, levees, and appuerant structures may represent an irreversible and irretrievable commitment of fiscal and land resources. These resources would include lands, state and Federal funding, labor, energy and project materials and equipment to build the storage sites, and the structures associated with the operation of these storage sites.

K.8.14 Cumulative Effects

Overall, the Restudy project elements may cumulatively slow or stop expansion of the Lower East Coast cities toward west of the protected levee, and may make other residential or potentially residential lands more valuable. It will likely prompt county and municipal governments to review and update their comprehensive plans to make them consistent with the new water management functions on site. An increase in development of multilevel structures may be one outcome of the Initial Draft Plan project features within the Lower East Coast.

Restudy project components are not expected to result in a cumulative negative effect to the environment of the Lower East Coast. Project components in the Lower East Coast, especially storage, seepage control, and water reuse plants, will act cumulatively to restore more natural freshwater flows to Biscayne Bay, but should not result in negative environmental effects or effects unfavorable to the restoration of the natural environment.

K.9 EVERGLADES NATIONAL PARK AND FLORIDA BAY

The following assessment includes possible affects of the Initial Draft Plan relative to the 2050 base, and in some instances the 1995 base, in Everglades National Park, including the Florida Bay estuaries, Florida Bay proper, Whitewater Bay, and the Ten Thousand Islands.

K.9.1 Vegetation

This assessment includes separate discussions of affects to vegetation attributable to the Initial Draft Plan within 1) the Everglades ecosystem and 2) within the estuarine ecosystem of Florida Bay, Whitewater Bay and the Ten Thousand Islands.

K.9.1.1 Everglades Vegetation

Vegetation responds directly and indirectly (*eg.* through effects on soil development) to hydrological conditions. Under the Initial Draft Plan, changes in vegetation patterns can be expected in several areas of the southern Everglades. These changes will necessarily include effects on soil production and compositional changes resulting from shifts in the vegetation that overlays them. Under the Initial Draft Plan, maintenance of tree islands, slough, and marsh plant communities can be expected in the deeper sloughs (Northeast Shark River Slough, Shark River Slough, Taylor Slough). Northeast Shark River Slough is expected to benefit from increases in water depths and hydroperiods, including favorable shifts in periphyton communities and an improvement in peat-forming conditions. The greatest degree of vegetation change should occur in the Rocky Glades/Eastern Marl Prairies, particularly among the graminoid plant communities, where conditions for the formation of sawgrass and other long hydroperiod plant communities, will be enhanced. In this area, tree islands (bayheads and hammocks) will reflect the reduction in fire frequencies that should result from increased water levels and duration. Woody plant invasion, including the establishment of “upland-type” exotic tree species, will also be curtailed.

Partial decompartmentalization of the system under the Initial Draft Plan will have significant effects on exotic plants by eliminating the deep-water habitats created by canals that support infestations of aquatic weeds. In addition, the removal of levees and other artificial, elevated sites will curtail the establishment of exotic “upland” woody species and grasses that spread along these corridors and are dispersed into wetland habitats. By approaching NSM conditions, restoring natural fluctuations in hydropatterns, and removing canals and levees, the Initial Draft Plan will reduce exotic plant establishment and spread in Everglades National Park.

K.9.1.2 Florida Bay and Estuarine Vegetation

Submerged vegetation along the coastal basins of the Bay will undergo significant seasonal change under the Initial Draft Plan as opposed to base conditions. Hydrologic performance measures under partial decompartmentalization of the Everglades system would likely lead to an increase in upland, low-salinity, fresh-water associated species such as Widgeon grass (*Ruppia)* and a freshwater alga (*Chara)*; particularly during the wet season in the upstream mangrove-associated creeks/rivers. An increase in shoal-grass (*Halodule*) and widgeon grass (*Ruppia)* would be likely in the four coastal basins during the wet season when compared to base conditions and provide foraging/shelter areas for decapod crustaceans such as juvenile pink shrimp. Increased water flow during the dry to wet season transition period would probably result in a decline of turtle grass (*Thalassia* sp.) in the coastal basins. This response would likely occur during the wet season, mimicking vegetation responses reported for the Whitewater Bay estuary, near the North River mouth during significant fluctuations in salinity prior to the opening of the Buttonwood Canal. Macroalgal green calcareous species, including *Udotea* and *Batophora* would increase, followed by a reduction in attached *Sargassum* communities near the mouth of the North River.

K.9.2 Fish and Wildlife

The following is a discussion of the affects to fish and wildlife resources within the freshwater environment of Everglades National Park and the estuarine environment of Florida Bay and its estuaries.

K.9.2.1 Aquatic Invertebrates and Fishes

The discussion below begins with the lower trophic animals and fishes of the freshwater Everglades and estuarine waters of Everglades National Park.

K.9.2.2 Everglades Aquatic Invertebrates and Fishes

The changes resulting from the Initial Draft Plan in the hydrology and infrastructure of the water-delivery system reflect a positive direction of change for aquatic animals relative to the 1995 and 2050 base conditions. Native fish and aquatic invertebrate communities in the southern Everglades should respond to the changes from the Initial Draft Plan in several ways. The degradation of levees and infilling of canals along the southern and western edges of WCA-3A, and elsewhere, will allow freer movement by aquatic animals across that landscape. Populations that have been virtually isolated since the mid-1960’s will be brought into contact to interbreed. Aquatic animals will be able to move across the landscape between Everglades National Park and Big Cypress National Preserve, or among Everglades habitats, in response to changing hydrological conditions. Presently, and under the 2050 base, movements of these organisms are blocked by levees, which can trap them in unfavorable habitats during dry-down. The reduction of canal habitats under the proposed plan will decrease potential for invasions by non-indigenous aquatic biota into natural habitats and reduce the unnaturally high population sizes of both native and non-native predatory fishes supported by canals. Canals will no longer serve as dry-season sinks for native fish and invertebrates. The removal of canals will allow these organisms to remain in the shallow wetlands where they will be available to wading birds and other predators. This improvement is seen in the ATLSS output for the Initial Draft Plan relative to the 2050 base.

The Initial Draft Plan closely resembles NSM hydroperiod and ponding depths for Northeast Shark River Slough and Shark River Slough. An additional benefit of the Initial Draft Plan was the reduction in the number of drying events for Shark River Slough. This condition should enhance aquatic animal community development and survival.

Currently, the Rocky Glades are among the most degraded aquatic habitat within the southern Everglades. Adequate hydrologic conditions in this area are only marginally recovered under the Initial Draft Plan. In the Rocky Glades, the mean duration of flooding was 12 weeks under 1995 and 23 weeks under 2050 base conditions, respectively, and only improved to 30 weeks under the Initial Draft Plan, compared with 44 weeks in NSM. The timing of this flooding is important to animals. Under a 30 week duration of flooding, water would be above ground surface from approximately June 1 to December. This average annual hydroperiod would create improved foraging conditions for wading birds during the early dry season, but would not recover ideal habitat for marsh fishes. Fish breeding season begins in winter and early spring. A mean duration of flooding of 30 weeks would not coincide with the early portion of fish breeding season, resulting in a truncated breeding season and a concomitant decrease in fish recruitment. Under NSM, flooding duration would last until April, translating into potentially higher recruitment of animals and a shorter amount of time spent in dry season refuges, where mortality is high.

An important hydrological factor that affects the ecology of aquatic animals and plants in the Rocky Glades is water depth below ground surface during the dry season. Although there is not a good measure of this minimum depth range under NSM, it is assumed that it was higher than under the 1995 and 2050 base cases. Back-cast modeling by Everglades National Park hydrologists several years ago supported this assumption (Loftus, Johnson and Anderson, 1992). The lower the water level drops in the dry season, the fewer solution holes remain wetted, thus reducing the survival of aquatic animals and the seed stocks for the following wet season.

Although the Initial Draft Plan went farther than the 1995 and 2050 base cases and most of the previous alternatives in providing hydrological conditions closer to those predicted for NSM, there are still opportunities for improvement either through a future detailed planning stage and/or adaptive management operational strategies. This is clearly shown in the achievement indices of 82 percent and 76 percent for Shark River Slough and the Rocky Glades, respectively.

K.9.2.2.1 Florida Bay and Estuarine Invertebrates and Fishes

Conditions expected under the Initial Draft Plan, when compared to base conditions, particularly along the northern Bay coastal basins, produce better nursery and foraging conditions for juvenile pink shrimp. These improved habitat conditions are expected to occur as a result of a greater frequency in the number of low salinity events in coastal basins. Data on sponges and spiny lobster in the coastal basins, however, are too spotty to predict changes in their populations based on the Initial Draft Plan conditions verses base conditions.

The effects of the Initial Draft Plan onselected larger species of estuarine-dependent, resident or transient sportfish, such as spotted seatrout, snook, and red drum were reviewed Initial Draft Plan salinity conditions appear to be biologically important, demonstrating major improvement over 1995 and 2050 base conditions. Spawning and reproductive conditions are expected to improve for spotted seatrout in Crocodile Point, Terrapin Bay, and Garfield Bight areas. This improvement should result in an increase in distribution and abundance of this very popular sportfish in north-central Florida Bay, based on the decrease in frequency of high salinity events. Although this is a major improvement over base conditions, low salinity conditions (<20ppt) east of Terrapin Bay (Little Madeira and Joe Bays) are less than optimum for spotted seatrout spawning activities. Spotted seatrout reproductive activities would likely move west of this area.

Compared to base conditions, the Initial Draft Plan should also lead to the increased survival, abundance, and distribution of snook. This assessment is based on an increase in lower salinity nursery areas within coastal basins in or near the northern Florida Bay shoreline. The increase in the frequency of desirable lower salinity events, which should improve conditions for red drum from Garfield Bight to Little Madeira Bay. Red drum in Florida Bay are mostly comprised of larger juveniles, subadults and adult-sized fish. The area from Garfield Bight to Little Madeira Bay supports nursery and foraging activities for this species.

The improved salinity conditions resulting from the Initial Draft Plan may be expected to have both positive and negative affects on non-game native and exotic species of fish in the Bay. The distribution and abundance of the smaller, native, non-game, species of fish including benthic, canopy and pelagic resident or transient species (i. e. killifishes, mojarras, gobies, engraulids) may be expected to benefit when the Initial Draft Plan salinity conditions are significantly lower than the base cases. Planktivorous feeding pelagic estuarine species, such as bay anchovy, would be expected to increase during lowered salinity periods, particularly at the tidally influenced western Bay coastal basins than at the east Bay basins. Lowered salinity conditions occur primarily during the wet season, as a result of high rainfall and runoff. Upstream of the Bay coastal basins, the conditions resulting from the Initial Draft Plan would be expected to produce a greater number of low salinity, mangrove associated species, including certain killifishes and livebearers (*Poeciliidae*). Exotic fishes, such as Mayan cichlids, can be expected to show substantial increases in reproductively viable populations as a result of any lower salinity conditions within the freshwater transition zones in the Bay. The problem of increasing reproductive populations of these and other exotic fish due to restoring salinity regimes will occur under any alternative lowering salinity in Florida Bay and must be addressed during detailed design.

K.9.2.3 Alligators

One of the major environmental variables influencing the annual production of alligator hatchlings within Shark River Slough is surface water conditions antecedent to each nesting season. Surface water conditions influence the number of females nesting each year and the resultant total production of eggs. More alligators nest when water conditions are higher in the early wet season. During years in which low water levels occur or there is extensive drying during the late dry season, few females attempt to nest during the subsequent wet season months. For these reasons, a priority for ecological restoration related to alligators in Shark River Slough should be the re-establishment of higher antecedent surface water conditions preceding each nesting season. These antecedent conditions must also follow natural topography and natural rainfall repeat frequencies that occur within the Everglades catchment area. These conditions are best simulated by the Natural Systems Model.

The 1995 base and 2050 base are significantly different from NSM and do not in any way approach restoration of antecedent surface water conditions that are important to alligators. The Initial Draft Plan shows significant improvement over the 1995 and 2050 base conditions in improving antecedent surface water conditions. For the Initial Draft Plan, the late dry season water depths in Shark River Slough suggest that the final drying pool is more persistent over the 31-year evaluation period. Under this alternative dry downs occur only 5-15 percent of the time compared with the current 35 - 45 percent under the 1995 base conditions. Dry downs under NSM, however, are predicted to occur only 5 percent of the time in Southwest Shark River Slough and not at all in Mid-Shark River Slough or

Northeast Shark River Slough. So while the Initial Draft Plan represents a distinct improvement over both base conditions, and can be described as moving towards full restoration, further attention to this issue during the detailed planning phase will benefit the plan overall.

Differences in predicted alligator population sizes for the natural system simulation model compared with proposed water management scenarios, have been related to increased nesting effort and success and reduced drought-related mortality (NPS, 1990). This increased nesting effort was apparently a result of the increased stage duration that occurred during the peak mating period (late April/early May). Although much improved over base conditions, the shortcomings of the Initial Draft Plan in duration of uninterrupted flooding and duration of dry conditions may be biologically significant to the alligator. However, in the absence of an appropriate model for alligators in the Southern Everglades, there is a high degree of uncertainty about these effects.

Major and frequent dry downs, as predicted for the 1995 and 2050 base conditions, also adversely impact aquatic prey populations that are important food sources for alligators. Following major dry downs, several years are required for recovery of aquatic food organisms. Major dry down intervals, occurring as frequently as predicted by the 1995 and 2050 bases, would probably prevent such recovery and lead to a downward trend in overall aquatic productivity and capacity to support higher order consumer populations, such as the alligator. Compared with the base conditions, the Initial Draft Plan should improve overall aquatic productivity in Shark River Slough, benefiting the alligator. However, the frequency and duration of dry conditions remain a problem during the alligator mating season.

In the Rocky Glades/Eastern Marl Prairies, the Initial Draft Plan predicts enhanced hydrological conditions compared with the 2050 base, so it is expected to increase nesting effort, nesting success, and abundance of alligators in this area. There may also be a corresponding increase in the number of occupied alligator holes to serve as drought refugia and increase habitat heterogeneity.

K.9.2.4 Wading Birds

For short- and long-legged wading birds, the Initial Draft Plan shows an improvement over 2050 base conditions. Based on the ATLSS modeling, foraging conditions are slightly improved in the peripheral marshes. Under high rainfall conditions, foraging conditions are better than 2050 base conditions in the peripheral wetlands east and west of Shark River Slough. Under low rainfall, the Initial Draft Plan indicated better foraging conditions compared with 2050 base conditions due to a persistent pool of water in the lower end of central Shark River Slough. The Initial Draft Plan shows an overall improvement in wading bird foraging conditions over both 1995 and 2050 bases. This improvement in foraging conditions should benefit the endangered wood stork.

K.9.3 Threatened and Endangered Species

Of the eighteen listed plant and animal species submitted by letter from the USFWS as likely to be affected by the C&SF Restudy, seven are thought to occur within the affected area of Everglades National Park. A brief description of affects to these State and Federally listed threatened and endangered species follows.

K.9.3.1 Snail Kite

Project modifications, proposed under the Initial Draft Plan, are expected to restore more natural hydroperiods to Shark River Slough and the peripheral wet prairies on the east and west sides of the slough. These hydrological improvements, although still short of NSM, will likely provide conditions beneficial to the snail kite. Overall, across all years, the ATLSS snail kite model predicts slightly higher foraging index conditions along the eastern and western edges of Shark River Slough, under the Initial Draft Plan compared with the 2050 base. There is very little difference between the Initial Draft Plan and 2050 in a typical rainfall year. There is also no difference in snail kite foraging conditions between the Initial Draft Plan and 2050 base in a low rainfall year. ATLSS predicts no suitable foraging conditions in either scenario during a regional drought (such as 1990). In keeping with the vagility of the snail kite in Florida as described by Bennetts and Kitchens (1997), under drought conditions the kite would be expected to disperse great distances to other parts of its potential breeding range. ATLSS predicts that under high rainfall years, the Initial Draft Plan will produce slightly higher snail kite index conditions along the east and west sides of Shark River Slough compared with the 2050 base, and lower index conditions in central Shark River Slough. The Initial Draft Plan is not expected to result in adverse modifications to designated snail kite critical habitat.

K.9.3.2 Cape Sable Seaside Sparrow

The Initial Draft Plan is a improvement over the 2050 and 1995 base conditions, which provides more natural hydroperiods in the peripheral wet prairies that the Cape Sable Seaside Sparrow inhabits. Maintaining longer hydroperiods in the Rocky Glades should curtail the invasion of woody vegetation and reduce the frequency and intensity of fires in sparrow habitat east of Shark River Slough. The results of the ATLSS individual based modeling, in a sub-population west of Shark River Slough, show that the Initial Draft Plan is more conducive for sparrow production than the 2050 base and suggests that the sparrow population could reach higher levels more often under the Initial Draft Plan. Model results show that the Initial Draft Plan produces a more stable sparrow population, which appears to be more responsive to breeding population recovery after a decline than under 2050 base conditions. The Initial Draft Plan is not expected to result in adverse modifications to designated Cape Sable seaside sparrow critical habitat.

K.9.3.3 Wood Stork

The Initial Draft Plan shows an overall improvement in wading bird foraging conditions over both 1995 and 2050 bases. This is supported by both the ATLSS high resolution hydrology results and inspection of the Shark River Slough inundation duration and mainland estuary flow volume information, which show significant improvements in hydroperiods, volume and timing of flows relative to the 2050 base. This improvement in foraging conditions should benefit the endangered wood stork, particularly in the Florida Bay estuaries which historically supported the majority of wood stork nesting.

K.9.3.4 American Crocodile

Freshwater flows to Florida Bay estuaries and Shark River Slough are significantly enhanced under the Initial Draft Plan, relative to the 2050 and 1995 bases. Critical habitat has been designated by the USFWS, and extends throughout Florida Bay and the Florida Bay estuaries from about Turkey Point to Cape Sable. According to acknowledged crocodile experts (F. Mazzotti, pers. comm.) these enhanced conditions extend to critical nesting areas including Little Madeira Bay and Joe Bay, which are among the most critical crocodilian habitat. Implementation of the Initial Draft Plan is reasonably expected to benefit the American crocodile, through increased freshwater flows, and decreased salinities in Florida Bay and Shark River Slough estuarine habitats, including its designated critical habitat.

K.9.3.5 West Indian Manatee

As with the crocodile, increased freshwater flows, and decreased salinities in the Florida Bay estuaries and Shark River Slough will likely benefit, and may greatly benefit, the West Indian manatee. Implementation of the Initial Draft Plan is not likely to adversely modify designated critical habitat for the manatee.

K.9.3.6 Eastern Indigo Snake

Eastern indigo snakes inhabit the pine forests and hardwood hammocks of Everglades National Park. Since hydrologic affects are expected to be largely limited to hydroperiod enhancements to existing or historic wetlands, no significant affects would be expected to this upland reptile species.

K.9.3.7 Florida Panther

The Florida panther is known to utilize upland forested habitats pinelands and hammocks, and generally avoids habitats such as sloughs and mangrove forests. The ATLSS model results showed greatest affects on the white-tailed deer, a preferred panther prey species, to be outside of Everglades National Park, in the Water Conservation Areas. No direct affects on panthers are anticipated within Everglades National Park, although some affects on panther dispersal within their present range may result.

K.9.4 Hydrology

Hydrological patterns are a major determinant of plant and animal communities in the Everglades, so matching historical hydropatterns is a critical step in the restoration of plant and animal distributions. The Initial Draft Plan is a definite improvement over the 1995 and 2050 base conditions. Both base conditions are predicted to constitute serious ecological degradation compared with historical Everglades communities. Positive elements of the plan include reasonable matches with NSM conditions of hydroperiod, ponding depths, timing of flows, and the number of drydown events. The Initial Draft Plan has less emphasis on water deliveries via the Lake Belt flowway and reservoir, which reduces the diversion of water from the natural system.

The partial decompartmentalization of the system (removal of L-28, L-29, L-67C, and the Miami Canal) and the nearly complete decompartmentalization of the northern boundary of Everglades National Park with WCA-3A, under the Initial Draft Plan is one of the most important, positive components of the plan and will lead towards restoration of the system. Mean NSM hydroperiod matches (within 30 days shorter or longer) for the Initial Draft Plan, indicate over 95 percent of the Everglades National Park match or nearly match the performance measures. While this performance measure averages values across several hydrologic basins, it does provide a valuable indices of how well the Initial Draft Plan performs in achieving restoration targets within Everglades National Park. Relative to the 2050 base, the Initial Draft Plan improves hydroperiods in over 51 percent of the total Everglades National Park area. Furthermore, mean NSM ponding depths under the Initial Draft Plan are improved throughout Everglades National Park over the 2050 base, with 100 percent of the area matching NSM compared to about 86 percent for the 2050 base and 81 percent for the 1995 base.

As indicated above, the Initial Draft Plan shows an improvement in achieving NSM like conditions in most areas of Everglades National Park. Several of the important areas within Everglades National Park where the Initial Draft Plan demonstrates an improvement over the 2050 and 1995 bases are discussed below, beginning in the northern area of Everglades National Park and proceeding southwards. In Northeast Shark River Slough just south of the Tamiami Tail and east of the L-67 extension (gages NESRS 1-2), the Initial Draft Plan shows a definite improvement in stage duration, increasing flood stages towards the NSM target, although it does not attain the NSM target in stages > 1.25 feet. Average annual overland flows over the Tamiami Trail into Everglades National Park are improved relative to the 2050 base both east and west of the L-67 extension, conveying over 52 percent more flow volume into Northeast Shark River Slough than the 2050 base in the wet season, and 47 percent more in the dry season. Average monthly flows also show this improvement, varying between 7,000 ac-ft and about 70,000 ac-ft more flow volume into Northeast Shark River Slough between May and October, than that predicted under the 2050 base.

Although flow volume, as modeled by the SFWMM, in this and other areas fall short of the NSM target, it is important to note that flow is actually driven by stage, and stage is the more accurate hydrologic criterion to assess conditions which may then be used to assess ecological affects. It is generally accepted that it is the *products* of NSM such as inter-annual variability, frequency of drydowns, and the duration of uninterrupted hydroperiod that are the critical criteria that hydrologic targets strive to replicate, not an exact match of the NSM hydropattern. The conceptual ecological model for the southern Everglades sloughs suggests that changing patterns of hydroperiod and stage are the hydrological parameters which explain most of the adverse ecological responses in a managed system. Since the hydroperiod and stage targets are largely met, it is reasonable to conclude that the Initial Draft Plan should result in substantially improved conditions for native vegetation, and fish and wildlife habitat.

Downstream of the above area, the rockland marl marsh stage duration (gage G-1502) shows substantial improvement towards the NSM target under the Initial Draft Plan. Further south, within the C-111 basin, the Initial Draft Plan stages resemble NSM values, although show no clear improvement over either bases. Within Taylor Slough and at the southern end of Taylor Slough (Gage THSO and Gage NP-207 respectively), stage duration curves show stages under the Initial Draft Plan to be a moderate improvement over both bases particularly at the upper and lower stages. In both cases, the Initial Draft Plan very nearly replicates the NSM targets.

Stages in southern WCA-3A and flows across the Tamiami Trail, west of the L-67 levee are reduced, and resemble NSM more under the Initial Draft Plan than the 2050 base in both the wet and dry seasons. A marsh stage hydrograph, just south of the S-12 structures in Northern Shark River Slough (gage NP 201) shows a good approximation of the NSM characteristics deemed ecologically desirable as discussed above. Stage hydrographs of the alternatives indicate that the Initial Draft Plan more closely approximates the performance measures than does the 2050 base, although does not predict drawdowns as extreme as NSM in some years. In the marl lands, west of Shark River Slough, stage hydrograph and stage duration curves indicate a very close approximation to NSM conditions for all of the alternatives. The 2050 base actually shows a slightly closer approximation to NSM conditions, although the difference is slight, and this may be outside the precision of the model. In northwestern and central Shark River Slough, the Initial Draft Plan shows substantial improvement in depth and duration of flooding over both bases, as measured at gages NP 33 and NP 36 respectively. Stage hydrographs clearly demonstrate an improvement in matching the performance measures under the Initial Draft Plan, especially in reducing the regular extreme (relative to NSM) drydown depths associated with both base cases. In the marl lands east of Shark River Slough (NP 38) moderate improvements are demonstrated under the Initial Draft Plan relative to both bases and target hydroperiods are largely achieved.

K.9.5 Water Quality

The excellent water quality conditions in freshwater regions of Everglades National Park are not expected to be significantly changed by implementation of the Initial Draft Plan compared to the 1995 and 2050 base conditions. Water quality conditions in the estuarine portion of Everglades National Park and in Florida Bay are expected to be improved by the Initial Draft Plan relative to the 1995 and 2050 base conditions. The key water quality parameters of concern in the Everglades National Park and Florida Bay are total phosphorus (TP), mercury and salinity.

Currently Everglades National Park freshwater marshes are oligotrophic (nutrient poor) with TP concentrations in the Everglades National Park marsh routinely below 10 ppb. A primary evaluation tool used by the Restudy Water Quality Team to evaluate the relative water quality effects of the various Restudy alternatives reviewed during the Restudy Plan Formulation and Evaluation Phase (October 1997 - June 1998) was the Everglades Water Quality Model (EWQM) (SFWMD, 1998). The EWQM simulates phosphorus transport in the Everglades Protection Area (Everglades National Park and WCAs) and links to hydrologic output from the South Florida Water Management Model. The EWQM evaluation of the Restudy alternatives and the 1995 and 2050 base conditions indicated that Alternatives B and the Initial Draft Plan were the preferred alternatives from a water quality perspective. This conclusion is tied closely to the decompartmentalization aspects of the Initial Draft Plan and Alternative B, which reduce structural flows into Everglades National Park and increase surface water sheetflow of waters entering Everglades National Park. The EWQM results suggest and the Restudy Water Quality Team concluded that maximizing surface water sheetflow of hydrologic flows entering Everglades National Park would reduce the net nutrient load within Everglades National Park.

The following Initial Draft Plan components are of particular interest relative to potential positive and negative effects they may have on water quality conditions in Everglades National Park:

Western C-11 basin diversion (eliminates discharges of urban runoff to eastern WCA 3A and Everglades National Park via S-9 pump station);

Relocation of a portion of L-31 North canal with new water control structures (S-356 A&B) to increase flows to NE Shark River Slough (Everglades National Park);

Modified operation of S332- A/B/D structures in Everglades National Park, Taylor Slough area to increase flows delivered to Everglades National Park and Florida Bay;

Relocation and increase in capacity of pump station S-140 to improve hydropatterns and hydroperiods in WCA 3A, Everglades National Park and Florida Bay;

Big Cypress-L-28 Interceptor Canal modifications and stormwater treatment areas: convert existing canal flow discharge into western WCA 3A to surface water sheetflow through Everglades marsh and add two stormwater treatment areas to clean water prior to sheetflow.

The Western C-11 diversion impoundment and the L-28 Interceptor canal modifications will have beneficial effects on water quality conditions in Everglades National Park. The C-11 diversion will relocate the discharge of C-11 west basin stormwater runoff at the S-9 pump structure, which now discharges to WCA 3A, south to the North Lake Belt storage area with eventual routing of these flows to Biscayne Bay. The Initial Draft Plan will result in 185,800 acre feet/year (SFWMM 31 year average) less water being discharged from S-9 into WCA 3A then the 2050 base condition. This feature will therefore result in a significant reduction of pollutant loading into WCA 3A and downstream Everglades National Park. Modifications to the L-28 Interceptor Canal will also result in a reduction of pollutant loading to the western portion of WCA 3A and the downstream Everglades National Park. Structure L28WQ, shows that average flows (SFWMM 31 year average) from the L-28 I canal will be reduced from 89,300 acre feet/year in the 2050 base condition to zero.

Construction of the S-356 A&B structures, modifications to C-111 Canal operations in south Miami-Dade County, and relocation and enlargement of Pump Station S-140 will result in increased flows entering Everglades National Park as a result of Initial Draft Plan hydrological restoration actions. The Initial Draft Plan components will result in 263,600 acre feet/year, 106,000 acre feet/year and 285,000 acre feet/year (SFWMM 31 year average) greater water discharges into WCA 3a and Everglades National Park than the 2050 base condition. Although these increased flows are important to future restoration of the WCAs, Everglades National Park and Florida Bay, it is important to note that the implementation of the Initial Draft Plan will have to ensure that all additional flows greater than 2050 base condition flows will have to be adequately treated in order to meet all State/Tribal water quality standards in the receiving waterbodies (Everglades National Park is an Outstanding Florida Water). For these three Initial Draft Plan components it is assumed that additional waters delivered to the Everglades Protection Area by these structures will be adequately treated consistent with the water quality requirements of the Everglades Forever Act.

The focus of the Restudy Water Quality Team's water quality evaluation for Florida Bay relates to restoring ecologically desirable freshwater flows to the Bay, thereby restoring seasonal salinity conditions across the Bay to as close to historic conditions as possible.

The following Initial Draft Plan components are expected to operate synergistically in a manner which will improve estuarine water quality conditions in the Everglades National Park/Florida Bay region:

The Modified regulation schedule for Lake Okeechobee would provide increased environmental water delivers to the WCAs, Everglades National Park and Florida Bay;

The Everglades Agricultural Area reservoir - 60,000 acres at a maximum of 6 feet depth, would result in increased environmental water delivers to the WCAs, Everglades National Park and Florida Bay;

Everglades rain-driven operations in WCAs 2 and 3 would improve hydropatterns and hydroperiods in the WCAs and Everglades National Park;

The Central Lake Belt Storage Area would be operated to improve hydropatterns and hydroperiods in WCA 3B and Everglades National Park;

The Bird Drive Basin recharge area would store water, control seepage, attenuate peak floods in C-4 basin, and deliver water to the South Miami-Dade Conveyance System;

L 31 North levee improvements would provide seepage management, eliminating seepage to the east out of Everglades National Park from NE Shark River Slough, maintaining higher water stages and longer water duration in NE Shark River Slough;

Additional water control structures between WCA 3A and 3B will increase flows to Everglades National Park;

Relocation of a portion of L-31 North canal, with new water control structures (S-356 A&B) to increase flows to NE Shark River Slough, Everglades National Park;

Regional-scale Lake Okeechobee Aquifer Storage and Recovery (1000 MGD) would improve water flows to WCAs and Everglades National Park;

Modified operation of S332- A/B/D structures in Everglades National Park, Taylor Slough area will increase flows delivered to Everglades National Park and Florida Bay;

Removal of L-68 A levees, L-67 C levee, backfilling L-67A canal, removal of L-29 levee and canal; removal of L-28 and L-28 tieback levees, and backfilling Miami Canal, will partially de-compartmentalize WCA-3Aand reestablish historic hydrologic sheetflow between WCA 3 and Everglades National Park;

Relocation to the south and increase in capacity of pump station S-140 would improve hydropatterns and hydroperiods in WCA 3A, Everglades National Park and Florida Bay;

The C-111N Spreader Canal and backfilling of C-110/lower C-111 canal systems, removal of the S-197/S-18C structures and eastward extension of C111N will improve water management for the Everglades National Park panhandle area and Northeast Florida Bay;

Diversion of excess WCA 2B water to NE Shark River Slough or Central Lake Belt storage area would enhance hydropatterns/hydroperiods in NE Shark River Slough, Everglades National Park and Florida Bay;

Storage of excess flows from WCA 2A/B & WCA 3A in a new Central Lake Belt storage area, to be returned to WCA 3B, and Everglades National Park would assist in to achieving preferred hydropatterns and hydroperiods, and would provide benefits to downstream Florida Bay also;

The West Miami-Dade Reuse component would enhance groundwater recharge in Bird Drive basin and provide additional water supplies to the South Miami-Dade Conveyance System to enhance seepage control in eastern Everglades National Park.

Considering cumulative water quality benefits to Florida Bay, several hydrological performance measures developed by the Restudy, relating to improved freshwater flows to Florida Bay and improved salinity conditions in Florida Bay, demonstrate the positive synergistic effect of the above listed 16 Initial Draft Plan components. The hydrological performance measures entitled "Average Annual Flows toward Florida Bay across Taylor Slough for the 31 yr. Simulation" indicates that Initial Draft Plan freshwater flows from Taylor Slough to Florida Bay are closer to the Natural System model target than either the 1995 or 2050 base condition flows. Another relevant hydrological performance measures in the Florida Bay area entitled "Average Annual Overland Flows toward Whitewater Bay and Florida Bay for the 31 year simulation period" indicates that: 1) Initial Draft Plan flows from the Shark River Slough are closer to the Natural System model target than either the 1995 or the 2050 base condition Shark River Slough flows (Shark River Slough freshwater flows enter the western portion of Florida Bay) and 2) Total southward flows to the northeastern portion of Florida Bay from three Everglades National Park basins indicate that the Initial Draft Plan freshwater flows are much closer to the NSM target then the 1995 base condition flows and are generally equal to 2050 base condition freshwater flows.

Relative to hydrological performance measures that relate to restoration of ecologically beneficial salinity conditions in eastern Florida Bay, which receives flows from the Taylor Slough/River, the hydrological performance measures entitled "Number of Months high/low Salinity Criteria Exceeded for Little Madeira Bay" is especially important. Little Madeira Bay receives freshwater from Taylor Slough/River in a portion of northeastern Florida Bay where ecologically damaging hypersalinity conditions have been documented in the past decade. This hydrological performance measures clearly indicated that the Initial Draft Plan salinity characteristics in Little Madeira Bay are much closer to the Natural System model salinity targets than either the 1995 or 2050 base conditions.

In summary, the above discussed hydrological performance measures indicate that improved hydroperiods and hydropatterns of Initial Draft Plan (synergistic effect of above referenced 16 Initial Draft Plan components) freshwater flows to Florida Bay, relative to both the 1995 and 2050 base conditions, will result in improved water quality conditions in Florida Bay.

K.9.6 Socio-Economics

Everglades National Park is operated by the National Park Service, United States Department of the Interior. As Federal land, it does not directly produce an economic output. The Park generates indirect income to neighboring counties through eoctourism, operation of its three visitor concessions, and through spending of Park visitors in adjoining communities. The Initial Draft Plan is expected to lead to significant improvement in fish and wildlife habitat, and has been predicted to improve habitat for alligators, increases in forage fish populations, and improved foraging and nesting success for colonial wading birds, among other Park wildlife. These improvements may cause an increase in Park visitation and possibly prolonged stays in and near the Park by these visitors. Therefore, the indirect income generated by Park visits can be expected to increase, relative to 1995 and 2050 base conditions.

K.9.7 Land Use

No significant changes in land use are expected inside Everglades National Park.

K.9.8 Agriculture

There is no significant agricultural production in this region.

K.9.9 Recreation Resources

If native wildlife populations, especially large consumers (alligators and raptors) and wading bird colonies, increase substantially under the Initial Draft Plan as predicted, there will be a greater abundance of "watchable wildlife" in the park. This should increase visits to the Park for bird watching, photography and other wildlife-related recreation. Florida Bay fisheries are also expected to increase, which may lead to increased sport fishing trips and increased demand for guide and outfitter services.

K.9.10 Aesthetics

Removal of the L-29 levee and bridging of part of Tamiami Trail should lead to an improvement in the visual aesthetics along this northern Park boundary. Partial re-flooding of the marl prairie regions on either side of Shark River Slough should likewise increase the visual diversity of this area, as observable from access points and observation towers, and probably attract more birdlife into these areas, especially during the winter drydowns.

K.9.11 Unavoidable Adverse Environmental Effects

Compared to either the 1995 or 2050 base conditions, most environmental effects resulting from implementation of the Initial Draft Plan would be positive. There will be temporary adverse effects related to construction of some project elements that impinge on the Park, with temporary intrusion of heavy machinery into Park borderlands during construction or demolition of water management structures. Implementation of the Initial Draft Plan in general should not result in significant unavoidable adverse effects. Localized, slight to moderate environmental effects may occur in the vicinity of project construction sites. Of note would be project features requiring extensive and prolonged use of heavy machinery and possibly blasting, in the vicinity of, or within the Everglades marsh. This would likely be the case with the proposed degradation of the L-67Extension, L-29 levee, filling in of borrow canals, and removal of associated water conveyance systems. Moreover, the construction of a bridge, causeway, or other such structure which would replace the Tamiami Trail, while fulfilling the intended project purposes as outlined in the Initial Draft Plan, may pose important localized effects to the marsh ecosystem for the duration of construction activities. Noise and disruption of the viewscape are probably the most significant adverse environmental effects. Some wading bird roosts may be temporarily disturbed, as has occurred in the past during modification of water management structures. Adverse impacts to Park trust resources would be minimized by scheduling work outside major life-cycle periods (e.g., nesting or peak foraging cycles of breeding birds).

K.9.12 Relationship Between Short Term Uses and Long Term Productivity

Removal of the L-67 Extension, and L-29 levees, backfilling of borrow canals, and removal of associated water control facilities represents a significant short-term disruption to the environment, and possible unintentional direct and indirect environmental consequences. Localized impacts to water quality, and possible disruption to, and taking of fish and wildlife due to construction and possibly blasting may result. The L-67A, immediately north of Everglades National Park, may represent another proposed project feature, which could represent a trade-off between recreation within the canal versus sheetflow restoration within Shark River Slough. Short-term effects due to construction activities such as use of heavy machinery, vehicular and equipment access, creation of staging and turnaround areas etc.) may also include localized impacts to aesthetics, wetlands, noise, air quality during the construction phase of the project. These impacts will be minimized wherever possible.

Once completed, the area impacted should quickly return to a more natural state. Vegetation would be expected to regrow over the existing project footprint and over time, the area would return to providing the natural qualities and functions that it provided historically. In addition, these modifications to the water management system will have a beneficial long-term effect on Everglades National Park by restoring more natural overland flows and hydroperiods to these areas. This in turn, it is expected, will result in providing the conditions necessary for a healthier sustainable ecosystem, including appropriate conditions to sustain native vegetation assemblages, and fish and wildlife habitat.

K.9.13 Irreversible and Irretrievable Commitment of Resources

The proposed degradation of levees, backfilling of canals, and removal of structures, as described above, represents, in all likelihood, an irreversible and irretrievable commitment of resources. These resources would include state and Federal funding, labor, energy and project materials and equipment to degrade the existing levees proposed for removal, back filling the canals, and removal of the existing water conveyance structures. It is possible that certain of the water conveyance structures may be retrievable for use elsewhere, however since the levees upon which they are built would no longer exist, they would no longer be able to function at their existing location. Upon implementation of upstream project features which would affect headwater elevations in WCA-3A, regional water flow, distribution and timing, these structures would no longer be necessary, and their removal would facilitate more natural flows through Shark River and Taylor Sloughs, enhance de-compartmentalization and reduce fragmentation of the natural landscape and its ecological components.

K.9.14 Cumulative Effects

The restoration of the more natural flows from WCA 3A, WCA 3B, and Big Cypress National Preserve, greater overland flow volumes, and additional flows beyond the existing flow sources relative to the 2050 base, is not expected to result in a cumulative negative effect to the environment of Everglades National Park. Project features designed to restore more natural flows result in substantially enhanced and more NSM like hydroperiods throughout much of Everglades National Park and downstream estuaries. These changes, a result of various project elements, involve minimal construction and structural features within Everglades National Park itself, although there are important project features under the Initial Draft Plan which occur at the boundary of Everglades National Park (see sections 9.12 and 9.13, above).

K.10 BIG CYPRESS REGION

The area of the Big Cypress region primarily affected by the Initial Draft Plan lies within the Big Cypress National Preserve (BCNP) boundary, the BCNP addition lands, the Big Cypress Seminole Indian Reservation and Miccosukee Indian Reservation. Components of the Initial Draft Plan affecting the hydrology, and thus the ecology of this area include: 1) modifications to the L-28 Interceptor canal that would reroute water from the West and North feeder canals to wetlands in northeast Big Cypress, including degradation of the southwest L-28 Interceptor levee and filling in the adjacent canal to enhance sheetflow into the BCNP addition lands; 2) Pump stations and spreader canals built or relocated along the L-28 Interceptor in order to facilitate sheet flow off of the Seminole and Miccosukee reservations; 3) Assumption that this alternative will comply with the Seminole Indian Tribes' Conceptual Water Conservation System master plan; 4) construction of two stormwater treatment area to ensure acceptable water quality prior to discharge from the North and West Feeder canals; and 5) Degradation of the L-28 levee (south of the gap with the L-28 Interceptor), L-28 Tieback and L-29 Levee between Forty-mile bend and the L-67, and removal of all associated structures, including the S-344, S-343(A), S-343(B) and the four S-12 (A-D) structures. Reference Section 9 for a detailed description of the Initial Draft Plan.

In general, given the location of the operational and structural changes to the existing C&SF system described above, and the fact that the Big Cypress represents a distinctly different hydrologic and ecological region than the adjacent Everglades, only limited and somewhat scattered effects should be expected due to the Initial

Draft Plan. These effects would be in the lands along the eastern boundary of the BCNP, along the L-28 Interceptor and in the sloughs draining the BCNP towards the Gulf of Mexico south of Loop Road. Hydrologic effects should be most dramatic and widespread in the area southwest of the L-28 Interceptor, where the Initial Draft Plan converted hydroperiods to NSM conditions (M. Duever, pers. comm.).

Finally, as the water quality entering the northeastern Big Cypress from the Feeder canals is, at present, of poor quality, it is important that the recommended plan ensure adequate water quality treatment prior to restoring more natural flows from this area. It is assumed, for planning purposes, that compliance with the Big Cypress Seminole Water Conservation Master Plan, in combination with the two proposed stormwater treatment area along the Western and Northern Feeder canals, will achieve these water quality standards. Without successful achievement of water quality targets, flows entering the northeastern Big Cypress may, in fact, cause more harm than good to the receiving waters (M. Duever, pers. comm.).

K.10.1 Vegetation

Implementation of the Initial Draft Plan would not likely result in a significant change to existing vegetation and cover within the affected area, assuming inflows from the Feeder canals are treated to acceptable standards prior to discharge into northeastern Big Cypress, except in the area southwest of the L-28 Interceptor. This area is expected to return to NSM conditions, which would benefit native vegetation through more natural timing, depth, and duration of flooding. Communities in western BCNP, including extensive areas of pinelands, cypress/mixed swamp, freshwater marl prairie, and cypress prairie, would likely not be affected by the alternative, as hydrologic conditions in these areas are nearly unchanged between the Initial Draft Plan and the 1995 and 2050 base cases. The primary effects to vegetation and cover would occur as a result of more natural flow characteristics, including inundation time, depth and flood duration, generally in the eastern region of BCNP, east of Monroe Station. Hydroperiods along the eastern region of the BCNP more closely match natural hydroperiods as simulated by the NSM model in many of the key indicator regions, particularly in the area of the L-28 Interceptor, the gap between the L-28 Interceptor and the L-28 Tieback, both north and south of the L-28 Tieback, and south of Loop Road in the Lostmans Slough area (southeast BCNP; T26; Row 21, C11-16). These changes produce hydrologic conditions more suitable to sustaining viable and healthy populations of native vegetation, including medium to longer hydroperiod vegetation classes indicative of the eastern BCNP. Uplands and hardwood hammocks within this eastern area will remain largely unaffected by hydrologic change resultant from implementation of the Initial Draft Plan.

Plant communities that may benefit from hydroperiods more closely resembling those of the NSM include the cypress prairie communities, which typically have hydroperiod ranges from 90 to 270 days (Duever et al., 1978; Duever, 1980, Weakley et al., 1996); mixed-hardwood cypress strand (125 to 365 days; Gunderson and Loope, 1982a; USDI, 1991); and cypress strand/cypress dome (240 and 340 days; Duever et al., 1986; Olmstead et al., 1980; USDI, 1991). Cypress strands and cypress domes are found in abundance within the BCNP, particularly north of Hwy 41 and west of the L-28 levee in an area that is expected to experience the greatest hydroperiod benefit. Extensive areas of graminoid marsh south and west of Forty-mile bend would also benefit from more natural hydrologic conditions under the Initial Draft Plan, relative to the 2050 base, by reducing average annual overland flow to more NSM like conditions. This vegetation type, with a hydroperiod of 220 to 365 days (Gunderson and Loope, 1982b; Olmstead et al., 1980; Weakley et al., 1996; USACE, 1990), would likely benefit by the somewhat lower water levels, although there are slightly fewer but longer periods of inundation than for NSM or either of the two bases under the Initial Draft Plan.

K.10.2 Fish and Wildlife

Fish and wildlife resources would not be directly affected by implementation of the Initial Draft Plan (the Initial Draft Plan). Restoration of the natural hydropattern characteristics in the eastern Big Cypress may result in minor shifts in habitat structure. No effect either positive or detrimental would be expected in the western region of the BCNP due to the negligible hydrologic changes. Restoration of the NSM hydropattern and fire regime should provide for optimum wildlife habitat conditions in the eastern BCNP and Lostmans Slough area.

The Initial Draft Plan also demonstrates variable improvement in overland flows toward the Gulf of Mexico in terms of volume and timing that may affect estuarine species. Volume and timing of freshwater flow in the Lostmans Slough area shows improvement over the 2050 base case and existing conditions, nearly replicating the NSM. However, in the eastern Big Cypress the Initial Draft Plan flows are only slightly closer to NSM as compared to current or 2050 conditions.

Significant improvements to the water regime in northeast Big Cypress, in the gap between the L-28 Interceptor and the L-28 Tieback and in the vicinity of the L-28 Tieback, would be expected to benefit water-dependent species such as the gallinule, the snowy egret, and the American alligator. The endangered wood stork may also benefit by an improvement to the availability of quality foraging habitat.

Critical upland wildlife habitat, such as pine forests and hardwood hammocks, is not expected to be significantly affected by the modifications to the existing hydrologic regime. Fish and other water dependent species will not likely be directly affected by implementation of the Initial Draft Plan throughout most of the Big Cypress region, although some species may benefit in terms of reproductive success, through longer, more natural hydroperiods in the eastern Big Cypress and northeast BCNP addition lands. The Initial Draft Plan produces flows closer to NSM flows in the Lostmans Slough area south of Loop Road. The reduction in overland flow volume may result in somewhat lower biomass of large fish due to the shallower depths, but is likely to increase the density of smaller fish as well as their availability to predators. The Initial Draft Plan may produce conditions more favorable to wading birds then than the 2050 base condition by enhancing their forage base.

K.10.3 Threatened and Endangered Species

Of the eighteen listed plant and animal species submitted by the USFWS as likely to be affected by the C&SF Restudy, seven are thought to occur within the affected area of the Big Cypress region. A brief description of effects to these state and federally listed threatened and endangered species follows.

K.10.3.1 Florida Panther

The Florida panther (*Felis concolor coryi*) known to reside within the Big Cypress region is one of the most endangered large mammals in the world. Although it is listed as endangered by the USFWS and GFC, no critical habitat has been designated. The panther prefers upland habitat, hardwood hammocks and pine flatwoods being a preferred habitat. White-tailed deer, feral hogs, raccoon, and armadillo are preferred prey species, which reside primarily within the higher elevation areas of the Big Cypress. The Initial Draft Plan is expected to affect mainly the wetland areas of the Big Cypress, and mainly within the eastern section of the Preserve. No effect is anticipated to the panther, its preferred habitat or its forage base, as a result of modified hydroperiods within the eastern Big Cypress.

K.10.3.2 Snail Kite

In a letter dated July 15, 1996 from the USFWS, the L-28 levee was identified as the western boundary for designating critical habitat for the snail kite (*Rostrhamus sociabilis plumbeus*), a Federal and state listed endangered raptor. Project modifications proposed under the Initial Draft Plan are expected to restore more natural hydroperiods to the eastern Big Cypress, an area that may be frequented by the snail kite. These hydroperiod improvements should provide conditions beneficial to the snail kite and its primary food source, the apple snail, to the extent that this habitat supports kite foraging.

K.10.3.3 Red-cockaded Woodpecker

The USFWS has listed the Red-cockaded woodpecker (*Picoides borealis*) as endangered, due largely to destruction of its habitat, and fragmentation of its historic home range. It is listed as threatened by the GFC. Red-cockaded woodpeckers make their home in pine dominated hardwood stands, with longleaf and hydric slash pine a preferred nesting habitat. There are about 24 nesting colonies (clusters) identified in the BCNP within the area expected to be affected by the Initial Draft Plan (USFWS 1998). Hydrologic modifications made under the Initial Draft Plan are closer to the NSM target (nearly 100 percent match in areas known to contain woodpecker clusters) relative to the 2050 base. In the long term, this alternative should act to restore and maintain quality habitat, by maintaining a more natural fire periodicity, and impede invasive exotic vegetation. As a whole, restoration of conditions similar to NSM in the north Big Cypress and within the pinelands located westward of the L-28 Tieback, should result in a slight benefit to Red-cockaded woodpeckers by protecting and restoring habitat quality.

K.10.3.4 Wood Stork

The USFWS and the GFC list the wood stork (*Mycteria americana*) as an endangered species. Environmental conditions, including more NSM like flows throughout much of the eastern Big Cypress, in the vicinity of Loop Road, should provide moderate benefits to the wood stork. Stage duration curves and stage hydrograph data for this area indicate that the Initial Draft Plan provides hydroperiods closer to the NSM than does the 2050 base throughout most of the year. Similar data for the southeastern Big Cypress, at gauge NP-34, near the border with Everglades National Park, are less conclusive, with most of the alternatives following similar trends, and the Initial Draft Plan flows slightly below that of the NSM target and the 2050 base throughout most of the year. Although not conclusive, this data would seem to indicate slightly poorer conditions for the wood stork for this area, beyond those conditions expected under the 2050 base. The ATLSS fish model did predict slightly better conditions for predicted fish density within this area, which would benefit storks. The ATLSS long-legged wading bird model overall predicts little change, with an overall slight benefit in foraging conditions in the central and eastern areas of the BCNP, and slightly poorer conditions relative to the 2050 base in the southeastern Big Cypress.

K.10.3.5 Cape Sable Seaside Sparrow

Cape sable seaside sparrows (*Ammodramus maritima mirabilis*) are listed as endangered by the USFWS and the GFC. Disparate populations of sparrows exist within the physiographic region of the Big Cypress, and are located primarily within the short-hydroperiod marl prairies along the west side of Shark River Slough (SRS), and the Stairstep area of BCNP and Everglades National Park. Results of the ATLSS breeding potential index (BPI) for these populations, predict overall positive effects to sparrow breeding potential in typical rainfall (1977), low rainfall (1990), and mean years for most of the northern and western most populations and slightly poorer breeding potential for the southern most portion of the western population. This is probably due to substantially lengthened hydroperiods within Shark River Slough due to project modifications outside the sphere of influence of those described above for the Big Cypress region. Curnutt et al. (1998) concluded that the Initial Draft Plan produced lower BPI values relative to the 2050 base in the southern portion of the western breeding area under most hydrologic conditions. The results of the individual based model (SIMSPAR), which accounts for detailed effects of localized water dynamics on individual bird growth, survival, and reproduction, suggested that the sparrow population may be able to reach higher levels under the Initial Draft Plan than the 2050 base. Moreover Curnett et al. (1998) suggested that conditions under the Initial Draft Plan predict a more stable sparrow population and conditions appeared to be more conducive to breeding population recovery after a decline relative to the 2050 base. It is therefore reasonable to conclude that conditions under the Initial Draft Plan may favor a healthier and sustained population of Cape sable sparrows west of SRS beyond that predicted by the 2050 base or that which exists today.

K.10.3.6 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is listed as threatened by both the USFWS and the GFC. The effects on hydrology through water management practices proposed under the Initial Draft Plan as well as the levee proposed for removal, should have minimal effect on bald eagles. Increased overland flow through the eastern Big Cypress, at all times of the year, towards the Gulf of Mexico, may result in slight benefits to eagle foraging.

K.10.3.7 Eastern Indigo Snake

The eastern indigo snake (*Drymarchon corais couperi*) is a large, black, non-venomous snake and occurs within every major physiographic region within the study area. The USFWS and GFC list it as a threatened species. Water level changes under the Initial Draft Plan would not be expected to impact upland areas such as tropical hammocks, pine flatwoods, coastal dunes or other areas where indigo snakes are known to reside. No effects to indigo snakes are expected under the Initial Draft Plan.

K.10.4 Water Management

Management of freshwater flows to the Big Cypress region will be moderately affected by the proposed modifications to the L-28 Interceptor, L-28, L-28 Tieback, L-29 and all associated water control and delivery structures. Since the Big Cypress is distinct physiographically, topographically, and hydrologically from the adjacent Everglades system, the effects of these water management changes are somewhat scattered, and largely localized to the eastern side of the BCNP, extending from the Seminole Big Cypress Indian Reservation, through the BCNP addition lands, and into the Lostmans Slough area to the Everglades.

In an effort to re-establish sheet flow south of the Western Feeder Canal, and rehydrate wetlands in the northeast Big Cypress, sheet flow will be allowed at designated locations south of the Western Feeder Canal. The L-28 Interceptor will be degraded and the canal filled at a point south of the S-190 structure, and S-190 will be converted to a pump station. Hydroperiods in the Initial Draft Plan were improved over a large area from the southern end of the Western Feeder Canal, along the L-28 Interceptor, to just south of the L-28 Tieback. This is probably due to flows from the Western Feeder canal and the removal of the southwest L-28 Interceptor levee and filling of the adjacent canal (M. Duever, pers. comm.). Too much water is allowed to accumulate below the S-190 pump station and along the extreme eastern boundary of the Big Cypress physiographic region (outside and to the east of the BCNP addition lands), at the southern end of the L-28 Interceptor. According to the model, these hydroperiods have overshot the NSM by greater than 30 days, and in some cases longer. These areas may be experiencing biologically significant amounts of flooding, which could have localized negative impacts to vegetation and wildlife habitat.

Average monthly overland flow towards the Gulf of Mexico through the eastern Big Cypress and Lostmans Slough areas are variably improved under the Initial Draft Plan. In the eastern Big Cypress overland flow volume, duration and timing are slightly improved over the 2050 base case during the period June though December. The Initial Draft Plan flow volume falls short of the NSM target by between 1,000-6,000 acre-feet during this period. The remainder of the time, the Initial Draft Plan overland flow is similar to the base condition and nearly matches the NSM. In Lostmans Slough, the Initial Draft Plan overland flows are significantly improved over the 2050 base, which overshoots the NSM the entire year. the Initial Draft Plan mimics the NSM well particularly from May to September, then falls slightly short of the NSM target from about October through December. In all cases however the Initial Draft Plan is a significant improvement in attaining more natural flows through the southeastern Big Cypress than does the 2050 base condition.

Average annual overland flows to the Gulf in the Big Cypress, are variable geographically, but tend to support the monthly overland flow scenario described above. For the Eastern Big Cypress, the Initial Draft Plan overland flows increased just more than 10 percent towards NSM flows in the wet season, and little change in dry season flows beyond the 2050 base case. In the Lostmans Slough area, there is a significant reduction in overland flow volume towards the NSM target in both the wet and dry season. The Initial Draft Plan overland flows nearly match the NSM in both seasons, while the 2050 base case overshoots the NSM by about 25 percent in the wet season and over 35 percent in the dry season.

These changes in flow volume, timing and duration are probably attributable to the increased flows from the L-28 Interceptor area and through the area of the L-28 Tieback (now removed). Removal of the L-28 and the water control structures S-344, S-343(A) and S-343(B), may also have an effect on flows, but modeling by the

SFWMM appears to show that these project modifications have a relatively minor effect in the case of flows through the southeastern Big Cypress and act to diminish flows through the eastern Big Cypress. Removal of the L-28, and S-344 probably has less of an effect on the southeastern Big Cypress than does removal of the L-29 and the S-12(A-D) structures (M. Duever, pers. comm.).

K.10.5 Water Quality

Water quality conditions in the Big Cypress Region are expected to improve compared to both the 1995 and 2050 base conditions through implementation of the Initial Draft Plan. The key water quality parameters of concern in the Big Cypress region are: TP, NOx and DO. The largest beneficial effect of the Initial Draft Plan on Big Cypress water quality conditions will result from implementation of modifications to the L-28 Interceptor Canal. Less significant beneficial effects to Big Cypress water quality conditions are expected to result from implementation of decompartmentalization of WCA 3A.

Implementation of Initial Draft Plan component, Big Cypress / L-28 Interceptor Modifications would result in the backfilling of the southern portion of the L-28 Interceptor canal south of existing structure S-190 (approximately 12 miles) and degrading the existing levee on the southwest side of the L-28 I canal. Current canal water flows in the west feeder and north feeder canals upstream from structure S-190 will be modified to be surface water sheetflows south across the Big Cypress National Preserve, downstream from the Seminole Tribe's Big Cypress Reservation, using several pump stations and a spreader canal system. Additionally, Structure S-190 would be converted from a gated structure to a pump station to maintain upstream flood protection. Two new stormwater treatment areas would be constructed adjacent to the west and north feeder canals to treat stormwater runoff from upstream basins prior to entering the Seminole Tribe's Big Cypress Reservation. The two stormwater treatment areas, a 1100-acre stormwater treatment area adjacent to the north feeder canal and a 800-acre stormwater treatment area adjacent to the west feeder canal are sized to reduce TP and other pollutant loads entering the downstream waters of the Seminole Tribe, the BCNP, the Miccosukee Tribe Reservation and ultimately WCA 3A, so as to assure that Tribal and State water quality standards in the receiving waterbodies are met. Modification of the existing west and north feeder canal flows and L-28 I canal flows to Initial Draft Plan surface water sheetflows across the BCNP is also anticipated to provide beneficial water quality treatment for the downstream nutrient sensitive waterbodies.

Initial Draft Plan component, Decompartmentalization of Water Conservation Area 3 would result in the partial decompartmentalization of WCA-3A. Of particular relevance to Big Cypress region water quality conditions is the degradation of the L-28 and L-28 Tieback levees with backfilling of the adjacent borrow canals and removal of the S-343A and S-344 structures in the L-28 levee. Removal of the L-28 and L-28 Tieback levees/canals and S-343A/344 will enable wet season surface water sheetflows in the western region of WCA 3A to flow in a southwesterly direction across the eastern region of BCNP. Therefore, existing pollutant loading being delivered to the southeastern region of BCNP and the westernmost region of Everglades National Park through the S-343A/S-344 structures will be spread out across an approximate 15 mile long front in the eastern area of BCNP. Replacing the existing structural point source wet season flows from WCA 3A with broad dispersed surface water sheetflows will result in pollutant uptake and sequestration by the native vegetation in the area and generally improve water quality conditions in the eastern BCNP.

K.10.6 Water Supply

The area of the Big Cypress, which may be affected by this project, is wilderness and largely undeveloped, other than some residential development along Loop Road, Preserve infrastructure and scattered municipal and private sector development. Potable water supplies are from wells, which capture underground water from the surficial aquifer. Modifications to flow volume, timing and duration due to implementation of the Initial Draft Plan are thought not to be of sufficient magnitude to affect local water supply needs, either existing or future.

K.10.7 Socio-Economics

Implementation of the Initial Draft Plan and concomitant moderate changes to the hydrology of the eastern portion of BCNP is not expected to have material effects to the socio-economic conditions in either the short or long term.

K.10.8 Land Use

The following description of effects on land use is organized into three sections. One section discusses land use within the BCNP, the second for those areas such as state and Federal protected lands outside of the BCNP, and thirdly, agricultural land use, primarily on the Seminole reservation, and northeastern Big Cypress.

K.10.8.1 Big Cypress National Preserve

Land use within the Big Cypress basin will not likely be significantly affected by implementation of the Initial Draft Plan. Removal of the L-29 includes raising SR 41, either by construction of a bridge or causeway. Residential development and future Miccosukee Indian residences along Loop Road will not be affected by flow modifications to southeast Big Cypress. Permitted uses within the BCNP such as the Dade-Collier Transition and Training Airport (Jetport), oil and gas fields located at Bear Island, and Raccoon Point will not be significantly affected by the Initial

Draft Plan. Roads, canals, levees and borrow pits, other than those canals and structures proposed for degradation or removal in the Initial Draft Plan alternative, will remain unaffected by modifications to the areas hydrology.

Traditional use of lands within BCNP, guaranteed to the Miccosukee Tribe of Indians of Florida and members of the Seminole Tribe of Florida under Public Law 93-440, would not be affected by implementation of the Initial Draft Plan. This would include tribal use of Federally acquired lands within the BCNP for tribal activities including hunting, fishing, trapping on a subsistence basis and traditional tribal ceremonies.

K.10.8.1.1 Urban Areas

The urban areas along the coast, including the municipalities of Naples, Everglades City, and Marco Island are outside the area of hydrologic influence of the Initial Draft Plan and land use will be unaffected by the project.

K.10.8.2 Land Use Outside the Big Cypress National Preserve

Lands west of the Big Cypress National Preserve, including Fakahatchee Strand State Preserve, Southern Golden Gate Estates, and Florida Panther National Wildlife Refuge, will be unaffected by modifications made by the Initial Draft Plan, nor will this preclude or materially affect possible future, separable restoration efforts in these areas.

K.10.8.3 Agriculture

The Initial Draft Plan substantially improves water supply to the Big Cypress Reservation over the future without-project condition due to increased water deliveries from Lake Okeechobee and Rotenberger Wildlife Management Area. Irrigation demands not met are reduced from 17.6 percent under the 2050 base to only 1.6 percent under the Initial Draft Plan. This represents a substantial benefit to irrigated agricultural production in the Reservation. Modifications to the L-28 Interceptor Canal and S-190 Structure are planned to rehydrate the Northeast Big Cypress south of the West Feeder Canal. Model results from the Initial Draft Plan indicate that there will be overland flow and ponding in this area, which contains native vegetation. No effect is expected north of the West Feeder Canal where agricultural production takes place.

K.10.9 Recreation Resources

Forecasted water flows under the 2050 base plan show minor changes in marsh or marl land water elevations in the region (Stage Hydrographs for Loop Road, Big Cypress National Preserve Gage BCNPA9, Cell R23 C13 – SFWMM V3.5). Projected decreased water sheet flows towards the Gulf of Mexico could provide additional recreational access for bird watching, environmental interpretation, and ORV use. Recreational fishing, levee hiking and biking would be unaffected. Recreational boating could be more difficult in some locations of the Big Cypress region. Airboat access to tree island hunting encampments could be restricted by low water levels (T. Towles, pers. comm.). This could decrease recreational hunting in the marsh, sawgrass, and slough areas of the Big Cypress region.

Overall, the proposed Initial Draft Plan hydroperiods will not substantially change the water flows or levels in a significant manner according to daily stage hydrographs for the Big Cypress region. The southern portion of the region, where levee degradation is proposed, will promote sheet water flows to the south. Some site specific, popular recreation resource areas would be adversely affected by dike and levee degradations. The improved hydroperiods and flows could facilitate easier access to hunt camps on tree islands and increase hunting in these areas (T. Towles, pers. comm.). Some overland and water-based access could be impeded if not completely removed.

The proposed levee degradation, canal backfill, construction of stormwater treatment areas, and resulting increased outflows are forecasted to improve sheetflow in a more natural and historical manner to the south. Boat access to high quality fishing areas could be limited or denied due to the L-28 canal backfilling. Levee bank fishing, hiking, and biking access could be limited or removed due to the L-28 levee and tie-back levee degradation (T.Towles, pers. comm.).

The proposed development of approximately 1900 acres of stormwater treatment area in the northeast Big Cypress region could provide recreational fishing if these areas are constructed to provide adequate fish habitat. Depending on the stormwater treatment area, excavated material disposal, access for bank fishing, hiking, biking, and other recreation activities could be developed. The 2050 base plan would propose no such component.

K.10.10 Aesthetic Resources

Restoration of this region, primarily by modifications (degradation or removal) to existing canals, and levees, and their conveyance structures, will provide a more natural scenic panoramic environment and viewshed than the existing canals and levees now provide. The project does not propose increasing the visibility of existing or future project features such as structures, beyond that which is existing. The resulting hydroperiod restoration is expected to contribute to the long-term maintenance of natural Big Cypress landscapes and visible natural features. Removal of man-made features, in combination with a re-establishment of more natural flows should enhance conditions, which lend high aesthetic appeal to this area.

K.10.11 Unavoidable Adverse Environmental Effects

Implementation of the Initial Draft Plan should not result in unavoidable adverse effects other than possible moderate localized ponding below the new S-190 pump station, along the L-28 Interceptor. This action may have long-term, localized negative impacts to native vegetation and wildlife habitat due to high tailwater elevations below the S-190.

K.10.12 Relationship Between Short Term Uses and Long Term Productivity

Construction of the S-190 pump station, water treatment areas, and removal of the L-28 Interceptor levee, L-28, L-28 Tieback, and L-29 levees and associated water control facilities represents a significant short-term disruption to the environment, and possible unintentional direct and indirect environmental consequences. Short-term effects due to construction (levee removal and backfilling of canals, vehicular access, creation of staging and turnaround areas etc.) such as impacts to wildlife habitat, aesthetics, wetlands, noise, air and water quality will be minimized wherever possible.

Once completed, the area impacted should quickly return to a more natural state. Vegetation would be expected to reestablish over the existing project footprint and over time, the area would return to providing the natural qualities and functions that it provided historically. In addition, these modifications to the water management system will have a beneficial long-term effect on the northeastern, eastern and southeastern Big Cypress area by restoring more natural overland flows and hydroperiods to these areas. This in turn, it is expected, will result in providing the conditions necessary for a healthier sustainable ecosystem, including appropriate conditions to sustain native vegetation assemblages, and fish and wildlife habitat.

K.10.13 Irreversible and Irretrievable Commitments of Resources

The proposed degradation of levees and backfilling of canals, as described above, represents, in all likelihood, an irreversible and irretrievable commitment of resources. These resources would include state and Federal funding to build the S-190 pump station, labor, energy and project materials and equipment to degrade the existing levees proposed for removal, back filling the canals, and removal of the existing water conveyance structures. It is possible that certain of the water conveyance structures may be retrievable for use elsewhere, however since the levees upon which they are built would no longer exist, they would no longer be able to function at their existing location. Upon implementation of upstream project features which would affect headwater elevations in WCA-3A, regional water flow, distribution and timing, these structures would no longer be necessary, and their removal would facilitate more natural flows through the Big Cypress, enhance decompartmentalization and reduce fragmentation of the natural landscape and its ecological components.

K.10.14 Cumulative Effects

The restoration of the eastern Big Cypress region is not expected to result in a cumulative negative effect to the environment. Project features designed to restore more natural flow results in only moderate changes to the overall hydroperiod and only to the eastern side of the Big Cypress. These changes, a result of various project elements, involve minimal structural component development within the Big Cypress itself. The major action that acts to modify flows, and in itself is an improvement to water flow and hydroperiod, is the construction of the S-190 pump station, water treatment areas, and degradation of the L-28 Interceptor levee, L-28 South, L-28 Tieback, and L-29 levee as described above. This action in combination with the other project features located in this area such as relocating the S-140 pump station, spreader canals and implementation of the Big Cypress Seminole Tribes Water Conservation Plan, may act cumulatively to restore more natural flows to the Big Cypress, but should not result in negative environmental effects or effects unfavorable to the restoration of the natural environment.

K.11 CALOOSAHATCHEE RIVER REGION

This assessment will cover only those consequences realized within the Caloosahatchee River geographic planning region. The project features of the Initial Draft Plan that would affect the hydrology and ecological sustainability of the Caloosahatchee River region are: (1) a large scale above ground storage reservoir, with an associated aquifer storage and recovery system; and (2) a stormwater treatment area with backpumping facilities. These changes will provide a substantial net increase in regional storage capacity, provided in the past by Lake Okeechobee. An approximately 20,000 acre above ground storage reservoir would be built, at a location to be determined, with a maximum design depth of 8 feet, and with inflow pump capacity and outflow structure size to be determined during detailed design. In conjunction with this reservoir, aquifer storage and recovery is being proposed, to provide additional storage while reducing evaporative loss, and to reduce the amount of land that would be needed for above ground storage alone. Forty-four 5-MGD (million gallons per day) aquifer storage and recovery wells and associated infrastructure are proposed. Water from the storage reservoir that will be injected into the aquifer storage and recovery wells will need to meet Everglades Protection Area coliform standards before injection. Efficiency of aquifer storage and recovery is estimated for planning purposes to be about 70 percent, although there is considerable uncertainty associated with this estimate. Recovery rates may vary depending on area geology and other factors.

Additionally, a stormwater treatment area, about 5,000 acres in size, with associated backpumping facilities, will be built in the upper Caloosahatchee basin. The backpumping facilities will consist of 1 pump of 2000 cfs capacity to take water from the lower Caloosahatchee Basin to the upper Caloosahatchee Basin; 1 pump of 2000 cfs capacity to take water from the Caloosahatchee River into the stormwater treatment area; and 1 pump of 2000 cfs capacity to discharge water from the stormwater treatment area to Lake Okeechobee.

The report below will address potential effects (beneficial or harmful) of the Initial Draft Plan compared to the 2050 base, on several key physical, ecological and socio-economic resources of the Caloosahatchee River region.

K.11.1 Vegetation

Approximately 25,000 acres of agricultural lands, with included wetlands and upland, would be converted to a water storage reservoir and stormwater treatment area under the Initial Draft Plan. Small amounts of upland forest (pine flatwoods) and wetlands would be included in the total acreage. These lands would be permanently removed from agricultural production, and are expected to develop emergent or floating vegetation, depending on depth. The 4-foot deep areas (stormwater treatment area) will function as emergent marsh and probably become dominated by cattails. The deep (8') reservoirs will become colonized by floating and rooted aquatic vegetation. Many of these sites are located near marginal wetlands that could be enhanced through active management or passively through seepage from the storage facility. The storage sites will remove sediments and some nutrients, particularly phosphorus.

K.11.2 Fish and Wildlife

It is difficult to predict what aquatic plan communities will be present in the water storage areas, due to the unusual hydrologic patterns they will experience. These areas will act primarily as “surge tanks,” storing large amounts of excess water during wet periods and drying out completely during dry times. These alternating wet and dry conditions may last only a few days or may last for many months to more than a year, and water depths will vary widely, from as deep as 6 feet to only a few inches, depending on rainfall conditions and operational demands. These irregular hydrological patterns will certainly cause profound and widespread changes in wildlife habitats existing in these areas at the time of construction. Any trees standing in areas converted to deep water storage areas are expected to die. If they presently serve as roosting or nesting habitat for raptors or water birds, they will eventually be lost.

Under some conditions, large areas of habitat suitable for foraging wood storks, snail kites, bald eagles, and Audubon’s crested caracaras may be created and may provide some benefits to these and other wildlife species. However, the USFWS is concerned that these areas would become “attractive nuisances” when temporarily favorable conditions are created, drawing in opportunistic wildlife species. Favorable conditions could induce species such as wood storks, snail kites, bald eagles and others to nest nearby, and could produce artificially inflated populations of some species. When reservoir operations then cause a rapid change in conditions, widespread nesting failures and direct mortality of adult individuals due to loss of foraging resources could result. In addition, the rapid filling of storage areas that have been dry for extended periods would likely result in direct mortality due to drowning of less mobile species such as the eastern indigo snake.

K.11.3 Threatened and Endangered Species

Of the eighteen listed plant and animal species submitted by the USFWS as likely to be affected by the C&SF Restudy, seven are thought to occur within the affected area of the Caloosahatchee River region. A brief description of effects to these state and Federally listed threatened and endangered species follows.

K.11.3.1 West Indian Manatee

The West Indian manatee (*Trichechus manatus*) has been recognized as an endangered species since 1967. Both the USFWS and GFC list it as an endangered species. In this region, manatees are most prominent year round in the Estero Bay and Caloosahatchee River areas. Manatees feed on a variety of submergent, emergent and floating vegetation and usually forage in shallow grass beds adjacent to deeper channels. The primary threats to manatees today are due to collisions with watercraft, degradation of seagrasses and accidents occurring at water control structures. Implementation of the Initial Draft Plan is not anticipated to adversely affect the manatee.

K.11.3.2 Wood Stork

The wood stork (*Mycteria americana*) is listed as an endangered species by the USFWS and the GFC. Wood storks forage in freshwater marshes, seasonally flooded roadside or agricultural ditches, narrow tidal creeks, shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. No adverse effect on the wood stork is anticipated due to construction of water storage facilities in this region. Under some conditions the water storage areas may provide suitable habitat for foraging wood stork. However, the USFWS is concerned that these areas would become “attractive nuisances” when temporarily favorable conditions are created, drawing in opportunistic wildlife species. Temporary favorable conditions could induce species such as wood storks, snail kites, bald eagles and others to nest nearby; but nesting success would depend on continued favorable foraging conditions. Short term success could produce artificially inflated populations of some species. When reservoir operations then cause a rapid change in conditions, widespread nesting failures and direct mortality of adult individuals could result due to loss of foraging resources.

K.11.3.3 Audubon's Crested Caracara

The Florida population of this resident, non-migratory raptor is listed as threatened by the USFWS and GFC. The caracara (*Polyborus plancus*) commonly occurs in dry or wet prairie areas, as well as improved or semi-improved pasture. The region of greatest abundance is a five county area north and west of Lake Okeechobee, including Glades, DeSoto, Highlands, Okeechobee, and Osceola counties (Kissimmee River and Caloosahatchee River regions). Their numbers continue to decline throughout their range due largely to loss of habitat. Implementation of the Initial Draft Plan components in this region could impact this species through loss of habitat. No effect on the caracara is anticipated at this conceptual level of planning, until definitive sites are identified and selected for the project features it is impossible to determine precise impacts to caracara or caracara habitat.

K.11.3.4 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) should benefit by implementation of the Initial Draft Plan water storage components in this region due to the reduction of lake level fluctuations. Lake Okeechobee levels, with fewer occurrences of lake stages in the vicinity of 11-12 feet NGVD and below should benefit the bald eagle by providing for a more sustainable and reliable foraging ground within the shallow littoral areas. The regular occurrence of lake level recessions, would concentrate prey fish over an extended period of time, which may further benefit the eagle. Both the USFWS and GFC currently list the bald eagle as a threatened species.

K.11.3.5 Eastern Indigo Snake

The eastern indigo snake (*Drymarchon corais couperi*) could potentially be affected by construction of storage reservoirs, the stormwater treatment area and their associated facilities. No effect is anticipated at this conceptual level of planning. When definitive sites are identified and selected, it will be possible to determine precise impacts. The USFWS and the GFC classify the eastern indigo snake as a threatened species.

K.11.3.6 Red-cockaded Woodpecker

The Red-cockaded woodpecker (*Picoides borealis*) is listed as endangered by the USFWS, due largely to destruction of its habitat, and fragmentation of its historic home range. It is listed as threatened by the GFC. Active colonies of red-cockaded woodpeckers are interspersed throughout the study area, most notably in

Osceola, Highlands, St. Lucie, Palm Beach, Glades, Charlotte, Lee, and Monroe Counties. Pine stands, or pine-dominated hardwood stands, with a low or sparse understory and ample old-growth pines, constitute primary red-cockaded woodpecker nesting and roosting habitat (USFWS 1998). Longleaf pine provides critical nesting habitat where available, however cavities are also constructed in other pines, and in southwest Florida, the hydric slash pine is preferred. The Red-cockaded woodpecker could potentially be affected by construction of storage reservoirs, the stormwater treatment area and their associated facilities. No effect is anticipated at this conceptual level of planning. When definitive sites are identified and selected, it will be possible to determine precise impacts.

K.11.3.7 Florida Scrub-jay

The Florida scrub-jay (*Aphelocoma coerulescens*) is known to inhabit well drained, sandy uplands, typical of a xeric oak scrub habitat. A "core population" of scrub-jays is also located within the Lake Wales Ridge sub-region, northwest of Lake Okeechobee. An essential feature of the Initial Draft Plan is the construction of a 20,000-acre above ground storage reservoir and a 5,000-acre stormwater treatment area with backpumping facilities. Although no definitive site has been selected for these project features, preliminary sites identified are outside of the Lake Wales Ridge sub-region. No effect on the scrub-jay is anticipated at this conceptual level of planning, until definitive sites are identified and selected for the project features it is impossible to determine precise impacts to scrub-jays or scrub-jay habitat.

K.11.4 Water Management

Under the Initial Draft Plan all flood control releases to the Caloosahatchee River estuary are expected to be eliminated except pulse releases in zone A of the regulation schedule for Lake Okeechobee. The Caloosahatchee Basin storage reservoir and aquifer storage and recovery system will capture local basin runoff and releases from Lake Okeechobee. Water from the reservoir will be used to provide environmental deliveries to the Caloosahatchee estuary, to meet demands in the Caloosahatchee Basin, and to inject water into the aquifer storage and recovery wellfield for long-term (multi-seasonal) storage. Water from the aquifer storage and recovery facilities will be used to meet the environmental demands of the estuary and local basin demands. Any estuarine demands not met by basin runoff, the reservoir and the aquifer storage and recovery system will be met by Lake Okeechobee, as long as lake stages are above 11.5 feet NGVD. Lake Okeechobee water will also be used to meet any remaining local basin demands subject to supply-side management.

The Caloosahatchee Basin storage reservoir and aquifer storage and recovery system will be operated in conjunction with the Caloosahatchee backpumping facilities, which include a stormwater treatment area for water quality treatment.

This component operates after estuary and agricultural/urban demands have been met in the basin and when the level of water in the storage reservoir exceeds 6.5 feet and Lake Okeechobee is below the pulse release zone. When this situation occurs, then water is released from the reservoir and delivered to the stormwater treatment area at the capacity of the backpumping /treatment system of 2000 cfs. The stormwater treatment area water is then backpumped to Lake Okeechobee.

The operation of project components in the Caloosahatchee Basin will significantly improve regional water managers' abilities to meet local basin agricultural/urban demands as well as the environmental needs of the downstream estuary.

K.11.5 Water Quality

Water quality conditions in the Caloosahatchee River Region are expected to improve, compared to both 1995 and 2050 base conditions through implementation of the Initial Draft Plan. The key water quality parameters of concern in the Caloosahatchee River region are: TP, NOx, DO, conductivity, coliforms and pesticides. The following Initial Draft Plan components are expected to operate synergistically in a manner that will improve freshwater and estuarine water quality conditions in the Caloosahatchee River basin:

Storage North of Lake Okeechobee - 20,000 acres at a maximum of 10 feet depth, Kissimmee River watershed; regional storage reduces flood discharges from Lake Okeechobee to the Caloosahatchee River;

C-44 (St. Lucie) Canal reservoir - 10,000 acres at a maximum of 4 feet depth, increases C-44 basin and regional storage capacity and reduces need to release Lake Okeechobee flood discharges to the Caloosahatchee River basin;

Caloosahatchee (C-43) Canal reservoir with aquifer storage and recovery wells - 20,000 acres of reservoir at a maximum of 8 feet depth, 44 five MGD aquifer storage and recovery wells (220 MGD maximum capacity) increases Caloosahatchee River basin storage and reduces Lake Okeechobee flood releases to the Caloosahatchee estuary;

Environmental water supply deliveries to the Caloosahatchee estuary to achieve optimal salinity;

Modified regulation schedule for Lake Okeechobee to provide increased environmental deliveries to the WCAs/Everglades National Park and reduce flood discharges to the Caloosahatchee estuary;

Everglades Agricultural Area reservoir - 60,000 acres at a maximum of 6 feet depth; regional system storage that reduces Lake Okeechobee flood releases to the Caloosahatchee estuary;

Regional-scale aquifer storage and recovery of Lake Okeechobee water - 1000 MGD maximum capacity, reduces Lake Okeechobee flood discharges to the Caloosahatchee estuary and improves low flow augmentation from Lake Okeechobee to the Caloosahatchee River/estuary during dry periods;

Caloosahatchee River (C-43) stormwater treatment area with backpumping to Lake Okeechobee - increases regional water storage by capturing C-43 excess stormwater runoff, and after water quality treatment via a 5000-acre stormwater treatment area, diverts stormwater flows to Lake Okeechobee when Lake Okeechobee is at appropriate water level.

Acting together, the above Initial Draft Plan components improve water quality in the Caloosahatchee River and estuary, by substantially reducing the levels of non-point source pollutants reaching basin waters from annual wet season rain events. They also reduce Lake Okeechobee flood control discharges by capturing these runoff waters in the regional water storage facilities. Of particular importance to water quality improvement in the C-43 basin are the 20,000-acre reservoir in the basin and the 60,000 acre reservoir in the Everglades Agricultural Area. When wet season stormwater runoff is retained in the regional water storage facilities, sedimentation processes will sequester pollutants. Further, biological uptake processes in the water storage facilities will sequester dissolved pollutants. Operation of the water storage facilities will reduce loading of TP, NOx, coliforms and pesticides to C-43 basin waters. Additionally, operation of the aquifer storage and recovery facilities in the C-43 basin and around Lake Okeechobee, implementation of the modified Lake Okeechobee regulation schedule and operation of the C-43 backpump / stormwater treatment area facility will reduce wet season peak flows to the Caloosahatchee River and estuary, thereby reducing non-point source pollutant loading to the river and estuary.

Conversely, during the dry season, when maintenance of adequate low flows to the river and estuary dominates water quality concerns in the region, the Initial Draft Plan components that increase flows to the river/estuary are important. The components that improve dry season river/estuary water quality conditions are the C-43 and Lake Okeechobee aquifer storage and recovery facilities and improved environmental flows from Lake Okeechobee. These components are expected to specifically improve DO and conductivity conditions in the river/estuary, identified as key water quality parameters in the basin.

K.11.6 Water Supply

The Initial Draft Plan will significantly improve the regional irrigation supply. Demands not met would drop from 22.4 percent for the future without-project condition to 2.6 percent in the Initial Draft Plan. This is a substantial improvement to the agricultural irrigation supply, but the change in water supply source is a concern. This region has historically relied primarily upon Lake Okeechobee for its supplemental irrigation water. More than half of the C-43 Basin irrigation supply would come from the storage reservoir and aquifer storage and recovery facilities with the Initial Draft Plan. The agricultural community is reluctant to relinquish the Lake Okeechobee water source and rely upon reservoir and aquifer storage and recovery technologies that are new to this basin.

K.11.7 Socio-Economics

Implementation of the Initial Draft Plan is not expected to have material effects to the socio-economic conditions in either the short or long term.

K.11.8 Land Use

The Initial Draft Plan would alter several different types of existing land uses within the Caloosahatchee River region. These existing land uses include agriculture, ranching, and forestry. However, agriculture is the predominant land use in the basin and will be the type most impacted by the Initial Draft Plan. The below discussion on impacts to agriculture will include all existing land uses except urban.

K.11.8.1 Agriculture

A 20,000 acre storage reservoir is proposed for the C-43 Basin to capture basin runoff and water releases from Lake Okeechobee for eventual use for water supply and environmental demands. This reservoir will likely be located in an area currently used for agricultural production and designated as unique farmland. Conversion of 20,000 acres from agriculture to reservoir would be an approximately 4 percent reduction of agricultural acreage, in a region that has experienced recent expansion of agricultural production.

K.11.9 Recreation Resources

The two principal features proposed in the Initial Draft Plan which may affect recreation resources are the construction of a 20,000 acre storage reservoir and an approximately 5,000 acre stormwater treatment area. Neither site has been definitively sited, although conceptual sites identified to date do not appear to affect any existing recreational areas. Important recreation benefits may be realized by both components depending on final design and operational management decisions. Potential recreation benefits include fishing, waterfowl hunting, wildlife viewing, day hiking, bird watching, camping, and nature interpretation. The Everglades Nutrient Removal Project (a trial stormwater treatment area) has shown to provide significant wildlife habitat potential, and similar benefits may be realized by the proposed stormwater treatment area within the Caloosahatchee River region.

Water quantity and quality improvements to the Caloosahatchee River estuary and Charlotte Harbor are expected to enhance conditions for seagrasses, benthic invertebrates and fishes. These improved conditions should also benefit other animals that rely on seagrass beds such as endangered manatees, which support recreation activities including manatee viewing by boaters.

K.11.10 Aesthetic Resources

The main visual components of the C&SF Restudy in the Caloosahatchee River region are the low levees of the reservoir and stormwater treatment area, water control structures, and pump stations. These features are not unlike existing features in the region. From a distance, the storage reservoir and stormwater treatment area would appear similar to flooded agricultural fields or marsh. The project components do not include any tall structures that would interrupt the existing landscape profile. The Initial Draft Plan would not significantly affect aesthetic resources within the Caloosahatchee River region.

K.11.11 Unavoidable Adverse Environmental Effects

The following unavoidable adverse effects are expected to occur with implementation of the project features described above, which are expected to have an affect within the Caloosahatchee River physiographic region.

Construction of 25,000 acres of above ground storage reservoir and stormwater treatment area with their associated facilities will take large tracts of agricultural lands out of production, and possibly remove the functional values of lesser amounts of wetlands, prairie, or other natural areas. There will be a change in the dominant plant cover (from emergent or crop to floating aquatic) and dominant animal groups (common terrestrial wildlife to aquatic birds, reptiles, amphibians, fish and invertebrates).

K.11.12 Relationship Between Short Term Uses and Long Term Productivity

Construction of the reservoir storage, stormwater treatment area, and associated facilities represents a significant short-term disruption to the environment, and possible unintentional direct and indirect environmental consequences. Short-term effects due to construction activities (clearing, grubbing, levee building, installation of structures, equipment noise, etc.) may be visually unpleasant and annoying to adjacent landowners. However, the storage areas will be sited in rural zones. Grading and restoration will improve the visual quality of the landscape when construction is finished, and adverse effects will be minimized wherever possible.

Once completed, vegetation would be expected to colonize the levees and reservoirs. In addition, these modifications to the water management system will have a beneficial long-term and permanent effect downstream throughout the Caloosahatchee River region. The construction of large Water Storage reservoir Areas and numerous Aquifer Storage and Recovery wells would capture and store much of the excess water available during wet periods. This makes more water available to the remaining Everglades system when it is needed to provide natural flow volumes, reduces damaging freshwater releases to estuaries, and reduces damage to Lake Okeechobee littoral zone habitats though attenuation of extreme high and low lake levels.

K.11.13 Irreversible and Irretrievable Commitments of Resources

The proposed construction of a 20,000 acre reservoir storage site and a 5,000 acre stormwater treatment area represents, in all likelihood, an irreversible and irretrievable commitment of land and monetary resources. These resources would include, in addition to the lands themselves, state and Federal funding, labor, energy and project materials and equipment to build the storage site and the structures associated with the operation of these facilities. Fish and wildlife habitat, located within the proposed component footprint would likely be inundated for much of the year, would be permanently altered and could represent a irreversible commitment of land and/or wetland resources.

K.11.14 Cumulative Effects

Restudy project components are not expected to result in a cumulative negative effect on the environment of the Caloosahatchee River physiographic region. Project components in the Caloosahatchee region, especially reservoir storage, will act cumulatively to restore more natural freshwater flows to the downstream estuary. To achieve restoration will require substantially more storage in the Caloosahatchee region then presently exists, in order to provide the correct quantity, quality, timing, and duration of flows. The land spatially occupying these Caloosahatchee areas once provided these important functions to the basin system. Today, they are largely developed, drained, and ditched agricultural lands. The restoration of these important natural functions will require some reversal of the current trend in order to provide the retention area for holding, storing and treating water prior to its discharge downstream. The proposed project features, along with a restored Lake Okeechobee, able to provide important storage functions, are necessary for the overall restoration of the study area downstream. The commitment of 25,000 acres of land represents a huge investment in funding and land resources. It may also cause some adverse consequences locally. However the overall benefit to the regional system will be far greater than the localized adverse effects. The localized adverse effects will not result in a detrimental cumulative effect within the region.

K.12 FLORIDA KEYS

The Florida Keys are not physically connected to the surface water management features of the C&SF system. They are also outside of the geographic envelope of the Restudy Performance Measures, the 2 x 2 hydrologic model and the NSM. Therefore, the Restudy cannot predict direct quantitative or semi-quantitative beneficial or adverse effects on Keys ecosystems. However, it is reasonable to expect some positive, though indirect, benefits from construction of the recommended plan. The Keys are "downstream" of Florida Bay, where a major Keys fishery (pink shrimp) depends on the seagrass communities. The Initial Draft Plan will change timing and volume of freshwater deliveries to this Bay, and may assist in restoration of some seagrass cover. Therefore, potential beneficial and adverse indirect effects of building the recommended plan will be discussed briefly in this chapter.

K.12.1 Vegetation

No component of the Initial Draft Plan will change terrestrial plant communities. No component of the Initial Draft Plan will directly affect marine plant communities fringing the Keys, but some indirect positive effects on algal flats and seagrass beds on the Bay side of the Keys may occur. If improved Florida Bay haloperiods help to reverse the spread of plankton blooms, coral growth may improve on the Florida Reef Tract, but this is speculative. It is believed that phytoplankton blooms near the Keys may be triggered by a combination of factors, and only one aspect of the Bay water quality could be changed as a result of the Initial Draft Plan implementation: timing and volume of freshwater discharges into the northern Bay.

The Initial Draft Plan components will send more fresh water, with a more natural seasonal timing, to Florida Bay through Shark Slough and Taylor Slough.. The receiving waters are the waters adjacent to the Bay's north shore, distant from the Keys. This additional fresh water should moderate extreme salinity in the north of Florida Bay, at least during some seasons of some years. Although the reasons for the seagrass die-off in Florida Bay are probably complex, and hypersalinity may be only one of the problems now stressing benthic plant communities, this improvement in Bay hydrology should benefit the seagrass community. In turn, partial restoration of the seagrass community may decrease the frequency and severity of algal blooms in the water column, as seagrasses utilize water column nutrients and remove them from solution. Most scientists believe that there are multiple causes for plankton blooms in the shallow waters surrounding the Keys, so predicting a more direct connection is speculative.

The shallow coral communities fringing Keys shorelines, as well as the offshore Florida Reef Tract, are dominated by animals (hard corals) whose symbiotic algae allow them to grow and deposit new carbonate skeletal materials. Because coral animals host living plant cells in their tissues, and the plants need ample light to survive and reproduce, reef corals need an environment of high water transparency in order to grow and spread. Blooms of microscopic plankton (algae) suspended in the water column block light to the reef, shading out the corals and causing them to die back. Colored, turbid water containing plankton blooms reduces visibility and makes the reefs less attractive to recreational divers.

It is thought that low-transparency water from Florida Bay negatively affects the reef tract by shading out the corals and providing increased nutrients. This may be one of the causes of observed decreases in hard coral cover. If plankton and nutrient exports from Florida Bay to the reef decrease, it is expected to allow affected reef areas to recover, showing increased coral cover and decreased algal overgrowth.

K.12.2 Fish and Wildlife

No positive or negative direct effect on land wildlife is expected as a consequence of any alternative considered in the Restudy. Some positive indirect effects on predatory and wading birds may occur. Many species of birds residing in the Keys fish in Florida Bay. Terns, skimmers, ospreys and bald eagles feed directly on fish. Wading birds, including ibis, wood stork and egrets of several species, also consume small fish and invertebrates. These species formerly utilized the seagrass covered shallows as foraging grounds, roosting in mangrove canopies both on the mainland and on the Keys. The Initial Draft Plan will improve fresh water deliveries and haloperiod of Florida Bay. It is expected that the production of small "bait" fish, invertebrates and larval fish dependent on the seagrass community may increase. These fish, in turn, may support larger populations of fish-eating birds.

To the extent that the Initial Draft Plan fosters re-growth of seagrasses in Florida Bay, some recovery of the commercial pink shrimp fishery may also occur, because the seagrass beds are vital shrimp maturation habitat. Although water deliveries under this alternative have not reached 100 percent of the restoration target for this part of the system, the Initial Draft Plan provides the best combination of actions to increase volume and timing of water deliveries over base conditions.

K.12.3 Water Management

The Keys are outside the geographic scope of all proposed changes in surface water management. Surface and groundwater management in the Keys will not be affected under any alternative considered by the Restudy.

K.12.4 Water supply

The Florida Keys water supply is provided by Miami-Dade County wellfields. The water conservation components in the Initial Draft Plan will reduce water demand. Other components will improve groundwater recharge to Miami-Dade County wellfields. Overall, there would be no adverse effects to water supply, and a potential benefit.

K.12.5 Water Quality

Water quality conditions in the Florida Keys are not expected to be significantly effected by the Initial Draft Plan relative to the projected 2050 base condition. Implementation of the Florida Keys Water Quality Protection Program established pursuant to the Florida Keys National Marine Sanctuary Plan is a significant element of projected 2050 base condition. Major water quality parameters of concern in waters of the Florida Keys are: DO; TP; NOx; turbidity; chlorophyll A and coliforms. For the purposes of this study, the waters of the Florida Keys are evaluated as those waters within the boundaries of the Florida Keys National Marine Sanctuary (FKNMS). The waters of Florida Bay are contiguous with Florida Keys waters on the northern side of the Keys. Salinity conditions in Florida Keys waters are dominated by marine influences, although in the area of northeast Florida Bay, freshwater runoff from the southern Everglades to the north seasonally influences Florida Keys water quality conditions.

Although Initial Draft Plan components, Modification to South Miami-Dade-Southern Portion of L-31N and C-111, and the C-111N Spreader Canal will alter freshwater flows to coastal waters near Key Largo, no evidence exists that these Restudy water management effects will significantly modify Florida Keys water quality relative to the 2050 base condition. Modification to South Miami-Dade-Southern Portion of L-31N and C-111 will increase freshwaters flows to the Taylor Slough/Florida Bay coastal region. C-111N Spreader Canal will eliminate C-111 canal flows and increase surface water sheet flows from the southern Everglades to coastal portions of northeast Florida Bay and, Blackwater Sound.

Further development of the Florida Bay hydrodynamic and water quality models currently under development should provide more information relative to the potential effects of Restudy components on water quality conditions in the Florida Keys. Also, the Restudy Feasibility Report and EIS may recommend initiation of a Florida Bay Feasibility Study. If this feasibility study is initiated, it is likely that future evaluations of potential removal/culverting of portions of Florida Keys highway causeways, currently restricting upper Florida Keys hydrological flushing, would be conducted. Future potential removal/culverting of highway causeways in the upper Florida Keys could have significant beneficial effects on water quality conditions in Florida Keys waters.

K.12.6 Socio-Economics

The Florida Keys are the object of a separate carrying capacity study. Tourism is the largest income producer in the Keys, and would not be impacted either positively or adversely by the Initial Draft Plan. As noted previously, pink shrimp are an important commercial fish species. This fishery is now in decline. If the pink shrimp fishery is indirectly benefited by the Initial Draft Plan features, a multiplier effect would be expected on the local economy, especially in Key West, home of the shrimp fleet.

K.12.7 Land Use, Recreation, and Aesthetics

No land use changes in the Keys are contemplated by the Restudy. Since no construction is proposed for this region, there will be no interruptions or enhancements of recreational use, and the visual characteristics will not be altered. The recommended plan is neutral in its environmental consequences.

K.12.8 Unavoidable Adverse Environmental Effects

No direct physical effects of any kind on Keys lands or waters are considered under any Restudy alternative. There would be no unavoidable adverse environmental effects.

K.12.9 Relationship between Short Term Uses and Long Term Productivity

No short term uses are proposed for any significant features of the human or natural environment of the Keys under this study. No trade-off of long-term productivity for short-term gain are proposed. The purpose of the Restudy is to improve ecosystem characteristics regionwide.

K.12.10 Irreversible and Irretrievable Commitments of Resources

No resources of the Keys would be committed under the Initial Draft Plan.

K.12.11 Cumulative Effects

The Florida Keys are the object of a separately funded, cooperative carrying capacity study. All identified indirect effects of the Initial Draft Plan by the Restudy on the Keys would be positive. It is possible that other measures recommended in the separate Carrying Capacity Study, when it is finished, might combine with the Initial Draft Plan to cause a much more significant cumulative improvement of the Keys' natural environment, if implemented. However, at this time, the study is still underway, and no specific improvement or management measures are known.

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APPENDIX L

PRIOR STUDIES, REPORTS, AND PROJECTS

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APPENDIX L

PRIOR STUDIES, REPORTS, AND PROJECTS

This appendix describes the authorizations for this study and the authorizations for the Central and Southern Florida (C&SF) Project. Also discussed are the discretionary changes made to the project and operation and maintenance responsibilities for the project.

L.1 STUDY AUTHORITY

The C&SF Project Comprehensive Review Study is authorized by *Section 309(l) of the Water Resources Development Act of 1992 (P.L. 580, 102nd Congress, 2nd Session,* approved October 31, 1992) which states:

> *"(1)CENTRAL AND SOUTHERN FLORIDA. -- The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as House document 643; 80th Congress, 2d Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation."*

This study is also authorized by two resolutions of the Committee on Public Works and Transportation, United States House of Representatives, dated September 24, 1992. The first resolution states:

> *"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes."*

The second resolution states:

> *"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes for Florida Bay, including a comprehensive, coordinated ecosystem study with hydrodynamic modeling of Florida Bay and its connections to the Everglades, the Gulf of Mexico, and the Florida Keys Coral Reef ecosystem."*

L.2 C&SF PROJECT AUTHORIZATIONS

The Corps of Engineers role in providing flood control in south Florida has its beginnings with the *Rivers and Harbors Act of 1930*. Passage of the *Flood Control Act of 1948* authorized the Central and Southern Florida Project. Subsequent authorizations since 1948 have resulted in the further development of the project as it exists today. This section describes these project authorizations.

L.2.1 Rivers and Harbors Act of 1930

It is generally understood that the birth of the C&SF Project began with the *Flood Control Act of 1948*, however, the Federal participation began much earlier with the *Rivers and Harbors Act of 1930*. There were even earlier efforts by private, local, State, and Federal interests. Following the disastrous hurricanes of 1926 and 1928, Congress provided disaster relief in the form of flood control and navigation in the 1930 Act. Potential land reclamation benefits were recognized at the time. Prior to the 1948 Act, the project was known as the Caloosahatchee River and Lake Okeechobee Drainage Areas (CR&LODA) Project. The flood control features were extended and incorporated into the C&SF Project. The navigation features were included in the Okeechobee Waterway Project. The *1930 Act (P.L. 520, 71st Congress,* approved July 3, 1930) reads as follows:

> *Miami River, Florida: The Secretary of War is hereby authorized to improve the Miami River with a view to securing a channel one hundred and fifty feet wide and fifteen feet deep for a distance from the mouth of three miles, thence one hundred and twenty-five feet wide and fifteen feet deep to a point four and one-eighth miles from the mouth, thence ninety feet wide and fifteen feet deep to a point five and one-half miles from the mouth; each section to have suitable side slopes; and there is authorized to be appropriated for the prosecution of this work the sum of $800,000: <u>Provided</u>, That no expense shall be incurred by the United*

States for acquiring any lands needed for the purpose of this improvement: Provided further, That local interests shall provide all needed spoil-disposal areas.

Caloosahatchee River and Lake Okeechobee drainage areas, Florida, in accordance with the report submitted in Senate Document Numbered 115, Seventy-first Congress, second session, and subject to the conditions set forth in said document, except that the levees proposed along Lake Okeechobee shall be constructed to an elevation of thirty-one feet instead of thirty-four feet above sea level and shall be so built as to be capable of being raised an additional three feet, and that the United States shall perform the work of constructing all levees: Provided, That the State of Florida or other local interests shall contribute $2,000,000 toward the cost of the above improvements, in lieu of the contributions called for in the aforesaid document: And provided further, That no expense shall be incurred by the United States for the acquirement of any lands necessary for the purposes of this improvement.

[Note that elevations were based on the Punta Rassa datum, later found to be -1.44 feet in error--i.e., the thirty-one foot elevation was actually 29.56 feet, NGVD.]

The 1930 Act authorized the following features:

a. Improvements to the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico to provide a 2,500 cfs capacity outlet from Lake Okeechobee and a navigation channel at least 6 feet deep.

b. Improvements to Taylor Creek to provide a 6 feet deep channel from Okeechobee City to Lake Okeechobee.

c. A levee to elevation 31 feet, Lake Okeechobee datum, which is 1.44 feet below National Geodetic Vertical Datum (NGVD) of 1929, and a channel 6 feet deep following in general the south shore of the lake from Fisheating Creek to the St. Lucie Canal.

d. A levee to elevation 31 feet, Lake Okeechobee datum, on the north shore of the lake from the Kissimmee River to Nubbin Slough.

e. Improvements to the St. Lucie River to provide a channel 6 feet deep.

f. Protection works in the St. Lucie Canal for erosion control.

Table L-1 lists CR&LODA Project features incorporated into the C&SF Project. The 1930 Act also provided for the Miami River project which authorized a 15 feet deep channel by 150 feet wide from the mouth for a distance of 3 miles, then 125 feet wide for a distance to 4.5 miles from the mouth, then 90 feet wide to a point 5.5 miles from the mouth. Even though this was a navigation project, it served as an excellent flood control outlet for part of the Miami urban area.

L.2.2 Flood Control Act of 1948

The 1948 Act modified and extended the CR&LODA Project. It created the Central and Southern Florida Project for Flood Control and Other Purposes and changed the project to conform with flood control law and regulations. Project purposes are for flood control, drainage, control of water, and other related purposes. These are preservation of fish and wildlife, regional groundwater control, salinity control, and navigation. The first phase of the Comprehensive Plan for the C&SF Project was authorized for construction. The first phase consisted of levees and channels and control works of Lake Okeechobee, protection and major drainage of the Everglades agricultural area, conservation of water for control of regional groundwater levels, the protection of east coast urban areas from overflow from the Everglades, flood control and water control for salinity control in the existing urban areas along the east coast, and the main outlets for the water conservation areas. The authorization contained in the *1948 Act (P.L. 858, 80th Congress, 2nd Session,* approved June 30, 1948) is as follows:

CENTRAL AND SOUTHERN FLORIDA

> *The project for Caloosahatchee River and Lake Okeechobee drainage areas, Florida, authorized by the River and Harbor Act of July 3, 1930, as amended, is hereby modified and expanded to include the first phase of the comprehensive plan for flood control and other purposes in central and southern Florida as recommended by the Chief of Engineers in House Document Numbered 643, Eightieth Congress, subject to the conditions of local cooperation prescribed therein, and there is hereby authorized to be appropriated the sum of $16,300,000 for partial accomplishment of said plan.*

Table L-2 lists project features authorized or authorized to be modified by the 1948 authorization.

L.2.3 Flood Control Act of 1954

The 1954 Act authorized the remainder of the Comprehensive Plan for the C&SF Project. This included flood control, water conservation, and navigation in the Upper St. Johns and Kissimmee River Basins; an increase in the outlet capacity of the Caloosahatchee River from Lake Okeechobee; the remainder of protective levees for the Everglades agricultural area and the water conservation areas; and the remaining salinity barrier in south Dade County. The 1954 authorization is contained in *P. L. 780*

(83rd Congress, 2d Session, approved September 3, 1954). The authorization pertaining to the C&SF Project is as follows:

CENTRAL AND SOUTHERN FLORIDA

> *The authorization for the comprehensive plan for flood control and other purposes in central and southern Florida given by the Flood Control Act of June 30, 1948, as amended, is hereby modified and expanded to include the entire comprehensive plan of improvement as recommended by the Chief of Engineers in House Document Numbered 643, Eightieth Congress, with such modifications thereof as the Congress may hereafter authorize, or as in the discretion of the Chief of Engineers may be advisable: Provided, That the conditions of local cooperation for the authorized first phase heretofore approved by said flood control Act shall apply to that authorized first phase, but for all work over and beyond that previous authorization such conditions shall apply on an interim basis only until they shall be modified as deemed appropriate by the Congress, based on recommendations to be submitted at the earliest practicable date by the Chief of Engineers, through the Bureau of the Budget to the Congress: Provided further, That whatever conditions of local cooperation are established by the Congress as the result of such recommendations shall be retroactive to any units of the comprehensive plan authorized in this Act which may be started prior to establishment of the exact conditions of local cooperation: And provided further, That in addition to previous authorizations there is hereby authorized to be appropriated the sum of $7,000,000 for partial accomplishment of said plan.*

Table L-3 lists project works authorized by the 1954 Act.

L.2.4 Flood Control Act of 1958

The 1958 Act authorized cost sharing for the project works authorized by the 1954 Act. It also authorized changes to the Comprehensive Plan presented in *House Document 85-186* which deleted the project works listed in Table L-4. The Act also authorized flood protection for 64 square miles of Hendry County west of Levees 1, 2, and 3. The Hendry County plan was superseded by the *Flood Control Act of 1965.* The 1958 authorization is contained in *P. L. 85-500 (85th Congress,* approved July 3, 1958). The portion applicable to the C&SF Project follows:

CENTRAL AND SOUTHERN FLORIDA

> *In addition to previous authorizations there is hereby authorized to be appropriated the sum of $40,000,000 for the prosecution of the comprehensive plan for flood control and other purposes in central and*

> *southern Florida approved in the Act of June 30, 1948, and subsequent Acts of Congress, and such comprehensive plan is hereby modified as recommended by the Chief of Engineers in House Document Numbered 186, Eighty-fifth Congress, and to include the following items:*
>
> *The project for canals, levees, water control structures on the west side of the Everglades agricultural and conservation areas in Hendry County, Florida, substantially in accordance with the recommendations of the Chief of Engineers contained in Senate Document Numbered 48, Eighty-fifth Congress, at an estimated cost of $3,172,000.*

Project works authorized by the 1958 Act are listed in Table L-4.

L.2.5 Flood Control Act of 1960

The 1960 Act authorized flood protection for the Nicodemus Slough area, Glades County, Florida and authorized the name of all the levees around the shore of Lake Okeechobee to be the Herbert Hoover Dike. The 1960 authorization is contained in *P. L. 86-645 (86th Congress,* approved July 14, 1960). The portion applicable to the C&SF Project follows:

CENTRAL AND SOUTHERN FLORIDA

> *In addition to previous authorizations, there is hereby authorized to be appropriated the sum of $23,000,000 for the prosecution of the comprehensive plan for flood control and other purposes in central and southern Florida approved in the Act of June 30, 1948, and subsequent Acts of Congress, and such comprehensive plan is hereby modified to include the following:*
>
> *The project for canals, levees, and water control and drainage structures in the Nicodemus Slough area, Glades County, Florida, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers contained in Senate Document Numbered 53, Eighty-sixth Congress, at an estimated cost of $318,000.*
>
> *That the levees around Lake Okeechobee, Florida, authorized by the Rivers and Harbors Act approved July 3, 1930, and modified by the Flood Control Act approved June 30, 1948, and subsequent Acts, shall be known and designated as Herbert Hoover Dike, and any law, regulation, document, or record of the United States in which such levees are referred to under any other name or designation shall be held to refer to such levees as the Herbert Hoover Dike.*

Project features authorized by the 1960 Act are shown in Table L-5.

L.2.6 Flood Control Act of 1962

The 1962 Act authorized modification and extension of the C&SF Project for flood control and major drainage. The 1962 authorization is contained in *P.L. 87-874 (87th Congress, 2nd Session*, approved October 23, 1962). The portion applicable to the C&SF Project follows:

CENTRAL AND SOUTHERN FLORIDA

> *The comprehensive plan for flood control and other purposes in central and southern Florida approved in the Act of June 30, 1948, and subsequent Acts of Congress, is hereby modified to include the following items:*
>
> *The project for flood protection of West Palm Beach Canal is hereby authorized substantially as recommended by the Secretary of the Army and the Chief of Engineers in Senate Document Numbered 146, Eighty-seventh Congress, at an estimated cost of $3,220,000.*
>
> *The project for flood protection on Boggy Creek, Florida, is hereby authorized substantially as recommended by the Chief of Engineers in Senate Document Numbered 125, Eighty-seventh Congress, at an estimated cost of $1,176,000.*
>
> *The project for South Dade County, Florida, is hereby authorized substantially in accordance with the recommendations of the Secretary of the Army and the Chief of Engineers in Senate Document Numbered 138, Eighty-seventh Congress, at an estimated cost of $13,388,000.*
>
> *The project for Shingle Creek, Florida, between Clear Lake and Lake Tohopekaliga, for flood control and major drainage is hereby authorized substantially as recommended by the Chief of Engineers in Senate Document Numbered 139, Eighty-seventh Congress, at an estimated cost of $3,250,000: Provided, That no obligation shall be incurred for development of Reedy Creek Swamp as a wildlife management area unless the State or one or more other non-Federal entities shall have entered into an agreement in advance to assume at least 50 per centum of the cost associated with that feature of the project.*
>
> *The project for flood protection in the Cutler drain area, Florida, is hereby authorized substantially in accordance with recommendations of the Chief of Engineers in Senate Document Numbered 123, Eighty-seventh Congress, at an estimated cost of $2,063,000:*

> *Provided, That local interests shall receive credit in the Contributed Fund Account of the project for moneys shown to have been spent after March 1, 1960, for construction of units of the authorized plan for Cutler Drain: Provided further, That such completed work must be inspected and accepted by the Chief of Engineers as constituting useful parts of the authorized plan: And provided further, That the credit established shall be in accordance with cost sharing arrangements for the central and southern Florida flood control project in an amount not to exceed $124,000.*

The 1962 authorization affected the following areas:

a. West Palm Beach Canal, east of Water Conservation Area 1, to provide for removal of 30-percent standard project flood from the west agricultural reaches of the canal simultaneously with the 60-percent standard project flood runoff from the east urban reaches,

b. Boggy Creek, tributary to East Lake Tohopekaliga in the Kissimmee River Basin, to remove without damaging ponding the 30-percent standard project flood from the entire 80.5-square-mile drainage area,

c. South Dade County, to remove the 40-percent standard project flood runoff from the entire 206-square-mile effective drainage area, to reduce depth and duration of larger floods, and to provide water control to prevent overdrainage in the area,

d. Shingle Creek, tributary to Lake Tohopekaliga in the Kissimmee River Basin, to remove the 30-percent standard project flood runoff from the area directly tributary to Shingle Creek, to provide sufficient capacity in the lower reach to accommodate the future runoff from Reedy Creek Swamp and its tributaries, to create a wildlife management area in the Reedy Creek Swamp area, to reduce depth and duration of larger floods, and to provide water control to prevent overdrainage in the area, and,

e. Cutler Drain area of Dade County, to remove the 40-percent standard project flood runoff from the entire 38.4-square-mile contributing drainage area, to reduce depth and duration of larger floods, to provide water control for the area by maintaining optimum water levels, and provide means for diversion of waters (when available) from the C-1 and C-2 canals for salinity and water control purposes.

Table L-6 lists project features authorized by the 1962 authorization.

L.2.7 Flood Control Act of 1965

The 1965 Act authorized a new plan for Hendry County west of levees L-1, 2, and 3. The new plan provided for flood protection and major drainage for 261 square miles. It provided for protection of the original 64-square-mile pumped area comparable to that provided in the agricultural area to the east. In addition, it provided for removal of the 10-year flood runoff from the 197-square-mile area west of the proposed interceptor canal; for reduction in the depth and duration of floods of greater magnitude than the 10-year flood; and for water control in the area, insofar as possible. The Act also provided for a seasonal flood protection plan in Southwest Dade County. The plan would provide levees, canals, water control structures, and pumping stations capable of removing 15 inches of runoff per month plus seepage into the area following a 10-year flood. The plan would enable desirable levels for winter agriculture to be achieved by October 10 in a dry year, by October 20 in a normal year, and by November 10 following a 1-in-10-year flood. During a 1-in-10-year flood during the November through April period the pumps would permit 0.50 to 0.75-inch a day runoff removal from the 118-square-mile drainage area. This area is known as the East Everglades area and is authorized for addition to Everglades National Park except for the developed areas. The 1965 authorization is contained in *P.L. 89-298 (89th Congress, 1st Session*, approved October 27, 1965).

CENTRAL AND SOUTHERN FLORIDA BASIN
Comprehensive Plan

> *The comprehensive plan for flood control and other purposes in central and southern Florida approved in the Act of June 30, 1948 and subsequent Acts of Congress, is hereby modified to include the following items:*
>
> *The project for flood protection in Hendry County, west of levees 1, 2, and 3, Florida, is hereby authorized substantially as recommended by the Chief of Engineers in House Document Numbered 102, Eighty-eighth Congress, at an estimated cost of $4,986,000.*
>
> *The project for flood protection in southwest Dade County, Florida, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in Senate Document Numbered 20, Eighty-ninth Congress, at an estimated cost of $4,903,000.*

Project features authorized by the 1965 Act are shown in Table L-7.

L.2.8 Flood Control Act of 1968

The *1968 Act (Public Law 483, 90th Congress, 2nd Session*, approved August 13, 1968) authorized modification to the existing project in the interest of improved conservation and distribution of available water and extended flood protection. The Act authorized an interrelated system of canals, levees, a pumping station, and other structures necessary to supply irrigation water, to maintain optimum water-control levels, and to remove flood runoff for portions of St. Lucie and Martin Counties. The authorization also included provisions to meet the long-term needs of urban and agricultural users and the Everglades National Park. Authorizations for the C&SF Project contained in the 1968 Act are as follows:

CENTRAL AND SOUTHERN FLORIDA

> *The project for Central and Southern Florida, authorized by the Flood Control Act of June 30, 1948, is further modified in accordance with the recommendations of the Chief of Engineers in Senate Document Numbered 101, Ninetieth Congress, at an estimated cost of $8,072,000, and in accordance with House Document Numbered 369, Ninetieth Congress, at an estimated cost of $58,182,000.*

Senate Document Numbered 101 contains the plan of improvement for the Martin County Plan. *House Document Numbered 369* contains the Water Resources Plan for Central and Southern Florida. The project features authorized include:

a. Martin County. For Martin and St. Lucie Counties:

(1) Main channel improvements - including 59 miles of canal, 7 highway bridges, 3 railroad bridges and secondary improvements to convey runoff to project canals.

(2) Primary control structures—including 11 gated spillways, 2 gated culverts, and 1 pumping station.

(3) Inlet structures—provided at existing and proposed inflow points to protect the project canals from siltation and to prevent erosion.

b. Water Resources for Central and Southern Florida. For conservation and conveyance of additional water supplies to users:

(1) Facilities for pumping excess water from east coast areas into storage in Lake Okeechobee and the water conservation areas;

(2) A system of interrelated canals, levees, pumping stations, and control structures for conveyance and distribution of water to demand areas;

(3) Deepening the navigation channel across Lake Okeechobee;

(4) Construction of recreation facilities;

(5) Raising the Lake Okeechobee levees to provide for an increase of about 4 feet in the authorized regulation Stages;

(6) Deletion of the deepening of the St. Lucie Canal from the authorized project; and

(7) The construction of the small craft lock in Buttonwood Canal.

Project features authorized by the 1968 Act are shown in Table L-8.

L.2.9 River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970

The *1970 Act (P.L. 282, 91st Congress, 1st Session*, approved June 19, 1970) provided funding for the accelerated construction of borrow canal L-70, canal C-308, canal C-119W, and pumping station S-326 in order to meet the increased water requirements of the Everglades National Park. The Act further provided for the delivery from the project to Everglades National Park a minimum of 315,000 acre-feet of water according to a monthly distribution and to locations stated in the National Park Service letter of October 20, 1967, to the Chief of Engineers, or 16.5 percent of total project deliveries for all purposes, whichever is less. *S.D. 91-895*, which accompanied the law, provided a formula for deciding when the 16.5 percent quantity applied. The formula was found to be faulty and hasn't been applied since the earliest months following enactment. The following is a quote from this act:

> *SEC. 2. In addition to previous authorizations, there is hereby authorized to be appropriated the sum of $25,000,000 for the prosecution of the central and southern Florida comprehensive plan for flood control and other purposes approved in the Flood Control Act of 1948, and subsequent Acts of Congress: Provided, That not to exceed $5,000,000 of this authorization shall be available solely for the accelerated construction of borrow canal L-70, canal C-308, canal C-119W, and pumping station S. 326, together with such other works in the plan of improvement as the Director of the National Park Service and the Chief of Engineers agree are necessary to meet the water requirements of the Everglades National Park: Provided further, That as soon as practicable and in any event upon completion of the works specified in the preceding proviso, delivery of water from the central and southern Florida project to the Everglades National Park shall be not less than 315,000 acre-feet annually, prorated according to the monthly schedule set forth in the*

> *National Park Service letter of October 20, 1967, to the Office of the Chief of Engineers, or 16.5 per centum of total deliveries from the project for all purposes including the park, whichever is less.*

L.2.10 Small Boat Navigation Authorization of 1970

Authorization for navigation improvements suitable for recreational craft were approved in *H.D. No. 394 (91st Congress, 2d Session).* These improvements were authorized by the Committee on Public Works on December 12, 1970, under provisions of *Section 201 of the Flood Control Act of 1965.* Project features included a number of small navigation locks with connecting channels in the Upper Kissimmee River Basin and a separate system of locks and channels in the Upper St. Johns River Basin.

The facilities authorized are shown on Table L-9.

None of the features authorized in *H.D. 91-394* have been constructed; therefore, these features were deauthorized January 1, 1990, under the authority of the *Water Resources Development Act of 1986 (P.L. 99-662)* and the *Water Resources Development Act of 1988 (P.L. 100-676).*

L.2.11 Economic Update, C&SF Project, November 1973

H.R. 93-327 required the Corps of Engineers to update the economics of the C&SF Project. As a result, several project features were deleted from the project and many others were relegated to inactive status.

L.2.12 Supplemental Appropriations Act of 1984

This act modified the schedule for delivery of water from the Central and Southern Florida Project to Everglades National Park as required in the *River Basin Authorization and Miscellaneous Civil Works Amendments Act of 1970.* Furthermore, it authorized an experimental program for the delivery of water to Everglades National Park for the purpose of determining an improved schedule for water delivery. The Act of 1984 is contained in *P.L. 98-181 (98th Congress, 1st Session*, approved November 30, 1984), which modified the water delivery schedule to Everglades National Park. Below is an excerpt from this act:

> *SEC. 1302. The Secretary of the Army is authorized, for a period of two years beginning with the enactment of this Act with the concurrence of the Director of the National Park Service and the South Florida Water Management District, to modify the schedule for delivery of water from the central and southern Florida project to the Everglades National Park required by section 2 of the River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970*

(Public Law 91-282) and to conduct an experimental program for the delivery of water to the Everglades National Park from such project for the purpose of determining an improved schedule for such delivery.

The Secretary of the Army is further authorized to acquire such interest in lands currently in agriculture production which are adversely affected by any modification of schedule for water delivery to Everglades National Park under the preceding paragraph. The Secretary shall acquire any interest in land at the fair market value of such interest based on conditions existing after the construction of the project described in the preceding paragraph of this section and before any modification of such delivery schedule. The Secretary is also authorized to construct necessary flood protection measures for protection of homes in the area affected by any modification of such delivery schedule, at an estimated cost of $10,000,000.

This law has since been amended twice to extend the experimental program for water deliveries to the Everglades National Park. The first such amendment was contained in *P.L. 99-190 (99th Congress, 1st Session,* approved December 19, 1985).

L.2.13 Water Resources Development Act of 1986

Public Law 662 (99th Congress, 2nd Session) was approved November 17, 1986. This act authorized a study by the Corps of Engineers in conjunction with the Environmental Protection Agency of the water quality and water supply potential of Lake Okeechobee. The Act also authorized a study of various alternatives for flood protection in the Upper St. John's River Basin. The following are excerpts from this act:

SEC. 733. LAKE OKEECHOBEE STUDY

(a) The Secretary, in consultation with the Administrator of the Environmental Protection Agency, is authorized to undertake a study of the water supply potential of Lake Okeechobee in Florida, with particular emphasis on determining the causes of water quality deterioration in the lake and the impact, if any, that the Central and Southern Florida Irrigation [sic] Project may have on water quality in the lake. In undertaking the study authorized pursuant to this section, the Secretary shall coordinate with the State of Florida and shall assess the impact of short- and long-term solutions proposed by Federal, State, and local entities to alleviate the water quality and water supply problems of Lake Okeechobee.

(b) Within two years after the first appropriation of funds for the study, the Secretary shall report to the Committee on Public Works and

Transportation of the House of Representatives and the Committee on Environment and Public Works of the Senate on the results of the study authorized pursuant to this section and any recommendations of the Secretary concerning measures which may be implemented at the Federal, State, or local level to improve the water quality and the water supply potential of Lake Okeechobee.

(c) There are authorized to be appropriated $1,000,000 for fiscal years beginning after September 30, 1986, to carry out this section.

SEC. 1153. UPPER ST. JOHN'S RIVER BASIN, FLORIDA

(a) For any survey, planning, or design of any water resources project for the Upper St. John's River Basin, Florida, the Secretary shall give equal consideration to structural, nonstructural, and primarily nonstructural alternatives including, but not limited to, floodproofing of structures; flood plain regulation; acquisition of flood plain lands for recreation, fish and wildlife, and other public purposes; relocation; reductions in water demand; water-borne traffic scheduling; and vessel modification with a view toward formulating the most economically, socially, and environmentally acceptable means of solving the water resources problem.

(b) Cost sharing applicable to nonstructural local flood protection projects shall apply to any water resources project on the Upper Saint John's River Basin, consistent with section 903(c).

L.2.14 Water Resources Development Act of 1988

This act authorized several different items that pertain to the Central and Southern Florida Project. First, a simulation model of the hydrologic ecosystem for use in predicting the effects of modifications to the project, changes in operation of the project, and other activities in the vicinity of the project was authorized. Second, the Supplemental Appropriations Act of 1984 was amended by extending the date for completion of the modified water delivery schedule to Everglades National Park. Third, a demonstration project on the Kissimmee River was authorized. Last, a study of the need for internal drainage in the Frog Pond agricultural area of south Miami-Dade County was authorized. *Public Law 100-676 (100th Congress)* was approved November 17, 1988. The following are excerpts from the Act:

SEC. 11. SIMULATION MODEL OF SOUTH CENTRAL FLORIDA HYDROLOGIC ECOSYSTEM

(a) IN GENERAL. - The Secretary, in cooperation with affected Federal, State, and local agencies and other interested persons, may

develop and operate a simulation model of the central and southern Florida hydrologic ecosystem for use in predicting the effects--

(1) of modifications to the flood control project for central and southern Florida, authorized by the Flood Control Act of 1948,

(2) of changes in the operation of such project, and

(3) of other human activities conducted in the vicinity of such ecosystem which individually or in the aggregate will significantly affect the ecology of such ecosystem, on the flow, characteristics, quality, and quantity of surface and ground water in such ecosystem and on plants and wildlife within such ecosystem. Such model shall be capable of producing information which is applicable for use in evaluating the impact of issuance of proposed permits under section 10 of the Act of March 3, 1899 (30 Stat. 1151; 33 U.S.C. 403), commonly known as the River and Harbors Appropriation Act of 1899, and under section 404 of the Federal Water Pollution Control Act.

(b) AVAILABILITY TO STATE AND LOCAL AGENCIES - The Secretary shall allow Federal, State, and local agencies to use, on a reimbursable basis, the simulation model developed under this section.

(c) COST SHARING - The Federal share of the cost of developing and operating the simulation model under this section shall be 75 percent.

SEC. 40. EXTENSION OF MODIFIED WATER DELIVERY SCHEDULES, EVERGLADES NATIONAL PARK.

The first sentence of section 1302 of the Supplemental Appropriations Act, 1984 (97 Stat. 1292-1293) is amended by striking out "January 1, 1989" and inserting in lieu thereof "January 1, 1992".

SEC. 46. KISSIMMEE RIVER, FLORIDA.

The Secretary is directed to proceed with work on the Kissimmee River demonstration project, Florida, pursuant to section 1135 of the Water Resources Development Act of 1986.

SEC. 47. WATER RESOURCES STUDIES.

(a) INTERNAL DRAINAGE SYSTEM, FROG POND AGRICULTURAL AREA, FLORIDA - The Secretary shall conduct a study for the purpose of determining the need for an internal drainage

system in the Frog Pond agricultural area of south Dade County, Florida. Within 1 year after the date of the enactment of this Act, the Secretary shall submit to Congress a reconnaissance report on the need for such system.

L.2.15 Everglades National Park Protection and Expansion Act of 1989

The purpose of the Everglades National Park Protection and Expansion Act of 1989 (P.L. 101-229) was *"To modify the boundaries of the Everglades National Park and to provide for the protection of lands, waters, and natural resources within the park, and for other purposes". Public Law 101-229 (101st Congress)* was approved on December 13, 1989. This act also authorized the construction of modifications to the Central and Southern Florida Project to improve water deliveries to the park and to the extent practicable permits steps to restore the natural hydrological conditions within the park. These modifications are *"justified by the environmental benefits to be derived by the Everglades ecosystem in general and the park in particular".* The following are excerpts from the Act:

SEC. 104. MODIFICATION OF CERTAIN WATER PROJECTS.

(a) IMPROVED WATER DELIVERIES.

(1) Upon completion of a final report by the Chief of Army Corps of Engineers, the Secretary of the Army, in consultation with the Secretary [of the Interior], is directed to construct modifications to the Central and Southern Florida Project to improve water deliveries into the park and shall, to the extent practicable, take steps to restore the natural hydrological conditions within the park.

(2) Such modifications shall be based upon the findings of the Secretary's experimental program authorized in section 1302 of the 1984 Supplemental Appropriations Act (97 Stat. 1292) and generally set forth in a General Design Memorandum to be prepared by the Jacksonville District entitled "Modified Water Deliveries to Everglades National Park". The Draft of such Memorandum and the Final Memorandum, as prepared by the Jacksonville District, shall be submitted as promptly as practicable to the Committee on Energy and Natural Resources and the Committee on Environment and Public Works of the United States Senate and the Committee on Interior and Insular Affairs and the Committee on Public Works and Transportation of the United States House of Representatives.

(3) Construction of project modifications authorized in this subsection and flood protection systems authorized in subsections (c) and (d) are justified by the environmental benefits to be derived by the

Everglades ecosystem in general and by the park in particular and shall not require further economic justification.

(4) Nothing in this section shall be constructed to limit the operation of project facilities to achieve their design objectives, as set forth in the Congressional authorization and any modifications thereof.

(b) DETERMINATION OF ADVERSE EFFECT.

(1) Upon completion of the Final Memorandum referred to in subsection (a), the Secretary of the Army, in consultation with the South Florida Water Management District, shall make a determination as to whether the residential area within the East Everglades known as the "Eight and One-Half Square Mile Area" or adjacent agricultural areas, all as generally depicted on the map referred to in subsection 102(a), will be adversely affected by project modifications authorized in subsection (a).

(2) In determining whether adjacent agricultural areas will be adversely affected, the Secretary of the Army shall consider the impact of any flood protection system proposed to be implemented pursuant to subsection (c) on such agricultural areas.

(c) FLOOD PROTECTION; EIGHT AND ONE-HALF SQUARE MILE AREA. - If the Secretary of the Army makes a determination pursuant to subsection (b) that the "Eight and One-Half Square Mile Area" will be adversely affected, the Secretary of the Army is authorized and directed to construct a flood protection system for that portion of presently developed land within such area.

(d) FLOOD PROTECTION; ADJACENT AGRICULTURAL AREA. - If the Secretary of the Army determines pursuant to subsection (b) that an adjacent agricultural area will be adversely affected, the Secretary of the Army is authorized and directed to construct a flood protection system for such area. Such determination shall be based on a finding by the Secretary of the Army that:

(A) the adverse effect will be attributable solely to a project modification authorized in subsection (a) or to a flood protection system implemented pursuant to subsection (c), or both; and

(B) such modification or flood protection system will result in a substantial reduction in the economic utility of such area based on its present agricultural use.

(2) No project modification authorized in subsection (a) which the Secretary of the Army determines will cause an adverse effect pursuant to subsection (b) shall be made operational until the Secretary of the Army has implemented measures to prevent such adverse effect on the adjacent agricultural area: Provided, That the Secretary of the Army or the South Florida Water Management District may operate the modification to the extent that the Secretary of the Army determines that such operation will not adversely affect the adjacent agricultural area: Provided further, That any preventive measure shall be implemented in a manner that presents the least prospect of harm to the natural resources of the park.

(3) Any flood protection system implemented by the Secretary of the Army pursuant to this subsection shall be required only to provide for flood protection for present agricultural uses within such adjacent agricultural area.

(4) The acquisition of land authorized in section 102 shall not be considered a project modification.

(e) PERIODIC REVIEW. - (1) Not later than 18 months after the completion of the project modifications authorized in subsection (a), and periodically thereafter, the Secretary of the Army shall review the determination of adverse effect for adjacent agricultural areas.

(2) In conducting such review, the Secretary of the Army shall consult with all affected parties, including, but not limited to, the Secretary, the South Florida Water Management District and agricultural users within adjacent agricultural areas.

(3) If, on the basis of such review, the Secretary of the Army determines that an adjacent agricultural areas has been, or will be adversely affected, the Secretary of the Army is authorized and directed, in accordance with the provisions of subsection (d), to construct a flood protection system for such area: Provided, That the provisions of subsection (d)(2) shall be applicable only to the extent that the Secretary, in consultation with the Secretary of the Army, determines that the park will not be adversely affected.

(4) The provisions of this subsection shall only be applicable if the Secretary of the Army has previously made a determination that such adjacent agricultural area will not be adversely affected.

(f) CURRENT CANAL OPERATING LEVELS. - Nothing in this section shall be construed to require or prohibit the Secretary of the Army or the South Florida Water Management District from maintaining the

water level within any project canal below the maximum authorized operating level as of the date of enactment of this Act.

(g) NO LIMITATION ON OTHER CLAIMS. - If the Secretary of the Army makes a determination of no adverse effect pursuant to subsection (b), such determination shall not be considered as a limitation or prohibition against any available legal remedy which may otherwise be available.

(h) COORDINATION. - The Secretary and the Secretary of the Army shall coordinate the construction program authorized under this section and the land acquisition program authorized in section 102 in such a manner as will permit both to proceed concurrently and as will avoid unreasonable interference with property interests prior to the acquisition of such interests by the Secretary under section 102.

(i) WEST DADE WELLFIELD. - No Federal license, permit, approval, right-of-way or assistance shall be granted or issued with respect to the West Dade Wellfield (to be located in the Bird Drive Drainage Basin, as identified in the Comprehensive Development Master Plan for Dade County, Florida) until the Secretary, the Governor of the State of Florida, the South Florida Water Management District and Dade County, Florida enter into an agreement providing that the South Florida Water Management District's water use permit for the wellfield, if granted, must include the following limiting conditions: (1) the wellfield's peak pumpage rate shall not exceed 140,000,000 gallons per day; (2) the permit shall include reasonable, enforceable measures to limit demand on the well field in times of water shortages; and (3) if, during times of water shortage, the District fails to limit demand on the wellfield pursuant to (2), or if the District limits demand on the wellfield pursuant to (2), but the significant adverse impacts on the resources of the Park, the Governor shall require the South Florida Water Management District to take necessary actions to alleviate the adverse impact, including, but not limited to, temporary reductions in the pumpage from the wellfield.

(j) PROTECTION OF NATURAL VALUES. - The Secretary of the Army is directed in analysis, design and engineering associated with the development of a general design memorandum for works and operations in the "C-111 basin" area of the East Everglades, to take all measures which are feasible and consistent with the purpose of the project to protect natural values associated with Everglades National Park. Upon completion of a general design memorandum for the area, the Secretary shall prepare and transmit a report to the Committee on Energy and

> *Natural Resources and the Committee on Environment and Public Works of the United States Senate and the Committee on Interior and Insular Affairs and the Committee on Public Works and Transportation of the United States House of Representatives on the status of the natural resources of the C-111 basin and functionally related lands.*

Project features authorized by this act are shown on Table L-10.

L.2.16 Water Resources Development Act of 1990

This act authorized a feasibility study for the purpose of determining modifications to the Kissimmee River portion of the Central and Southern Florida Project for the environmental restoration of the Kissimmee River. *Public Law 101-640 (101st Congress)* was approved November 17, 1990. The following are excerpts from the Act:

Sec 107(h) KISSIMMEE RIVER,
CENTRAL AND SOUTHERN FLORIDA

> *(1) STUDY. - The Secretary shall conduct a feasibility study of the Kissimmee River in central and southern Florida for the purpose of determining modifications of the flood control project for central and southern Florida, authorized by section 203 of the Flood Control Act of 1948 (62 Stat. 1176), which are necessary to provide a comprehensive plan for the environmental restoration of the Kissimmee River. The study shall be based on implementing the Level II Backfilling Plan specified in the Kissimmee River Restoration, Alternative Plan Evaluation and Preliminary Design Report, dated June 1990, published by the South Florida Water Management District.*
>
> *(2) REPORT. - Not later than April 1, 1992, the Secretary shall transmit to Congress a final report of the Chief of Engineers on the results of the study conducted under this subsection, together with such modifications as are recommended by the Secretary.*
>
> *(3) POST-STUDY WORK. - All work necessary to prepare the project recommended by the Chief of Engineers, as modified by the Secretary, for construction bidding, including Feature Design Memoranda, shall be completed by June 1, 1994.*

L.2.17 Water Resources Development Act of 1992

This act *(Public Law 580, 102nd Congress, 2nd session, approved October 31, 1992)* which authorized the C&SF Project Comprehensive Review Study also authorized the Kissimmee River Restoration Project, including the Headwaters

Revitalization Project. Construction of a quarantine facility for melaleuca control was also authorized. Pertinent sections of the Act follow:

> *Section 101 (8) Kissimmee River Restoration, Florida.*
>
> *The project for the ecosystem restoration of the Kissimmee River, Florida: Report of the Chief of Engineers, dated March 17, 1992, at a total cost of $426,885,000, with an estimated Federal cost of $139,943,999 and an estimated non-Federal cost of $286,942,000. The Secretary is further authorized to construct the Kissimmee River headwaters revitalization project in accordance with the report prepared under section 1135 of the Water Resources Development Act of 1986 (100 Stat. 4251 - 4252) for such headwaters project and any modifications as are recommended by the Secretary based on the benefits derived for the environmental restoration of the Kissimmee River basin, at a total cost of $92,210,000, with an estimated Federal cost of $46,105,000 and an estimated non-Federal cost $46,105,000. The Secretary shall take such action as may be necessary to ensure that implementation of the project to restore the Kissimmee River will maintain the same level of flood protection as is provided by the current flood control project.*
>
> *Section 108. Quarantine Facility.*
>
> *a. Construction. The Secretary, in consultation with the Governor of Florida, shall construct a research and quarantine facility in Broward County, Florida, to be used in connection with efforts to control Melaleuca and other exotic plant species that threaten native ecosystems in the State of Florida.*
>
> *b. Operation and Maintenance. After construction, the Secretary shall transfer the facility constructed under this section to the Secretary of Agriculture. The facility shall be jointly maintained and operated by the Department of Agriculture and an appropriate agency or agencies of the State of Florida.*
>
> *c. Authorization of Appropriations. There is authorized to be appropriated for fiscal years beginning after September 30, 1992, $1,000,000 for the construction of the facility described in subsection (a). Such sums shall remain available until expended.*

L.2.18 Everglades Forever Act, 1994

The Florida Everglades Statutes 373.4592 passed after many years of litigation involving the United States, the State of Florida, the SFWMD, the DEP, and certain large agricultural interests to determine how and at whose expense pollution of the Everglades should be abated. The Everglades Forever Act established two funding sources for pollution abatement in the Everglades Agricultural Area (EAA): the Everglades agricultural privilege tax, and the levy of a 0.1 mill ad valorem tax on property within the Okeechobee Basin. Therefore, the law in effect at the time of the adoption of Amendment 5 was designed to divide the burden of the costs of pollution abatement on the public by the 0.1 mill tax and the agricultural users by the privilege tax of $24.89 per acre. The Florida Constitution was amended after this Act to direct the legislature to make those in the EAA who cause water pollution in the EAA and Everglades Protection Area (EPA) "primarily responsible" for the costs of cleaning up the pollution.

L.2.19 Water Resources Development Act of 1996

This act *(Public Law 843, 104th Congress)* authorizes cost sharing changes for flood control and environmental restoration and protection projects, a number of significant environmental provisions, and clarification of cost sharing for dredged material disposal facilities. Pertinent sections of the Act follow:

Section 315 Central and Southern Florida, Canal 51.

The project for flood protection of West Palm Beach, Florida (C-51), authorized by section 203 of the Flood Control Act of 1962 (76 Stat. 1183), is modified to provide for the construction of an enlarged stormwater detention area, Storm Water Treatment Area 1 East, generally in accordance with the plan of improvements described in the February 15, 1994, report entitled "Everglades Protection Project, Palm Beach County, Florida, Conceptual Design", with such modifications as are approved by the Secretary. The additional work authorized by this section shall be accomplished at Federal Expense. Operation and maintenance of the stormwater detention area shall be consistent with regulations prescribed by the Secretary for the Central and Southern Florida project, and all costs of such operation and maintenance shall be provided by non-Federal interests.

Section 316 (a) Central and Southern Florida, Canal 111.

In General. - - The project for Central and Southern Florida, authorized by section 203 of the Flood Control Act of 1948 (62 Stat. 1176) and modified by section 203 of the Flood Control Act of 1968 (82 Stat. 740-741), is modified to authorize the Secretary to implement the recommended plan of improvement contained in a report entitled "Central and Southern Florida Project, Final Integrated General Reevaluation Report and Environmental Impact Statement, Canal 111 (C-111), South Dade County, Florida", dated May 1994, including *acquisition by non-Federal interests of such portions of the Frog Pond and Rocky Glades areas as are needed for the project.*

Section 528 Everglades and South Florida Ecosystem Restoration.

(a) The Secretary is to expeditiously develop a comprehensive plan for restoring, preserving, and protecting the South Florida ecosystem including water quality, fresh water supply, flood control, and water supply.

(b) NLT July 1, 1999, provide a report on the comprehensive plan and complete the feasibility phase of the Central and Southern Florida Project.

(c) The Secretary may proceed with any features authorized under the Central and Southern Florida Project and other independent critical restoration projects compatible with the overall task force framework.

(d) All activities should be integrated with other ongoing State and Federal projects and activities.

(e) Establishes a South Florida Ecosystem Restoration Task Force to provide consultation with the Secretary during development of the comprehensive plan, and provide a forum for developing consistent policies and strategies for restoring the South Florida ecosystem and coordinating information with the public and other related organizations. The task force will provide a biennial report to Congress.

A summary of the authorized project purposes and the applicable authorizations is found on Table L-11.

L.3 DISCRETIONARY PROJECT CHANGES

The Comprehensive Plan for flood control and other project purposes was presented in the report to the Chief of Engineers on Central and Southern Florida, published as *House Document 643 (80th Congress, 2d Session)* in 1948. The project was partially authorized by the *Flood Control Act of 1948 (Public Law 858, 80th Congress, 2d Session).* That authorization included most of the works necessary to afford flood protection to the rich agricultural development south of Lake Okeechobee and to the highly developed area along the lower east coast. The remaining works of the Comprehensive Plan as presented in *House Document 643*, were authorized by the

Flood Control Act of 1954, approved September 3, 1954 *(Public Law 780, 83rd Congress, 2d Session).* This authorization specifically recognized that the plan of improvement would require refinement and that modifications, within the scope and purpose of the authorization, could be made at the discretion of the Chief of Engineers.

The Central and Southern Florida Project for Flood Control and Other Purposes resulted in a comprehensive series of reports and design memorandums used in planning and designing the water control system. Many of these reports recommended additions and/or deletions and modifications to the originally authorized project. These recommendations were made as a result of more detailed studies, or at the request of the local sponsor. The original local sponsor for the project was the Central and Southern Florida Flood Control District (C&SFFCD) created by the Florida Legislature in 1949. However, in 1972 the State of Florida reorganized the flood control districts and the new local sponsors became the South Florida Water Management District (SFWMD) and the St. Johns River Water Management District (SJRWMD). What follows is an account of project features by area which were added, deleted, or modified by the District Engineer after authorization. Tables L-1 through L-10 summarize the status of project features by authorization.

L.3.1 Kissimmee River Basin

Project works in the basin were authorized by the *Flood Control Act of 1954*, approved September 3, 1954 (*Public Law 780, 83rd Congress, 2d Session).* However, earlier *Congressional Acts in 1937, 1939, and 1946* had directed that studies on regulating the Kissimmee River and its tributaries be made at the request of State interests. The existing project works now in the Kissimmee -Lake Istokpoga basin conform closely with the general plan outlined in the 1948 report to Congress. The major lakes of the upper basin which are used as water conservation reservoirs, are connected by channels, in most cases channels excavated by Hamilton Disston in the 1880s but enlarged to varying degrees under the Congressionally authorized plan. Nine control structures regulate water levels and flows in the lakes channel system. Five water control structures control water elevations in the lower basin canal and regulate flows originating in both the upper and lower basins. These structures also have locks which provide year-round navigability within and through the Kissimmee basin.

a. Part II, Supplement 5, - General Design Memorandum. Kissimmee River Basin dated October 8, 1956, presents the results of hydrologic and hydraulic investigations for development of the plan of improvement of the Kissimmee River basin. The report recommended several significant changes from the original comprehensive plan. First, this report recommended that the following project features not included in the Comprehensive Plan be included in the plan of improvement. This included the construction of canals 29, 45, 46, and 47 and structures 62, 63, 63A, 86, 87, 87A, 87B, 88, 88A, and 88B, plus all necessary secondary drainage structures. Secondly, the report recommended that structures 56 and 65F be deleted from the plan. These recommendations were approved by the Chief of Engineers on February 27, 1957.

b. Part II, Supplement 5, Section 2, dated April 11, 1969, recommended the following additions to the authorized plan: construction of Canal 46A and spillway structure 87C, and the inclusion of tieback levees at structures 87, 87A and 87B. The memorandum also requested that the construction of the recommended project features (C-46, C-46A, S-87, S-87A, S-87B, and S-87C) be deferred until they were economically justified. In a follow-up letter dated February 24, 1983, the District Engineer requested that S-87 be deleted from the plan of improvements. To date C-46, C-46A, S-87, S-87A, S-87B, and S-87C have not been constructed.

c. Letter to the Chief. In a letter to the Chief of Engineers, dated October 6, 1961, the District Engineer recommended the deletion of structure 64 from the authorized plan. This request was made following Resolution 462 requesting this action by the Governing Board of the Central and Southern Flood Control District on September 8, 1961. The Flood Control District reanalyzed the regulation schedules for Lakes Kissimmee, Cypress, and Hatchineha. They determined that Lake Kissimmee could be regulated approximately one-half foot higher and Lakes Cypress and Hatchineha could be regulated one-half foot lower than proposed in the *General Design Memorandum (Part II, Supplement 5).* This eliminated the need for the control structure (S-64) at the outlet of Lake Hatchineha. The flood storage in Lakes Kissimmee, Hatchineha, and Cypress did not appreciably change with this modification. In a letter dated October 10, 1961, the Chief of Engineers concurred with the elimination of S-64 from the authorized project as recommended by the Jacksonville District.

d. SFWMD Alteration. On December 1, 1976, an extreme drawdown of Lake Kissimmee was begun in order to eliminate by exposure and drying most of the hyacinths found at elevations 44.0 ft. and above. To accomplish this drawdown an earthen plug was placed in C-37 between Lakes Hatchineha and Kissimmee and a temporary bypass structure was constructed adjacent to the mouth of C-37 as it enters Lake Kissimmee. The variable crest structure (stop-log riser) is capable of controlling upstream elevations between 46.0 and 49.5 ft. Once the drawdown had been completed and the lake stage had returned to the normal elevation, the plug in C-37 was removed. However the temporary bypass structure remained to provide drawdown capabilities in the future. The design, construction, and maintenance of the structure was accomplished by the SFWMD with a Department of Army Permit. Approval for the extreme drawdown of Lake Kissimmee was received from the Chief of Engineers on November 2, 1976.

L.3.2 Lake Istokpoga

Part II, Supplement 2, Design Memorandum, Hydrology and Hydraulic Design, Lake Istokpoga - Indian Prairie Area, dated November 28, 1955, specifically dealt with the project features in these areas. This report recommended the following changes to the authorized plan. First, that Levee 46 along the south shore of Lake Istokpoga be retained as an unplanned item of the authorized project, but that its construction be deferred for consideration when the need therefore becomes apparent. Under the recommended plan in this report, authorized canal 39 and structures 73 and 74 would not be constructed. The plan further recommended the addition of canal 41A and structures 82, 83, and 84 to the plan of improvement for the Lake Istokpoga-Harney Pond-Indian Prairie Canal Area. The original purpose of canal 39 would be accomplished by canal 41A and the purpose envisioned in the project document for structures 73 and 74 would be accomplished by structures 72 and 75 respectively. Inasmuch as the functions of canal 39 and structures 73 and 74 would be accomplished by the recommended plan, it was recommended that they be deleted. The Division Engineer and Chief of Engineers in approving the recommended plan of improvements, both requested that further studies be made into need for Levee 46. In a follow-up letter dated October 16, 1956, the District Engineer recommended the deletion of Levee 46 from the project. However, in a letter dated October 31, 1956, and a letter dated December 13, 1956, both the Division Engineer and the Chief of Engineers, respectively, rejected the arguments for the deletion of Levee 46.

a. <u>The Survey-Review Report on Central and Southern Florida Project - Water Resources for Central and Southern Florida</u>, dated February 15, 1968, examined the water supply potential in the C&SF project. Raising the Lake Istokpoga regulation schedule about four feet was considered. This amounted to a potential storage of approximately 130,000 acre-feet. However, the costs of necessary levees and modifications were relatively high and the net increase in deliveries would be only a fraction of the potential storage. It was estimated that the small amounts of water that could be delivered by this plan would cost about $23 per acre-foot. Subsequently, this plan was rejected.

b. <u>Letter Report</u>. Currently, the Jacksonville District is preparing a letter report for the placement of weirs downstream of S-68, S-82, and S-83. These weirs are necessary due to tailwater constraints resulting from a design deficiency that does not permit design capacity discharges through S-68.

L.3.3 Upper St. Johns River Basin

The original plan presented in the project document (*House Document 643, 80th Congress, 2d Session*) has undergone major modifications twice under discretionary authority of the Chief of Engineers (OCE) since authorization. The initial comprehensive plan of improvement for the basin contemplated improvements of Lake Poinsett, Washington, and Wilmington (Blue Cypress Lake). Levees and control works were provided downstream from Lakes Poinsett and Washington, and outlet channels with control works were to be provided from each of the three lakes to the Indian River with capabilities of discharging floods up to the maximum of record. The original plan was authorized in 1954. Control structures were provided to prevent overdrainage of lakes during dry periods, and the outlet canals were to permit discharges during flood periods and prevent salt water intrusion from the Indian River.

a. Authorized Plan (Part III, Supplement 2). The Comprehensive Plan (authorized plan) prepared March 20, 1957 required several hundred thousand acres of valley lands for water storage and was not acceptable to landowners and local groups. This led to the development of a new plan to provide for flood control and irrigation for the Upper St. Johns River Basin. The first change was approved by Chief of Engineers on September 17, 1957. In this action the plan was changed from primarily a diversion plan to a plan emphasizing valley floodways and conservation areas. Basically, levees would provide for flood protection of developed areas and control structures would permit retention of sufficient water to supply irrigation needs during the dry season. The plan included two conservation areas and a control structure below Lake Poinsett. C-26, S-51, C-27, S-52, C-28, S-54 canals and control structures intended to divert the Upper St. Johns River floodwater to the Indian River were deleted from the plan. The method of flood control was changed from diversion to storage, making these works unnecessary. They were replaced by L-52, L-53, L-54, L-55, L-56, S-95, S-96, and S-98. No improvements were proposed in the Upper St. Johns River Basin below Structure 55.

b. Addendum 1 (1962 Plan). *Addendum 1 to the General Design Memorandum* was prepared on February 15, 1962. This modification emphasized a combination of upland and valley reservoirs, channelization, and diversion. With some subsequent minor revisions, this was the plan under construction that was halted in 1972 for environmental reasons. The 1957 plan proposed that the majority of marshlands in the basin be used as either floodways or water conservation areas. However, that plan was unacceptable to the various interests involved because over 200,000 acres of land in the flood plain above Lake Poinsett was included in the conservation areas. In May 1960, the Flood Control District (now SFWMD) proposed a plan of improvement consisting of a limited floodway in the valley, seven upland retention reservoirs on the western slope of the basin, and a diversion canal from Blue Cypress Lake (Lake Wilmington) to Indian River for discharge of excess floodwaters. The plan developed was essentially a modification of the Flood Control District's plan, with expansion of certain basic features. The seven small upland reservoirs in the Flood Control District's plan were interconnected to form three larger upland reservoirs, thus permitting greater flexibility in releases between those upland reservoirs and to the valley reservoirs. Runoff from a drainage area of 540 square miles (nearly half of the total Upper St. Johns River Basin area) would have been stored and regulated by the upland reservoirs. The advantage of interconnecting channels between the two northerly upland reservoirs was that storage could be released into any one or all of the valley lakes.

c. Addendum 2 (1969 Plan). On March 17, 1969, *Addendum 2 to the General Design Memorandum* was prepared. Because encroachment of development into the Blue Cypress Lake (Lake Wilmington) valley reservoir created land acquisitions problems, and the limited conservation storage available in the Fort Drum and Blue Cypress upland reservoir areas made the value of those storage areas questionable, the Flood Control District (now SFWMD) requested reconsideration of project plans in the Blue Cypress Lake area. In addition, changes in drainage patterns and levee alinement were necessary due to construction activities which took place after the 1962 plan was developed. These activities included construction of Florida's Turnpike, large scale drainage projects, and private dike and floodway construction. For these reasons, a modified plan was developed for the Blue Cypress Lake, Fort Drum, and Blue Cypress Reservoirs. The plan called for elimination of conservation storage in the upland Fort Drum and Blue Cypress areas; modification of Blue Cypress Lake Reservoir limits resulting a reduction of 5,000 acres (15 percent) in the reservoir area; revised alinement for retention levees in Fort Drum and Blue Cypress areas; and provision of a tieback levee at the downstream end of Blue Cypress Lake Reservoir. L-44 and L-45, levees crossing the valley in Upper St. Johns River area, were replaced by a revised levee system as a result of the change from a diversion plan to a storage plan. On July 11, 1969 the *Addendum* was approved by the Chief of Engineers subject to the satisfaction of comments.

d. Addendum 3 (1985 Plan). The current plan uses valley conservation areas and floodways, some diversion, and upland detention areas. While the scope of the project remains relatively unchanged, the current plan is more compatible with the environment of the basin. The current plan eliminated the upland detention areas consisting of L-71, L-72, S-159, S-160, S-162; the Wolf Creek portion of the Jane Green Reservoir including S-163; the Blue Cypress Reservoir including C-52 and C-53S; the Lake Washington Reservoir, including C-55 and S-53; the Lake Poinsett Reservoir, including C-56, and S-55; and the weir on Puzzle Lake. The plan also modified a portion of the Jane Green Reservoir making it a detention area. The plan also added the Fort Drum Marsh Conservation Area, including L-78, L-79, S-252A,B and C; the Blue Cypress Marsh Conservation Area including L-74W, L-75, S-250A,B and C, and S-96C; the St. Johns Water Management Area including L-74E, S-96B; new levees and structures north of the Fellsmere Grade including L-74N, L-80, L-81, L-82, S-255, S-256, and S-257; and a new structure in the Jane Green Detention Area, S-161A. This plan was approved by the Chief of Engineers on September 1, 1986.

L.3.4 Fisheating Creek

Part II, Supplement 4, General Design Memorandum - Hydrology and Hydraulic Design, Fisheating Creek Area, dated April 24, 1956, recommended the deletion of Canal 22 and control Structure 69. The report further recommended that no further studies be made of the upper Fisheating Creek basin under existing survey-review-report authorization. These recommendations were made because flood protection to the area could not be economically justified. In a letter dated July 13, 1956, the Chief of Engineers declined to delete the two project works and instead classified them as "inactive" since the possibility of future development in the basin may justify flood protection and the report did not indicate whether the Flood Control District had concurred with the decision to delete them. In a letter dated December 4, 1956, the District Engineer again requested that Canal 22 and Structure 69 be deleted from the project since the Flood Control District concurred with the decision to delete them from the project. In a letter dated December 7, 1956 from the Division Engineer to Chief of Engineers the following was stated, *"The agreement to delete rather than defer project works in the Fisheating Creek area is in accordance with instructions given by Chief of Engineers representatives during conference on cost-sharing report held in Jacksonville District office August 14-15, 1956".*

L.3.5 Moore Haven-Newhall Area

Part II, Supplement 1, Design Memorandum, Moore Haven-Newhall Area, dated July 21, 1955 recommended the following changes. Control structures 47A and 47C be deleted from the authorized project works since their function could be carried out with minor changes made to structures 47B and 47D. The enlargement of Structures 47G and 47H (existing Lake Okeechobee culverts 5 and 5A) could not be economically justified. Canal 19A, Structure 47E, and secondary drainage also could not be economically justified and also were recommended for deletion from the authorized plan. The deletion of these structures was approved by the Chief of Engineers on February 7, 1956.

L.3.6 Lake Okeechobee

The original Comprehensive plan included modifications to raise the levee system (Herbert Hoover Dike) around Lake Okeechobee to permit conservation of additional water for use during dry periods and provide full protection during severe hurricanes. The plan also called for the construction of outlet works to move water to the rich agricultural areas to the south. Additional outlets were authorized by the *Flood Control Act of 1954*. Along with the 1948 authorization, they included most of the works necessary to afford flood protection to the rich agricultural development south of Lake Okeechobee and to the highly developed urban area along the lower east coast of the State. *Part IV Supplement 2 - Hydrology and Hydraulic Design, Section 7 - General Design Memorandum, Combinations of Hydrologic and Hydraulic Factors Affecting Height of Levees,* dated February 25, 1959, recommended the plan of improvement that provided for project works to maintain a conservation pool in Lake Okeechobee which varies seasonally from 15.5 to 17.5 ft, and that the Caloosahatchee River be enlarged to a regulatory capacity of 9,300 cfs. The plan included the following items in order of priority: (1) Construct levees on the northwest and northeast shores of Lake Okeechobee, (2) Raise existing levees, (3) Construct the primary canals and pumping stations to protect the area behind the existing north shore levees from increased flooding when the Lake levels are raised, (4) Increase the lake-regulation capacity of the Caloosahatchee River to 9,300 cfs, and (5) Stabilize the banks of the St. Lucie Canal to prevent erosion when releases are made. The Chief of Engineers approved the report on June 3, 1959 subject to the satisfaction of the Division Engineer's comments.

a. St. Lucie Canal. The Port Mayaca lock and spillway (S-308B & S-308C) were presented in *House Document 369 (90th Congress, 2d Session)*, and subsequently authorized by the *Flood Control Act of 1968* approved August 13, 1968 *(Public Law 90-483*). C&SF Report entitled *Part IV, Supplement 31 - General and Detail Design Memorandum, Port Mayaca Lock (S-308B) and Spillway (S-308C),* dated November 30, 1972, recommended the following change. The authorized plan contained in the *Water Resources Report* provided for these structures as one part of an overall scheme to raise the ultimate lake range to 19.5 to 21.5 ft. Studies had shown that with the interim lake range, the stability of St. Lucie Lock and Dam (located downstream) under hurricane tide conditions was questionable. The higher canal stages would also render numerous local structures inoperable. Modification of the St. Lucie Lock and Dam and local structures would be very costly and would not solve future water control or hurricane tide problems under the ultimate lake range. The proposed plan in the G&DDM called for the early construction of the Port Mayaca Lock and Spillway for the interim lake range (15.5 to 17.5 ft.). The proposed plan provided hurricane tide protection, permitted water control in the St. Lucie Canal and eliminated the expense of costly modifications to the existing structures. On October 23, 1973, Chief of Engineers gave approval to the recommended plan subject to the satisfaction of the comments of the Division Engineer and the Chief of Engineers. On November 30, 1973, all comments had been satisfied and final approval was received.

b. Northeast Shore Area. *Part IV, Supplement 21, General Design Memorandum - Lake Okeechobee Northeast Shore Area*, dated March 12, 1963, recommended the following additions to the works included in the Comprehensive Plan. Levees 62, 63, 64, and 65, Tieback levees at St. Lucie Canal, Lettuce Creek and Taylor Creek, Pumping Stations 133, 134, and 135 and Structures 152, 153, and 154 and three recreation areas. No items were recommended for deletion.

(1) Addendum 1. In a letter dated November 24, 1964, *Addendum 1 to Part IV, Supplement 21* was presented. The District proposed changes to the plan of improvement presented in the *General Design Memorandum*. The letter recommended the addition of the following project features: Canal 59, Levees 63(N) and 63(S), Control Structures 191 and 192, and Structure 193 (navigation lock at HGS 6). The following features were recommended for deletion from the approved plan: Levee 63, tieback levees at Taylor Creek and Lettuce Creek, Pumping Station 134, and Structure 152. In a letter dated February 1, 1965, the Chief of Engineers approved the changes subject to comments.

(2) Addendum 2. In a letter dated December 20, 1966, *Addendum 2 to Part IV, Supplement 21*, was presented. The plan of improvement presented in addendum 1 had been modified at the request of the local sponsor to better serve the areas involved. Specifically, the proposed plan provided for the realinement of the Taylor Creek diversion canal (L-63(N)), increased the capacity of that canal and Canal 59, modified structure 191, and added an additional pumping unit at Pump Station 133. The plan also called for the addition of S.A.L. Railroad bridge (B-142) to the recommended plan. These changes were approved on January 25, 1967 by Chief of Engineers.

(3) *Addendum 3*, dated February 12, 1969, revised the plan presented in addendum 2. These changes were brought about by the needs of both the interim Lake Okeechobee schedule (15.5 to 17.5 ft.) and the ultimate plan (19.5 to 21.5 ft.) and authorized by the survey-review report on *Water Resources for Central and Southern Florida (Flood Control Act of 1968*, adopted August 13, 1968 under *Public Law 90-483*). The new plan called for shifting unconstructed portions of the interceptor levees from the 20-foot contour to the 25-foot contour, and providing protective interceptor and tieback levee grades for ultimate lake levels. The plan also revised the design of structures 191 and 193 for higher lake stages, and Structure 192 was moved to the new junction of Levee 63(N) and Taylor Creek. No project features were added or deleted in addendum 3. On June 4, 1969, the Chief of Engineers gave his approval to the revised plan by letter.

(4) *Part IV, Supplement 27, Lake Okeechobee and Outlets - Detail Design Memorandum*, dated October 20, 1969, presented a plan of improvement that was basically the same as that presented in *Addendums 1, 2, and 3 to Part IV, Supplement 21*. There were some changes, the electric sump pump at Pumping Station 133 would be relocated to Control Structure 192, the addition of a gated culvert in L-62 at Popash Slough, and minor changes to the levee alinements, all of which were requested by local interests. The design memorandum and the requested changes were approved on December 12, 1969.

(5) *Part IV, Supplement 28, Lake Okeechobee and Outlets - Detail Design Memorandum Lock Structure 193*, dated June 5, 1967, proposed the following changes from the approved *General Design Memorandum*. The report recommended that the lock be outfitted with a sector gate in lieu of the vertical gate proposed in the GDM to provide unlimited vertical clearance. These changes were approved by the Chief of Engineers on June 27, 1968.

(6) During October 30 through November 2, 1979, a Florida Power and Light (FP&L) containment levee of a power plant cooling water reservoir failed. Approximately 80,700 acre-feet of water moved westward washing out the adjacent Florida East Coast Rail line and Levee 65. The water continued to flow north, west,

and south causing extensive flooding and damage to S-135 and S-153. These structures and L-65 were repaired following the preparation of a *Rehabilitation Report (under PL 84-99 authority).* In an August 1982 letter, the Jacksonville District gave permission to SFWMD to modify S-153 by splitting the lift gates in half so that the two top sections could be lifted while the bottom sections remained closed, or the sections could be operated in unison. With the segment gates unlatched, accidental, or possibly vandalic, drawdown of the water level in the L-65 Borrow Canal below the tops of the closed, bottom gate sections could not occur. This would decrease the possibility of jeopardizing the stability of the adjacent FP&L reservoir and avoid another potential failure.

c. Northwest Shore Area. *Part IV, Supplement 7, - General and Detailed Design Memorandum, Lake Okeechobee Northwest Shore Levees*, dated May 29, 1959, the following changes were made to the original authorized plan. The plan recommended the addition of Pumping Stations 127, 128, 129, 130, 131, and 132; and three interceptor dikes L-59, L-60, and L-61. No deletions from the authorized plan were recommended. These improvements were recommended based on the need to mitigate the effect on the northwest shore of raising the conservation level of Lake Okeechobee to provide irrigation water for lands south and east of the lake. On September 30, 1959, the Office of the Chief of Engineers (OCE) returned the design memorandum. OCE questioned the land values and method used to calculate the cost-benefit ratios. On November 10, 1959, the Jacksonville District responded to OCE comments and requested further guidance on how to proceed. In this letter, the District Engineer stated that the design memorandum was prepared on the assumption that the project was intended to prevent flood damages and to protect the lands of the area rather than to buy easements, flood the land, and remove it from production. The District also submitted further information on the land values in question using appraisals from both the Corps and the Flood Control District. The District Engineer stated *"that a decision on whether to build levees or to purchase easements involves policy and multiple considerations other than engineering and economics. If levees are the most tenable solution under the objectives of the flood control project, it would appear that little purpose would be served in revising the report except for the pending changes described in the latter part of paragraph 1, above. ... Consideration of the above remarks is requested, together with further advice as to policy and other pertinent matters."* A conference was held on November 24-25, 1959 to discuss the direction of the project. On December 4, 1959, the Chief of Engineers agreed to the changes and additions to the authorized plan as requested by the Jacksonville District subject to comments. In a letter dated February 17, 1960, the Central and Southern Florida Flood Control District presented a new alinement for Levee 48 as a solution to a dispute between the Florida Game and Fresh Water Fish Commission, which insisted on an upland alinement, and local landowners who favored a more lakeward alinement. On March 1, 1960, the District presented requested approval for this change from the Chief of Engineers. These changes were incorporated into *Part IV, Supplement 13, - Detailed Design Memorandum, Pumping Stations 127, 129, and 131* dated September 7, 1960.

(1) *Part IV, Supplement 13, Detailed Design Memorandum - Pumping Stations 127, 129, and 131*, dated September 7, 1960, presented the construction of 3 pumping stations in lieu of the 6 proposed in the *General Design Memorandum*. The three pumping stations were adopted because they provided a more economical solution to the problem. The report also recommended that the pumping stations be located on the landside of the lake levees with the pump discharge tubes installed through the levees. This change was made to protect the pumping stations from hurricane forces. These forces were not fully considered in the *General Design Memorandum*. In addition, the capacity of the pumping stations was increased to account for the increased drainage area caused by upland relocations of the interceptor levees. On December 27, 1960, the Chief of Engineers approved the recommended changes subject to satisfaction of OCE comments. On December 27, 1960, the District Engineer requested clarification of SAD comments concerning *"removal of gravity flow from the leveed area by operating the pumps"*. The Division Engineer contended that the pumps could be used as siphons and thereby eliminate the culverts. However further analysis done by the Jacksonville District showed that there was a need for gravity drainage at these pump sites in order to insure flood damage did not occur to the pumps prior to starting them. In a letter dated January 6, 1961 the Division Engineer responded that culverts could be added to the pump stations during the preparation of plans and specifications if they were economically justified. In a letter dated January 11, 1961, the District Engineer justified the culverts by the reduction of standby personnel, particularly during (a) the interim lake regulation period when possibilities of gravity drainage will exist almost yearly, and (b) the infrequent long-duration droughts which can be expected about once in 10 years and extend for as long as 18 months. During these periods, use of the pumps as siphons would not be a comparable alternative, as personnel must be available to prime the pumps. In a letter dated February 6, 1961, the Division Engineer recommended culverts be included in the plan.

d. <u>Caloosahatchee River (Canal 43)</u>. The *River and Harbor Act of July 3, 1930*, authorized improvement of the Caloosahatchee River and Canal (C-43) as recommended in the report published as *Senate Document 115 (71st Congress, 2d Session)*. Under the authority of the *River and Harbor Act of March 2, 1945*, the river was improved to provide a navigation channel eight feet deep and 90 feet wide.

(1) *Part IV, Supplement 6, Lake Okeechobee and Outlets - General Design Memorandum, Caloosahatchee River and Control Structures (Canal 43 and Lock and Spillway Structures 77, 78, 79)*, dated April 24, 1957 presented a plan of improvement that provided for the removal of runoff from a storm equal to 30-percent standard project flood, reduced the depth and duration of floods of greater magnitude than the 30-percent standard project flood and if feasible, permit discharge of 4,200 cfs from

Lake Okeechobee during periods when the canal capacity was not required for drainage of its tributary area. The report also recommended that secondary capacity of 9,300 cfs be provided at a later time. The limiting factor for the existing 4,200 cfs canal was the canal size above Ortona Lock. This approval of the report by the Chief of Engineers was withheld in the 2nd endorsement dated June 20, 1957. The Chief stated, *"It is believed that the discharge capacity of the Caloosahatchee River should be as large as it is practicable to provide from an engineering and economic standpoint, in order to provide flexibility of operation for regulation of Lake Okeechobee. This factor should be given further consideration and coordinated with the preliminary analyses made for the scheduled design memorandum, Section 7 of Part IV - Lake Okeechobee and Outlets, Supplement 2, 'Combination of Hydrologic and Hydraulic Factors Affecting the Height Of Levees.'"*.

Part IV Supplement 2 - Hydrology and Hydraulic Design, Section 7 - General Design Memorandum, Combinations of Hydrologic and Hydraulic Factors Affecting Height of Levees, dated February 25, 1959 and approved June 3, 1959, recommended the plan of improvement that provided for project works to maintain a conservation pool in Lake Okeechobee which varies seasonally from 15.5 to 17.5 ft, and that the Caloosahatchee River be enlarged to a regulatory capacity of 9,300 cfs. An addendum to *Part IV, Supplement 6* was prepared dated August 28, 1959, which revised the plan of improvement for Canal 43 to agree with *Part IV Supplement 2, Section 7*. The addendum included the plan for further improvements in the Caloosahatchee area between Moore Haven Lock at Lake Okeechobee and Ortona Lock. The revised plan increased from 4,200 to 9,300 cfs the regulatory discharge capacity from Lake Okeechobee when the Canal 43 capacity is not required for drainage of its tributary area. The addendum was approved on November 19, 1959 by the Chief of Engineers.

(2) *Part IV, Supplement 15, Lake Okeechobee and Outlets - Detail Design Memorandum, Canal 43 Section 2 (Caloosahatchee River),* dated August 4, 1961, requested the deletion of inlet structures previously recommended in *Part IV, Supplement 6*. On October 2, 1961, the Chief of Engineers approved these changes subject to the satisfaction of comments of the Division Engineer. On November 6, 1961, all comments had been addressed and approval of the deletions was finalized.

(3) *Part IV, Supplement 16, Lake Okeechobee Outlets - Detailed Design Memorandum, Structure 79, Lock and Spillway on Canal 43*, dated July 7, 1961, made the following changes to the approved *General Design Memorandum*: the lock size was changed to meet the Corps minimum of 56' X 400', the location was moved about one mile above the site proposed in the *GDM*, and the spillway crest was lowered. On October 4, 1961, OCE approved these changes subject to the satisfaction of comments. After several endorsements trying to resolve the comments, the plan of improvements was approved on November 21, 1961 by the Chief of Engineers.

(4) *Part IV, Supplement 20, Lake Okeechobee and Outlets, Detailed Design Memorandum, Structures 77 and 78 on Canal 43*, dated November 15, 1962, recommended the following departures from the approved *GDM*. Structure 77 was modified to obtain a more economical structure by changing to an open type structure with a service bridge rather than a culvert-type structure. The structure would have four 20-foot gate bays in lieu of the three 26-foot bays proposed in the *GDM*, and the apron elevation was raised from minus 4.5 to elevation 0.0. Structure 78 was changed from a rounded crest to a more efficient ogee crest spillway. The intake channel was deepened to reduce the water velocities at the structure. An upstream approach slab and additional downstream riprap were added to prevent erosion. On January 15, 1963, the recommendations were approved subject to the comments of the Division and Chief of Engineers. On March 1, 1963, the Chief of Engineers gave his final approval on the requested changes.

e. <u>South Shore Area</u>. The original Comprehensive plan included modifications to raise the levee system (Herbert Hoover Dike) around Lake Okeechobee to permit conservation of additional water for use during dry periods and provide full protection during severe hurricanes. However, modifications were needed for Hurricane Gate Structure (HGS) Numbers 3, 4, and 5 to operate as water control structures under higher lake levels. Stilling basins were needed for operations under the higher heads. The modifications were considered corrections to the Herbert Hoover Dike system and were considered a part of the 1948 Authorization. For the conversion of HGS-4 to spillway structure *Part IV, Supplement 33, General Design Memorandum - Spillway Structure 351 (HGS-4)*, dated June 29, 1984 was prepared. Approval for the modifications was received on November 27, 1984. For the conversion of HGS-5 to spillway structure *Part IV, Supplement 35 - General Design Memorandum, Spillway Structure 352 (HGS-5)*, dated August 20, 1985, was prepared. Approval for the modifications was received on October 9, 1985. For the conversion of HGS-3 to spillway structure *Part IV, Supplement 36, General Design Memorandum - Spillway Structure 354 (HGS-3)*, dated December 1986, was prepared. Approval for the modifications was received on August 28, 1987.

(1) Canals 21A, 21B, and 21C were authorized by the *Flood Control Act of 1948*. These canals were deleted from the project in *House Document 186 (85th Congress, 1st Session). House Document 186 (Appendix B, pg 40)* stated, *"C-21A, C-21B, C-21C: Lateral drainage canals leading to pumping stations on south shores of Lake Okeechobee. These canals are not compatible with Flood Control District's secondary drainage plan and are not required."* Local interests later requested that C-21A be reinstated to the project because of the increased stages in Lake Okeechobee, as recommended in the Water Resources Plan. Reinstatement of C-21A (Miami Stub Canal) as an authorized item in the Central and Southern Florida Project was approved by the Office of the Chief of Engineers October 17, 1968.

(2) *Part I, Supplement 46, General and Detail Design Memorandum - Pumping Station 236*, dated February 28, 1972, presented the hydraulic design and detail design criteria for the structure. Pumping Station 236 was designed to provide drainage to an area which discharged directly to the lake by a local pumping plant. The local pumping plant could not operate efficiently with the new authorized increase in the Lake Okeechobee regulation levels. The structure was designed to remove 3/4 inch per day plus 50 cfs seepage for its tributary area. Pumping Station 236 was provided to protect an agricultural area of about 10.2 square miles located just south of Lake Okeechobee in lieu of providing the authorized Canal 21A project feature. Alternative plans were considered and it was concluded that C-21A would be more costly than S-236 and the canal could cause adverse effects on the adjacent roadbed of U.S. Highway 27. C-21A was originally included in the 1948 authorization. It was subsequently deleted from the project because it was not compatible with the secondary drainage canals in the area. In 1968, local interests requested that C-21A be reinstated because of the increased stages in Lake Okeechobee as recommended in the Central and Southern Florida Water Resources Plan. C-21A was reinstated by the Chief of Engineers on August 9, 1968. The plan to build S-236 in lieu of C-21A was approved subject to the satisfaction of comments by the Chief of Engineers in a letter dated August 30, 1972.

(3) The Herbert Hoover Dike began as a project of the State of Florida with the construction of 47 miles of low levees in 1927. Work was again done on the levees around Lake Okeechobee when the Caloosahatchee River and Lake Okeechobee drainage areas project was adopted and authorized by the *River and Harbor Act of July 3, 1930*. This was later modified by the *River and Harbor Act of August 3, 1935* to provide for maintenance of all project works completed. Construction of the levees under the *River and Harbor Act of 1930* was started in 1931 along the south shore of the lake and by 1937, 69.2 miles of continuous levee along the west, south, and east shore of Lake Okeechobee was completed. In 1948, the levee works around the lake were included in the Comprehensive plan. In January 1961 the levee system around the lake was dedicated and renamed the Herbert Hoover Dike in honor of former President Herbert Hoover and the part he played in implementing the construction of these levees. The Herbert Hoover Dike was raised and improved from 1962 to 1967 as part of the 1948 plan. The *Flood Control Act of 1968 (Public Law 483, 90th Congress, 2d Session*) included further raising of the Lake Okeechobee regulation schedule and accordingly the Herbert Hoover Dike. A letter report was prepared August 29, 1975 recommending improvements to 60.3 miles of the dike. The letter report was approved December 12, 1975.

(a) *Addendum 1* was prepared in January 1980 recommending stone revetment for the portion of levee from Moore Haven to Port Mayaca, approximately 50 miles with the first priority given to a reach south of Port Mayaca around the Pahokee State Park. In March 1980, the *Addendum* was returned by the Division Engineer for resubmission. The Division Engineer contended that the report did not contain economic justification for the project and also required the testing of stone sources for the rock. A revised *Addendum 1 to the Letter Report* was prepared and sent on July 8, 1982. In August 1982 the report was approved by SAD and OCE subject to the satisfaction of comments. Final approval was received in October 1982. Subsequent reaches of the dike improvements have been submitted as addendums to the original letter report.

(b) *Addendum 7 to the Letter Report* was dated November 29, 1989. On July 12, 1990, the report was returned from SAD, stating that the costs were too high for slope protection and continued efforts in this direction should be terminated. Any future work required to restore eroded sections of the dike will need to be incorporated into the maintenance program. When work on the Herbert Hoover Dike was terminated, six construction contracts had been completed totaling 24.3 miles of the 72.6 miles of levee that had been scheduled for slope protection.

L.3.7 Everglades Agricultural Area (EAA)

a. Nine-Mile Canal. *Part I, Agricultural and Conservation Areas, Supplement 39 - General Design Memorandum, Nine-Mile Canal Area, (C-20, C-21, L-D1 Borrow Canal, S-4, S-47, S-169, S-170, Railroad Bridges, Etc.)*, dated March 29, 1963, recommended additions to the Comprehensive Plan. The items added were connections of the Levee D1 borrow pits, extension of Canal 21 to join Industrial Canal, including two railroad bridges (B-136 and B-137), S-169, a 2-barrel gated culvert in C-21, S-170, a 2-barrel gated culvert in Industrial Canal, and railroad bridge B-135 over Canal 20. No items were recommended for deletion. These additions were approved by the Chief of Engineers on August 5, 1963. On June 6, 1969, *Part I, Supplement 45, Agricultural and Conservation Areas, Detail Design Memorandum Canal 21 and Control Structure 169* recommended several changes to the plan presented in the previous report. The alinement of C-21 was changed resulting in reduced costs. Structure 169 was modified to include a third 72-inch barrel. The report further recommended that the alinement of Canal 20 be studied further and that Structure 170 be retained in the authorized plan although the need for it would depend on the Canal 20 studies. The recommendation was made to delete railroad bridges B-136 and B-137. On November 22, 1971 a Letter Report entitled *Nine Mile Canal Area (Part)* presented a modified plan for C-21 and S-169, and the design criteria for C-20 (Section 1) which was necessary for C-21 to be effective, and design criteria for L-D1 and L-D3 Connecting Canal and S-235. During the studies for C-20 it became apparent that it was impractical to drain about 28-1/2 square miles of the S-4 area to the pump. However, the construction of S-4 was about 50% complete and it was not economical to alter S-4, therefore S-4 has an excess capacity of about 570 cfs. The report recommended that S-169 and C-21 should be enlarged to pass an additional 570 cfs (equal to the excess capacity of S-4), and as a result of deleting the 28-1/2 square mile area from the C-20 basin, that S-233 and S-47 be deleted from the project. Furthermore the report recommended that a portion of C-20 be constructed to connect the existing drainage outlet of the Sugarland Drainage District and C-21 and

Pumping Station 4. This section of C-20 was needed, regardless of the final design of C-20. The L-D1 and L-D3 Connecting Canal and Structure 235 were recommended in *Part I, Supplement 47 - Detail Design Memorandum, Canal 20, Levees D1 and D3 Connecting Canal, and Control Structures 47, 233, 234, and 235,* but this report had not been approved due to differences with the local sponsor over C-20. Therefore these features were included in the letter report also. In a letter dated June 6, 1972, the Division Engineer approved the construction of the L-D1 and L-D3 Connecting Canal and S-235 because they were considered necessary for operational flexibility. However the modification of C-21, S-169 and the remaining work were not approved since the plan presented did not demonstrate that it was the most economical plan and that it would be more economical to provide Pumping Station 236 than the alternative plan to utilize excess capacity at Pumping Station 4. Therefore C-21 and S-169 were approved as designed in *Part I, Supplement 45*. In a memorandum, which followed the letter report dated August 15, 1972, S-169 was changed during the preparation of plans and specifications to three 84-inch barrels.

(1) In December 1970, C&SF report entitled *Part I, Agricultural and Conservation Areas, Supplement 47 - Detail Design Memorandum, Canal 20, Levees D1 and D3 Connecting Canal, and Control Structures 47, 233, 234, and 235* made the following changes to the authorized plan. The L-D1 and D3 Connector Canal and Structures 233, 234, and 235 were additions to the plan and considered refinements. This plan was later withdrawn from consideration due to differences with the local sponsor. In June 1972, C&SF report entitled *Part I, Agricultural and Conservation Areas, Supplement 47 - Revised Detail Design Memorandum Canal 20* revised the previously presented plan. The plan presented a shorter, refined plan for Canal 20 and included a gated culvert in Canal 21. It also recommended that Structure 47 be eliminated from the project as it was no longer a part of the proposed plan for C-20. Control Structure 233, previously located upstream of the intersection of C-20 and C-21 was eliminated at the request of the local sponsor and not included in the *Revised Detail Design Memorandum*. These changes were approved by the Division Engineer on March 14, 1973 in the 3rd Indorsement to the report.

b. Agricultural Canals. Four major agricultural canals (West Palm Beach, Hillsboro, North New River and Miami) were dug by the State of Florida for drainage of lands, principally into Lake Okeechobee, and to provide a source of water for agricultural use. It was originally thought that the canals would drain water from Lake Okeechobee and discharge into the Atlantic Ocean. However because of the small hydraulic slope and insufficient cross section, the four canals were not effective in removing water from the lake during flood periods. The comprehensive plan provided for the construction of canals and pump stations to serve the agricultural area. However, Congress authorized only the first phase of the plan which provided the principal water-control structures to serve a small area. In the reports following, several changes were made to the authorized plan to better serve the agricultural area.

(1) *Part I, Supplement 8, Agricultural and Conservation Areas - Design Memorandum, Development of Plan of Protection for Agricultural Area,* dated February 6, 1953, recommended that Levees 10 and 12 (West Palm Beach Canal), 14 and 15 (Hillsboro Canal), and Levees 19 and 20 (North New River Canal) be constructed to the size required to remove 3/4 inch of run-off a day from the tributary area. It also recommended Levees 17, 22, 26, and the western portions of levee 24 and 15 be constructed to a height and cross-section required to serve as a main encircling levee for the agricultural area. Pumping stations S-2, S-3, S-5A, and S-6 were recommended to be constructed to their authorized capacity and Pumping Station 1 was recommended to be deleted from the project. In a letter dated July 20, 1953, these changes were approved by the Chief of Engineers subject to satisfaction of comments.

(2) *Part I, Supplement 18, Agricultural and Conservation Areas, - Design Memorandum, Revision of Hydrology and Hydraulic Design of West Palm Beach, Hillsboro, North New River, and Miami Canals,* dated November 16, 1953, proposed the improvement of these canals be carried out in two stages.

<u>First-stage development</u> provided water control for their tributary areas. A small capacity for regulatory discharge from Lake Okeechobee would be provided. Providing water control would involve (1) removing excess rainfall; (2) supplying irrigation water; (3) protecting lands adjacent to the canal from overflow by canal stages; and (4) maintaining optimum water elevations insofar as possible. Design of the levees and canals was based on satisfying the first three criteria.

<u>Second-stage development</u> for North New River and Miami Canals is identical to that for the first-stage development. In addition to water control provided by first-stage development for West Palm Beach and Hillsboro Canals, second-stage development would provide diversion capacities from Lake Okeechobee equivalent to capacities of pump stations at the conservation area ends of those two canals. This was approved by the Office of the Chief of Engineers on January 7, 1954. In a letter dated February 19, 1954, the Jacksonville District requested that *"this office be authorized to advise the Flood Control District that plan 3 [first-stage development] will be constructed first and that plan 4 [second-stage development] will be constructed only if and when it has been established that there is a definite need for it."* Economic analysis showed that plan 4 would be more expensive than increasing the capacity of the St. Lucie Canal. In a letter dated April 27, 1954, the Chief of Engineers approved the *"first-stage construction of the West Palm Beach and Hillsboro Canals will conform with Plan 3 and modification to conform with Plan 4 will not be undertaken until required for project purposes and economically justified".* The project was later justified in the 1968 report entitled *"Water Resources for Central and Southern Florida".* Finally, in C&SF report dated March 1978, entitled, *Part I, Supplement 51, Agricultural and Conservation Areas - General and Detail Design*

Memorandum, L-18 & L-19 (North New River Canal) and L-24 & L-25 (Miami Canal) - Hump Removal, approved the removal of humps from the bottom of the North New River and Miami Canal and eliminated the need for the authorized deepening of the St. Lucie Canal for greater flood discharge capacity. On October 29, 1979, the report was approved.

(3) *Part I, Supplement 19, Agricultural and Conservation Areas, Design Memorandum, North New River Canal*, dated December 1, 1953 requested that Levees 20 and 19 of the North New River Canal be enlarged to provide adequate capacity for water control for the highly developed farm lands along its banks and the development of other lands with high capabilities within its tributary area for the entire length of the canal and that improvement of the unauthorized portion of the canal (Levee and Canal 18) be deferred pending authorization of the greater encirclement plan of improvement. The plan provided for the capacity of the canal to be adequate to provide 4.3 cfs a square mile of irrigation water from the lake for the entire Miami Canal drainage area and 3/4 inches a day (20 cfs a square mile) of agricultural drainage from the same area. The Chief of Engineers approved this recommendation in a letter dated March 8, 1954.

(4) *Part IV Supplement 2 - Hydrology and Hydraulic Design, Section 7 -General Design Memorandum, Combinations of Hydrologic and Hydraulic Factors Affecting Height of Levees*, dated February 25, 1959, recommended the plan of improvement that provided for project works to maintain a conservation pool in Lake Okeechobee which varies seasonally from 15.5 to 17.5 ft, and that the Caloosahatchee River be enlarged to a regulatory capacity of 9,300 cfs. The plan included using the existing capacity of 3/4 inches a day for the determining the capacity of primary canals and pumping stations. The Chief of Engineers approved the report on June 3, 1959 subject to the satisfaction of the Division Engineer's comments.

(5) A letter dated August 21, 1961 from the Central and Southern Florida Flood Control District requested the construction of water control structures near the mid-points of the Miami and North New River Canals. After the completion of design studies the District Engineer recommended that control structures be built on these canals as part of the authorized project. This recommendation was made by letter dated May 22, 1963. The letter specifically recommended the construction of sheet pile stoplog structures in North New River (S-2A) and Miami (S-3A) Canals, with the cost sharing as specified in the 1954 authorization. In the 2nd Indorsement from the Chief of Engineers dated December 24, 1963, these project features were approved except that cost sharing was based on the 1948 Authorization. The structures were redesigned several times in the following years. Finally, in C&SF report dated March 1978, entitled, *Part I, Supplement 51, Agricultural and Conservation Areas - General and Detail Design Memorandum, L-18 & L-19 (North New River Canal) and L-24 & L-25 (Miami Canal) - Hump Removal*, recommended that structures 2A and 3A be

deleted from the project as they were no longer desired by the local sponsor. On October 29, 1979, the report was approved.

(6) *Part I, Supplement 20, Agricultural and Conservation Areas, Design Memorandum - Miami Canal*, dated February 5, 1954, requested that Levees 24 and 25 of the upper Miami Canal be enlarged for the entire length of the canal and that improvement of the unauthorized portion of the canal (Levee and Canal 23) be deferred pending authorization of the greater encirclement plan of improvement. The enlargement was based on satisfying agricultural and drainage requirements. The capacity of the canal would be adequate to provide 4.3 cfs per square mile of irrigation water from the lake for the entire Miami Canal drainage area and 3/4 inches per day (20 cfs a square mile) of agricultural drainage from the same area. The Chief of Engineers approved this recommendation in a letter dated April 5, 1954.

L.3.8 Water Conservation Areas - General

The plan of improvement for the Water Conservation Areas was recommended in the 1948 Authorization with subsequent modifications recommended in the 1954 Authorization. The functions of the conservation areas were considered to be (1) to act as a depository for excess water from the agricultural areas; (2) to provide the levees needed to prevent Everglades floodwaters from inundating the east coast; (3) to aid in recharging underground freshwater reservoirs; (4) to provide a water supply for east coast agricultural lands; (5) to benefit fish and wildlife in the Everglades; and (6) to release excess water to Everglades National Park and water from storage to assist in restoring and maintaining natural conditions by reducing damage from drought and fire.

a. Water Conservation Area 1. The original plan envisioned a series of levee-encircled pools for the conservation of floodwaters. Levee 39, along Hillsboro Canal, would separate Water Conservation Areas 1 and 2. Spillway 10, located in the eastern portion of Levee 39, would serve as an outlet for the passage of floodwaters from Water Conservation Area 1 to Water Conservation Area 2. Inflow to Water Conservation Area 1 would be contributed by: (1) Levee 8 area north of Water Conservation Area 1, (2) rainfall over Water Conservation Area 1, and (3) pumped inflow at the rate of 1/2 inch a day from the area served by Pumping Stations 5 and 6 on West Palm Beach and Hillsboro Canals respectively. S-10 would consist of four 100-foot spillway units with a crest elevation of 11.5 feet.

(1) *Partial Definite Project Report, Part I (basic report) Agricultural and Conservation Areas (With Preliminary Information on Lake Okeechobee and Principal Outlets)*, dated July 10, 1951. In this report inflow to Water Conservation Area 1 was changed as a result of studies made for Part I (basic report), which increased the pump capacity to 3/4-inch daily removal. The studies also included a maximum conservation stage in Water Conservation Area 1 at elevation 17.0 ft. after considering the storage required and flooding elevations in the Levee 8 area. The report

contemplated that Levee 39 would be constructed to a grade providing a 3-foot freeboard allowance above the standard project pool elevation. It was expected that the levee would be overtopped during hurricanes. However, since the levee separated two conservation areas, danger to life and private property from overtopping by wind tides and waves was not expected. The plan for the agricultural areas proposed the elimination of Pumping Stations 1 and 2 at the lake end of West Palm Beach and Hillsboro Canals. (That proposal was not approved by higher authority.) The capacities of Pumping Stations 5A and 6, at the conservation area ends of the canals, were increased to serve the entire drainage areas tributary to the respective canals. Pumping Station 5A would discharge into Water Conservation Area 1 and Pumping Station 6 would discharge into Water Conservation Area 1 when the stage was below the conservation stage of 17.0 ft; at other times the discharge would be into Water Conservation Area 2. The stations would pump lake-regulation releases from Lake Okeechobee when the need existed and canal and pump capacity was available.

(2) *Partial Definite Project Report, Part IV, Section I - Modified First Phase Plan*, dated March 26, 1952. To protect the existing agricultural development along the southerly shores of Lake Okeechobee during the construction program in that area, the Modified First Phase Plan proposed that the lake pumping stations be constructed to full capacity based on 3/4-inch daily removal rate. Since Pumping Station 2 would remove agricultural drainage from a portion of the Hillsboro Canal drainage area, Pumping Station 6 capacity was decreased.

(3) Plan Selected at Conference of August 29, 1952. At the conference held at the Jacksonville District Office, August 29, 1952, attended by representatives of the Office of the Chief of Engineers, South Atlantic Division, and Jacksonville District, the conclusion was reached that Pumping Station 6 should be constructed to a capacity required to remove 3/4-inch of runoff a day from the drainage area within the 1948 authorized encirclement.

(4) *Partial Definite Project Report, Part I, Supplement 8 - Design Memorandum, Development of Plan of Protection for Agricultural Area,* dated February 6, 1953. This plan proposed that Pumping Stations 5A and 6 be constructed to full capacities based on the requirement to remove 3/4-inch of runoff a day from the drainage area with the larger encirclement included in the 1954 authorization.

(5) *Partial Definite Project Report, Part IV, Section 4 - Modified First Phase Plan, 1953*, dated February 20, 1953. This report proposed the deletion of Pumping Station 1 from the authorized project. Pumping Station 5A would be built to transfer all runoff from the West Palm Beach Canal agricultural area southward to Water Conservation Area 1 to effect greater benefits and to make the water available to east coast interests. The canal and Pumping Station 5A would also be used to transfer water from Lake Okeechobee to the conservation area when such transfer was

desirable and when their full capacities were not needed for drainage of the agricultural area.

(6) *Partial Definite Project Report, Part I, Supplement 9 - Design Memorandum, Hydrology and Hydraulic Design of Hillsboro Canal and Related Works (L-14, L-15, S-2 and S-6)*, dated June 8, 1953. These studies made in connection with the hydraulic design of Pumping Station 6 and Hillsboro Canal indicated that Pumping Station 6 should discharge into Water Conservation Area 1 at all times and that additional spillway capacity should be provided through Levee 39.

(7) *Part I, Supplement 25 - General Design Memorandum, Plan of Regulation for Conservation Area 1*, dated November 29, 1957. Subsequent to submission of the design memorandum for Levee 39 and Spillway 10, the general design memorandum covering the plan of regulation of Water Conservation Area 1 had been approved as a basis for the more detailed design of an interim plan for construction of Structure 10 and Levees 39, 40, and 7. The decision as to whether raises in grades for Levees 7 and 40 would be necessary was deferred for future consideration. In accordance with the request from the Chief of Engineers, *Part I, Supplement 23, Design Memorandum, Levee 39, Spillway 10, and Interim Modifications to Levees 7 and 40* was revised and resubmitted July 16, 1958. The new plan of improvement for Water Conservation Area 1 would provide for seasonal regulation between elevations 14 and 17 ft., levees, and 3 spillway units capable of performing the following functions: (1) Store seasonal floodwaters for use during dry periods; (2) provide a reasonable degree of erosion resistance against wind tides and wave action caused by hurricanes; and (3) provide adequate spillway capacity to prevent flood crests from exceeding elevation 17.3 ft. This report was approved on July 23, 1958 by the Chief of Engineers.

(8) *Part I, Supplement 23 (Revised), Design Memorandum, Levee 39, Spillway 10, and Interim Modifications to Levees 7 and 40, resubmitted July 16, 1958*. This report superseded *Part I, Supplement* 23 dated June 20, 1955. The plan of improvement recommended in the revised report proposed Levee 39 and S-10, three spillway units capable of performing the following functions: (1) Store floodwaters within Water Conservation Area 1 up to elevation 17.3 ft. under standard project flood conditions; (2) withstand normal steady wind-produced wind tides and waves and provide a reasonable degree of erosion resistance against overtopping and wave action caused by hurricane forces; and (3) provide adequate spillway capacity to prevent the peak ponding stage from exceeding elevation 17.3 ft. in Water Conservation Area 1. This plan was approved by the Chief of Engineers on April 8, 1959.

(9) *Part I, Supplement 31 - Detail Design Memorandum, Levees 35B and 38 (Section 3), Spoil Islands - Levees 35B and 38 (Section 2), and Control Structure 38,* dated October 13, 1959 presented several changes to the approved plan contained in the *General Design Memorandum (Part I, Supplement 27)*. These changes were: (1) relocating Levee 38 (Section 3) approximately 100 feet west to allow for future

expansion of U.S. Highway 27; (2) the L-35B berm was reduced from 40 ft. to 30 ft. in order to reduce excavation quantities; (3) the side slopes of the L-35B borrow canal were steepened to 1 vertical on 1 horizontal; (4) the gated culvert in the North New River Canal through L-35B was reduced from 4-72 inch barrels to 2-72 inch barrels since irrigation discharges for the east coast in excess of the capacity of S-34 would not be required; and (5) the structure in L-38E was changed from a gated 2-72 inch pipe culvert to a steel sheet pile spillway. These changes were approved subject to the satisfaction of the Division Engineer's comments on November 24, 1959 by the Chief of Engineers. The Division Engineer gave his final approval on January 13, 1960.

b. Water Conservation Area 2. The plan of improvement for Water Conservation Area 2 was presented in the *Partial Definite Project Report, Part I (basic report) Agricultural and Water Conservation Areas (With Preliminary Information on Lake Okeechobee and Principal Outlets)*, dated July 10, 1951. Water Conservation Area 2 was authorized as an area where excess water could be stored to supply irrigation needs in developed areas south and east of the pool and as floodway to allow excess water to be released into Water Conservation Area 3.

(1) *Part I, Supplement 27 - General Design Memorandum, Plan of Regulation for Conservation Area 2*, dated February 28, 1958 recommended the following changes to the previously authorized plans of improvement. The modifications included that no change to the existing grades of Levees 6, 35, 35A, and 36, except that a portion of the landward side of Levee 36 be changed from 1 on 2 to 1 on 3 for greater stability, that interior Levee 35B with culverts be constructed from S-11A to Levee 36; the reach of L-38 east of the highway between S-34 and S-11A be constructed on the existing spoil bank elevation and that two 72-inch gated culverts be placed in the levee to allow regulation of pool 2B; the reach of L-38 east of the highway between S-11C and S-7 be constructed to a grade varying from 18 ft. at S-11C to 19 ft. at S-7; that US Highway 27 between S-11A and S-11C be raised to elevation 17.5 ft; the reach of L-38 west of the highway between L-37 and S-11A be constructed to elevation 17 and that two 72-inch gated culverts be placed in the levee so that irrigation releases could be made from Water Conservation Area 3 when desired; the reach of L-38 west of the highway between S-11C and S-7 be constructed to elevation 16.7 and two 72-inch gated culverts be placed in the levee, however, construction of the levee would be deferred; S-38 be constructed in L-36 near Canal 14; and a provision be retained in the cost estimates for deferred construction of additional facilities which may be required if marsh vegetation does not prevent wind tides and waves from attacking the levees. The recommendations also requested the deletion of Structure 35 since it would not be needed under the recommended plan. This plan was approved by the Chief of Engineers on April 16, 1959.

(2) *Part I, Supplement 21 - Design Memorandum, Agricultural Area Levees, Levees 4 (East), 5, and 6* dated November 1, 1954. This report recommended the following changes to the approved plan. First, the crown width of L-5 was increased to

15 ft. to permit access to Pumping Station 8 at Miami Canal from U.S. Highway 27. Secondly, it recommended that construction of these levees should be undertaken in two stages, with construction of the first stage to intermediate grades established in the interim report and completion to final grades in the second stage when pumping stations 7 and 8 are constructed and the lower agricultural area is developed. If backflow up the North New River and Miami Canals were controlled, the intermediate grade levees would prevent floodwaters in Water Conservation Area Nos. 2 and 3 from flowing into the agricultural area and would permit orderly development of the area within the encirclement. Damages that might result from overtopping of levees by waves and wind tide would not be extensive until such time as pumping stations 7 and 8 were constructed and the outer agricultural area developed. If construction of pumping stations and canals in the outer encirclement was delayed and the area remained undeveloped, considerable savings in annual charges on the greater costs of higher levees could be realized during the period of development of the area. Reduction in the final grade may possibly be achieved by more detailed study and analysis. A levee grade of 4 feet above average ground elevation was adopted as a minimum intermediate grade. The plan was approved by the Chief of Engineers in a letter dated March 3, 1955, however the use of excavated peat material in the base of the levee was not approved. The Chief of Engineers also left the final approval with the Division Engineer. In the 4th indorsement dated June 30, 1955, the Jacksonville District revised the levee design and the excavated peat was mixed with rock to provide a suitable base material. This was approved by the Division Engineer on August 9, 1955.

(3) *Part I, Supplement 42 - Detail Design Memorandum, Levee 38 (West), Section 1*, dated February 11, 1965 presented a plan very similar to the plan proposed in Part I, Supplement 27, except for the following deviations: (1) the levee had been relocated 350 ft. from the centerline of U.S. Highway 27 to allow for widening of the highway; and (2) the two 72-inch gated culverts located under the levee was reduced to a single gated culvert since studies indicated that seepage would be greater than first thought. These changes were approved by the Division Engineer in a letter dated March 23, 1965.

c. <u>Water Conservation Area 3</u>. The project document (*House Document 643*) provided for encircling Water Conservation Area 3 with levees so that floodwaters from adjacent areas could be put into the area and stored for beneficial uses or released into Everglades National Park. Pumping Stations 8 and 9 were to discharge into the pool from adjacent agricultural areas and Pumping Station 7 was to discharge into either Area 2 or Area 3, depending on relative water levels. A gated spillway (S-11) was to release water into Area 3 from Area 2, and another gated spillway (S-12) was to discharge water from Area 3 into the undeveloped Everglades south of Tamiami Trail. A structure (S-31) in the eastern levee at Miami Canal was to allow irrigation releases and discharges for control of salt-water intrusion. The levees along the east coast (Levees 30, 33, and 37), the gated spillways (Structures 11 and 12), Pumping Station 9, and Structure 31 were included in the 1948 authorization. The remaining Water Conservation Area 3 works were authorized in 1954.

(1) Subsequent to approval of the Comprehensive Plan, several minor changes were approved. The location of Levees 4 and 5 and Pumping Station 8 was moved about 3 miles south to the Palm Beach-Broward County line. The alinement for Levee 28 was moved from 1 to 4 miles east of the original alinement along the Collier County line to minimize construction costs through the cypress heads. This excluded a portion of the lands in the State Seminole Indian Reservation from the conservation area. The location of Spillway 12 (A-D) was moved from the vicinity of L-30 to the western end of the area so as to discharge directly into Everglades National Park. Pumping Station 7 was designed to discharge only into Water Conservation Area 2.

(2) *Part I, Supplement 33 - General Design Memorandum, Conservation Area 3*, dated June 22, 1960. The plan of improvement presented the facilities needed to regulate water levels in Water Conservation Area 3 during a standard project flood and prevent water in the Everglades from aggravating flood problems on adjacent lands. The plan added the following project features to the authorized plan: Levee 67, Levee 67 Extension, Levee 68, Levee 28 Extension, Structure 12E, Structure 24B, Structure 150, and Structure 151. In the second indorsement, dated August 25, 1960 the Chief of Engineers approved all the recommended additions to the project except the approval of L-67 Ext. and L-28 Ext. was deferred until further studies for the survey report on Southwest Dade County were completed and until planning and cooperative arrangements were further coordinated with the Park Service. The report was approved by the Chief of Engineers on January 13, 1961.

(3) On August 15, 1960 the District Engineer forwarded minutes of a conference held August 4-5, 1960 along with the views of the National Park Service on the proposed plan of improvement. The letter also recommended the deletion of S-147 (a pump station) from the L-28 plan; however, the Chief of Engineers on September 13, 1960, elected to put S-147 in deferred status rather than delete the structure.

(4) On December 6, 1960, the District Engineer requested guidance on building a berm for wildlife enhancement along L-67A. The Florida Game and Fresh Water Fish Commission had recommended this provision in their comments and had the backing of the Flood Control District. In a letter dated December 12, 1960, the Division Engineer stated that additional Congressional authority would be required to permit construction of the berm with project funds, however, the Division Engineer requested comments from the Chief of Engineers. In a subsequent letter dated December 30, 1960, the Chief of Engineers disagreed with the Division Engineer. The Chief stated that the *Fish and Wildlife Coordination Act* applied to any segment of the C&SF project that was less than 60 percent complete as of August 12, 1958. Therefore the proposed modification for mitigation of potential damages to wildlife could be made under the authority of the *Fish and Wildlife Coordination Act* if justified, and no

additional Congressional authority was required. However, the Chief stated that the information provided was insufficient to evaluate the merits of the proposed berm. In a letter dated January 19, 1961, the District Engineer withdrew his proposal for adding a berm to L-67A due to the cost and construction difficulties. Instead of providing a berm for the deer, the proposed modification was to provide a 12-inch peat layer above elevation 11.0 ft. and along the crown of the levee to support a lush growth of grass. This grass would be suitable for deer grazing. In a letter dated February 7, 1961, the Division Engineer gave his approval to this modification.

(5) *Part I, Supplement 30 - General Design Memorandum, Levee 28 (Section 2) and Related Works*, dated September 15, 1959, proposed the following changes to the project. Under the recommended plan of improvement, the following additions to the authorized project were required. Pumping Stations 139 and 140; a diffusion canal from Levee 4(W) borrow canal to Water Conservation Area 3; inlet structures at points of local inflow; enlargement of Levee 3 tieback and Levee 4(W) borrow canals; and two new canals (Big Cypress Canal and Levee 28 (Section 2) borrow canal). Structure 16 would not be needed and was recommended for deletion from the project. In a letter dated October 1, 1959 the Division Engineer returned the design memorandum for revision. The Division Engineer contended that Pump Station 140 would be one of the largest pumping stations in the world. The pump station had a very high initial cost, very high maintenance and depreciation cost and was considered not a good engineering or economic solution to the drainage problem of the area. The Division Engineer recommended that a gravity canal beginning near the upper end of Big Cypress Canal and running to the vicinity of S-140 be investigated. The other recommendations included an alternate alinement to L-28 (Section 2) that would provide storage for the drainage area, the deletion of Big Cypress Canal and pump station 139 and sizing pump station 140 to handle a larger drainage area. In a letter dated October 20, 1959, the District Engineer addressed the Division Engineer's concerns on the plan of improvement. The District Engineer recognized the need for more detailed studies to improve the details of the plan, however there was a need to expedite a solution. The District Engineer stated that the provision of a gravity canal from the upper end of Big Cypress Canal to the vicinity of Pumping Station 140 would not serve an area which had formerly been provided with drainage into Big Cypress Canal; that moving the alinement of L-28 would provide additional storage however at the expense of the conservation area; and the deletion of Pumping Station 139 and enlarging the capacity of pumping station 140 could not be economically justified unless the effect of the rearrangement of pumping station inflows on the design of secondary facilities were considered. Insofar as the plan of improvement recommended, it was possible that additional studies would refine some details, but it did not appear that a material change in the recommendations would be found feasible or reduce the overall costs. A conference was held on November 24, 1959 with representatives of SAD, OCE, and the Jacksonville District in attendance. In a follow-up letter from the Division Engineer to the Chief of Engineers the approval to extend L-28 approximately five miles was given. The Division Engineer also requested that

further investigations into the alinement and grades for the balance of L-28; the economics of reducing pumping capacities by utilizing a ponding area; and the magnitude of the problem for conveying and utilizing water south of L-29 be submitted in future design memorandums.

(a) Addendum 1. On May 24, 1960 the District Engineer submitted *Addendum 1, to Part I, Supplement 30. Addendum 1* was concerned with the drainage problem in the area west of L-28. The plan recommended in addendum 1 would remove runoff from the 1-in-10 year storm without appreciable damages. Approval of the plan would add the following works to the project: Interceptor canal; Big Cypress Canal; enlargement of Levee 4(W) borrow canal and Levee 3 tieback borrow canal; Pumping stations 139, 140 and 147; culverts in L-28; and inlet structures along L-28 borrow canal. Pumping station 147 construction would be deferred until warranted by increased land use in the area it would serve. Structures 16 and 17 would be deleted and structure 14 would remain in the plan of improvement. In a letter from the Division Engineer to the Chief of Engineers, dated June 21, 1960, this plan was recommended for approval. However, the Chief of Engineers stated in a letter dated August 31, 1960 that no action would be taken on this plan until the views of the Flood Control District were furnished.

(b) *Addendum 2.* In a letter dated June 13, 1961 the District Engineer presented a new plan in *Addendum 2* which incorporated the views of the Flood Control District. This addendum provided a single pumping station (S-140) for the northerly portion of the area under consideration in lieu of two pumping stations (S-139 and S-140); extended the interceptor canal to the northern and western extremities of the Seminole Indian Reservation to provide an outlet for excess water; placed the southern pumping station (S-147) in deferred-construction status; and left an 11-mile gap in L-28 immediately south of the interceptor canal with filling the gap in deferred status until the development of eastern Collier County. Additions to the authorized project were Pumping Stations 140 and 147; the interceptor canal, including two feeder canals, each with a headwater control structure; two culverts in L-28 south of the interceptor canal; Levee 3 tieback borrow canal enlargement; and the necessary lateral inflow culverts along the two feeder canals along the upper reaches of L-28 borrow canal, and along L-3 tieback borrow canal. The plan also recommended the deletion of Structures 16 and 17. *Addendum 2 to Part I, Supplement 30* was approved by the Chief of Engineers on August 28, 1961.

(6) *Part I, Supplement 32 - Detail Design Memorandum, Levee 28, Sections 2, 3, and 5* dated March 2, 1962 recommended that the previously approved Section 5 be modified to tieback to higher ground. This was necessary due to placing Section 4 in a deferred status. The tieback would block any discharge from Water Conservation Area 3 through the gap and would eliminate the possibility that water would be discharged south along the west side of Levee 28. The addition of the tieback levee was approved in a letter from the Chief of Engineers on April 11, 1962.

(7) *Part I, Supplement 37 - Detail Design Memorandum, Structures 24B, 31, and 150 (Conservation Area 3)* dated April 27, 1962 presented the same basic plan as was proposed in *Part I, Supplement 33*. However, Structure 31 was changed from a concrete box culvert to a 3-barrel, 84-inch corrugated metal-pipe culvert, and Structure 150 was changed from a concrete box culvert to a 5-barrel, 84-inch corrugated metal-pipe culvert. In addition the concrete headwalls for all three structures were eliminated and the operating platforms were changed from concrete to timber. These changes were made to arrive at the most economical structures. These changes were approved by the Chief of Engineers on June 8, 1962.

L.3.9 East Coast Canals

Following completion of that initial survey-review report, the *Flood Control Act of 1948* authorized Phase 1 of the C&SF Project. Phase 1 consisted of most of the works necessary to afford flood protection to the rich agricultural development south of Lake Okeechobee and to the highly developed urban area along the lower east coast of Florida. This authorization included a section entitled "Planning for subsequent phases." The *Flood Control Act of 1950* authorized further appropriations for Phase 1. The *Flood Control Act of 1954* authorized Phase 2 of the C&SF Project, that is, the remaining works presented in the Comprehensive Report. The *Flood Control Act of 1958* approved the cost-sharing report (*House Document 186, 85th Congress, 1st Session*) for those portions of the C&SF Project which were approved in the 1954 Act, but did not change local cooperation requirements imposed by the 1948 Act. Authorizations in 1962 and 1968 included further funding, modifications and extensions to the East Coast Canals portion of the C&SF Project.

a. St. Lucie and Martin Counties.

(1) *Part III, Supplement 1, General Design Memorandum - St. Lucie County Canals and Control Structures (Canals 23, 23A, 24 and 25, and Control Structures 48, 49, 50, 97, 98, and 99)*, dated January 23, 1957, presented the results of hydrologic and hydraulic investigations for development of the plan of improvement for the St. Lucie County canals. S-97, S-98, and S-99 were added to the C&SF Project by the Office of the Chief of Engineers by letter dated January 8, 1958. *Part III, Supplement 4, Detail Design Memorandum - Canal 25 (Belcher Canal), and Control Structures 50, 98, and 99*, dated December 10, 1959, presented design criteria and construction methods proposed for the improvement of C-25 and C-25(Ext) and the construction of inlet structures and three spillways. This plan differed from that of the *General Design Memorandum (Part III, Supplement 1)* in the proposed alignment of the Belcher Canal extension. Local interests had requested a realignment (to the northwest rather than along State Road 68) which would eliminate numerous bridge crossings and use spoil material for construction of five miles of proposed L-52 along Water Conservation Area A. The realignment increased the drainage area (from 174 to 184 square miles), and was more compatible to the existing and proposed lateral

system of canals (to include 29 inlet structures). S-98 was to permit withdrawal of irrigation water from Water Conservation Area A (Upper St. Johns Marsh), which would be bounded by proposed L-52. The Office of the Chief of Engineers on April 20, 1962, agreed to delete S-98 and L-52. C-25 Ext was added to the C&SF Project by the Office of the Chief of Engineers on April 9, 1963.

(2) *In Part III, Supplement 2 - General Design Memorandum, Upper St. Johns River Basin, C-26, C-27, C-28, S-51, S-52, S-54, L-44 and L-45* were deleted from the C&SF Project by the Office of the Chief of Engineers on September 17, 1957.

(3) *Part III, Supplement 2 - Addendum 1, February 15, 1962*, revised the plan of improvements for St. Lucie and Martin Counties. After the design memorandum studies on this portion of the project were made, development in the area became so intense that land acquisition costs became prohibitive and the planned conservation area had to be abandoned. (Refer to the Upper St. Johns River Basin description.)

(4) *Part III, Supplement 1, General Design Memorandum - St. Lucie County Canals and Control Structures (Canals 23, 23A, 24 and 25, and Control Structures 48, 49, 50, 97, 98, and 99)*, dated January 23, 1957, also provided for improvement of the channel in North Fork St. Lucie River (C-23A) to accommodate the design discharge from C-24 plus the 30% SPF runoff from North Fork St. Lucie River. That enlarged channel would have adequate depth for navigation (benefits incidental to flood control). C-24 would be improved along its entire length from North Fork St. Lucie River to State Road 68 bridge. Water control structure S-49 would maintain a design water-control elevation of 20.0 feet. Secondary drainage structures at inflow points would control runoff into the canal and protect the canal from silting and erosion. *C&SF Project Survey-Review Report, Water Resources for Central and Southern Florida*, (February 15, 1968) added S-311, which would control discharge from C-25 Ext. to the upper limit of C-24.

(5) *Part III, Supplement 11, General Design Memorandum, Martin County (St. Lucie County Water Supply Element)* dated June 29, 1984 proposed the following departures from the authorized plan. The design studies had revealed that the high lift pumping station required in the authorized alinement was not economical, and a less costly alternate alinement was sought. The plan presented was a surface diversion by means of a canal of Lake Okeechobee waters to St. Lucie County for irrigation water supply.C-131A conveys water at Port Mayaca via St. Lucie Canal (C-44) from upstream of St. Lucie Lock to C-23 upstream of S-97. A pumping station (S-214A) and a spillway structure (S-215A) were required near C-44 and C-23 respectively. C-23 required enlargement in the northern reaches. A spillway structure (S-312) was required at the junction of C-23 and C-24 for both irrigation flows and backflows. However, objection to the plan was raised at the local level and to date none of the proposed plan has undergone further development and no further studies have been done.

b. Palm Beach County.

(1) *Part V, Supplement 16, Design Memorandum - Canal 17 and Control Structures 43 and 44*, dated April 5, 1955 presented some of the improvements in Palm Beach County. The purpose of C-17 is to drain flood waters from the low area west of the coastal ridge between Lake Mangonia and the Earman River. The drainage and flood control needs of the area west and north of West Palm Beach required that an adequate outlet be constructed either to Lake Worth or West Palm Beach Canal. The existing outlet through Stub Canal at the south end of Clear Lake was inadequate, as evidenced by flooding of lands adjacent to the canal. A canal to Lake Worth was thus the only practicable solution. The plan of protection proposed in the Comprehensive Plan provided for the construction of about 9.5 miles of canal with a 50 foot bottom width and a design discharge of 600 cfs at a depth of eight feet. This proposed canal would drain from Lake Mangonia northward to State Road A1A, where the canal would divide. From State Road A1A one leg (C-17E) of the canal would drain eastward to Lake Worth through Earman River and the other leg (C-17N) would drain northeastward to the AIWW north of Lake Worth. Each outlet would be provided with a control structure (S-44 and S-45). *Part V, Supplement 16, Design Memorandum - Canal 17 and Control Structures 43 and 44*, dated April 5, 1955, provided for an 8.3 mile long canal, with a drainage area of 89 square miles, for removal of 60% of the SPF. This plan provided for two spillways which would discharge 800 cfs (S-43) and 2070 cfs (S-44). The then existing Earman River, which ran northwestward from Lake Worth to the site of S-44 and then southward to Lake Park Road, had an irregular hydraulic prism. S-43 was proposed at the upper end of the canal to control water levels in Lake Mangonia and Clear Lake. However, S-43 was deleted from the plan when the city of West Palm Beach purchased Lake Mangonia, Clear Lake, and adjacent lands from West Palm Beach Water Company on December 1, 1955. The city desired to retain full control of water levels within the area to insure there was no encroachment on the rights of the city to regulate water levels in its own interests. In addition, it became apparent that two outlets (each with a spillway structure) could not be justified. Since either outlet would serve the drainage area effectively, a study was made to determine which should be eliminated. The lower outlet, discharging through Earman River, would enter a relatively wide section of Lake Worth, while the northerly outlet (C-17N and S-45) would discharge into a rather constricted section of the AIWW. To eliminate any difficulty due to sedimentation in the AIWW, it was decided to concentrate the discharge from C-17 along the lower alignment, using Earman River, consequently the northerly outlet facilities (C-17N and S-45) were deleted from the project. S-45 was deleted from the C&SF Project by the Office of the Chief of Engineers on March 1, 1956.

(2) *Part I, Supplement 3, Partial Definite Project Report on Central and Southern Florida Project, Design Memorandum on Station 5A*. S-5A(E) was added to the C&SF Project by the Office of the Chief of Engineers on February 15, 1952.

(3) *Part V, Supplement 51, General Design Memorandum - West Palm Beach Canal and Related Areas, with Detail Design Appendix on Pumping Station 319,* dated May 31, 1972. The State of Florida's Everglades Drainage District had constructed the West Palm Beach Canal between 1919 and 1929, including a lock and box-culvert structure near the easterly end of the canal. The Central and Southern Florida Flood Control District installed a vertical lift gate in the lock in 1955. The West Palm Beach Canal (C-51) was partially authorized by the *Flood Control Act of 1948* and additional modifications of improvements to C-51 were contained in *P.L. 87-874 (87th Congress, H.R. 13272, October 23, 1962)* and in *P.L. 90-483 (90th Congress S-3710, August 13, 1968).* At the time of *Supplement 51*, no work had been accomplished on the primary outlet works of the West Palm Beach Canal eastward of S-5AE. Supplement 51 proposed the C-51 improvement of 21 miles to provide 30% SPF protection to agricultural areas and 60% SPF protection to urban and citrus areas. The flood control plan contained in *Supplement 51* differed from the authorized plan in that it recommended backpumping about one-half of the excess runoff to Water Conservation Area 1 rather than discharging all runoff to Lake Worth. The report recommended the addition of S-155A and that priority be given to the construction of Pumping Station 319. A detailed design of S-319 was submitted with the report for the basis of early construction. The Chief of Engineers approved the report on February 9, 1983, subject to the satisfaction of comments of the Division Engineer, however the comments and final approval for the plan was not received until April 19, 1974 from the Division Engineer.

(a) *Part V, Supplement 54 - Detail Design Memorandum, Canal 51 and Control Structures 155 and 155A,* dated November 15, 1972 recommended the same plan as presented in Supplement 51. On December 21, 1981, *Addendum 1* to the report was prepared to identify the significant changes to the project design. In this addendum the crest shape for S-155 was changed, the end sill heights and stilling basin baffle block for S-155 were revised to conform to new criteria, the length of riprap protection for S-155 was increased, and the original cross section for C-51 from S-155 eastward to its junction with Lake Worth was recommended to be enlarged.

(b) *Addendum 2 for Part V, Supplement 54* was prepared on July 26, 1984. This addendum included the redesigning of S-155A and relocating the structure about 1,000 feet west of State Road 7 Bridge, reducing the excavation in C-51 between S-155A and S-319, and reducing the design pumping capacity of S-319. These changes were necessary to enable water management practices in the C-51 basin which are in consonance with management practices in other tributary areas of Lake Okeechobee directed at preserving the lake's water quality. On September 18, 1984, the report was returned to the District by the Division Engineer. The Division Engineer stated that the report did not substantiate the statements that modifications to the authorized plan were necessary to enable water management practices in the C-51 basin which are in consonance with management practices in other tributary areas of

Lake Okeechobee directed at preserving water quality. The Division Engineer stated that the economic analysis for the proposed modification was inadequate.

(c) On November 29, 1989, *Part V, Supplement 54, Addendum 2 (Revised)* and a *Post Authorization Change (PAC) Report* was submitted to the Division Engineer. The changes recommended by the PAC included removing water supply to Water Conservation Area 1 as a project purpose although flood control at the authorized level of protection would still be provided. The major design changes dealt with providing backpumping to a detention area instead of Water Conservation Area 1. Backpumping directly into WCA 1 is not implementable because of State of Florida water quality standards. This requires the construction of a culvert structure (S-360) and levee (L-85) and enlargement of L-40. Pumping Station 319 and Spillway 155A designs were modified to eliminate water supply as a project purpose. A meeting was held on January 22, 1990 with representatives of the Division office to discuss various issues and project formulation guidance. On January 16, 1991, a revised report was forwarded to the Division Engineer for approval.

(4) *Part V, Supplement 24, General Design Memorandum, Canals 15 and 16 and Control Structures 40, 41, and 42*, dated December 31, 1958. *Part V, Supplement 34, Detail Design Memorandum - Canals 15 and 16 and Control Structures 40 and 41*, dated June 28, 1962. Canal 15 (Hidden Valley Canal) selected alignment extends from an existing LWDD canal (E-4) along existing Lateral 38 before turning to the southeast and emptying into the AIWW. This alignment is located in the approximate center of the area requiring additional outlet works, and was found to be the most suitable and economical and also the most preferable to local interests. The Central and Southern Florida Flood Control District requested shifting to the south the alignment of C-15 as planned in the General Design Memorandum, claiming the change would save in overall cost due to reduced land and relocation costs. The Jacksonville District conducted a brief investigation which showed that the estimated savings were reasonable and approved the change. The alinement change was officially accepted by the Chief of Engineers on April 3, 1959.

(5) *Part V, Supplement 34, Detail Design Memorandum - Canals 15 and 16, and Control Structures 40 and 41*, dated June 28, 1962, recommended that S-42 be deleted from the project. The proposed centerline of C-16 was offset about 20 to 40 feet to the north from the FEC Railway to the westerly limit of the work to avoid disturbing the existing south bank, eliminating the need for clearing, degrading of the existing spoil mounds, relocations and erosion control along the south bank and reducing land costs. These changes were accepted by the Office of the Chief of Engineers on August 23, 1962.

c. Broward County.

(1) *Part V, Supplement 23, General and Detail Design Memorandum - Canal 14 and Control Structures 37A, 37B and 38A,* dated May 5, 1958. S-37A and S-37B were added to and S-37 was deleted from the C&SF Project by the Office of the Chief of Engineers in its 6th Endorsement to the South Atlantic Division, dated April 21, 1959, of a letter from the Jacksonville District, dated May 8, 1958. The *1968 Water Resources Report* added C-301 and culvert S-322 to divert water from C-14 to the Hillsboro Canal where it could be backpumped at S-320 and used for water supply.

(2) *Part V, Supplement 1, Design Memorandum - Canal 11, dated January 17, 1952* and revised February 27, 1952, designated C-11 within 14.7 miles of the South New River Canal from S-9 at L-37 (C-11 Station 9+05, near U.S. Highway 27) to Pumping Station S-13 at U.S. Highway 441/State Road 7 (confluence with Dania Cut Off Canal and South New River Canal, and site of proposed L-34). The 6.4 mile improvement would drain the 98 square mile drainage area (of the 111.8 square mile Davie agricultural area) through C-11 to the west to Pumping Station S-9 which would flow into WCA 3. The existing channel in the remaining 8.3 miles was of sufficient capacity. C-11 was enlarged to the north where local interests had obtained rights-of-way. *Part V, Supplement 7, Design Memorandum (revised) - Canal 11 and Control Structure 13A*, dated August 8, 1952, was prepared in response to the concern of local interests for drainage of low lands (below elevation +5 feet NGVD, including the town of Davie). The revised plan limited the channel enlargement to the westernmost 3.6 miles and added culvert S-13A. S-13A divides the 98 square mile drainage area into two separate water control systems: the westerly (high) lands of 71 square miles which would drain westward to S-9 and WCA 3, and the easterly (low) lands of 27 square miles which would drain eastward by gravity to a spillway in pumping station S-13 and tidal waters, except during relatively short periods when pumping would be required (when there are high stages east of S-13). The two areas would be divided by canals and spoil banks extending north and south from C-11 at S-13A. *Part V, Supplement 9, Design Memorandum (revised) - Canal 11 and Pumping Station 13*, dated November 17, 1952. The purpose of this supplement was to show additional information, following further subsurface investigations and modifications to design. The design discharge at S-13A was reduced by 40 cfs due to a revised estimate of seepage from WCA 3. This reduction was not significant to the design of the canal. Addition of S-13B to the C&SF Project was recommended in an *Operations Report - Review of C&SF Flood Control Works in Davie Agricultural Area*, dated January 31, 1958, which was approved by the Office of the Chief of Engineers on April 24, 1958. Structure S-13B was later deleted in favor of a modification of S-13A. The *1968 Water Resources Report* added C-303 and culvert S-323 to allow water supply backpumping of the area to Water Conservation Area 3.

(3) C-42 and related L-35A were substituted for portions of L-35 and L-36 by the Office of the Chief of Engineers on September 21, 1949.

d. North Dade County.

(1) *Part V, Supplement 4, Hydrology and Hydraulic Design, Greater Miami Area (preliminary draft)*, February 23, 1952, provided for canal enlargements designated C-2, C-3, C-7, C-8, and C-9 to remove the SPF runoff from Area A, the developed portion of the Greater Miami Area; and, canal enlargements designated C-3, C-4, and C-6 (above C-4) and extension of C-9 to provide drainage to Area B, the remainder of the Greater Miami Area. The objections of local interests to this plan primarily concerned the lesser degree of protection for Area B, specifically that the plan did not meet the demands of present land use or provide for future urban expansion, was inflexible in meeting that expansion without excessive cost, and did not provide adequate water conservation and utilization. In June 1952, the Flood Control District recommended a plan which did not include the C-3 improvement but would provide protection for Area B by a system of canals and two pump stations at L-30, discharging into WCA 3. *Supplement 4* was superseded by *Part V, Supplement 12, Design Memorandum - Hydrology and Hydraulic Design, Canals in Greater Miami Area (C-2 through C-9) (Revised)*, dated March 23, 1954. Supplement 12 addressed plans for improvement of existing canals in the Miami area (C-3, C-4, C-6, and C-9) for which the Flood Control Acts of 1948 and 1950 had authorized construction and funding, and for improvement of those C&SF canals which were not yet approved (C-2, C-5, C-7, and C-8) but for which the 1948 Act authorized additional engineering studies. Supplement 12 presented the hydrologic and hydraulic criteria used to determine the dimensions and characteristics proposed for six of the eight major canals in the developed portion of the Greater Miami area (no improvement was necessary for C-5; C-9 was under construction). This supplement divided the Miami Area into three sub-areas: Area A consisted of about 164 square miles of developed urban and suburban land lying generally east of a line two miles west of Red Road. Area B consisted of about 224 square miles of low, flat, somewhat marshy, undeveloped land between the line about two miles west of Red Road and the water conservation area levees. Area C consisted of about 27 square miles of scattered areas along which drain to Biscayne Bay, either directly overland or through sewers or indirectly by infiltration and seepage. The planned improvements would not affect Area C. The plan of improvement which had been recommended in the Comprehensive Plan (representing the desires of local interests following the 1947 flood) was confined to Area A and consisted of enlarging existing canals to handle a discharge of about 30% SPF. That plan would provide for drainage of the entire area by gravity since no other facilities had been included to reduce flood damages in Area B. However, discharges at the head of improved sections were to be very small (ranging from 70 cfs for C-2 to 230 and 270 cfs for C-4 and C-6, respectively). The total removal capacity from Area B (available only after removal of the floodwaters from Area A) would have been 1,255 cfs. Supplement 12 did not discuss salt water intrusion or the planned structures near the easterly ends of the major canals. The salt water intrusion was addressed in *Part V, Supplement 13, Design Memorandum,*

Water- and Salinity-Control Structures in Greater Miami Area, dated July 2, 1954. The Office of the Chief of Engineers on August 6, 1954, substituted 3 canals and 3 structures in the Greater Miami Area, authorizing C-2, C-7 and C-8 and S-22, S-27 and S-28 for construction in Phase I in lieu of C-3, C-4 and C-6 and S-23, S-25B and S-26 (the construction of which were deferred until a later date). C-8 Ext and C-7 Ext were added to the C&SF Project by the Office of the Chief of Engineers on December 14, 1954. In planning for C-4 (about 1951), it was found that an additional structure would be needed for control of C-4 near its junction with C-3; S-26 was being planned for the control of C-6 only. The proposed additional structure could not be located east of the selected site because of extensive barge traffic on C-4 in the 4.6 mile reach between S-25B and C-6. S-25B was then included in the 1952 estimates of costs for Comprehensive Plan works, which estimates were subsequently approved by the Office of the Chief of Engineers. C-3 and S-23 and associated railroad bridges were deleted by Office of the Chief of Engineers on July 17, 1962. Part V, Supplement 46 - General Design Memorandum, Canals 4, 5, and 6, and Control Structures 25, 25A, 25B, and 26, dated April 18, 1967, recommended that these improvements be provided for salinity control in the three canals. The plan called for a spillway in C-6 (S-26), a spillway (S-25B) in conjunction with a lock in C-4, and culverts in C-5 be fitted with slide gates to provide upstream (S-25A) and downstream (S-25) control structures. In a letter dated November 15, 1967, the Chief of Engineers approved as recommended the design of S-25 and S-25. However, the approval of S-25B and S-26 were deferred until extensive comments about the structure locations could be answered. In a letter dated March 26, 1968, the District Engineer stated that the plan presented in the *GDM* was a compromise plan developed with other Agencies input. The proposed locations provided a reasonable degree of salinity protection and at the same time continued to serve existing navigation with a minimum of delay. The information provided by this letter was satisfactory and the report was approved by OCE on August 26, 1968.

(2) *Part V, Supplement 3, Design Memorandum - Canal 9 and Structure 29*, dated February 22, 1952. After investigation of the permeability and character of the foundation rock, it was decided to locate S-29 about 375 feet downstream of US Highway 1. *Part V, Supplement 12, Design Memorandum -Hydrology and Hydraulic Design, Canals in Greater Miami Area (C-2 through C-9) (Revised)*, dated March 23, 1954, included elimination of L-32 and the westward extension of C-9 to L-33, which would require relocation of S-30 west of L-33. Elimination of L-32 and addition of the westward extension of C-9 (Sections 4 and 5) to L-33 (and consequent relocation of S-30) were authorized by a letter of July 30, 1953 from the Office of the Chief of Engineers to South Atlantic Division. *Part V, Supplement 15, Design Memorandum - Snake Creek Canal Extension (C-9, Section 4)*, dated December 15, 1954, planned a 4.7 mile westward extension of the Snake Creek Canal to drain the areas west of Ludlum Road as well as to replace the Ludlum Road Bridge. *Part V, Supplement 19, Design Memorandum - Canal 9, Section 1*, dated January 6, 1956, recommended a change in the alignment of C-9. This design memorandum proposed to route C-9 through the

Oleta River and Maule Lake to the AIWW channel in Dumbfoundling Bay for the purpose of reducing the required channel excavation by utilizing a section of the AIWW to Biscayne Bay which would also provide the borrow material to local interests. *Part V, Supplement 27, General and Detail Design Memorandum - Canal 9 (Section 5) and Control Structure 30*, dated April 20, 1959, proposed the westward extension of C-9 to the L-33 borrow canal and the construction of S-30. With this canal extension, C-9 would convey from WCA 3 the water supply necessary to maintain fresh water heads at control structures on C-7, C-8 and C-9. This document completes the planning and design of C-9 as it currently exists.

e. South Dade County.

(1) *Part V, Supplement 30 - General Design Memorandum, Levee 31 and Related Works, S-20F and S-20G* were added to the C&SF Project by the Office of the Chief of Engineers on May 4, 1960.

(2) *Part V, Supplement 37 - General Design Memorandum, South Dade County, C-102N, C-103N, C-103S and S-179* were added to and S-20D and S-20E were deleted from the C&SF Project by the Office of the Chief of Engineers on November 29, 1963. A portion of C-103S within Florida City also deleted.

(3) *Part V, Supplement 37 - General Design Memorandum, South Dade County Addendum 1, S-198* was added to the C&SF Project by the Office of the Chief of Engineers on February 27, 1968. S-199 was added to the C&SF Project by the Office of the Chief of Engineers on October 5, 1967.

(4) *Part V, Supplement 39 - Coastal Areas South of St. Lucie Canal - Detail Design Memorandum Canals 102 (Princeton Canal), 102(N), and Control Structures 165, 194, and 195*, dated November 19, 1964, added S-194 and S-195 to the project. These additions were accepted on February 15, 1965 by the Division Engineer.

(5) *Part V, Supplement 40 - Coastal Areas South of St. Lucie Canal - Detail Design Memorandum, Canals 103 (Mowry Canal), 103 (N) and 103 (S) and Control Structures 20F, 166, 167, 179, and 196*, dated January 22, 1965, added S-196 in C-103. S-196 was required to hold the headwater in C-103 at elevation 6.5 ft. This change to the project was approved by the Division Engineer on March 23, 1965.

(6) The Senate Appropriations Committee, in its *Report 1768* on the Public Works Appropriations Bill, determined that the extension of C-1 to the northwest was within the scope of the authorized C&SF Project. This extension includes the continuation of the main canal westward to L-31 (C-1, Section 2, or C-1W or C-1 Ext) and the addition of a spur canal north of the main canal (C-1, Section 3, or C-1N). C-1 Ext, C-1N, S-148 and S-149 were added to the C&SF Project by letter from the Office

of the Chief of Engineers to the Chairman of the House Committee on Appropriations, dated September 7, 1960.

(7) In September 1967 a letter report entitled Control Structure 197 in Canal 111 was prepared. C-111 was authorized by the *Flood Control Act of October 23, 1962 (PL 87-874, 87th Congress)* and subsequently S-197 was considered part of this authorization. S-197 was requested by the United States Department of the Interior, National Park Service. S-197 enables overland flow of water across C-111 and thence southward to the Everglades National Park and also serves as a barrier against salt water intrusion. S-197 consisted of a three-barrel culvert located in the side of the existing canal in order to provide navigation while functioning and a canal plug. The letter report was approved by the Office of the Chief of Engineers on October 18, 1967. In March 1990, the SFWMD received a Department of the Army permit to modify S-197. An additional ten barrels were added to the structure to permit greater flows to the park.

L.4 C&SF PROJECT O&M RESPONSIBILITIES

All of the project works constructed as a result of the *Rivers and Harbors Act of 1930* were operated and maintained by the Corps of Engineers. Some channels, such as the St. Lucie Canal, were constructed by the State of Florida, and operation and maintenance (O&M) was taken over by the Corps of Engineers as a result of the 1930 Act. When the *Flood Control Act of 1948* approved the creation of the Central and Southern Florida Project for Flood Control and Other Purposes, those features of the old Caloosahatchee River and Lake Okeechobee Drainage Areas (CR&LODA) Project were retained by the Federal Government for operation and maintenance. The flood control features of the CR&LODA project were improved in some cases and incorporated into the C&SF Project. The existing channels and locks were included in the Okeechobee Waterway Project. Locks and channel improvements done as a result of the new project were included in the C&SF Project.

L.4.1 Corps of Engineers

Both the 1948 Act and the 1968 Act included language which spelled out those features of the project which would be operated and maintained by the Corps of Engineers for the Federal Government. The project features to be operated and maintained by the Corps of Engineers are *"the levees, channels, locks, and control works of the St. Lucie Canal, Lake Okeechobee, Caloosahatchee River, and the main spillways of the water conservation areas . . ."* In addition, *". . . 60 percent of the additional pumping costs due to the proposed modification [1968 Authorization], . . . [is] to be reimbursed by the Federal Government except for the additional pumping costs at Pumping Station 9 and for the pumping stations along the northeast and northwest shores of Lake Okeechobee which will be all local . . ."*

The project features operated and maintained by the Corps of Engineers are shown in Table L-12.

L.4.2 Local Sponsor

The C&SF Project has two sponsors. The St. Johns River Water Management District (SJRWMD) is responsible for local cooperation requirements for the Upper St. Johns River Basin. All other project features are the responsibility of the South Florida Water Management District (SFWMD). The local sponsor is responsible for operation and maintenance of all project facilities not operated and maintained by the Corps of Engineers in accordance with regulations approved by the Secretary of the Army.

TABLE L-1

1930 PROJECT FEATURES COMMENT SUMMARY	
STRUCTURE	COMMENT
Culvert 1 in L-D1	
Culvert 1A in L-D1	
Culvert 2 in L-D1	
Culvert 3 in L-D2	
Culvert 4A in L-D2	
Culvert 5 in L-D3	
Culvert 5A in L-D3	
Culvert 6 in L-D4	
Culvert 7 in L-D4	
Culvert 8 in L-D4	
Culvert 9 in L-D4	
Culvert 10 in L-D9	
Culvert 10A in L-D9	
Culvert 11 in L-D9	
Culvert 12 in L-D2	
Culvert 12A in L-D2	
Culvert 13 in L-D9	
Culvert 14 in L-D9	
Culvert 15 in L-D9	
Culvert 16 in L-D9	
HGS-1 (Moore Haven Lock)	Replace by S-310 lock
HGS-2	Replaced by S-354 spillway
HGS-3	Replace by S-354 spill way
HGS-4	Replaced by S-351 spillway
HGS-5	Replace by S-352 spillway
HGS-6	Replaced by S-193 lock
New Lock No.1 (St. Lucie Dam, Lock, and Spillway)	
Ortona Lock and Spillwa	
Spillway "ALLAPATTA NO.1" on St. Lucie Cn	
Spillway "ALLAPATTA NO.2" on St. Lucie Cn.	
Spillway "A" on St. Lucie Cn.	
Spillway "B" on St. Lucie Cn.	
Spillway "CANE SLOUGH" on St. Lucie Cn.	
Spillway "C" on St. Lucie Cn.	
Spillway "D" on St. Lucie Cn.	
Spillway "E" on St. Lucie Cn.	
Spillway "F" on St. Lucie Cn.	
Spillway "G" on St. Lucie Cn.	
Spillway "H" on St. Lucie Cn.	
Spillway "I" on St. Lucie Cn.	
Spillway "INDIANTOWN" on St. Lucie Cn.	
Spillway "MAYACA"	

1930 PROJECT FEATURES COMMENT SUMMARY	
on St. Lucie Cn. Spillway "MID" on St. Lucie Cn. Spillway "WEST END" on St. Lucie Cn. Taylor Creek Culverts on L-D4 Taylor Creek Lock	
LEVEE	COMMENT
L-D1 L-D2 L-D3 L-D4 L-D5 L-D6 **L-D7** **L-D8** L-D9	
CANAL	COMMENT
Rim Cn. C-42 (St. Lucie Cn. maint.) C-43 (Caloosahatchee Cn.) Taylor Creek Cn.	

TABLE L-2

1948 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-1	Pump	Deleted in H.D. 186, 85th Congress
S-2	Pump	
S-2A	Spillway	Inactive - Approved SAD 9/24/63 added
S-3	Pump	
S-3A	Spillway	Inactive - Approved SAD 9/24/63 added
S-4	Pump	
S-5A	Pump	
S-5A(S)	Spillway	
S-5A(E)	Culvert	
S-5A(W)	Culvert	
S-5A(X)	Culvert	
S-6	Pump	
S-9	Pump	
S-10A	Spillway	
S-10C	Spillway	
S-10D	Spillway	
S-11A	Spillway	
S-11B	Spillway	
S-11C	Spillway	
S-12A	Spillway	
S-12B	Spillway	
S-12C	Spillway	
S-12D	Spillway	
S-12E	Culvert	
S-12F	Culvert	
S-13	Pump	
S-13A	Culvert	
S-14	Culvert	
S-22	Spillway	
S-24	Culvert	
S-24A	Culvert	
S-24B	Culvert	Deleted part of W. Alignment plan; Replaced by S-335
S-27	Culvert	
S-28	Culvert	
S-29	Culvert	
S-30	Culvert	
S-31	Culvert	
S-32	Culvert	
S-32A	Culvert	Deleted (see 1968 Authorization)
S-33	Culvert	
S-34	Culvert	
S-36	Spillway	
S-38	Culvert	
S-38B	Culvert	
S-39	Spillway	
S-43	Spillway	Inactive; Authority ltr from SAD/OCE

1948 PROJECT FEATURES COMMENT SUMMARY		
S-44	Spillway	
S-45		Deleted in H>D> 186, 85th Congress
S-46	Spillway	
S-76	Spillway	
S-77	Spillway	
S-80 mod	Lock & Spillway Culvert	Inactive; Enlarging discharge capacity of spillway
S-85		Not approved
S-89		Never recommended
S-90		Never recommended
S-91		Never recommended
S-92		Never recommended
S-93		Never recommended
S-94	Culvert	Never recommended
S-124	Culvert	
S-125	Spillway	
S-126	Pump	Was not approved
S-127	Pump	
S-128	Pump	Cancelled
S-129	Pump	
S-130	Pump	Cancelled
S-131	Pump	
S-132	Pump	Cancelled
S-133	Pump	
S-134	Pump	Deleted, Add 1 to part IV Suppl 21
S-136	Pump	Never Recommended
S-137	Pump	Never Recommended
S-138	Culvert	Never Recommended
S-143	Culvert	
S-144	Culvert	
S-145	Culvert	
S-146	Culvert	
S-151	Pump	Deleted (see 1968 Autorization)
S-152	Spillway	Deleted, Add 1 to part IV Suppl 21
S-153	Culvert	
S-154	Culvert	
S-169	Culvert	
S-170	Culvert	Deleted
S-173	Spillway	Deleted; replace by S-331
S-191	Culvert	
S-192	Lock	
S-193	Spillway	Replaced HGS-6
S-223	Culvert	Deleted with Modified Water Del
S-224	Spillway	Inactive
S-232		
S-235	Pump	Added by letter report November 1971
S-236	Culvert	
S-237		Not used
S-306	Lock	Deleted in economic update
S-310	Spillway	Replaced HGS-2

1948 PROJECT FEATURES COMMENT SUMMARY		
S-351 S-352 S-354 S-360 S-361	Lock Spillway Culvert Spillway	Replaced HGS-4 Replaced HGS-5 Replaced HGS-3 Not approved plan Not used
LEVEES	COMMENT	
L-D1		
L-D1 rem	Inactive	
L-D2		
L-D2 rem	Inactive	
L-D3		
L-D3 rem	Inactive	
L-D4		
L-D4 rem	Inactive	
L-D9		
L-D9 rem	Inactive	
L-1		
L-1 rem	Built by SFWMD	
L-7		
L-7 rem	Inactive	
L-8		
L-9	Deleted in H.D. 186, 85th Congress	
L-10		
L-12		
L-14		
L-15		
L-17	Deleted in H.D. 186, 85th Congress	
L-19		
L-20		
L-22	Deleted in H.D. 186, 85th Congress	
L-24		
L-25		
L-26	Deleted in H.D. 186, 85th Congress	
L-30		
L-30 rem	Inactive	
L-31N		
L-31N rem		
L-33		
L-33 rem	Inactive	
L-34	Deleted in H.D. 186, 85th Congress	
L-35A		
L-35A rem	Inactive	
L-35B		
L-36		
L-37		
L-37 rem	Inactive	
L-39		
L-39 rem	Inactive	
L-40		
L-40 rem	Inactive	

1948 PROJECT FEATURES COMMENT SUMMARY	
L-43	
L-43 ext	
L-47	
L-48	
L-49	
L-50	
L-50 tiebacks	
L-59	
L-60	
L-61	
L-62	
L-63(N)	
L-63(S)	
L-64(N)	
L-64(S)	
St. Lucie Canal (N) rem, tieback	
L-65	
L-67A	
L-67B	Inactive
L-67C	
L-67D	Inactive
L-67E	Inactive
L-68A	
L-68B	Inactive
L-85	Not approved
CANAL	COMMENT
C-2	
C-7	
C-8	
C-9	
C-11	
C-12	
C-12(N)	
C-13	
C-17	
C-18	
C-21	
C-21A	Deleted in H.D. 186, 85th Congress
C-21B	Deleted in H.D. 186, 85th Congress
C-21C	Deleted in H.D. 186, 85th Congress
C-42	
C-43	Navigation improvement only; to 8ft. Deleted in H.D. 186, 85th Congress
C-44	
C-59	
Hillsboro Cn Part	
West Palm Beach Cn Part	
New River Cn Part	
Miami Cn Part	

TABLE L-3

1954 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-7	Pump	
S-8	Pump	
S-15		Deleted
S-18	Spillway	
S-18A		Structure not needed
S-18B		Deleted
S-18C	Spillway	
S-18D		Deleted
S-19	Spillway	Inactive
S-19A		Structure not needed
S-20	Spillway	
S-20A	Spillway	
S-20B		Structure not needed
S-20C		Structure not needed
S-20D		Deleted
S-20E		Deleted
S-20F	Spillway	
S-20G	Spillway	
S-21	Spillway	
S-21A	Spillway	
S-21B		Deleted OCE 2nd Ind. to GDM V37
S-23		Deleted OCE 2nd Inc. to GDM V 37
S-25	Culvert	
S-25A	Culvert	
S-25B	Spillway	Lock feature deleted Add. 1 to GDM V-46
S-26	Spillway	
S-37A	Spillway	
S-37B	Spillway	
S-40	Spillway	
S-41	Spillway	
S-47		Deleted DDM I-47
S-47B	Culvert	
S-47D	Spillway	
S-48	Spillway	
S-49	Spillway	
S-50	Spillway	
S-53	Lock	Deauthorized 1 Jan 1990
S-55	Lock	Deauthorized 1 Jan 1990
S-57	Spillway	Lock Authorized, small boat Nav; Oct 70
S-58	Spillway	Lock Authorized, small boat Nav; Oct 70
S-59	Spillway	Lock Authorized, small boat Nav; Oct 70
S-60	Spillway	Lock Authorized, small boat Nav; Oct 70
S-61	Spillway	
S-62	Spillway	Lock Authorized, small boat Nav; Oct 70
S-63	Spillway	Lock Authorized, small boat Nav; Oct 70
S-63A	Spillway	Lock Authorized, small boat Nav; Oct 70

1954 PROJECT FEATURES COMMENT SUMMARY		
S-64	Spillway	Deletion approved COE 6 Oct 1961
S-65	S, NL	(Spillway/Navigation Lock)
S-65A	S, NL	(Spillway/Navigation Lock)
S-65B	S, NL	(Spillway/Navigation Lock)
S-65C	S, NL	(Spillway/Navigation Lock)
S-65D	S, NL	(Spillway/Navigation Lock)
S-65E	S, NL	(Spillway/Navigation Lock)
S-66	Spillway	
S-68	Spillway	
S-70	Spillway	
S-71	Spillway	
S-72	Spillway	
S-75	Spillway	
S-78	S, L, D	Ortona Lock (Spillway, Lock, and Dam)
S-79	S, L, D	W.P. Franklin (Spillway, Lock, and Dam)
S-82	Spillway	
S-83	Spillway	
S-84	Spillway	
S-86	Spillway	
S-87	Culvert	Deleted; ltr 24 Feb 1983
S-87A	Culvert	
S-87B	Culvert	
S-87C	Culvert	Deferred (Not Added)
S-88	Spillway	
S-88A	Spillway	
S-88B	Spillway	
S-96	Spillway	
S-96A	Spillway	
S-96B	Spillway	
S-96C	Spillway	
S-96D	Spillway	
S-97	Spillway	
S-98		Deleted
S-99	Spillway	
S-140	Pump	
S-141	Spillway	
S-142	Culvert	
S-147	Pump	Inactive
S-149	Culvert	
S-150	Culvert	
S-157	Spillway	
S-158	Weir	
S-159	Spillway	Deleted with 85 GDM Part 3 Supp 2 add 3
S-160	Spillway	Deleted with 85 GDM Part 3 Supp 2 add 3
S-161	Spillway	
S-161A	Spillway	Added 85 GDM Part 3 Supp 2 add 3
S-162	Spillway	Deathorized 85 GDM Part 3 Supp 2 Add 3
S-163	Spillway	
S-164	Spillway	
S-170		Not used

1954 PROJECT FEATURES COMMENT SUMMARY		
S-171	Culvert	
S-172	Culvert	
S-174	Spillway	
S-175	Culvert	
S-190	Spillway	
S-221	Culvert	
S-222	Spillway	Deauthorized
S-225	Culvert	Not used
S-226	Culvert	Not used
S-227	Culvert	Not used
S-228	Culvert	Not used
S-229	Culvert	Not used
S-230	Culvert	Not used
S-231	Culvert	Old Cox Creek irrigation structure
S-233	Spillway	Not used
S-234	Culvert	Not used
S-235	Culvert	Not used
S-239	Spillway	
S-250A	Culvert	
S-250B	Culvert	
S-250C	Culvert	
S-251	Culvert	
S-252A	Culvert	
S-252B	Culvert	
S-252C	Culvert	
S-252D	Culvert	
S-252E	Culvert	
S-252F	Culvert	
S-254	Weir	
S-255	Culvert	
S-256	Culvert	
S-257	Culvert	
S-258	Culvert	
S-324		Not Authorized; Ltr dated 3 Oct 75
S-325		Not Authorized; Ltr dated 3 Oct 75
S-330		Not Authorized (Originally S-203)
S-339	Spillway	
S-340	Spillway	
S-343A	Culvert	
S-343B	Culvert	
S-344	Culvert	
LEVEES	COMMENTS	
L-2		
L-3		
L-3		
L- tieback		
L-4		
L-5		
L-5 rem	Inactive	
L-6		

1954 PROJECT FEATURES COMMENT SUMMARY	
L-6 rem	Inactive
L-13	
L-18	
L-23	
L-23 ext	
L-28 sec 1	
L-28 sec 2	
L-28 sec 3	
L-28 sec 4	Deferred - Inactive
L-28 sec 5, tieback	
L-28 ext	Recinded - Inactive
L-28 Big Cypress	Deleted Add 1
L-28 Interceptor	
L-28 N Feeder Cn	
L-28 W Feeder Cn	
L-29	
L-31 (E)	
L-31 (W)	
L-31 (S)	
L-31 (S) rem	Deleted
L-38 (E)	
L-38	
L-38 (E&W)	
L-38 (W)	
L-41	
L-42	
L-71	Deauthorized
L-72	Deauthorized
L-73	
L-73 rem	
L-74 (E)	
L-74 (W)	
L-74 (N)	
L-75	
L-76	
L-77	
L-78	
L-79	
L-80	Deleted
L-81	Deleted
L-82	
CANAL	COMMENT
C-1	
C-3	Deleted OCE 2nd Ind 29 Aug 1962
C-4	
C-5	
C-6	
C-7 ext	
C-8 ext	
C-10	

1954 PROJECT FEATURES COMMENT SUMMARY	
C-14	
C-15	
C-16	
C-19	
C-20	
C-23	
C-23A	
C-24	
C-25	
C-25 ext	
C-29	
C-30	
C-31	
C-32	All one canal, not B,C,D,E,F,G
C-33	
C-34	
C-35	
C-36	
C-37	
C-38	
C-39A	
C-40	
C-41	
C-41A	
C-43	
C-44A	Inactive
C-45	
C-46	
C-46A	
C-46B	
C-46C	
C-47	
C-52	Deleted
C-53 (N)	Deleted
C-53 (S)	Deleted
C-54	
C-55	Deleted
C-56	Deleted
C-57	Deleted from new plan; Not operable
C-58	Deleted from new plan; Not operable
C-60	
C-65	
C-123	Conveyance Canal, Sec 3
C-139	
C-139	
C-139	
C-308	W. Alignment Plan eliminated
Conveyance Cn Sec 1	
Conveyance Cn Sec	

1954 PROJECT FEATURES COMMENT SUMMARY	
2	

TABLE L-4

1958 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-47A	Culvert	Deleted
S-47C	Culvert	Deleted
S-47G	Culvert	Deleted
S-47H	Culvert	Deleted
S-51	Spillway	Deleted
S-52	Spillway	Deleted
S-54	Spillway	Deleted
S-56	Spillway	Deleted
S-65F	Spillway	Deleted
S-69	Spillway	Deleted
S-73	Spillway	Deleted
S-74	Spillway	Deleted
LEVEE	COMMENT	
L-11	Deleted	
L-27	Deleted	
L-32	Deleted	
L-44	Deleted	
L-45	Deleted	
L-46	Deleted	
CANAL	COMMENT	
C-19	Deleted	
C-22	Deleted	
C-26	Deleted	
C-27	Deleted	
C-28	Deleted	
C-39	Deleted	
C-39A	Deleted	

TABLE L-5

1960 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-81 S-5A S-5 mod S-342	Culvert Culvert Culvert Culvert	Replaced by S-342 (built by SFWMD)
LEVEE	COMMENT	
L-51 L-306	Replaced by L-306 built by SFWMD) & Lykes Dike (built by Lydes Co.)	
CANAL	COMMENT	
C-19 C-19 ext	Enlargement of existing canal (built by SFWMD) Extension of C-19 to L-306	

TABLE L-6

1962 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-110	Spillway	Replaced by new project design
S-111	Spillway	Replaced by new project design
S-112	Spillway	Replaced by new project design
S-113	Spillway	Replaced by new project design
S-114	Spillway	Replaced by new project design
S-115	Spillway	Project deauthorized 1 Jan 1990
S-116	Spillway	Project deauthorized 1 Jan 1990
S-117	Spillway	Project deauthorized 1 Jan 1990
S-118	Spillway	
S-119	Spillway	
S-120	Culvert	
S-121	Culvert	
S-122	Culert	
S-123	Spillway	Replaced S-21C
S-155	Spillway	
S-155A	Spillway	
S-156	Spillway	
S-165	Spillway	
S-166	Spillway	
S-167	Spillway	
S-168		Deleted
S-176	Spillway	
S-177	Spillway	
S-178	Culvert	
S-179	Spillway	
S-194	Culvert	
S-195	Culvert	
S-196	Culvert	
S-197	Culvert	
S-198	Spillway	Inactive
S-199	Spillway	
S-353	Spillway	
S-360	Culvert	Report Pending
S-361	Spillway	Dropped from plan
LEVEE	COMMENT	
L-85	Report pending approval	
CANAL	COMMENT	
C-51	Partially Built	
C-100		
C-100A		
C-100B		
C-100C		

1962 PROJECT FEATURES COMMENT SUMMARY	
C-102	
C-102(N)	
C-103	
C-103(N)	
C-103(S)	
C-106	Inactive
C-107	Inactive
C-108	Inactive
C-109	Inactive
C-110	
C-111	
C-111(E)	
C-113	
C-120A	
C-120B	
C-121	
C-353	
C-355	Dropped from plan
C-356	Dropped from plan
C-357	Dropped from plan
C-358	Dropped from plan

TABLE L-7

1965 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-100	Pump	Deleted from authorized plan
S-101	Culvert	Deleted from authorized plan
S-102	Spillway	Deleted from authorized plan
S-180	Spillway	Deauthorized 1 Jan 1990
S-181	Pump	Deauthorized 1 Jan 1990
S-182	Culvert	Deauthorized 1 Jan 1990
S-183	Spillway	Deauthorized 1 Jan 1990
S-184	Spillway	Deauthorized 1 Jan 1990
S-185	Culvert	Deauthorized 1 Jan 1990
S-186	Culvert	Deauthorized 1 Jan 1990
S-239	Spillway	Deauthorized 1 Jan 1990
S-241	Spillway	Deauthorized 1 Jan 1990
S-243	Culvert	
LEVEE	COMMENT	
L-70	Deauthorized 1 Jan 1990	
L-100	Deleted from authorized plan	
L-101	Deleted from original plan	
CANAL	COMMENT	
C-114	Deauthorized 1 Jan 1990	
C-115	Deauthorized 1 Jan 1990	
C-116	Deauthorized 1 Jan 1990	
C-117	Deauthorized 1 Jan 1990	
C-118	Deauthorized 1 Jan 1990	
C-119	Deauthorized 1 Jan 1990	
C-119(N)	Deauthorized 1 Jan 1990	
C-119(W)	Deauthorized 1 Jan 1990	
C-122		
C-139		
C-139(S)		
C-141	Deleted from plan	

TABLE L-8

1968 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-2 mod	Pump	Modification of structure
S-2A		Deleted with Part 1 Supp. 51
S-3 mod	Pump	Modification of structure
S-3A		Deleted with part 1 Supp. 51
S-4 mod	Pump	Modification of structure
S-5A	Spillway	Modification of structure
S-19	Spillway	Inactive
S-32A	Culvert	Moved – Project purpose changed from flood Control to water resources
S-65(E) mod	l & s	(Lock and spillway) Modification of structure
S-71 mod		Modification of structure
S-72 mod		Modification of structure
S-77 mod		Modification of structure
S-84 mod		Modification of structure
S-123 mod		Modification of structure
S-127 mod	Pump	Modification of structure
S-129 mod	Pump	Modification of structure
S-131 mod	Pump	Modification of structure
S-133 mod	Pump	Modification of structure
S-135 mod	Pump	Modification of structure
S-151 mod	Culvert	Enlarged – Project purpose change from Flood control to water resources
S-154 mod		Deleted from plan
S-173 mod, part	Culvert	Modification to part of W. Alignment Paln Replaced by S-331
S-185 mod	Spillway	Modification of structure – Deleted with Conveyance Cn Plan
S-191 mod	Lock	Modification of structure
S-192 mod	Culvert	Modification of structure
S-193 mod		Modification of structure
S-200	Spillway	
S-201	Spillway	
S-202	Spillway	
S-203	Spillway	Previously partially authorized-Changed to S-330
S-204	Spillway	
S-205	Spillway	
S-206	Spillway	
S-207	Culvert	Considered but not used
S-208	Spillway	Considered but not used
S-209	Spillway	Considered but not used
S-210	Culvert	Considered but not used
S-211	Spillway	Considered but not used
S-212	Spillway	
S-213	Spillway	
S-214	Spillway	
S-215	Spillway	
S-216	Culvert	

1968 PROJECT FEATURES COMMENT SUMMARY		
S-217	Culvert	
S-218	Spillway	
S-219		Considered but not used
S-220		Considered but not used
S-300	Pump	
S-301	Pump	
S-302	Pump	
S-303	Pump	Not used
S-304	Pump	
S-305	Culvert	Not used
S-306	Culvert	Not used
S-307	Pump	
S-308A	Pump	
S-308B	Lock	
S-308C	Spillway	
S-309	Pump	
S-310	Lock	
S-311	Spillway	
S-312	Spillway	
S-313	Pump	
S-314	Spillway	
S-315	Spillway	
S-316	Culvert	
S-317	Culvert	
S-318	Spillway	
S-319	Pump	
S-320	Pump	
S-321	Culvert	
S-322	Culvert	
S-323	Culvert	
S-324	Culvert	Deleted plan (Previously partially authorized)
S-325	Spillway	Deleted plan (Previously partially authorized)
S-326	Pump	Deleted from plan
S-327	Culvert	Deleted from plan
S-328	Culvert	Deleted from plan
S-329	Culvert	Deleted from plan
S-330	Pump	Deleted from plan
S-331	Pump	
S-332	Pump	
S-333	Spillway	
S-334	Spillway	
S-335	Spillway	
S-336	Culvert	
S-337	Culvert	
S-338	Culvert	
S-341	Culvert	
S-346	Culvert	
S-347	Culvert	
S-348	Spillway	Not approved - Recommended Part 3 Supp 11
S-350	Culvert	

1968 PROJECT FEATURES COMMENT SUMMARY		
S-Henry Crk Lock mod	Lock	Modification of structure
LEVEE	COMMENT	
L-D1 raised		
L-D2 raised		
L-D3 raised		
L-D9 raised		
L-18 part, borrow cn	Borrow canal enlargement	
L-19 part, borrow cn	Borrow canal enlargement	
L-20 part, borrow cn	Borrow canal enlargement	
L-23 part, borrow cn	Borrow canal enlargement	
L-24 borrow cn	Borrow canal enlargement	
L-25 borrow cn	Borrow canal enlargement	
L-29 borrow cn	Borrow canal enlargement	
L-31(N) borrow cn	Borrow canal enlargement	
L-47raised		
L-48 raised		
L-49 raised		
L-50 raised		
L-50 tiekback		
L-70 W. alignment	West Alignment plan deleted	
L-300		
L-301		
L-302		
L-303		
L-304	Not used	
L-305		
CANAL	COMMENT	
C-1 part at S-338		
C-11		
C-12(N) part		
C-23 mod, part		
C-42 mod, part		
C-103 mod		
C-119(W)mod	West alignment plan not used	
C-131		
C-132(W)		
C-133		
C-133(N)		
C-134		
C-135		
C-135(W)	Considered but not used	
C-136	Considered but not used	

1968 PROJECT FEATURES COMMENT SUMMARY	
C-137	
C-137(N)	Considered but not used
C-137(S)	Considered but not used
C-138	Considered but not used
C-140	
C-142	
C-300 part	
C-301	
C-303	
C-304	
C-305	
C-306	Deleted with Modified Water Deliveries
C-307	Inactive
C-308	Not used
C-310	Deleted with Modified Water Deliveries

TABLE L-9

1970 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-53	Lock	Small boat navigation only
S-55	Lock	Small boat navigation only
S-57	Lock	Small boat navigation only
S-58	Lock	Small boat navigation only
S-59	Lock	Small boat navigation only
S-60	Lock	Small boat navigation only
S-62	Lock	Small boat navigation only
S-63	Lock	Small boat navigation only
S-63A	Lock	Small boat navigation only
S-157	Lock	Small boat navigation only
S-158	Lock	Small boat navigation only
CANAL	COMMENT	
C-29	Small boat navigation only	
C-30	Small boat navigation only	
C-31	Small boat navigation only	
C-32	Small boat navigation only	
C-33	Small boat navigation only	
C-34	Small boat navigation only	
C-52	Small boat navigation only	
C-53(N)	Small boat navigation only	
C-53(S)	Small boat navigation only	
C-54	Small boat navigation only	
C-55	Small boat navigation only	
C-56	Small boat navigation only	

TABLE L-10

1989 PROJECT FEATURES COMMENT SUMMARY		
STRUCTURE	TYPE	COMMENT
S-334 mod	Spillway	Modified
S-345A	Culvert	
S-345B	Culvert	
S-345C	Culvert	
S-349A	Spillway	
S-349B	Spillway	
S-349C	Spillway	
S-355A	Spillway	
S-355B	Spillway	
S-356	Pump	
S-357 mod	Pump	Modified
LEVEE	COMMENT	
Seepage Levee		

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TABLE L-11
C&SF PROJECT AUTHORITIES

PROJECT PURPOSE	1948 PL 80-858[1]	1954 PL 83-780[2]	1958 PL 85-500[3]	1960 PL 86-645[4]	1962 PL 87-874[5]	1965 PL 89-298[6]	1968 PL 90-483[7]
Flood Control	X	x	X	X	X	X	X
Drainage/Water Control	X	X	X	X	X	X	X
Groundwater Recharge	X	X			X		
Salinity Intrusion	X	X			X		X
Evergaldes national park Water Supply	X	X					X
Fish/Widllife Preservation	X	X	X		X		X
Navigation	X	X					X
Water Supply	X	X					X
Environmental Protection Restoration							
Recreation	X				X		X
Irrigation	X						X
Hydrologic Ecosystem							

Notes can be found on page L-85

TABLE L-11 con't
C&SF PROJECT AUTHORITIES

PROJECT PURPOSE	1970 PL91-282[8]	1970 HD91-394[9]	1983 PL98-181[10]	1988 PL100-676[11]	1989 PL101-229[12]	1992 PL102-580[13]	1996 PL104-843[14]
Flood Control			X		X		
Drainage/Water Control							
Groundwater Recharge							
Salinity Intrusion							
Everglades national park Water Supply	X		X		X		
Fish/Wildlife Preservation							
Navigation		X					X
Water Supply							
Environmental Protection/Restoration				X	X	X	X
Recreation							
Irrigation							
Hydrologic Ecosystem Model				X			

Notes can be found on page L-85

1\PL 80-858 - Flood Control Act of 1948
2\PL 83-780 - Flood Control Act of 1954
3\PL 85-500 - Flood Control Act of 1958
4\PL 86-645 - Flood Control Act of 1960
5\PL 87-874 - Flood Control Act of 1962
6\PL 89-298 - Flood Control Act of 1965
7\PL 90-483 - Flood Control Act of 1968
8\PL 91-282 - River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970
9\HD 91-394 - Central and Southern Florida Small-Boat Navigation (Authorized under Section 201 of the Flood Control Act of 1965)
10\PL 98-181 - Supplemental Appropriations Act, 1984
11\PL 100-676 - Water Resources Development Act of 1988
12\PL 101-229 - Everglades National Park Protection and Expansion Act of 1989
13\PL 102-580 - Water Resources Development Act of 1992
14\PL104-843 - Water Resources Development Act of 1996

APPENDIX M

IMPLEMENTATION PLAN SCHEDULING AND SEQUENCING

APPENDIX M
IMPLEMENTATION PLAN SCHEDULING AND SEQUENCING

Figure M-1 provides a graphical representation of the schedule for implementing the components of the recommended Comprehensive Plan. Refer to ***Section 10*** for a complete discussion of this schedule. Each activity is graphically represented by a time scaled bar or diamond which reflects the starting date and ending date based on the estimated duration of that activity. The time scale is over the 41 years (starting in 1999 through 2040) of the project. In the figures that follow, solid gray bars (or black on poor quality copy reproductions) represent activities, hatched bars represent critical path activities, black bars with down pointing carats indicate a rolled up (summary bar) activity, and the black diamonds represent milestones.

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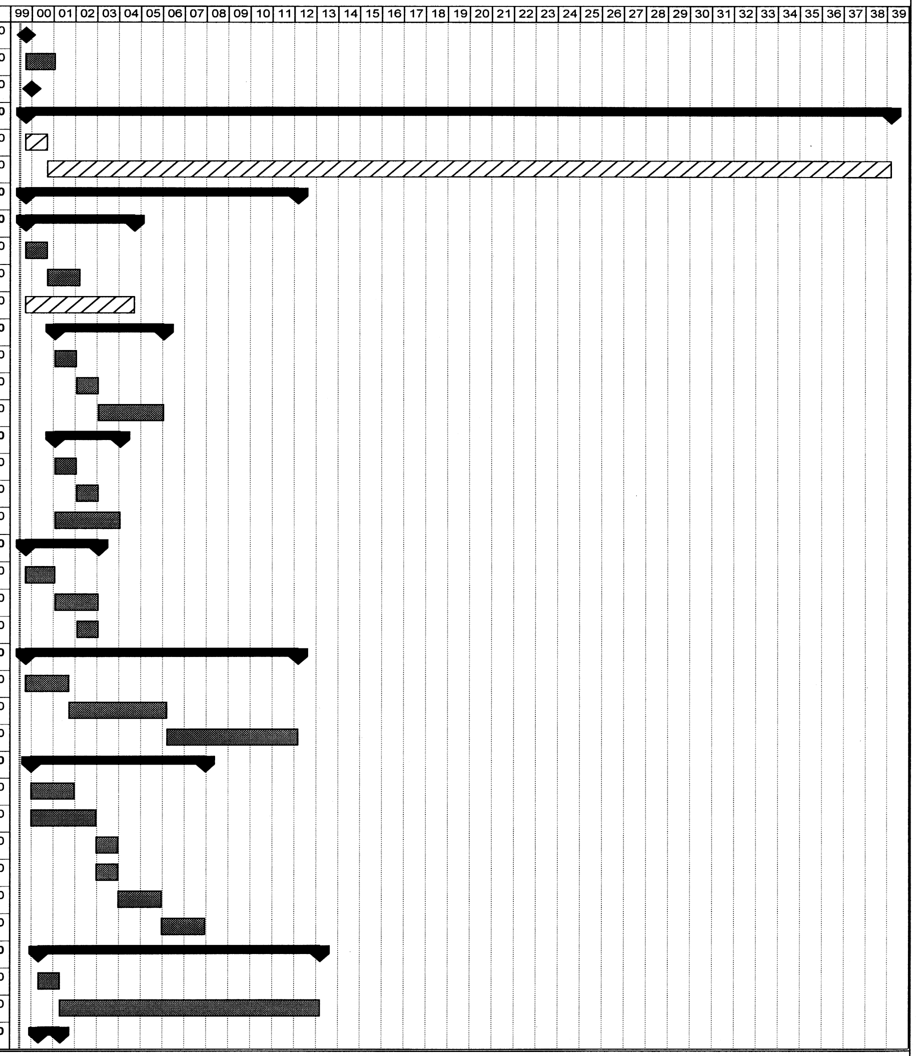
FIGURE M-1
PROJECT SCHEDULE

CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
1		Comprehensive Plan Submitted to Congress	0 w	7/1/99	7/1/99	$0
2		Comprehensive Plan Approved	70 w	7/1/99	11/1/00	$0
3		Design Agreement Executed	0 w	9/30/99	9/30/99	$0
4		**Restoration Evaluation and Verification Team**	**2060 w**	**7/1/99**	**12/22/38**	**$387,000,000**
5		RECOVER	52 w	7/1/99	6/28/00	$2,000,000
6		RECOVER and Monitoring	2008 w	6/29/00	12/22/38	$385,000,000
7		**PILOT PROJECTS**	**650 w**	**7/1/99**	**12/14/11**	**$97,000,000**
8		**LO ASR Pilot Project**	**260 w**	**7/1/99**	**6/23/04**	**$19,000,000**
9		Feasibility & Design	52 w	7/1/99	6/28/00	$1,000,000
10		Construction	78 w	6/29/00	12/26/01	$14,000,000
11		Monitoring	260 w	7/1/99	6/23/04	$4,000,000
12		**Caloosahatchee R. ASR Pilot Project**	**260 w**	**11/1/00**	**10/25/05**	**$6,000,000**
13		Design	52 w	11/1/00	10/30/01	$500,000
14		Construction	52 w	10/31/01	10/29/02	$5,000,000
15		Monitoring	156 w	10/30/02	10/25/05	$500,000
16		**Seepage Mgmt Pilot Project**	**156 w**	**11/1/00**	**10/28/03**	**$10,000,000**
17		Design	52 w	11/1/00	10/30/01	$500,000
18		Construction	52 w	10/31/01	10/29/02	$9,000,000
19		Monitoring	156 w	11/1/00	10/28/03	$500,000
20		**Site 1 ASR Pilot Project**	**174.4 w**	**7/1/99**	**11/1/02**	**$9,000,000**
21		Design/Permitting	70 w	7/1/99	11/1/00	$900,000
22		Construction	104 w	11/2/00	10/30/02	$7,000,000
23		Operational Testing	52 w	11/5/01	11/1/02	$1,100,000
24		**Lakebelt Technology Pilot Project**	**650 w**	**7/1/99**	**12/14/11**	**$23,000,000**
25		Design	104 w	7/1/99	6/27/01	$2,000,000
26		Construction	234 w	6/28/01	12/21/05	$20,000,000
27		Monitoring	312 w	12/22/05	12/14/11	$1,000,000
28		**Reuse Technology Pilot Project**	**416 w**	**10/1/99**	**9/20/07**	**$30,000,000**
29		Ecological Effects Of Reuse	104 w	10/1/99	9/27/01	$500,000
30		Design Reuse Pilot	156 w	10/1/99	9/26/02	$2,340,000
31		RE Acquisition Reuse Pilot	52 w	9/27/02	9/25/03	$2,800,000
32		P&S Reuse Pilot	52 w	9/27/02	9/25/03	$171,000
33		Construct Reuse pilot	104 w	9/26/03	9/22/05	$23,189,000
34		Monitor Reuse Pilot	104 w	9/23/05	9/20/07	$1,000,000
35	DD	**HOLEYLAND REGULATION SCHEDULE (DD)**	**672 w**	**1/31/00**	**12/14/12**	**$0**
36		Regulation Schedule Report (DD)	52 w	1/31/00	1/26/01	$0
37		Implement Regulation Schedule Change (DD)	620 w	1/29/01	12/14/12	$0
38	EE	**ROTENBERGER REGULATION SCHEDULE (EE)**	**52 w**	**1/31/00**	**1/26/01**	**$0**



File: CRS- D13RF
Date: 2/22/99 D13RFINAL 2/18/99
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Legend: Task, Critical Task, Progress, Milestone, Summary, Rolled Up Task, Rolled Up Critical Task, Rolled Up Milestone, Rolled Up Progress, Split, External Tasks, Project Summary

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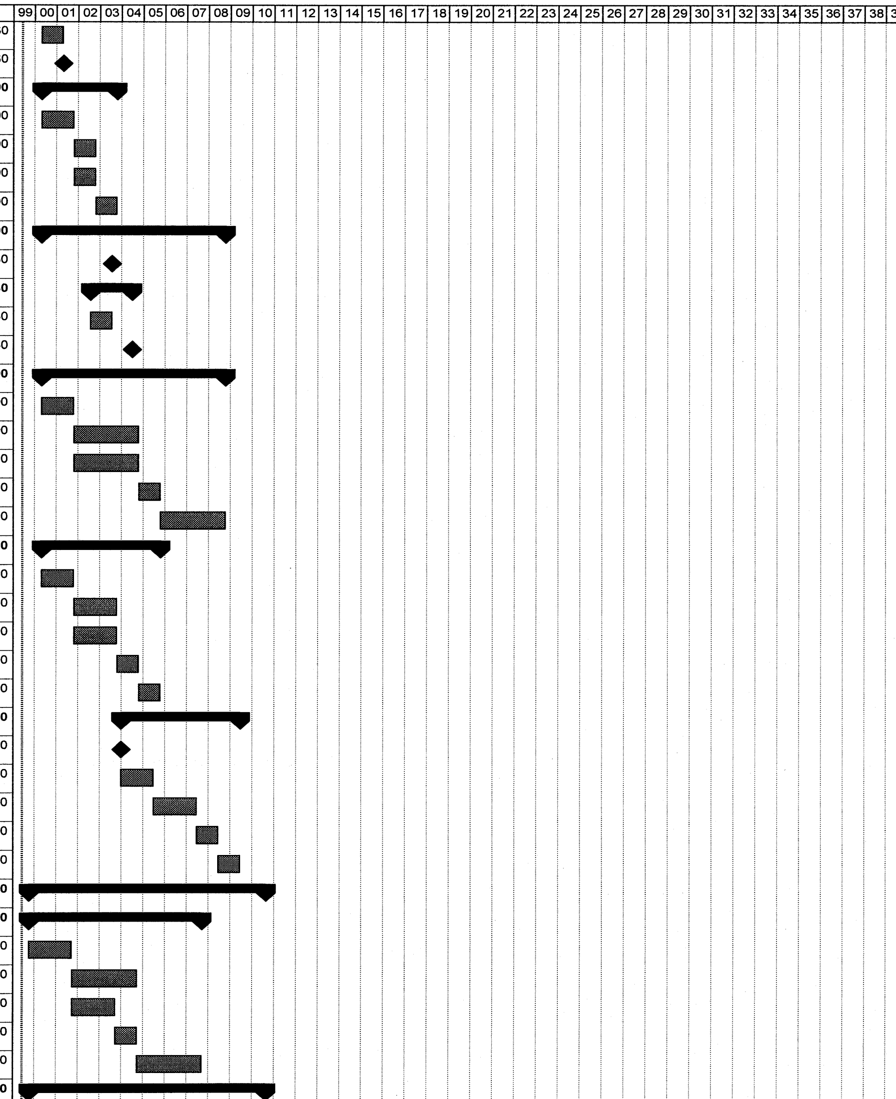
CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
39		Regulation Schedule Report (EE)	52 w	1/31/00	1/26/01	$0
40		Implement New Schedule (EE)	0 w	1/26/01	1/26/01	$0
41	KK	**WCA-1 INTERNAL STRUCTURES (KK)**	**182 w**	**1/31/00**	**7/25/03**	**$7,669,000**
42		PIR KK	78 w	1/31/00	7/27/01	$453,000
43		RE Acquisition KK	52 w	7/30/01	7/26/02	$345,000
44		P&S KK	52 w	7/30/01	7/26/02	$50,000
45		Construction KK	52 w	7/29/02	7/25/03	$6,821,000
46		**C-111 MODIFICATIONS (OO, WW, T, II)**	**442 w**	**1/31/00**	**7/18/08**	**$94,035,000**
47		C-111 Project Completed	0 w	4/30/03	4/30/03	$0
48	OO	**C-111 Operations Modifications (OO)**	**100.2 w**	**5/1/02**	**4/1/04**	**$0**
49		Interim Regulation Schedule Report (OO)	52 w	5/1/02	4/29/03	$0
50		Implement Interim Schedule (OO)	0 w	4/1/04	4/1/04	$0
51	WW	**C-111N Spreader Canal (WW)**	**442 w**	**1/31/00**	**7/18/08**	**$94,035,000**
52		PIR WW	78 w	1/31/00	7/27/01	$1,990,000
53		RE Acquisition WW	156 w	7/30/01	7/23/04	$45,766,000
54		Detailed Design WW	156 w	7/30/01	7/23/04	$995,000
55		P&S WW	52 w	7/26/04	7/22/05	$332,000
56		Construction WW	156 w	7/25/05	7/18/08	$44,952,000
57	T	**C-4 STRUCTURE (divide)**	**286 w**	**1/31/00**	**7/22/05**	**$2,330,000**
58		PIR C-4 Divide Structure	78 w	1/31/00	7/27/01	$76,000
59		RE Acquisition T	104 w	7/30/01	7/25/03	$495,000
60		Detailed Design T	104 w	7/30/01	7/25/03	$38,000
61		P&S T	52 w	7/28/03	7/23/04	$13,000
62		Construction T	52 w	7/26/04	7/22/05	$1,708,000
63	II	**G-404 PUMP STATION MODIFICATIONS**	**286 w**	**10/1/03**	**3/24/09**	**$10,138,000**
64		STA 3/ 4 Project Completed	0 w	10/1/03	10/1/03	$0
65		PIR II	78 w	10/1/03	3/29/05	$418,000
66		Detailed Design II	104 w	3/30/05	3/27/07	$209,000
67		P&S II	52 w	3/28/07	3/25/08	$70,000
68		Construction II	52 w	3/26/08	3/24/09	$9,441,000
69		**INDIAN RIVER LAGOON (B, UU)**	**569 w**	**7/5/99**	**5/28/10**	**$822,785,000**
70	B	**C-44 Basin Storage (B)**	**416 w**	**7/5/99**	**6/22/07**	**$112,562,000**
71		PIR B	104 w	7/5/99	6/29/01	$902,000
72		RE Acquisition B	156 w	7/2/01	6/25/04	$90,675,000
73		Detailed Design B	104 w	7/2/01	6/27/03	$451,000
74		P&S B	52 w	6/30/03	6/25/04	$150,000
75		Construction B	156 w	6/28/04	6/22/07	$20,384,000
76	UU	**C23/C24, C25, N&S-Fork Storage (UU)**	**569 w**	**7/5/99**	**5/28/10**	**$710,223,000**



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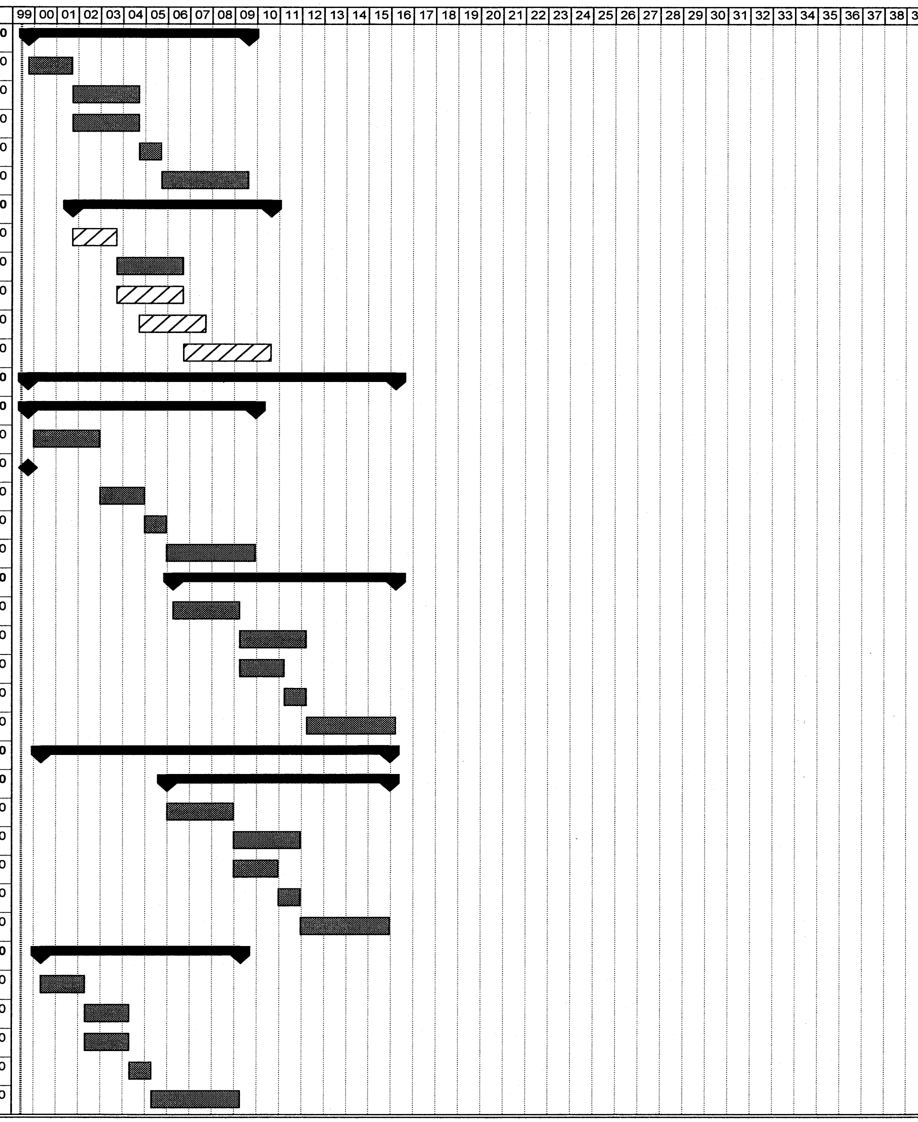
CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
77	UU P1	**C23 and C24 Storage (UU P1)**	**516 w**	**7/5/99**	**5/22/09**	**$369,316,000**
78		PIR UU1	104 w	7/5/99	6/29/01	$6,027,000
79		RE Acquisition UU1	156 w	7/2/01	6/25/04	$223,105,000
80		Detatiled Design UU2	156 w	7/2/01	6/25/04	$3,013,000
81		P&S UU2	52 w	6/28/04	6/24/05	$1,005,000
82		Construction UU2	204 w	6/27/05	5/22/09	$136,166,000
83	UU P2	**C25, North & South Fork /10 Mile Ck. (UU P2)**	**465 w**	**7/2/01**	**5/28/10**	**$340,907,000**
84		PIR UU2	104 w	7/2/01	6/27/03	$5,563,000
85		RE Acquisition UU2	156 w	6/30/03	6/23/06	$205,943,000
86		Detailed Design UU2	156 w	6/30/03	6/23/06	$2,782,000
87		P&S UU2	156 w	7/1/04	6/27/07	$927,000
88		Construction UU2	204 w	7/3/06	5/28/10	$125,692,000
89	G	**EAA STORAGE & CONVEYANCE (G)**	**860.4 w**	**7/1/99**	**12/25/15**	**$436,648,000**
90	G P1	**EAA Storage Ph 1 (G P1)**	**533.2 w**	**7/1/99**	**9/17/09**	**$233,408,000**
91		PIR G P1	156 w	10/1/99	9/26/02	$9,621,000
92		RE Acquisition G P1	0 w	7/1/99	7/1/99	$0
93		Detailed Design G P1	104 w	9/27/02	9/23/04	$4,811,000
94		P&S G P1	52 w	9/24/04	9/22/05	$1,603,000
95		Construction G P1	208 w	9/23/05	9/17/09	$217,373,000
96	G P2	**EAA Storage Area Ph 2 (G P2)**	**520 w**	**1/9/06**	**12/25/15**	**$203,240,000**
97		PIR G P2	156 w	1/9/06	1/2/09	$4,811,000
98		RE Acquisition G P2	156 w	1/5/09	12/30/11	$86,536,000
99		Detailed Design G P2	104 w	1/5/09	12/31/10	$2,405,000
100		P&S G P2	52 w	1/3/11	12/30/11	$802,000
101		Construction G P2	208 w	1/2/12	12/25/15	$108,686,000
102		**LAKE OKEECHOBEE HEADWATERS STORAGE (A, W)**	**816 w**	**1/31/00**	**9/18/15**	**$388,881,000**
103	A	**North of Lake Storage (A)**	**520 w**	**10/3/05**	**9/18/15**	**$284,854,000**
104		PIR A	156 w	10/3/05	9/26/08	$3,921,000
105		RE Acquisition A	156 w	9/29/08	9/23/11	$189,720,000
106		Detailed Design A	104 w	9/29/08	9/24/10	$1,961,000
107		P&S A	52 w	9/27/10	9/23/11	$654,000
108		Construction A	208 w	9/26/11	9/18/15	$88,598,000
109	W	**Taylor Ck Nubbin Sl Reservoir & STA (W)**	**468 w**	**1/31/00**	**1/16/09**	**$104,027,000**
110		PIR W	104 w	1/31/00	1/25/02	$3,064,000
111		RE Acquisition W	104 w	1/28/02	1/23/04	$29,700,000
112		Detailed Design W	104 w	1/28/02	1/23/04	$1,532,000
113		P&S W	52 w	1/26/04	1/21/05	$511,000
114		Construction W	208 w	1/24/05	1/16/09	$69,220,000



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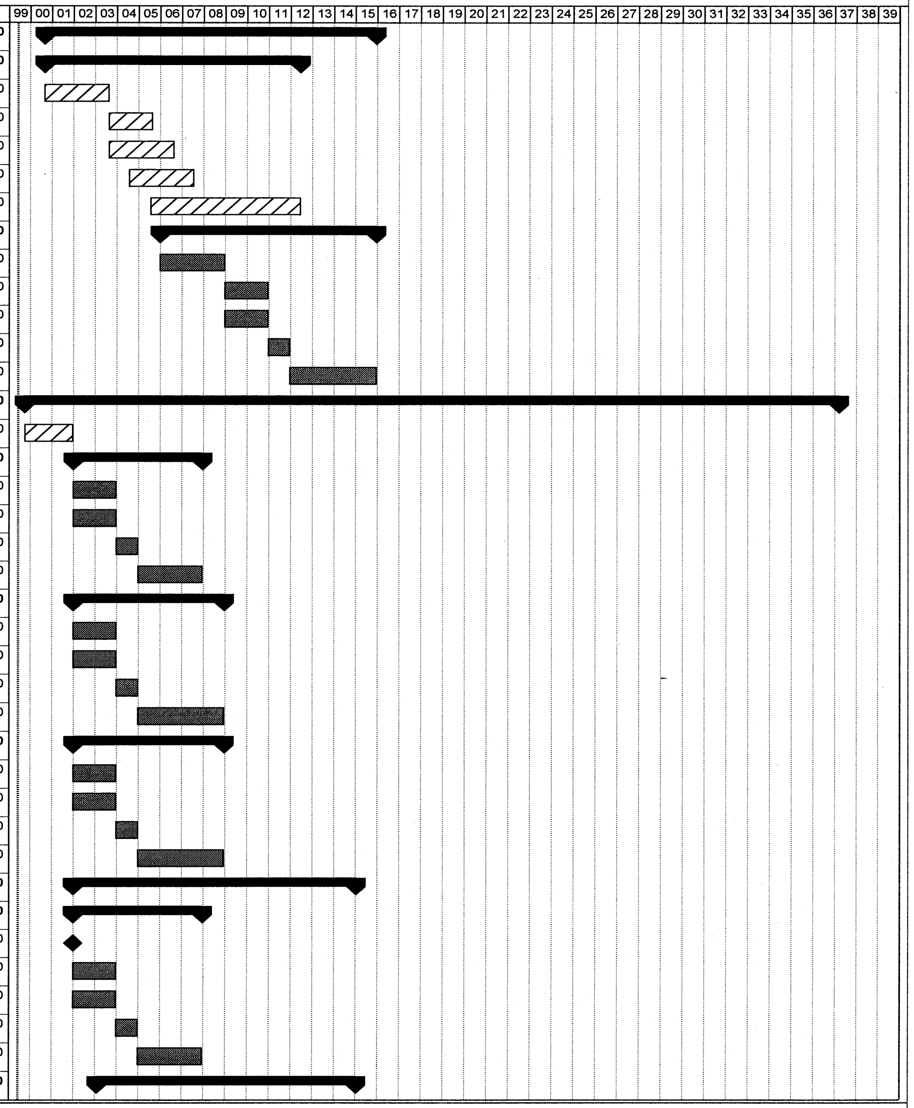
ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
115		**CALOOSAHATCHEE RIVER BASIN STORAGE (D, DDD)**	**798.4 w**	**6/1/00**	**9/18/15**	**$523,090,000**
116	**D**	**C43 Storage & ASR (D)**	**616.2 w**	**6/1/00**	**3/22/12**	**$440,195,000**
117		PIR D	156 w	6/1/00	5/28/03	$12,926,000
118		RE Acquisition D	104 w	5/29/03	5/25/05	$132,621,000
119		Detailed Design D	156 w	5/29/03	5/24/06	$6,463,000
120		P&S D	156 w	5/3/04	4/27/07	$2,154,000
121		Construction D (phased)	360 w	4/29/05	3/22/12	$286,031,000
122	**DDD**	**Caloosahatchee STA & Backpumping (DDD)**	**520 w**	**10/3/05**	**9/18/15**	**$82,895,000**
123		PIR DDD	156 w	10/3/05	9/26/08	$2,874,000
124		RE Acquisition DDD	104 w	9/29/08	9/24/10	$13,179,000
125		Detailed Design DDD	104 w	9/29/08	9/24/10	$1,437,000
126		P&S DDD	52 w	9/27/10	9/23/11	$479,000
127		Construction DDD	208 w	9/26/11	9/18/15	$64,926,000
128		**WATER PRESERVE AREAS**	**1955.4 w**	**7/1/99**	**12/19/36**	**$2,666,164,000**
129		PIR WPA (Feasibility Study)	117 w	7/5/99	9/28/01	$0
130	**R**	**C-9 Impoundment (R)**	**312 w**	**10/1/01**	**9/21/07**	**$89,146,000**
131		RE Acquisition R	104 w	10/1/01	9/26/03	$62,939,000
132		Detailed Design R	104 w	10/1/01	9/26/03	$1,620,000
133		P&S R	52 w	9/29/03	9/24/04	$180,000
134		Construction R	156 w	9/27/04	9/21/07	$24,407,000
135	**Q**	**C-11 Impoundment & Canal (Q)**	**364 w**	**10/1/01**	**9/19/08**	**$124,837,000**
136		RE Acquisition Q	104 w	10/1/01	9/26/03	$82,520,000
137		Detailed Design Q	104 w	10/1/01	9/26/03	$2,616,000
138		P&S Q	52 w	9/29/03	9/24/04	$291,000
139		Construction Q	208 w	9/27/04	9/19/08	$39,410,000
140	**BB**	**Dade Broward Levee / Pensucco (BB)**	**364 w**	**10/1/01**	**9/19/08**	**$18,778,000**
141		RE Acquisition - BB-	104 w	10/1/01	9/26/03	$8,676,000
142		Detailed Design BB	104 w	10/1/01	9/26/03	$624,000
143		P&S BB	52 w	9/29/03	9/24/04	$69,000
144		Construction BB	208 w	9/27/04	9/19/08	$9,409,000
145	**M**	**Site 1 Impoundment & ASR (M)**	**681 w**	**9/28/01**	**10/17/14**	**$131,379,000**
146	**M P1**	**Site 1 Impoundment Ph 1 (M P1)**	**312 w**	**9/28/01**	**9/21/07**	**$38,535,000**
147		RE Acquisition M P1 & M P2 (credit)	0 w	9/28/01	9/28/01	$15,331,550
148		RE to be acquired M P1 & M P2	104 w	10/1/01	9/26/03	$8,255,450
149		Detailed Design M P1	104 w	10/1/01	9/26/03	$924,000
150		P&S M P1	52 w	9/29/03	9/24/04	$103,000
151		Construction M P1	156 w	9/27/04	9/21/07	$13,921,000
152	**M P2**	**Site 1 ASR Ph 2 (M P2)**	**624 w**	**11/4/02**	**10/17/14**	**$92,844,000**



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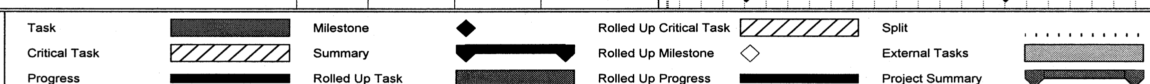

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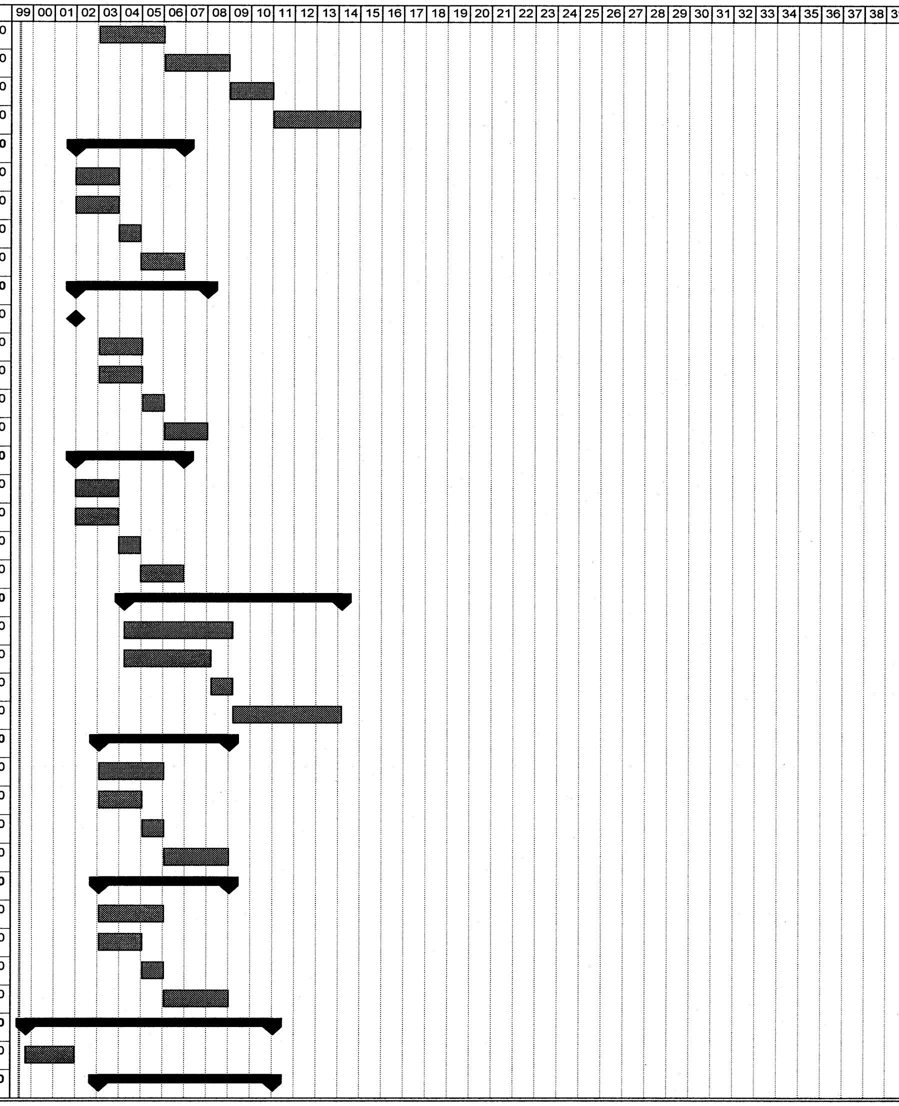
ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
153		PIR M P2	156 w	11/4/02	10/28/05	$4,198,000
154		Detailed Design M P2	156 w	10/31/05	10/24/08	$2,099,000
155		P&S M P2	104 w	10/27/08	10/22/10	$700,000
156		Construction Site M P2	208 w	10/25/10	10/17/14	$85,847,000
157	OPE	**ACME Basin B Discharge**	**260 w**	**10/1/01**	**9/22/06**	**$20,100,000**
158		RE Acquisition ACME Basin B	104 w	10/1/01	9/26/03	$8,500,000
159		Detail Design ACME Basin B	104 w	10/1/01	9/26/03	$717,000
160		P&S ACME BASIN B	52 w	9/29/03	9/24/04	$80,000
161		Construction ACME Basin B	104 w	9/27/04	9/22/06	$10,803,000
162	OPE	**Protect Wetlands adjacent to LNWR (Strazulla)**	**317 w**	**9/28/01**	**10/26/07**	**$52,772,000**
163		RE Acquisition Protect LNWR (Strazulla)	0 w	9/28/01	9/28/01	$36,729,000
164		RE Acquisition to be acquired ,Protect LNWR	104 w	11/4/02	10/29/04	$12,243,000
165		Detailed Design, Protect LNWR	104 w	11/4/02	10/29/04	$235,000
166		P&S, Protect LNWR	52 w	11/1/04	10/28/05	$26,000
167		Construction Protect LNWR	104 w	10/31/05	10/26/07	$3,539,000
168	OPE	**Pal-Mar Corbett Hydropattern Restoration**	**260 w**	**10/1/01**	**9/22/06**	**$10,500,000**
169		RE Acquisition Pal-Mar/Corbett	104 w	10/1/01	9/26/03	$8,000,000
170		Detail Design Pal-Mar/Corbett	104 w	10/1/01	9/26/03	$155,000
171		P&S Pal-Mar/Corbett	52 w	9/29/03	9/24/04	$17,000
172		Construction Pal-Mar/Corbett	104 w	9/27/04	9/22/06	$2,328,000
173	U	**Bird Drive Recharge Area (U)**	**520 w**	**1/1/04**	**12/18/13**	**$124,083,000**
174		RE Acquisition U	260 w	1/1/04	12/24/08	$71,625,000
175		Detailed Design U	208 w	1/1/04	12/26/07	$3,243,000
176		P&S U	52 w	12/27/07	12/24/08	$360,000
177		Construction U	260 w	12/25/08	12/18/13	$48,855,000
178	X	**C-17 Backpumping & Treatment (X)**	**312 w**	**11/4/02**	**10/24/08**	**$20,190,000**
179		RE Acquisition X	156 w	11/4/02	10/28/05	$10,367,000
180		Detailed Design X	104 w	11/4/02	10/29/04	$607,000
181		P&S X	52 w	11/1/04	10/28/05	$67,000
182		Construction X	156 w	10/31/05	10/24/08	$9,149,000
183	Y	**C-51 Backpumping & Treatment (Y)**	**312 w**	**11/4/02**	**10/24/08**	**$32,632,000**
184		RE Acquisition Y	156 w	11/4/02	10/28/05	$13,475,000
185		Detailed Design Y	104 w	11/4/02	10/29/04	$1,185,000
186		P&S Y	52 w	11/1/04	10/28/05	$132,000
187		Construction Y	156 w	10/31/05	10/24/08	$17,840,000
188		**Levee Seepage Management (V, O, F)**	**589.8 w**	**7/1/99**	**10/19/10**	**$284,552,000**
189		PIR V, O, FF	117.5 w	7/1/99	10/1/01	$4,317,000
190	V	**L-31 N Levee Improvement (V)**	**416 w**	**10/30/02**	**10/19/10**	**$65,782,000**



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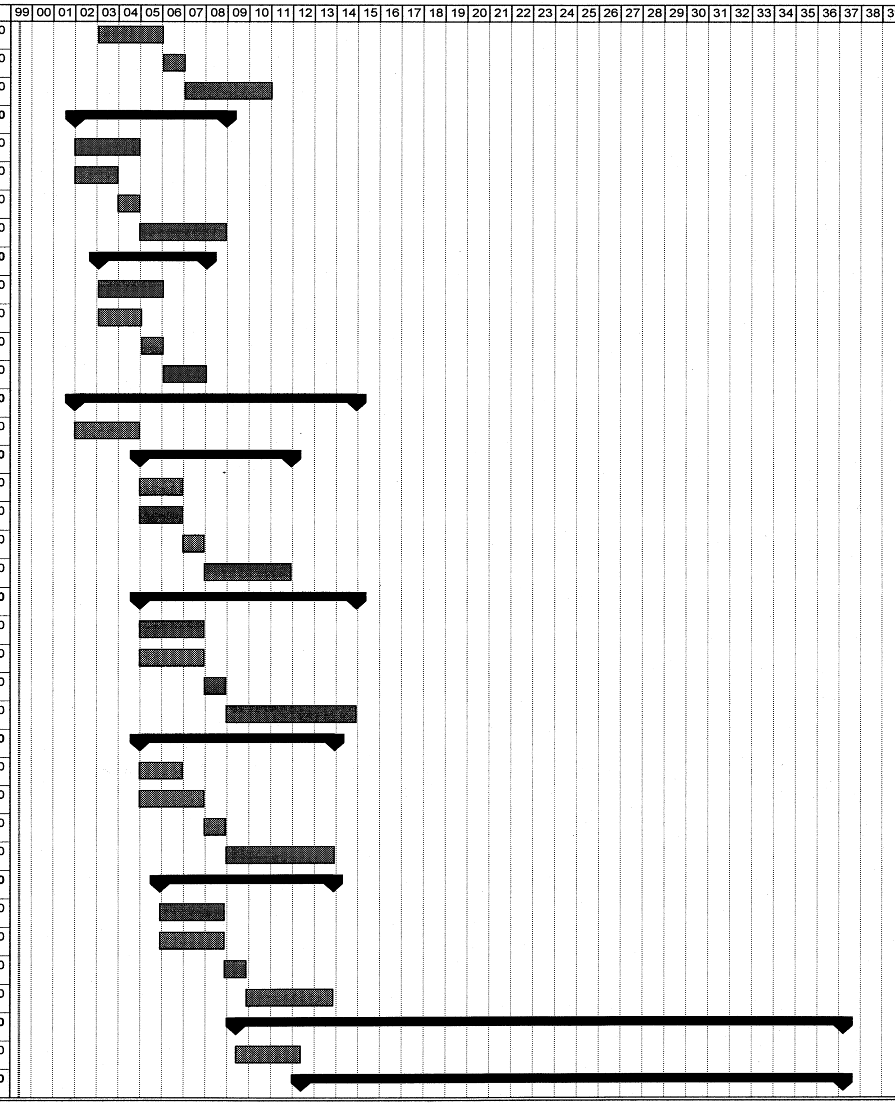
ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
191		Detailed Design V	156 w	10/30/02	10/25/05	$1,414,000
192		P&S V	52 w	10/26/05	10/24/06	$471,000
193		Construction V	208 w	10/25/06	10/19/10	$63,897,000
194	O	**WCA-3A &3B Levee Seepage Mgmt (O)**	**364 w**	**10/1/01**	**9/22/08**	**$99,707,000**
195		RE Acquisition O	156 w	10/1/01	9/27/04	$85,126,000
196		Detailed Design O	104 w	10/1/01	9/29/03	$313,000
197		P&S O	52 w	9/29/03	9/27/04	$104,000
198		Construction O	208 w	9/27/04	9/22/08	$14,164,000
199	FF	**S-356 Structures (FF)**	**260 w**	**11/4/02**	**10/26/07**	**$114,746,000**
200		RE Acquisition FF	156 w	11/4/02	10/28/05	$94,704,000
201		Detailed Design FF	104 w	11/4/02	10/29/04	$431,000
202		P&S FF	52 w	11/1/04	10/28/05	$144,000
203		Construction FF	104 w	10/31/05	10/26/07	$19,467,000
204		**Storage and ASR Storage (K, GGG, LL, VV)**	**676 w**	**10/1/01**	**9/12/14**	**$671,616,000**
205		PIR K, GGG, LL, VV	156 w	10/1/01	9/24/04	$23,594,000
206	K	**L-8 Basin Modifications (K)**	**364 w**	**9/27/04**	**9/16/11**	**$71,316,000**
207		RE Acquisition K	104 w	9/27/04	9/22/06	$4,290,000
208		Detailed Design K	104 w	9/27/04	9/22/06	$1,441,000
209		P&S K	52 w	9/25/06	9/21/07	$480,000
210		Construction K	208 w	9/24/07	9/16/11	$65,105,000
211	GGG	**C51 & Southern L-8 Reservoir (GGG)**	**520 w**	**9/27/04**	**9/12/14**	**$328,056,000**
212		RE Acquisition GGG	156 w	9/27/04	9/21/07	$27,351,000
213		Detailed Design GGG	156 w	9/27/04	9/21/07	$6,464,000
214		P&S GGG	52 w	9/24/07	9/19/08	$2,155,000
215		Construction GGG	312 w	9/22/08	9/12/14	$292,086,000
216	LL	**C-51 Regional Groundwater ASR (LL)**	**468 w**	**9/27/04**	**9/13/13**	**$127,291,000**
217		RE Acquisition LL	104 w	9/27/04	9/22/06	$9,945,000
218		Detailed Design LL	156 w	9/27/04	9/21/07	$2,522,000
219		P&S LL	52 w	9/24/07	9/19/08	$841,000
220		Construction LL	260 w	9/22/08	9/13/13	$113,983,000
221	VV	**Ag Reserve Reservoir (VV)**	**416 w**	**9/1/05**	**8/21/13**	**$121,359,000**
222		RE Acquisition VV	156 w	9/1/05	8/27/08	$57,657,000
223		Detailed Design VV	156 w	9/1/05	8/27/08	$1,369,000
224		P&S VV	52 w	8/28/08	8/26/09	$456,000
225		Construction VV	208 w	8/27/09	8/21/13	$61,877,000
226		**Lakebelt Storage and Conveyance (S, EEE, ZZ, YY, XX)**	**1451 w**	**3/2/09**	**12/19/36**	**$1,085,579,000**
227		PIR S, EEE, ZZ,YY,XX	156 w	3/2/09	2/24/12	$35,043,000
228	S	**Central Lake Belt Storage Area**	**1295 w**	**2/27/12**	**12/19/36**	**$466,725,000**



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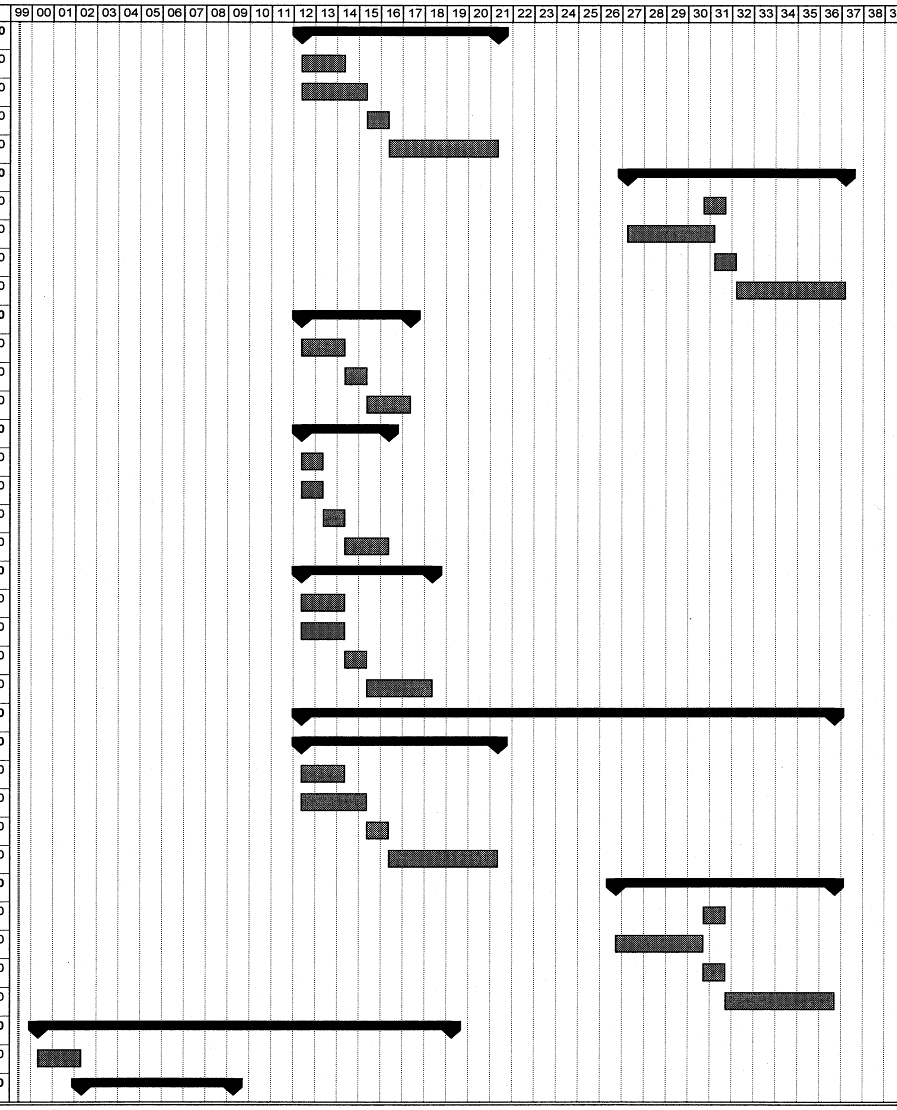
229	**S P1**	**Central Lake Belt Storage Ph 1 (S P1)**	**468 w**	**2/27/12**	**2/12/21**	**$346,793,000**
230		RE Acquisition S P1	104 w	2/27/12	2/21/14	$75,269,000
231		Detailed Design S P1	156 w	2/27/12	2/20/15	$6,115,000
232		P&S S P1	52 w	2/23/15	2/19/16	$2,039,000
233		Construction S P1	260 w	2/22/16	2/12/21	$263,370,000
234	**S P2**	**Central Lake Belt Storage Ph 2 (S P2)**	**520 w**	**1/4/27**	**12/19/36**	**$119,932,000**
235		RE Acquisition S P2	52 w	7/1/30	6/27/31	$25,090,000
236		Detailed Design S P2	208 w	1/4/27	12/27/30	$2,039,000
237		P&S S P2	52 w	12/30/30	12/26/31	$679,000
238		Construction S P2	260 w	12/29/31	12/19/36	$92,124,000
239	**EEE**	**Flows from CLB to WCA-3B (EEE)**	**260 w**	**2/27/12**	**2/17/17**	**$6,544,000**
240		Detailed Design EEE	104 w	2/27/12	2/21/14	$141,000
241		P&S EEE	52 w	2/24/14	2/20/15	$47,000
242		Construction EEE	104 w	2/23/15	2/17/17	$6,356,000
243	**ZZ**	**Flows from WCA-3A & 3B to CLB (ZZ)**	**208 w**	**2/27/12**	**2/19/16**	**$765,000**
244		RE Acquisition ZZ	52 w	2/27/12	2/22/13	$308,000
245		Detailed Design ZZ	52 w	2/27/12	2/22/13	$10,000
246		P&S ZZ	52 w	2/25/13	2/21/14	$3,000
247		Construction ZZ	104 w	2/24/14	2/19/16	$444,000
248	**YY**	**Divert Flows from WCA-2 to CLB (YY)**	**312 w**	**2/27/12**	**2/16/18**	**$76,156,000**
249		RE Acquisition YY	104 w	2/27/12	2/21/14	$13,013,000
250		Detailed Design YY	104 w	2/27/12	2/21/14	$1,357,000
251		P&S YY	52 w	2/24/14	2/20/15	$452,000
252		Construction YY	156 w	2/23/15	2/16/18	$61,334,000
253	**XX**	**North Lake Belt Storage Area (XX)**	**1269 w**	**2/27/12**	**6/20/36**	**$500,346,000**
254	**XX P1**	**North Lake Belt Storage Ph 1 (XX P1)**	**468 w**	**2/27/12**	**2/12/21**	**$250,173,000**
255		RE Acquisition XX P1	104 w	2/27/12	2/21/14	$77,434,000
256		Detailed Design XX P1	156 w	2/27/12	2/20/15	$3,928,000
257		P&S XX P1	52 w	2/23/15	2/19/16	$1,309,000
258		Construction XX P1	260 w	2/22/16	2/12/21	$167,502,000
259	**XX P2**	**North Lake Belt Storage Ph 2 (XX P2)**	**520.6 w**	**7/1/26**	**6/20/36**	**$250,173,000**
260		RE Acquisition XX P2	52 w	7/1/30	6/27/31	$77,434,000
261		Detailed Design XX P2	208 w	7/1/26	6/25/30	$3,928,000
262		P&S XX P2	52 w	6/26/30	6/24/31	$1,309,000
263		Construction XX P2	260 w	6/30/31	6/20/36	$167,502,000
264		**WCA CONNECTIVITY (SS, AA, QQ)**	**988 w**	**1/31/00**	**1/4/19**	**$211,687,000**
265		PIR SS, AA, QQ Ph 1, Decomp Components	104 w	1/31/00	1/25/02	$5,202,000
266	**SS**	**Reroute Miami Canal (SS)**	**364 w**	**1/28/02**	**1/16/09**	**$74,973,000**



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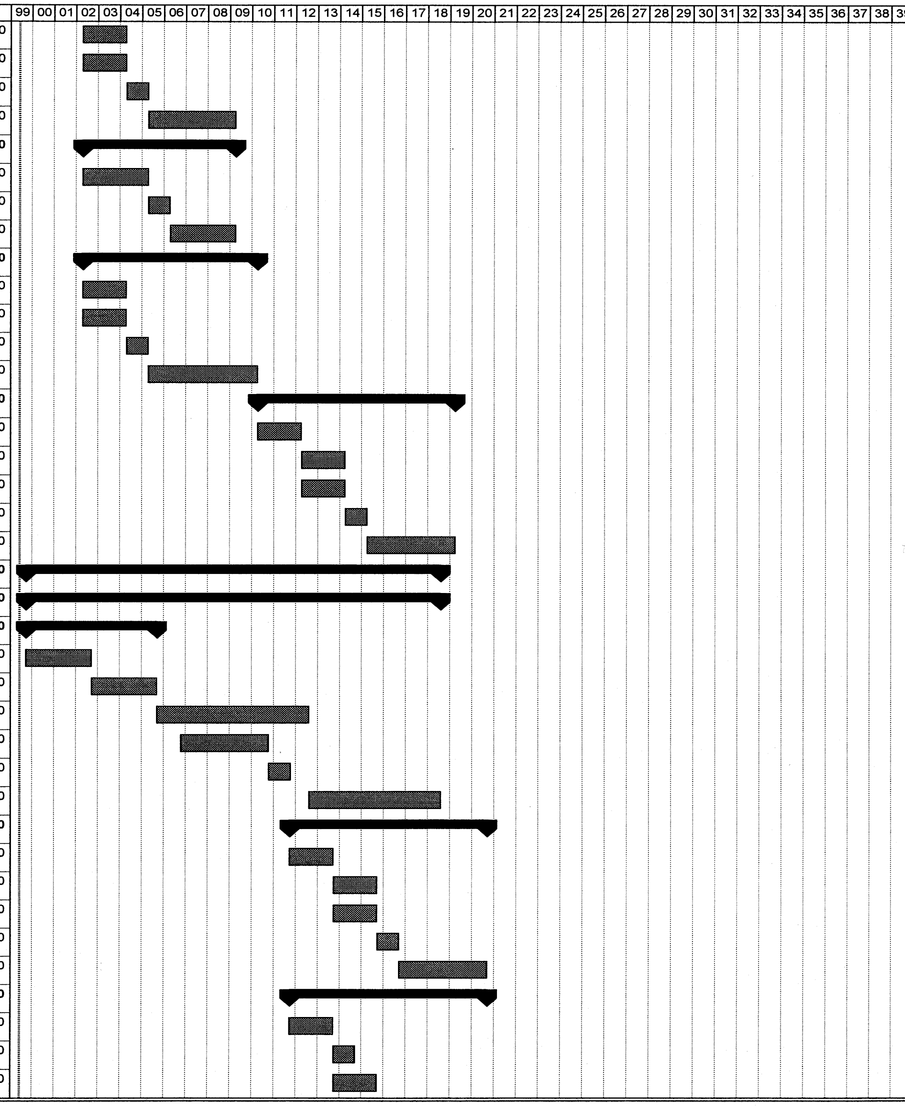
CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
267		RE Acquisition SS	104 w	1/28/02	1/23/04	$25,800,000
268		Detailed Design SS	104 w	1/28/02	1/23/04	$1,057,000
269		P&S SS	52 w	1/26/04	1/21/05	$352,000
270		Construction SS	208 w	1/24/05	1/16/09	$47,764,000
271	**AA**	**Additional S-345 Structures (AA)**	**364 w**	**1/28/02**	**1/16/09**	**$46,453,000**
272		Detailed Design AA	156 w	1/28/02	1/21/05	$999,000
273		P&S AA	52 w	1/24/05	1/20/06	$333,000
274		Construction AA	156 w	1/23/06	1/16/09	$45,121,000
275	**QQ P1**	**WCA-3 Decomp Ph 1 (QQ P1)**	**416 w**	**1/28/02**	**1/15/10**	**$25,855,000**
276		RE Acquisition QQ P1	104 w	1/28/02	1/23/04	$479,000
277		Detailed Design QQ P1	104 w	1/28/02	1/23/04	$545,000
278		P&S QQ P1	52 w	1/26/04	1/21/05	$182,000
279		Construction QQ P1	260 w	1/24/05	1/15/10	$24,649,000
280	**QQ P2**	**WCA-3 Decomp Ph 2 (QQ P2)**	**468 w**	**1/18/10**	**1/4/19**	**$59,204,000**
281		PIR QQ P2	104 w	1/18/10	1/13/12	$2,440,000
282		RE Acquisition QQ P2	104 w	1/16/12	1/10/14	$0
283		Detailed Design QQ P2	104 w	1/16/12	1/10/14	$1,220,000
284		P&S QQ P2	52 w	1/13/14	1/9/15	$407,000
285		Construction QQ P2	208 w	1/12/15	1/4/19	$55,137,000
286		**BISCAYNE BAY (FFF/OPE)**	**984 w**	**7/1/99**	**5/9/18**	**$299,583,000**
287	**FFF**	**Biscayne Bay Coastal Wetlands (FFF/OPE)**	**984 w**	**7/1/99**	**5/9/18**	**$299,583,000**
288	**OPE**	**PIR FFF, Biscayne Bay Coastal Wetlands OPE**	**312 w**	**7/1/99**	**6/22/05**	**$3,871,000**
289		Est. BB Perf Targets & Alt Sources	156 w	7/1/99	6/26/02	$100,000
290		PIR FFF, Biscayne Bay Coastal Wetlands OPE	156 w	6/27/02	6/22/05	$3,771,000
291		RE Acquisition FFF/OPE	360 w	6/23/05	5/16/12	$205,655,000
292		Detailed Design FFF/OPE	208 w	7/26/06	7/20/10	$1,936,000
293		P&S FFF/OPE	52 w	7/21/10	7/19/11	$645,000
294		Construction FFF/OPE	312 w	5/17/12	5/9/18	$87,476,000
295	**HHH**	**WEST MIAMI-DADE REUSE (HHH)**	**468 w**	**7/4/11**	**6/19/20**	**$437,237,000**
296		PIR HHH West Miami Dade Reuse	104 w	7/4/11	6/28/13	$17,972,000
297		RE Acquisition HHH	104 w	7/1/13	6/26/15	$3,540,000
298		Detailed Design HHH	104 w	7/1/13	6/26/15	$8,986,000
299		P&S HHH	52 w	6/29/15	6/24/16	$2,995,000
300		Construction HHH	208 w	6/27/16	6/19/20	$403,744,000
301	**BBB**	**SOUTH MIAMI-DADE REUSE (BBB)**	**468 w**	**7/4/11**	**6/19/20**	**$363,024,000**
302		PIR BBB	104 w	7/4/11	6/28/13	$14,827,000
303		RE Acquisition BBB	52 w	7/1/13	6/27/14	$3,324,000
304		Detailed Design BBB	104 w	7/1/13	6/26/15	$7,413,000



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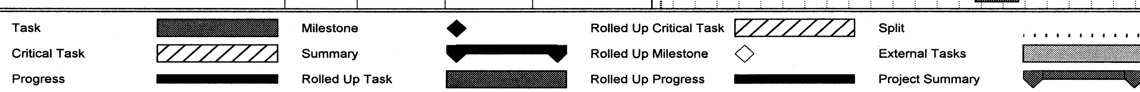

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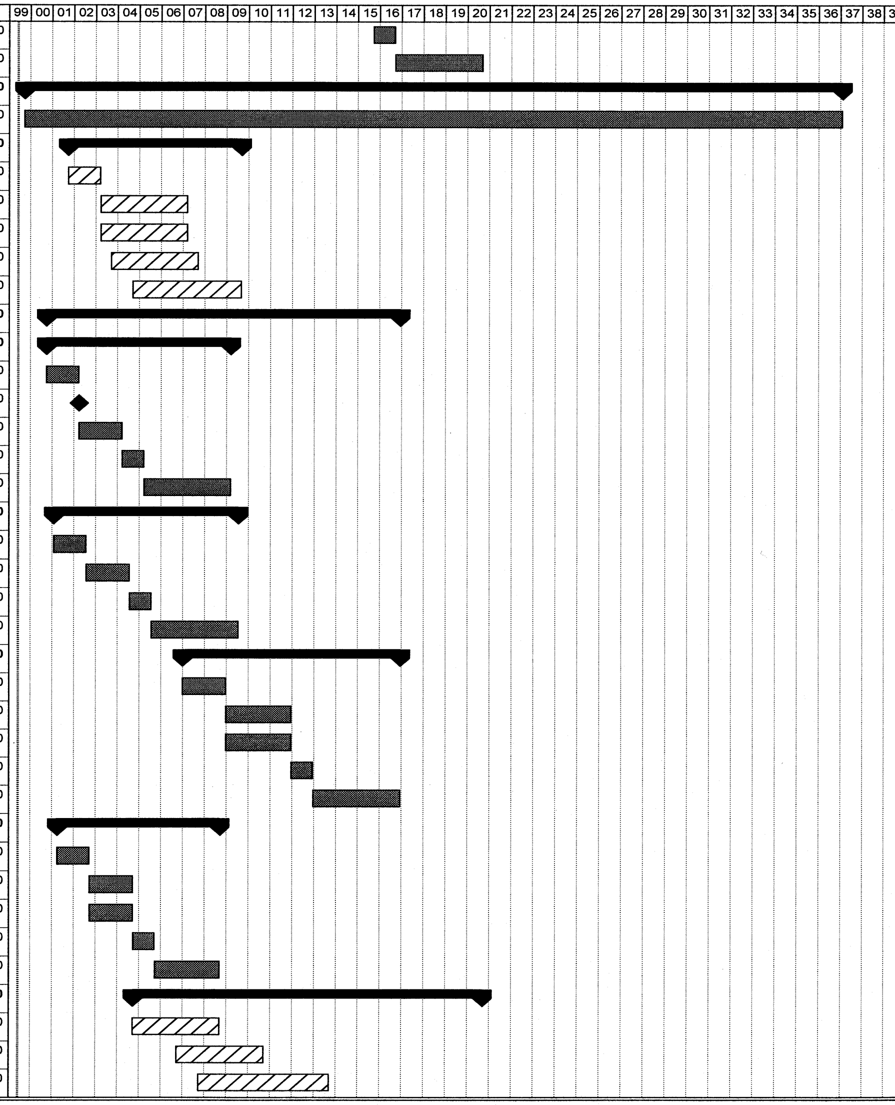
CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

ID	Cmpt	Task Name	Dur	Sch Start	Sch Finish	Estimated Cost
305		P&S BBB	52 w	6/29/15	6/24/16	$2,471,000
306		Construction BBB	208 w	6/27/16	6/19/20	$334,989,000
307		**LEC SERVICE AREAS**	**1950 w**	**7/1/99**	**11/12/36**	**$12,898,000**
308	**AAA**	**Initiate LEC Water Conservation (AAA)**	1950 w	7/1/99	11/12/36	$0
309	**CC**	**Broward County Secondary Canals (CC)**	**415 w**	**7/2/01**	**6/12/09**	**$12,898,000**
310		PIR CC (phased)	78 w	7/2/01	12/27/02	$453,000
311		RE Acquisition CC	208 w	12/30/02	12/22/06	$1,920,000
312		Detailed Design CC	208 w	12/30/02	12/22/06	$226,000
313		P&S CC	208 w	6/26/03	6/20/07	$75,000
314		Construction CC	260 w	6/21/04	6/12/09	$10,224,000
315		**WESTERN BASIN IMPROVEMENTS**	**846 w**	**7/3/00**	**9/16/16**	**$163,237,000**
316	**CP**	**Miccosukee Water Management Plan**	**442 w**	**7/3/00**	**12/19/08**	**$24,459,000**
317		PIR Miccosukee Water Management Plan	78 w	7/3/00	12/28/01	$937,000
318		RE Miccosukee Water Management Plan	0 w	12/28/01	12/28/01	$1,718,000
319		Detailed Design Miccosukee Water Management Plan	104 w	12/31/01	12/26/03	$469,000
320		P&S Miccosukee Water Management Plan	52 w	12/29/03	12/24/04	$156,000
321		Construction Miccosukee Water Mangement Plan	208 w	12/27/04	12/19/08	$21,179,000
322	**RR**	**Flows to NW & Central WCA 3A (RR)**	**442 w**	**11/2/00**	**4/22/09**	**$20,739,000**
323		PIR RR	78 w	11/2/00	5/1/02	$855,000
324		Detailed Design RR	104 w	5/2/02	4/28/04	$427,000
325		P&S RR	52 w	4/29/04	4/27/05	$142,000
326		Construction RR	208 w	4/28/05	4/22/09	$19,315,000
327	**CCC**	**Big Cypress / L-28 interceptor (CCC)**	**520 w**	**10/2/06**	**9/16/16**	**$42,751,000**
328		PIR CCC	104 w	10/2/06	9/26/08	$1,486,000
329		RE Acquisition CCC	156 w	9/29/08	9/23/11	$6,700,000
330		Detailed Design CCC	156 w	9/29/08	9/23/11	$743,000
331		P&S CCC	52 w	9/26/11	9/21/12	$248,000
332		Construction CCC	208 w	9/24/12	9/16/16	$33,574,000
333	**OPE**	**Seminole Water Conservation Plans (East & West)**	**390 w**	**1/1/01**	**6/20/08**	**$75,288,000**
334	CP	PIR Seminole Water Conservation Plan	78 w	1/1/01	6/28/02	$2,867,000
335		RE Seminole Water Conservation Plan	104 w	7/1/02	6/25/04	$5,735,000
336		Detailed Design Seminole Plan	104 w	7/1/02	6/25/04	$1,433,000
337		P&S Seminole Plan	52 w	6/28/04	6/24/05	$478,000
338		Construction Seminole Plan	156 w	6/27/05	6/20/08	$64,775,000
339	**GG**	**Lake Okeechobee ASR (GG) phased**	**834 w**	**6/24/04**	**6/17/20**	**$1,097,312,000**
340		PIR GG (multiple & phased)	208 w	6/24/04	6/18/08	$45,705,000
341		RE Acquisition GG (phased)	208 w	7/3/06	6/25/10	$7,515,000
342		Detailed Design GG (phased)	312 w	7/3/07	6/24/13	$22,852,000



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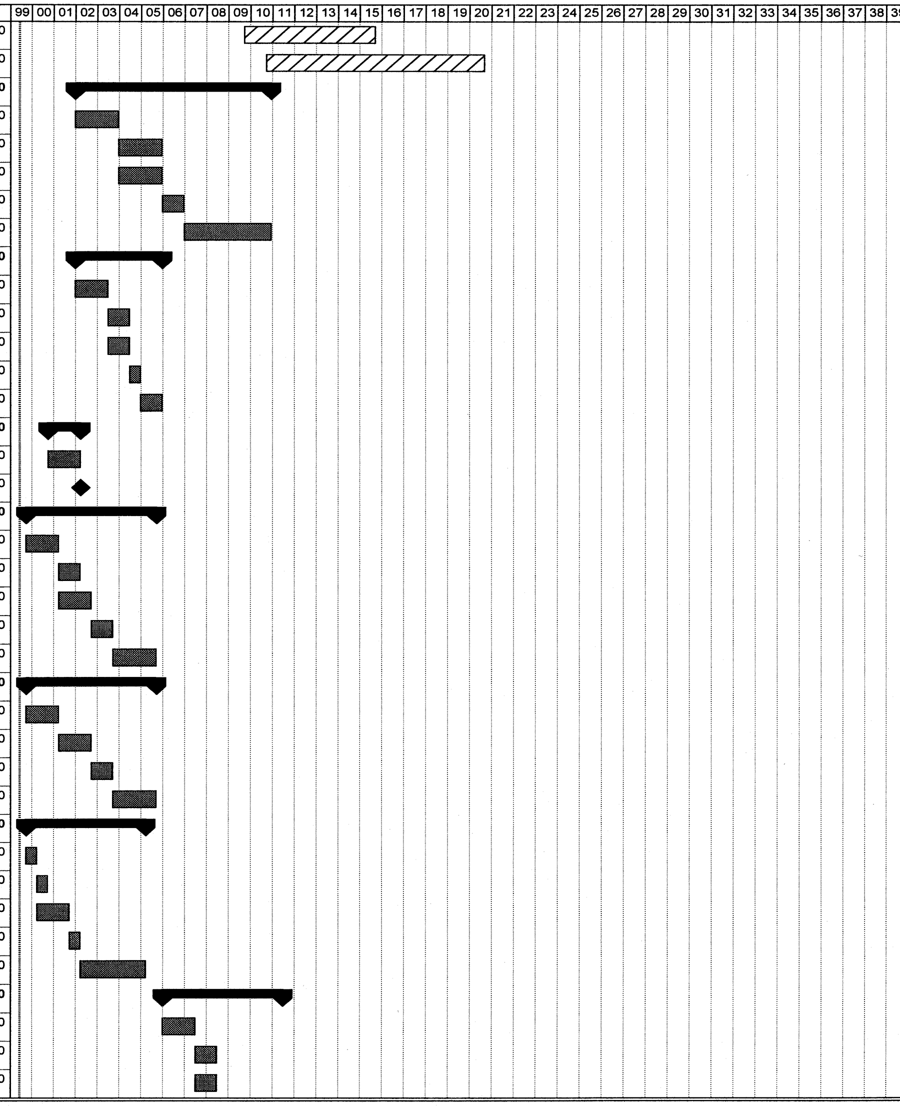
343		P&S GG (phased)	312 w	7/1/09	6/23/15	$7,617,000
344		Construction GG (phased)	520 w	7/1/10	6/17/20	$1,013,623,000
345	OPE	**LO Water Quality Treatment Facility**	**468 w**	**10/1/01**	**9/17/10**	**$62,247,000**
346		PIR LOWQTF	104 w	10/1/01	9/26/03	$1,970,000
347		RE Acquisition LOWQTF	104 w	9/29/03	9/23/05	$14,448,000
348		Detail Design LOWQTF	104 w	9/29/03	9/23/05	$985,000
349		P&S LOWQTF	52 w	9/26/05	9/22/06	$328,000
350		Construction LOWQTF	208 w	9/25/06	9/17/10	$44,516,000
351	OPE	**LO Tributary Dredging & Water Retention Ph Removal**	**208 w**	**10/2/01**	**9/26/05**	**$4,700,000**
352		PIR LO Trib. Dredging	78 w	10/2/01	3/31/03	$157,000
353		RE Acquisition LO Trib Dredging	52 w	4/1/03	3/29/04	$900,000
354		Detail Design LO Tributary Derdging	52 w	4/1/03	3/29/04	$78,000
355		P&S LO Tributary Dredging	26 w	3/30/04	9/27/04	$26,000
356		Construction LO Tributary Dredging	52 w	9/28/04	9/26/05	$3,539,000
357	CP	**Lake Istakpoga Regulation Schedule**	**78 w**	**7/3/00**	**12/28/01**	**$50,000**
358		Regulation Schedule Report	78 w	7/3/00	12/28/01	$50,000
359		Implement New Schedule	0 w	12/28/01	12/28/01	$0
360	CP	**Southern Golden Gates Estates Hydrologic Restoration**	**312 w**	**7/1/99**	**6/22/05**	**$45,654,000**
361		PIR Southern Golden Gates Restoration	78 w	7/1/99	12/27/00	$641,000
362		RE Acquisition Southern Golden Gates Restoration	52 w	12/28/00	12/26/01	$30,104,000
363		Detailed Design Southern Golden Gates Restoration	78 w	12/28/00	6/26/02	$320,000
364		P&S Southern Golden Gates Restoration	52 w	6/27/02	6/25/03	$107,000
365		Construction Southern Golden Gates Restoration	104 w	6/26/03	6/22/05	$14,482,000
366	CP	**Southern CREW Project Add'l Imperial River Flowway**	**312 w**	**7/1/99**	**6/22/05**	**$3,435,000**
367		PIR Southern CREW	78 w	7/1/99	12/27/00	$142,000
368		Detailed Design Southern CREW	78 w	12/28/00	6/26/02	$71,000
369		P&S Southern CREW	52 w	6/27/02	6/25/03	$24,000
370		Construction Southern CREW	104 w	6/26/03	6/22/05	$3,198,000
371	CP	**Lake Trafford Restoration**	**286 w**	**7/1/99**	**12/22/04**	**$15,408,000**
372		PIR Lake Trafford Restoration	26 w	7/1/99	12/29/99	$604,000
373		RE Acquisition Lake Trafford Restoration	26 w	12/30/99	6/28/00	$744,000
374		Detailed Design Lake Trafford Restoration	78 w	12/30/99	6/27/01	$302,000
375		P&S Lake Trafford Restoration	26 w	6/28/01	12/26/01	$101,000
376		Construction Lake Trafford Restoration	156 w	12/27/01	12/22/04	$13,657,000
377	OPE	**Lake Worth Lagoon Restoration**	**286 w**	**10/4/05**	**3/28/11**	**$2,300,000**
378		PIR Lake Worth Lagoon Restoration	78 w	10/4/05	4/2/07	$82,000
379		RE Acquisition LW Lagoon Restoration	52 w	4/3/07	3/31/08	$300,000
380		Detail Design LW Lagoon Restoration	52 w	4/3/07	3/31/08	$41,000



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CENTRAL AND SOUTHERN FLORIDA PROJECT COMPREHENSIVE REVIEW

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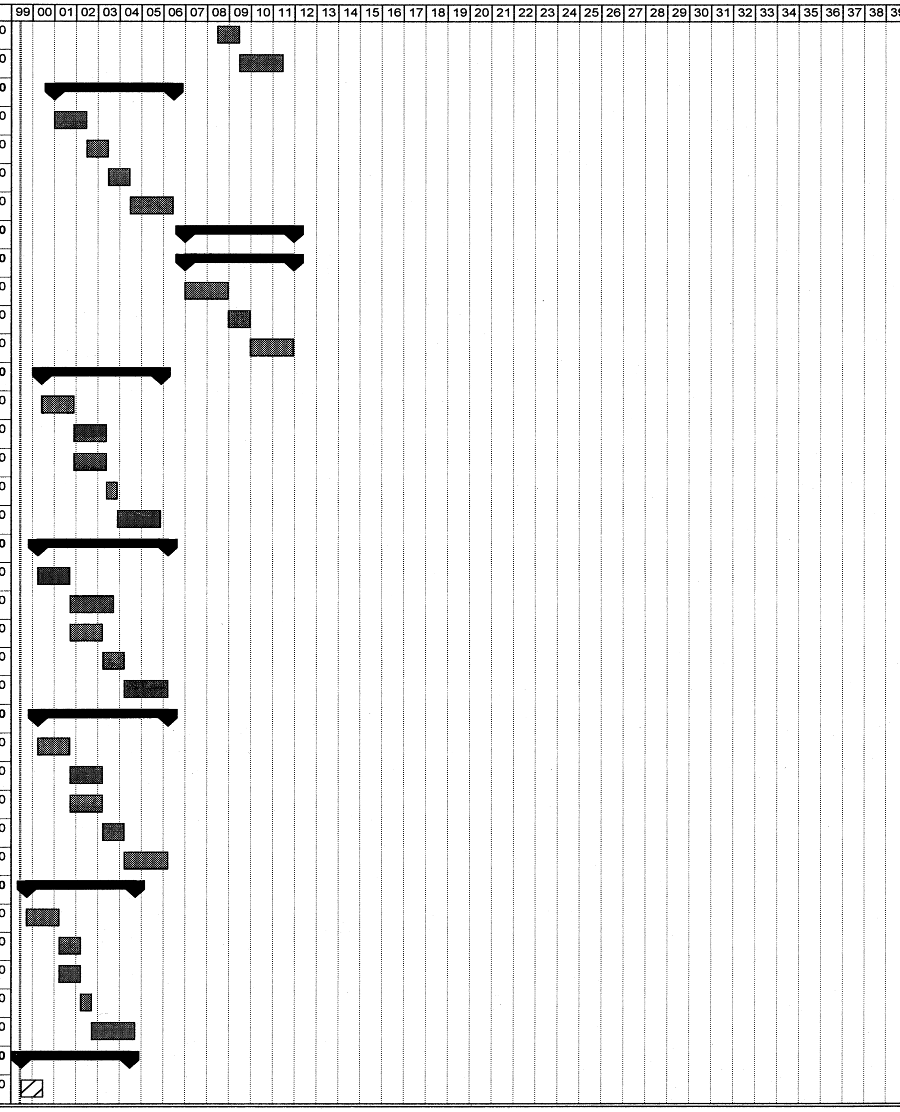
381		P&S LW Lagoon Restoration	52 w	4/1/08	3/30/09	$14,000
382		Construction LW Lagoon Restoration	104 w	3/31/09	3/28/11	$1,863,000
383	OPE	**Pineland Hardwood Restoration**	**286 w**	**10/2/00**	**3/24/06**	**$600,000**
384		PIR Pineland/Hardwood Restoration	78 w	10/2/00	3/29/02	$25,000
385		Detail Design Pineland/Hardwood Restoration	52 w	4/1/02	3/28/03	$12,000
386		P&S Pineland Hardwood Restoration	52 w	3/31/03	3/26/04	$4,000
387		Construction Pineland/Hardwood Restoration	104 w	3/29/04	3/24/06	$559,000
388	OPE	**Melaleuca & Other Exotoc Plants**	**260 w**	**10/2/06**	**9/23/11**	**$5,772,000**
389		**Retrofit Existing Melaleuca Quarintine Facility**	**260 w**	**10/2/06**	**9/23/11**	**$5,772,000**
390		Detailed Design Mel. Retro QF OPE	104 w	10/2/06	9/26/08	$357,000
391		P&S Mel Retro QF OPE	52 w	9/29/08	9/25/09	$40,000
392		Construction Mel. Retro QF OPE	104 w	9/28/09	9/23/11	$5,375,000
393	CP	**Florida Keys Tidal Restoration**	**286 w**	**3/6/00**	**8/26/05**	**$1,251,000**
394		PIR Florida Keys Tidal Restoration	78 w	3/6/00	8/31/01	$49,000
395		RE Acquisition Florida Keys Tidal Restoration	78 w	9/3/01	2/28/03	$51,000
396		Detailed Design Florida Keys Tidal Restoration	78 w	9/3/01	2/28/03	$25,000
397		P & S Florida Keys Tidal Restoration	26 w	3/3/03	8/29/03	$8,000
398		Construction Florida Keys Tidal Restoration	104 w	9/1/03	8/26/05	$1,118,000
399	CP	**Henderson Creek/Belle Meade Restoration**	**312 w**	**1/3/00**	**12/23/05**	**$4,806,000**
400		PIR Henderson Creek/Belle Meade Restoration	78 w	1/3/00	6/29/01	$156,000
401		RE Acquisition Henderson Creek/Belle Meade Restoration	104 w	7/2/01	6/27/03	$1,029,000
402		Detailed Design Henderson Creek/Belle Meade Restoration	78 w	7/2/01	12/27/02	$78,000
403		P & S Henderson Creek/Belle Meade Restoration	52 w	12/30/02	12/26/03	$26,000
404		Construction Henderson Creek/Belle Meade Restoration	104 w	12/29/03	12/23/05	$3,517,000
405	CP	**Winsburg Farms Wetlands**	**312 w**	**1/3/00**	**12/23/05**	**$14,140,000**
406		PIR Winsburg Farms Wetlands	78 w	1/3/00	6/29/01	$412,000
407		RE Acquisition Winsburg Farms Wetlands	78 w	7/2/01	12/27/02	$4,140,000
408		Detailed Design Winsburg Farms Wetlands	78 w	7/2/01	12/27/02	$206,000
409		P & S Winsburg Farms Wetlands	52 w	12/30/02	12/26/03	$69,000
410		Construction Winsburg Farms Wetlands	104 w	12/29/03	12/23/05	$9,313,000
411	CP	**Lake Park Restoration**	**260 w**	**7/1/99**	**6/23/04**	**$5,166,000**
412		PIR Lake Park Restoration	78 w	7/1/99	12/27/00	$206,000
413		RE Acquisition Lake Park Restoration	52 w	12/28/00	12/26/01	$166,000
414		Detailed Design Lake Park Restoration	52 w	12/28/00	12/26/01	$103,000
415		P & S Lake Park Restoration	26 w	12/27/01	6/26/02	$34,000
416		Construction Lake Park Restoration	104 w	6/27/02	6/23/04	$4,657,000
417		**SOUTHWEST FLORIDA FEASIBILITY STUDY**	**260 w**	**4/1/99**	**3/24/04**	**$8,100,000**
418		Recon Study	52 w	4/1/99	3/29/00	$100,000



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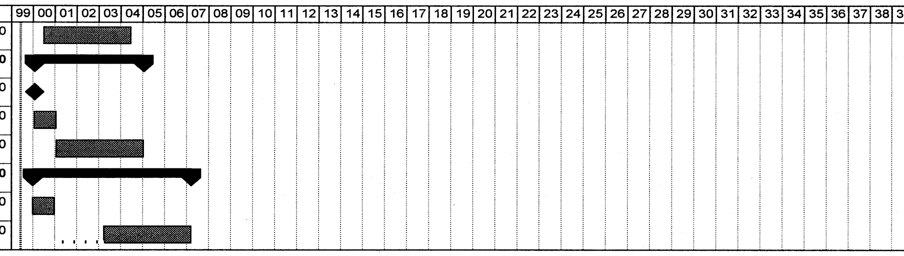
419		Feasibility Study	208 w	3/30/00	3/24/04	$8,000,000
420		**FLORIDA BAY FEASIBILITY STUDY**	**260 w**	**10/29/99**	**10/22/04**	**$4,100,000**
421		Complete Circulation & WQ Modeling	0 w	10/29/99	10/29/99	$0
422		Recon Study	52 w	11/1/99	10/27/00	$100,000
423		Feasibility Study	208 w	10/30/00	10/22/04	$4,000,000
424		**COMPREHENSIVE ECOSYSTEM WQ IMPROVEMENT STUDY**	**377.2 w**	**10/1/99**	**12/22/06**	**$8,100,000**
425		Recon Study	52 w	10/1/99	9/28/00	$100,000
426		Feasibility Study	208 w	9/29/00	12/22/06	$8,000,000



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APPENDIX N

COMMENTS AND RESPONSES

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APPENDIX N
COMMENTS AND RESPONSES

The Central and Southern Florida Project Comprehensive Review Study Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement (Draft Report) was released to the public in October 1998. The report was released in a 9 volume printed set, in viewable format on CD, and as downloadable files from the Restudy web page (www.restudy.org). Notification of the report's availability was provided in the Federal Register on 23 October 1998. A period of time was set aside in accordance with the National Environmental Policy Act (NEPA) to provide all interested parties an opportunity to comment on the contents of the Draft Report. The comment period was open between 23 October 1998 and 31 December 1998.

During the comment period a number of public meetings were held in south Florida for all interested parities. The public meetings provided an opportunity for the public to become familiar with the major concepts associated with the Draft Report through review of displays and interaction with Restudy Team members. The public meetings included a forum for interested individuals to make public comment to the attending audience and the Restudy Team. Detailed information regarding these public meetings is available in Section 11 of this report.

In addition, written comments were received in response to the Draft Report. This Appendix is a compilation of the written comments and the responses to them.

Comment letters were received from Federal, state, and local governments, native American tribes, various non-governmental organizations, and individuals. The comments were summarized and categorized into the following groups: plan formulation, water quantity and modeling, ecological, compliance with NEPA and other relevant policies, socio-economics, real estate, water quality, plan implementation and monitoring, authorization/funding, and public outreach. In this appendix, each category of comments is presented in a comment/response format where the comment is paired with its response and includes a number for tracking purposes. Many comments received were similar in nature and have been answered with a single response.

The letters received during the Draft Report comment period are listed in the following ***Section N.1***. The list of letters includes the following information for each letter received: the author; group or organization represented; author's address; the date of the letter; and a list of comment numbers. The comment numbers correspond to the categories of comments outlined above.

It should be noted that a number of letters were received that did not require a specific response. This group of letters included form letters and general letters of support for the recommended plan outlined in the Draft Report. Further, some comments received were editorial in nature, recommending specific text changes to the report. These comments have been considered and incorporated in the report, as appropriate.

N.1 LETTERS RECEIVED DURING THE COMMENT PERIOD

More than 350 letters, faxes, and e-mailed comments were received during the draft report comment period. Many of these letters were quite lengthy and had specific comments regarding the effects of the recommended Comprehensive Plan. Others were more general in nature. Many offered support for the recommended plan. Others were less supportive and more critical of the recommended plan.

N.1.1 Federal Agencies

Miccosukee Tribe of Indians of Florida
P.O. Box 440021
Tamiami Station
Miami, FL 33144
December 30, 1998

The Miccosukee Tribe of Indians of Florida had the following comments: 48,188,366,439, 440 – 443 and 476 – 478.

Program Management Committee
Florida Bay and Adjacent Marine Systems
Attn: John Hunt and Tom Armentano
Florida Bay Interagency Science Office
98630 Overseas Highway
Key Largo, FL 33037
December 1, 1998

The Florida Bay and Adjacent Marine Systems had the following comments: 193 - 195, 227 – 229 and 271 – 273.

Seminole Tribe of Florida
Lewis, Longman & Walker
1700 Palm Beach Lakes Blvd
Suite 1000
West Palm Beach, Fl 33401
December 30, 1998

Lewis, Longman & Walker, representing the Seminole Tribe of Florida had the following comments: 112 – 116, 159 –161, 290, 357, 465, 511, 512, 515, 565 and 567.

U.S. Department of Commerce
Office of the Under Secretary for Oceans and Atmosphere
Washington, DC 20230
December 30, 1998

The U.S. Department of Commerce, Office of the Under Secretary for Oceans and Atmosphere had the following comments: 42, 108, 308, 469 and 515.

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, FL 33702
December 24, 1998

The National Marine Fisheries Service, Southeast Regional Office had the following comment: 42.

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Florida Keys National Marine Sanctuary
P.O. Box 500368
Marathon, FL 33050
December 29, 1998

The Florida Keys National Marine Sanctuary had the following comments: 42 and 308.

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, FL 33149
December 29, 1998

The National Marine Fisheries Service, Southeast Fisheries Science Center had the following comments: 35, 42, 69, 77, 108, 120, 191, 192, 226, 266, 468, 514, 527 and 541.

U.S. Department of Health & Human Services
Centers for Disease Control and Prevention (CDC)
National Center for Environmental Health
Atlanta, GA 30341-3724
November 24, 1998

The U.S. Public Health Service concurs that the beneficial effects of the Comprehensive Plan outweights any adverse effects that may occur.

U.S. Department of the Interior
Office of the Secretary
Office of Environmental Policy and Compliance
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
December 23, 1998

The U.S. Department of the Interior had the following comments: 64, 65, 141, 213, 242, 243, 270, 302, 303, 333, 410 and 411.

U.S. Department of Interior
National Park Service
Everglades National Park
40001 State Road 9336
Homestead, FL 33034-6733
December 31, 1998

The Everglades National Park had the following comments: 7, 46, 77, 92, 93, 94, 95, 151, 168, 177, 189, 202, 211, 227, 252-265, 312, 351, 383 – 386 and 495.

United States Environmental Protection Agency
Region 4, Atlanta Federal Center
61 Forsyth Street
Atlanta, GA 30303-8960
December 30, 1998

The United States Environmental Protection Agency, Region 4, had the following comments: 40 –49, 153, 160, 225, 226, 266, 297 – 300, 429 – 433, 453, 479, 481, 486, 527 and 539.

N.1.2 State Agencies

Florida Department of Agriculture & Consumer Services
Bob Crawford, Commissioner
The Capitol
Tallahassee, FL 32399-0800
December 7, 1998 and December 29, 1998

The Florida Department of Agriculture & Consumer Services had the following comments: 58, 71, 500, 501, 507, 559, 568 and 569.

Florida Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
December 14, 1998 and December 30, 1998

The Florida Department of Community Affairs had the following comments: 3, 59,60 and 557

Florida Department of Environmental Protection
Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, FL 32399-3000
December 11, 1998

The Florida Department of Environmental Protection had the following comments: 40, 42, 45 – 47, 57, 104, 105, 160, 366, 445 - 451, 458, 479, 480 - 482, 487 and 514.

Florida Department of Transportation
605 Suwannee Street
Tallahassee, FL 32399-0450
December 14, 1998

The Florida Department of Transportation had the following comments: 1 and 2

Florida Game and Fresh Water Fish Commission
Office of Environmental Services
Farris Bryant Building
620 South Meridian Street
Tallahassee, FL 32399-1600
December 14, 1998

The Florida Game and Fresh Water Fish Commission had the following comments: 56, 57, 142 – 146, 149, 170, 196, 223, 270, 283 –287, 336 – 342, 409 and 501.

Office of Tourism, Trade, and Economic Development
The Capital
Tallahassee, FL 32399-0001
December 17, 1998

The Office of Tourism, Trade, and Economic Development pointed out that the Comprehensive Plan is consistent with Chapter 288, Florida Statutes, which directs the State to provide guidance and promotion of beneficial development through encouraging diversification and promoting tourism. Further, they state that the Comprehensive Plan appears to have no unreasonable negative impacts on income and employment nor adverse effects to any key Florida industry which will not be justly mitigated, and the Restudy project demonstrates official local agency support. Moreover, the proposed project would achieve the goals of Chapter 288 by developing a long range master plan for south Florida's water resources which would contribute to economic diversification.

South Florida Water Management District
Samuel E. Poole III
Executive Director
3301 Gun Club Road
West Palm Beach, FL 33406
December 28, 1998

The South Florida Water Management District is the co-author of this report. A Letter of Intent, is included in Appendix G that describes their views of the Comprehensive Plan.

Southwest Florida Water Management District
2379 Broad St
Brooksville, FL 34609-6899
November 6, 1998

The Southwest Florida Water Management District stated that the Comprehensive Plan is consistent with their mission.

N.1.3 Regional, County Governments and Agencies

Broward County
Department of Natural Resource Protection
218 S.W. 1st Avenue
Fort Lauderdale, FL 33301
November 12, 1998 and December 21, 1998

The Broward County Department of Natural Resource Protection had the following comments: 13, 124, 125, 207, 208, 275, 364, 365, 507 and 520.

Charlotte County Board of County Commissioners
18500 Murdock Circle
Port Charlotte, FL 33948
December 31, 1998

The Charlotte County Board of County Commissioners had the following comments: 147 and 163.

County of Monroe
530 Whitehead Street
Key West, FL 33040
December 15, 1998

The County of Monroe supports a strong plan to restore the Everglades and states that ridding south Florida of the pollutants in our watershed is essential.

Dade County Farm Bureau
1850 Old Dixie Highway
Homestead, FL 33033
December 29, 1998

The Dade County Farm Bureau had the following comments: 132, 204, 321, 546, 547 and 571.

Glades County Board of County Commissioners
P.O. Box 1018
Moore Haven, FL 33471
December 30, 1998

The Glades County Board of County Commissioners had the following comments: 328, 466 and 542.

Hendry County Board of County Commissioners
P.O. Box 1760
Labelle, FL 33975
December 3, 1998

The Hendry County Board of County Commissioners had the following comments: 12, 13, 40, 97, 171, 316 – 318 and 563.

Highlands County Board of County Commissioners
P.O. Box 1926
Sebring, FL 33871-1926
December 29, 1998

The Highlands County Board of County Commissioners had the following comments: 8, 40, 50, 51, 53, 152, 180, 292 and 376.

Lee County Board of County Commissioners
P.O. Box 398
Ft. Myers. FL 33902-0398
November 25, 1998 and November 30, 1998

The Lee County Board of County Commissioners had the following comments: 20, 66, 164, 165, 166, 354, 378, 379, 506, 507 and 561.

Martin County Board of County Commissioners
2401 SE Monterey Road
Stuart, FL 34996
December 29, 1998

The Martin County Board of County Commissioners had the following comments: 375, 487 and 551.

Metropolitan Dade County
Office of County Manager
Suite 2910
111 N.W. 1st Street
Miami-Dade, FL 331218-1994
November 13, 1998

The Metropolitan Dade County had the following comments: 69, 120, 126 – 131, 166, 205, 206, 266, 516-519, 526, 548 and 549.

South Florida Regional Planning Council
3440 Hollywood Boulevard, Suite 140
Hollywood, FL 33021
December 15, 1998

The South Florida Regional Planning Council had the following comments: 160 and 360.

Southwest Florida Regional Planning Council
P.O. Box 3455
N. Ft. Myers, FL 33918-3455
December 23, 1998

The Southwest Florida Regional Planning Council had the following comments: 147, 149, 160, 169 – 174, 205, 322 –326, 504 and 505.

St. Lucie County Board of County Commissioners
Barnes, Cliff
2300 Virginia Avenue
Fort Pierce, FL 34982-5652
December 30, 1998

Mr. Cliff Barnes of the St. Lucie County Board of County Commissioners had the following comments: 487 and 551.

St. Lucie County Board of County Commissioners
Bruhn, John D.
2300 Virginia Avenue
Fort Pierce, FL 34982-5652
December 30, 1998

Mr. John D. Bruhn of the St. Lucie County Board of County Commissioners had the following comments: 487 and 551.

St. Lucie County Board of County Commissioners
Coward, Doug
2300 Virginia Avenue
Fort Pierce, FL 34982-5652
December 30, 1998

Mr. Doug Coward of the St. Lucie County Board of County Commissioners had the following comments: 487 and 551.

St. Lucie County Board of County Commissioners
Hutchinson, Frannie
2300 Virginia Avenue
Fort Pierce, FL 34982-5652
December 30, 1998

Ms. Frannie Hutchinson of the St. Lucie County Board of County Commissioners had the following comments: 487 and 551.

St. Lucie County Board of County Commissioners
Lewis, Paula A.
2300 Virginia Avenue
Fort Pierce, FL 34982-5652
December 30, 1998

Ms. Paula A. Lewis of the St. Lucie County Board of County Commissioners had the following comments: 487 and 551.

Tampa Bay Regional Planning Council
9455 Koger Boulevard, Suite 219
St. Petersburg, FL 33702-2491
November 5, 1998

Tampa Bay Regional Planning Council had no specific comments.

Treasure Coast Regional Planning Council
301 East Ocean Boulevard, Suite 300
Stuart, FL 34994
December 8, 1998

The Treasure Coast Regional Planning Council had the following comments: 490, 552, 554 and 555.

N.1.4 Local Governments

City of Cooper City, Florida
City Commission
P.O. Box 290910
Cooper City, FL 33329-0910
November 10, 1998

The City Commission supports the goals of the Restudy.

City of Ft. Myers
Planning Dept.
P.O. Drawer 2217
Ft. Myers, FL 33902-2217
January 13, 1999

The City of Ft. Myers Planning Department had the following comments: 381 and 513.

City of Hollywood
P.O. Box 229045
Hollywood, FL 33022-9045
December 2, 1998

The City of Hollywood had the following comments: 13, 160, 364 – 366, 368, 521 and 570.

City of Key West
P.O. Box 1409
Key West, FL 33041-1409
305-292-8193
December 7, 1998

Josephine Parker, City Clerk for the City of Key West had the following comment: 42.

City of Layton
Larry Braun, Vice Mayor
P. O. Box 533
Long Key, Florida 33001
Resolution Number: 98-12-01
December 11, 1998

The City of Layton had the following comment*:* 42.

City of Naples, Florida
735 Eighth St. South
Naples, Fl 34102
December 28, 1998

The City of Naples, Florida supports the Comprehensive Plan and in particular, the proposed Southwest Florida Feasibility Study.

Cypress Grove Community Development District
P.O. Box 1057
Loxahatchee, FL 33470-1057
November 10, 1998

The Cypress Grove Community Development District had the following comments: 119, 197 and 198.

Islamorada, Village of Islands
88500 Overseas Hwy. #509
Islamorada, FL 33070
November 15, 1998

Mr. George Giesler, Councilman for Islamorada, Village of Islands, had the following comment: 42.

Village of Wellington
Carmine A. Priore, D.D.S., Mayor
14000 Greenbriar Boulevard
Wellington, FL 33414
December 28, 1998

The Village strongly supports the Restudy in general and urges the Corps to include the Acme Basin B Discharge OPE in the final plan.

N.1.5 Non-Governmental Organizations

Biodiversity Legal Foundation
P.O. Box 1359
Buxton, NC 27920
December 31, 1998

The Biodiversity Legal Foundation had the following comments: 4,5,7,89,106 – 108, 110, 111, 154, 160, 189, 190, 231 – 235, 276, 278, 304, 305, 346, 366, 434 – 437, 459, 483, 484, 497, 508, 527 and 540.

Building Industry Association of South Florida
15225 NW 77 Avenue
Miami Lakes, FL 33014-6895
December 28, 1998

The Building Industry Association of South Florida had the following comments: 355, 556 and 557.

Chamber South
6410 SW 80th Street
Miami, FL 33143
December 29, 1998

Chamber South passed a resolution in support of the Everglades Restudy.

Collier County Audubon
P.O. Box 11387
Naples,FL 34101-1387
December 14, 1998

Collier County Audubon had the following comments: 99, 160 and 330.

Collier County Citizens for Constitutional Property Rights
1221 Cypress Drive
Naples, FL 34120
November 30, 1998

The Collier County Citizens for Constitutional Property Rights had the following comment: 352.

Divers Alert Network
The Peter B. Bennett Center
6 West Colony Place
Durham, NC 27705 USA
December 10, 1998

The Divers Alert Network had the following comments: 42, 134, 160, 362 and 391.

Environmental Economics Council
C/O NAS, 444 Brickell Ave, Suite 850
Miami, FL 33131
December 23, 1998

The Environmental Economics Council had the following comments: 20, 148, 166, 168, 176, 180, 182, 183, 266 and 462.

Everglades Restoration Oversight Group
93351 Overseas Highway, #3
Tavernier, FL 33070
December 28, 1998

The Everglades Restoration Oversight Group had the following comments: A32 and 485.

Florida Audubon Society
1331 Palmetto Avenue
Suite 110
Winter Park, FL 32789
December 30, 1998

The Florida Audubon Society had the following comments: 38, 160, 199 and 202.

Florida Biodiversity Project
1060 Tyler Street
Hollywood, FL 33019
December 28, 1998

Florida Biodiversity Project had the following comments: 4-9, 154, 162, 168, 178, 305, 307, 497 and 564.

Florida Citrus Mutual
P.O. Box 89
Lakeland, FL 33802
December 23, 1998

Florida Citrus Mutual had the following comments: 148 and 355.

Florida Farm Bureau Federation
P.O. Box 147030
Gainesville, FL 32614-7030
December 8, 1998

The Florida Farm Bureau Federation had the following comments: 58, 354, 355, 507, 562 and 563.

Florida Fruit & Vegetable Association
4401 Colonial Drive
P.O. Box 140155
Orlando, FL 32814
December 21, 1998

The Florida Fruit & Vegetable Association had the following comments: 58, 148 and 503.

Florida League of Anglers, Inc.
P.O. Box 1109
Sanibel, FL 33957
December 15, 1998

The Florida League of Anglers, Inc. is no longer a lead organization in conservation and has asked their members to work with and support other conservation organizations in this regard.

Florida Power & Light
Environmental Services Department
P.O. Box 14000
Juno Beach, FL 33408
December 18, 1998

Florida Power and Light had the following comments: 355, 356, 496, 498, 499, 507 and 542.

Florida Water Council
4524 W. Gun Club Road
Suite 203
West Palm Beach, FL 33415
December 1, 1998

The Florida Water Council had the following comments: 67-71, 160, 329, 380, 507 – 510 and 558 – 560.

Fulltrack Conservation Club of Miami-Dade County
email from Jack Moller
LJMoller@aol.com
December 1, 1998

The Fulltrack Conservation Club of Miami-Dade County had the following comment: 98.

Greater Miami Chamber of Commerce
Omni International Complex
1601 Biscayne Boulevard
Miami, FL 33132
December 29, 1998

The Greater Miami Chamber of Commerce had the following comments: 121, 122, 266, 470, 526 and 542.

Highlands Soil and Water Conservation District
4505 George Blvd
Sebring, FL 33872-5837
December 31, 1998

The Highlands Soil and Water Conservation District had the following comments: 8, 40, 50 – 53, 152, 268, 282, 292 – 295, 444, 452.

League of Women Voters
540 Beverly Court
Tallahassee, FL 32301-2506
December 11, 1998

General support for the Restudy Comprehensive Plan; no specific comments at this time.

National Audubon Society and
444 Brickell Avenue
Suite 850
Miami, FL 33131-2405
December 24, 1998

National Audubon Society
Donal C. O'Brien, Jr.
Chairman, Board of Directors
700 Broadway
New York, NY 10003-9562
December 28, 1998

The National Audubon Society had the following comments: 6 –8, 12, 15 –38, 40, 52, 55, 60, 69, 72-84, 160, 162, 163, 166, 168, 169, 176, 181, 189, 191, 199, 202, 203, 209, 211, 213 – 216, 218 – 221, 244, 267, 269, 277 – 281, 288, 313, 315, 334, 335, 347 –349, 358, 359, 366, 393, 395 – 408, 412 – 424, 472, 492, 502, 514, 522 – 525 and 528 – 537.

National Parks and Conservation Association
1776 Massachusetts Avenue, N.W.
Washington, D.C. 20036
December 31, 1998

The National Parks and Conservation Association had the following comments: 12, 15 – 41, 52, 69, 81, 139, 140, 151, 160, 166, 168, 176, 181, 189, 190, 199, 200, 202, 211 – 217, 219, 244, 249 – 251, 267, 269, 277, 278 – 281, 288, 296, 313 – 315, 347 – 350, 359, 366, 393 – 408, 455 – 457, 491 –494, 502, 532, 534 – 535 and 537.

National Wildlife Federation
5051 Castello Drive
Suite 240
Naples, FL 34103
December 31, 1998

The National Wildlife Federation had the following comments: 77, 160, 162, 331 and 497.

Natural Resources Defense Council
40 West 20th Street
New York, NY 10011
December 22, 1998 and December 30, 1998

The Natural Resources Defense Council had the following comments: 13, 16, 20, 69, 101 – 103, 148, 160, 166, 168, 178, 179, 236 – 238, 426 – 428, 472 – 475, 502, 540 and 550.

One Thousand Friends of Florida
Post Office 5948
Tallahassee, Florida 32314-5948
December 30, 1998

One Thousand Friends of Florida had the following comments: 42, 49, 65, 77 and 389.

ORCA, Ocean Reef Community Association
100 Anchor Drive, #505
Key Largo, FL 33037-5273
November 19, 1998

The Ocean Reef Community Association had the following comments: 42 and 54.

St. Lucie River Initiative
P.O. Box 2082
Stuart, FL 34995
December 8, 1998

The St. Lucie River Initiative had the following comments: 62, 184, 185, 240, 241, 375, 487, 488, 489, 552 and 553.

The Nature Conservancy
Florida Chapter
222 S. Westmonte Drive, Suite 300
Altamonte Springs, FL 32714
December 28, 1998

The Nature Conservancy Florida Chapter had the following comments: 42, 91 and 557.

University of Florida
Institute of Food and Agricultural Sciences
18905 SW 280 Street
Homestead, FL 33031
November 17, 1998 and December 31, 1998

The University of Florida Institute of Food and Agricultural Sciences had the following comments: 5, 10 –15, 167, 354, 369, 461 and 496.

World Wildlife Fund
1250 Twenty-fourth Street
NW Washington, DC 20037-1175

World Wildlife Fund had the following comments: 15, 20, 32, 55, 168, 189, 200, 288, 289, 305, 372 – 374, 472 and 502.

N.1.6 Individuals

Alexander, J. D.
PO Box 921
Dania Beach, FL 33004
no date

Mr. Alexander requests that the Corps restore the term “wild” back to the Everglades.

Appelberg, Renee Z.
17758 Park Village Blvd.
Fort Myers, FL 33908-6130
December 20, 1998

Mrs. Renee Z. Appelberg strongly urges the Corps to implement the Restudy.

Avellino, Nancy Carroll
4750 NE 23rd Avenue
Ft. Lauderdale, FL 33308
November 9, 1998

Ms. Nancy Carroll Avellino notes that we must strengthen the protection of wetlands, stop urban sprawl and pollution. Further, we need to add lands to conservation, not pave and destroy.

Ballinger, G.
PO Box161152
Miami, FL 33116
December 24, 1998

G. Ballinger had the following comment: 41.

Bishop, James D. P.
P.O. Box 947
Boca Grande, FL 33921
December 11, 1998

Mr. James D. P. Bishop had the following comment: 147.

Boomer, Anne
E-mail: Aboomer1@aol.com

Ms. Anne Boomer requested that the Corps help the Everglades, implement the Restudy.

Brumfield, Lloyd
11225 Meadowlark Circle
Stuart, FL 34997-2730
December 29, 1998

Mr. Lloyd Brumfield had the following comments: 175, 176, 425 and 460.

Censits, R.
688 Annemoore Lane
Naples, FL 34108
November 21, 1998

Mr. Censits' letter urges the Corps to implement the C&SF Restudy and take strong action to protect the Everglades natural resources, restore lost wetlands, and improve water quality.

Charnoski, Glen
University of Colorado, Faculty
735 University Ave.
Boulder, CO 80302
December 23, 1998

Mr. Glen Charnoski had the following comments: 169, 366 and 392.

Clark, R. H.
Rep. of Broward County League of Women Voters
651 S.W. 6th St. #215
Pompano Beach, FL 34108
December 26, 1998

Ms. Clark, as representative to the South Florida Water Management District's, Lower East Coast Regional Water Supply Plan Advisory Committee, offers the following comments:

The C&SF Comprehensive plan should be supported as a great step forward toward a possibly sustainable future for south Florida's natural resources, and water supply.

Funding on the federal and state levels should be supported so land acquisitions can be made before they are further developed, and pilot projects can be started to find out which technologies are feasible.

More natural levels and flows to the Everglades and Florida Bay are desirable, as well as recharging the aquifer, and the provision of water preserve areas for water storage and seepage management.

Applauds the consideration of water quality (at long last), flows to estuaries, and salinity impacts in the estuaries.

Supports the regional monitoring program and adaptive management strategy.

Hopes that the complexity and scope of the multi-agency, multi-discipline, multi-government level project will not founder in a political quagmire before citizens realize what a once in a lifetime opportunity they have to save south Florida for future generations by supporting Congressional adoption of the study recommendations.

Corcoran, Thomas
P.O. Box 273675
Boca Raton, FL 33427
December 29, 1998

Mr. Tom Corcoran had the following comment: 13, 168 and 538.

Dunavan, G.
1221 Cypress Drive
Naples, FL 34120
November 30, 1998

G. Dunavan had the following comment: 65.

Ellenby, Marc J.
25250 S.W. 194th Ave.
Homestead, FL 33031
November 17, 1998

Mr. Marc J. Ellenby had the following comments: 63 and 183.

E-mail: BahiaBoo@aol.com

BahiaBoo had the following comments: 4, 6, 155, 305 and 359.

E-mail: Candler@ix.netcom.com

Candler requested that the Corps return the Everglades to their natural state by restoring the flow of water.

E-mail: GiGi0708@aol.com

GiGi notes that we need the Everglades, and recommends implementing the Restudy.

E-mail: Harrisrd@aol.com

Harris stated that we cannot save every species of animal life. Leave the Everglades, as they are today, canals and all.

Fisikelli, Alfred
16700 SW 69 Street
Fort Lauderdale, FL 33331-2048

Mr. Alfred Fisikelli had the following comments: 4, 17, 150 and 158.

Flisk, A.
4106 24 Ave West
Bradenton, FL 34205
December 29, 1998

A. Flisk had the following comment: 57.

Fodor, Mark
4370 NE 15th Terrace
Pompano Beach, FL 33064
October 27, 1998

Mr. Mark Fodor had the following comments: 7 and 463.

Forman, M. Austin
Kendall Properties & Investments
C/O Gillis Investments Ltd.
888 Southeast 3rd Ave
Suite 501
Fort Lauderdale, FL 33316
December 28, 1998

Kendall Properties & Investments had the following comments: 69, 94, 138, and 353.

Gammonley, Denise
3000 South Ocean Drive #7J
Hollywood, FL 33019

Ms. Denise Gammonley had the following comment: 63.

Golling, P.
5312 S.W. 11th Pl.
Cape Coral, FL 33914
November 24, 1998

Mr. Golling states that it is clear that restoring the Everglades will benefit not only the wildlife, water quality, and wetland areas, but will benefit the future of other ecosystems which are being or may be restored. He requests that the Corps proceed with the Restudy and the proposed plan.

Hamilton, Patrick and Norma B.
29001 Boyce Road
Punta Gorda, FL 33982
December 13, 1998

Patrick and Norma B. Hamilton had the following comments: 41 and 454.

Hart, Robin L,
5086 Barrington, Circle
Sarasota, FL 34234
December 14, 1998

Robin L. Hart supports the Comprehensive Plan.

Heffernan, J. W.
PO Box 687
Boca Grande, FL 33921
November 23, 1998

Mr. Heffernan writes urging the Corps take up the projected Restudy to restore the Everglades to full health and help bring back the “River of Grass.”

Hepburn, G. G.
6142 Whiskey Creek Dr. Apt 605
Ft. Myers, FL 33919
December 7, 1998

G.G. Hepburn states support for Implementation of the Restudy Recommendations based on discussion of the Plans with a team member (Bill Hunt) at a December 1, 1998, public meeting in Ft. Myers.

Holmes, Charles F.
E-mail: Cfholmes@mindspring.com

Mr. Charles F. Holmes recommends implementing the Restudy and resisting the enticement of developers and agriculturists.

Huesman, Richard & Joan
19329 Green Valley Court
North Ft. Myers, FL 33903

Richard & Joan Huesman strongly urges that the Corps implement the Restudy.

Hutchins, M.
27063 Allan Street
Bonita Springs, FL 33923
December 24, 1998

M. Hutchins had the following comment: 65.

Johnson, Lois L.
7072 W. County Club Drive North
Sarasota, FL 34243-3513

Lois L. Johnson recommended restoring the ecosystem in the Everglades, and hopes the plan is endorsed.

Kirschner, M.
1401 SW 128th Terrace #H409
Pembroke Pines, FL 33027
December 8, 1998

Mr. M. Kirschner recommneds leaving nature alone and that the money should be used to repay the national debt.

Klein, Helene
P.O. Box 14394
Fort Lauderdale, FL 33302
October 27, 1998

Ms. Helene Klein had the following comments: 63 and 100.

Larsen, Paul
Larsen and Associates
First Union Financial Center, Suite 2940
Miami, FL 33131
December 27, 1998

Larsen and Associates had the following comments: 69, 155, 200, 201 and 202.

Levitis, Esther G.
2055 Harwood E
Deerfield Beach, FL 33442
December 26, 1998

Esther G. Levitis commented for support of immediate land acquisition and would like the Corps to address the hydrologic needs of the Everglades.

Martin, Richard
2301 Ringling Blvd
Sarasota, FL 34237

Mr. Richard Martin had the following comments: 149 and 150.

Moss, T.
2436 Pinewoods Circle
Naples, FL 34105
No date

T. Moss had the following comment: 359.

Murchie, Stephen B.
901 NE 18 Court, #202
Ft. Lauderdale, FL 33305
October 27, 1998

Mr. Stephen B. Murchie had the following comments: 7, 63, 186, 187, 239, 332, 337 and 464.

Myers, Arno R.
100 Glenview Place #505
Naples, FL 34108

Arno R. Myers strongly urges the Corps to implement the Restudy.

Oehlbeck, Barbara
Grassy Run Muse
Rt. 1 Box 1771
Labelle, FL 33935
December 12, 1998

Mrs. Barbara Oehlbeck had the following comments: 96, 156, 319, 467,

Oehlbeck, Luther W.
Grassy Run Muse
Rt. 1 Box 1771
Labelle, FL 33935
December 12, 1998

Mr. Luther W. Oehlbeck had the following comments: 7, 149 and 157.

Oltmans, Judy
No return address provided
November 16, 1998

Ms. Judy Oltmans had the following comments: 7, 100 and 160.

Pedersen, Amy
1725 N.W. 91 Ave.
Plantation, FL 33322
November 6, 1998

Ms. Amy Pedersen had the following comments: 4, 6, 63, 103, 133, 162, 305 and 545.

Piner, J.A. and D.M.
87851 Old Hwy. Unit P-1
State Road 4-A
Islamorda, FL 33036
December 22, 1998

J.A. and D.M. Piner had the following comment: 392.

Podgor, Joe
244-A Westward drive
Miami Springs, FL 33166
E-mail: podgor@icanect.net
December 31, 1998
(this e-mail was received from six other individuals)

Mr. Joe Podgor and the others had the following comment: 154.

Quackenbos, Max
1778 NW Palmetto Terrace
Stuart, FL 34994
December 31, 1998

Mr. Max Quackenbos noted that ecosystem restoration is no longer the clear project priority, but is co-equal with flood control and water supply.

Rauschenberger, E.
5563 Pendlewood Lane
Fort Myers, FL 33919-2742
November 22, 1998

Mrs. E. Rauschenberger noted that anything that can be done to restore the Everglades to its original design should be done. Our children's grandchildren will never know the wildlife of past generations if nothing is done to restore it.

Reef Relief Environmental Center and Store
201 William Street, P.O. Box 430
Key West, FL 33041
December 10, 1998

The Reef Relief Environmental Center and Store had the following comments: 42, 391 and 438.

Reynolds, S.
345 Shoreland Dr.
Ft. Myers, FL 33905
November 25, 1998

Mr. Reynolds urges the Corps to take necessary action to restore the Everglades. He has canoed parts of the Everglades and finds it beautiful even considering that it has declined 85-90% from what it was originally. Concludes that this generation will not see the full benefit of the restoration, but perhaps future generations will.

Rippeteau, D. D.
1011 NW Third Ave
Delray Beach, FL 33444
December 12, 1998

Mr. Rippeteau expresses strong support of the Draft Plan and requests a copy of the final report. Further states that the damage done to the Everglades and the ecosystem of south Florida by a century of mis-management must be repaired now.

Romeo, Theresa C.
3224 S. Ocean Blvd., #510
Highland Beach, FL 33487
December 15, 1998

Ms. Theresa C. Romeo had the following comments: 42, 305 and 362.

Scharf, K.
4755 NW 3rd Court Apartment C
Deray Beach, FL 33445
November 12, 1998

Ms. Scharf writes to express strong support of the Draft Plan for restoring the Everglades and acknowledges that nowhere in the world has such as plan for restoration of the ecosystem of so large an area ever been undertaken.

Simon, E. & E.
5501 Heron Point Dr. Apt 904
Naples, FL 32232
November 24, 1998

Mr. and Mrs. Simon writes to urge the Corps to implement the Restudy.

Tinnerman, William R.
150 North Federal Highway, Suite 220
Fort Lauderdale, FL 33301
December 7, 1998

Mr. William R. Tinnerman had the following comments: 5, 6, 13, 36, 40, 103, 118 and 471.

Tirrell, Roderick T.
2101 NE 55th Court
Fort Lauderdale, FL 33308-3111
December 21, 1998

Mr. Roderick T. Tirrell had the following comments: 4-7, 35, 85-90, 210, 245 –248, 291, 301, 305 – 307, 309, 387 and 388.

Trabulsy, Norman M. Jr.
P.O. Box 268
Key West, FL 33041
(no Date)

Mr. Norman M. Trabulsy Jr. had the following comments: 42, 123, 320 and 543.

Tunnell, Arthur W. Jr.
2354 Burton Avenue
Fort Myers, FL 33907
November 21, 1998

Mr. Arthur W. Tunnell, Jr., commented to Implement the Restudy and take strong action to protect natural resources, restore lost wetlands, and improve water quality.

van Steenderen, M.
13220 Southampton Drive
Bonita Springs, FL 34135
November 23, 1998

Mr. van Steenderen states that it is absolutely essential that the Corps of Engineers take necessary action to restore the Everglades. States that developers and agri-business have developed lands at an alarming rate that should be checked.

Vecellio, Leo Jr., President
White Rock Quarries
101 Sansbury's Way
West Palm Beach, FL 33416
December 16, 1998

White Rock Quarries had the following comments: 13, 94, 135, 230 and 351.

Weaver, W. A.
230 Salem Street
Swampscott, MA 01907
December 19, 1998

W. A. Weaver had the following comments: 390 – 392.

Weller, S.
65 Belvedere Ave
Belvedere, CA 94920
December 26, 1998

S. Weller had the following comments: 390 – 392.

Wittman, M.
17455 Woodland Trace Apt B
Ft. Myers, FL 33905
no date

Ms. Wittman states that the Army Corps should be the push to get the Restudy going full speed so the Everglades can be restored and thus the habitat also restored.

Yawn, Margaret
No address given
November 15, 1998

Margaret Yawn believes the Army Corps of Engineers has made a proper decision to restore freshwater to the Everglades and Florida Bay and strongly urges the Corps to implement the Restudy.

Yorra, Arnold S.
P.O. Box 5088
Marco Island, FL 34145-5454

Mr. Arnold S. Yorra recommends implementing the Restudy. He also notes that the Everglades belong to all the American People forever and wants the Corps to help stop urban sprawl and the spread of subsidized sugar.

Zorki, Ron & Claudia
1024 Capitan Drive
Forked River, NJ 08731

Ron and Claudia Zorki had the following comment: 42.

N.1.7 Form Letters

129 "form" letters were received during the comment period. An example of that form letter follows.

Mr. Stewart Applebaum
P.O. Box 4970
Jacksonville, FL 32232-0019

November 29, 1998

Dear Mr. Applebaum,

I wish to express my strong support of the Draft Plan for the Restoration of the Everglades as proposed by the U.S. Armay Corps of Engineers.

This plan is a comprehensive proposal for Everglades Restoration and further will provide clean drinking water for the growing population of South Florida.

Nowhere else in the world has such a plan for the restoration of the eco system of so large a region ever been undertaken. The damage done to the Everglades and the eco system of South Florida by a half century of mismanagement must be repaired now. Very soon it will be too late.

Sincerely,
Dora and Ron Linamore

N.2 COMMENTS AND RESPONSES

N.2.1 Plan Formulation

1. There is no discussion of the potential impacts to transportation facilities.

Response: Due to the conceptual nature of the Comprehensive Plan, potential impacts to roads, bridges, utilities, etc are addressed in the construction cost contingencies. Future plan and design studies will fully address site specific impacts as described in the Implementation Plan, Section 10.

2. The need for bridging Tamiami Trail is not justified in the report.

Response: The Comprehensive Plan includes 20 100-foot bridges along Tamiami Trail below Water Conservation Area 3. These bridges are part of a larger component to enhance hydrologic and ecological connectivity between the Water Conservation Areas and Everglades National Park.

3. The Implementation Plan lacks specific information.

Response: The Implementation Plan, Section 10, underwent a major rewrite as a result of comments received during the review of the Draft Report. Further, numerous Federal, State, County and local government agencies as well as stakeholders and the public were given an opportunity to review and comment on this rewrite. The revised Implementation Plan is provided as Section 10 of this report.

4. The flow-way option similar to the option previously included in the Reconnaissance Report should be part of the proposed Comprehensive Plan.

Response: A flow-way between Lake Okeechobee and the Water Conservation Areas has appeal regarding re-connecting the “river of grass” with the Lake. However, modeling has shown that the flow-way concept fails to restore ecological values to the remaining Everglades, given the reduced size and water storage capacity of the remaining natural system compared to pre-drainage conditions. A flow-way regains little of the water storage that is required to deliver adequate quantities of water to the remaining Everglades. To the contrary, a flow-way consumes water that would otherwise be directed to the Everglades for restoration purposes. This is because the flow-way would greatly exacerbate evapotranspiration water losses, seepage losses, and dry-season water demands of the flow-way to maintain it as a viable wetland system.

A flow-way could not operate as a passive “natural” conveyance system under today’s conditions. Soil subsidence in the Everglades Agricultural Area has changed the slope and contour of the land by reducing land elevations. A flow-way in this area would require additional canals, levees, and pumping facilities to get the water into the Everglades.

5. The Comprehensive Plan should be peer reviewed.

Response: The success of the Restudy in achieving ecological restoration is heavily dependent on an adaptive assessment plan. That adaptive assessment strategy, as described in the Implementation Plan, will incorporate external scientific peer review at every stage of the implementation process.

As part of the adaptive assessment strategy, peer review will be an integral part of a number of processes that will be ongoing throughout the next several decades. These include: 1) the refinement of ecological performance measures; 2) the development and oversight of a system-wide monitoring program; 3) the inclusion of new findings from ongoing research and modeling into the planning process; 4) detailed project design and modeling; and, 5) analysis of monitoring results to measure progress toward the achievement of ecological targets and to recommend shifts in the plan to maximize that achievement. These steps commence almost immediately, even before the Comprehensive Plan is submitted to Congress. The Chair of the Restudy Alternative Evaluation Team contacted the Science Coordination Team of the South Florida Ecosystem Restoration Working Group during summer 1998 to request a peer review process to evaluate the science behind the performance measures used in the Restudy.

As of early 1999, the Restudy has undergone more than a year of review by an interdisciplinary, multi-agency team of approximately one hundred scientists, hydrologists and modelers, many of whom have long records of research and management in south Florida ecosystems. The formulation and evaluation of alternative plans underwent a public review through the use of the internet. It must be emphasized that the Restudy is presently a conceptual plan, based on broad-scale hydrologic modeling and performance measures that will be refined continually. The plan at this time is a toolbox of various water management components that have been demonstrated, in combination, to achieve high levels of success in the restoration of ecological values. Based on the adaptive assessment process described above, these components may be combined in any number of ways as more detailed scales of science and modeling are applied over the next several decades. It is here that peer review by external scientists plays an integral and essential role in the Restudy.

The Restudy Team welcomes an ongoing external review by scientists with the highest level of national and international recognition in their fields. Indeed, the Restudy Team has already taken steps to initiate such a review process.

6. More land should be purchased for the project within the Everglades Agricultural Area to reduce the need for "high tech" solutions and provide for greater spatial extent.

Response: Due to soil subsidence and extensive utilization of the land within the Everglades Agricultural Area, conversion of these farmlands to a viable wetland system that could support native flora and fauna would have a significant economic and environmental cost to the remainder of the system.

7. The Comprehensive Plan does not include sufficient dismantling of the existing project features within the remaining natural areas. Further, the report is not clear as to how decisions were made regarding the extent of decompartmentalization (eliminating obstructions to sheetflow within the natural areas).

Response: During the development of alternative plans, one of three decompartmentalization scenarios modeled included unconstrained decompartmentalization of all of the Water Conservation Areas. Hydrologic modeling during the past year has clearly demonstrated that removing all the dikes and levees in the Water Conservation Areas would have devastating effects on the remaining natural system. Upper portions of each Water Conservation Area are over-drained, Lake Okeechobee water levels drop to record lows, and Everglades National Park dries out most years because the free-flowing water runs out early in the dry season. Appendix B describes these scenarios. The full set of performance measures comparing three decompartmentalization scenarios developed for the scenarios modeled after Alternative 3 (unconstrained was one of the three) was posted on the Hydrologic Performance Measures web page on January 30, 1998 and a summary of the results was presented during the February 9, 1998 Restudy Team meeting in West Palm Beach. A more complete description of the extensive modeling results of the decompartmentalization scenarios is included in Section 7 of the report.

8. Aquifer Storage and Recovery should not be implemented at the scale proposed in the Comprehensive Plan. If it is determined to be necessary for urban needs, regional government should fund it without cost to the Federal government.

Response: The uncertainties related to Aquifer Storage and Recovery will be addressed through additional studies and pilot projects before any large-scale projects are recommended for authorization. The Comprehensive Plan does not include Aquifer Storage and Recovery for the sole purpose of providing water supply to urban areas.

9. Seepage barriers should not be included in the Comprehensive Plan due to the technical feasibility, irreversibility, cost effectiveness and the potential for unintended consequences.

Response: The uncertainties related to seepage barrier technology and "unintended consequences" will be addressed through additional studies and pilot projects before any large-scale projects are recommended for authorization.

10. Need topographic information for the C-111 basin for its design and management.

Response: Concur. This task has been identified as an early expedited action and is presently underway by the Corps of Engineers.

11. More precise farm scale data is needed for C-111 basin.

Response: Concur. A number of activities are presently underway to provide such data. The Corps is participating with the Miami-Dade County in conducting a land-use study that will be completed in 2000.

12. The Comprehensive Plan does not have enough detail and there are no disaster contingencies such as pump failures in the plan. Operational plans are needed before construction begins.

Response: The Comprehensive Plan is a large-scale, regional plan that lays a framework for future detailed project planning and design. To address the concerns about the lack of detail in the plan, the Comprehensive Plan includes an Implementation Plan, Section 10, which identifies a process to collect more data and allow for additional public input before construction activities commence. Further, operational plans will be developed as part of detailed project design.

13. Need additional data on Aquifer Storage and Recovery, seepage controls, etc. before being implemented.

Response: Concur. The uncertainties related to Aquifer Storage and Recovery and seepage control alternatives will be addressed through additional studies and pilot projects before any large-scale projects are recommended for authorization.

14. All pilot projects should be given equal priority to balance interests.

Response: Pilot projects have been scheduled based on the guidelines set forth in the Implementation Plan (Section 10).

15. Ongoing restoration efforts should be expedited. There should be maximum integration of ongoing environmental restoration projects such as, the Kissimmee River Restoration Project, the C-111 Project, and the Modified Waters Delivery Project, with the Comprehensive Plan.

Response: Ongoing Federal/State restoration programs including the Everglades Construction Project, the Modified Water Deliveries Project, the C-111 Project and the Kissimmee River Restoration Project are considered in the Restudy's “without project” condition and are key considerations of the Restudy Implementation Plan. These projects are being implemented as quickly as possible.

There has been a considerable amount of coordination and integration of these ongoing projects with the Comprehensive Plan. The Restudy Team, to ensure full integration of these projects, worked closely with engineers and scientists involved in these projects throughout the formulation and design phases of this study. This integration of the ongoing projects with the Comprehensive Plan will continue as each project is fully implemented.

16. The Comprehensive Plan should use the 8.5 Square Mile Area (SMA) in restoring flows to Northeast Shark River Slough.

Response: The flood protection alternative (with flowway) for the 8.5 SMA is included in the future "without project" condition. If the area is acquired as a Locally Preferred Option under the Modified Waters Delivery Project, the Comprehensive Plan will be modified accordingly.

17. The Comprehensive Plan needs to eliminate the hydrologic barrier effect of Tamiami Trail.

Response: The Comprehensive Plan includes 20 100-foot bridges along Tamiami Trail below Water Conservation Area 3. These bridges are part of a larger component to enhance hydrologic and ecological connectivity between the Water Conservation Areas and Everglades National Park.

18. Redevelopment of the former Homestead Air Force Base must be ecologically compatible with the nature and function of Biscayne Bay and Everglades National Parks.

Response: Future land development is not within the scope of the Restudy and shall properly remain a responsibility of state and local governmental entities. Every effort will continue to be made to ensure the widest possible distribution of the Restudy recommended plan and to keep vital information in front of local authorities.

19. Promote more natural sheet flow into Biscayne Bay instead of the current point source discharges.

Response: The Comprehensive Plan includes features to promote natural sheetflow into Biscayne Bay. (see component WW5).

20. The Restudy should investigate additional sources of water. Reuse water should not be used to achieve targets in Biscayne Bay. Other sources of water should be investigated. Reuse is not cost effective.

Response: Subsequent to the release of the draft report, the Restudy Team developed additional scenarios to address the concern of using reuse to achieve targets in Florida Bay. The effort resulted in the evaluation of four scenarios known as D-13R_{1-4}. This investigation revealed that through modification of the Comprehensive Plan (namely Water Preserve Areas features), additional water could be captured and diverted from upstream urban areas and conveyed into the Water Conservation Areas or in canals adjacent to the Water Conservation Areas to Biscayne Bay. However, degraded performance of the plan in other areas as a result of these modifications has not been fully resolved. Consequently, upon resolution of these outstanding issues, the Corps of Engineers is committed to incorporating features of D-13R_{1-4} that allow for the capture and conveyance of additional water to the natural system. It is recognized that reuse features have a high capital and annual operations and maintenance cost. Accordingly, these components have been sequenced late in the implementation in order to take full advantage of other sources that may be identified during future project development.

21. Natural vegetation should be utilized in shoreline protection efforts.

Response: This suggestion will be considered during future detailed design efforts.

22. The Comprehensive Plan should include the use of a floodway to replace canal drainage in the Southern Golden Gates Estates drainage system.

Response: The Southern Golden Gates Restoration Project is included in the Comprehensive Plan as an Other Project Element.

23. The Comprehensive Plan needs to restore pre-drainage water distribution, timing, quality and quantity to the southern Big Cypress National Preserve by modifying or eliminating L-28 and the S-343 and S-344 structures.

Response: Concur. These features are included in the Comprehensive Plan.

24. The Comprehensive Plan needs to restore historical drainage patterns associated with the Western Big Cypress and Fakahatchee Strand.

Response: The Southwest Florida Feasibility Study will address the concerns in this region.

25. Decompartmentalize WCA 3 to maximize hydrologic connectivity. Use passive structures whenever possible.

Response: The Comprehensive Plan removes approximately 228 miles of levees and canals within Water Conservation Area 3.Where removal of levees causes harm to the natural system, earthen weirs are proposed to prevent over-drainage and flooding of these areas.

26. The Comprehensive Plan should include filling and degrading the entire L-67 system.

Response: Hydrologic modeling revealed that removal of the L-67 system would cause extensive ecological damage to the Water Conservation Areas and Everglades National Park. Therefore, a series of earthen weirs are proposed to replace the existing levee system.

27. The Comprehensive Plan should fill and degrade Miami River Canal within the Water Conservation Areas.

Response: This component is included in the Comprehensive Plan.

28. Fill and degrade L-28 and cease discharges of water from L-28 basin into the Water Conservation Areas.

Response: L-28 is removed in the Comprehensive Plan. The L-28 basin provides important water quantity to the Everglades. Stormwater Treatment Areas are proposed in the L-28 basin to ensure that this water achieves the objectives of Everglades restoration.

29. Restoration of the Water Conservation Areas (WCAs) should include mitigation of hydrologic impacts resulting from limerock mining, particularly in the Lake Belt area.

Response: In general, rock mining activities in wetland areas located within, or nearby, the WCAs are regulated under Section 404 of the Clean Water Act as well as State and/or local regulatory authorities. Permits for these activities contain special conditions that require compensatory mitigation to offset unavoidable direct environmental impacts as well as secondary and cumulative impacts. The direct, secondary, and cumulative impacts of the intense mining activity in the Lake Belt Area are being evaluated in a holistic manner through the Lake Belt Committee, an intergovernmental/private sector body. The Draft Programmatic Environmental Impact Statement (PEIS) for the Lake Belt Plan was released in February 1999. The PEIS contains a Recommended Lake Belt Plan as a framework under which limerock would be permitted within specified areas. A principal feature of the Recommended Lake Belt Plan is the creation of a comprehensive hydrologic and wetlands mitigation plan. Development of the Lake Belt Plan has occurred in two phases. Among Phase I activities was development of a Lake Belt Mitigation Plan which includes identification of areas within the Lake Belt suitable for mitigation and, establishment of a dedicated funding mechanism for mitigation activities. Analysis of the hydrologic impacts of mining is being accomplished in Phase II. Specific hydrologic mitigation measures, if necessary, will be recommended for addition to the Lake Belt Mitigation Plan.

30. Lands in the Northwest Miami-Dade County Lake Belt region should be used to offset impacts of rehydrating Water Conservation Area 3B.

Response: The recommend Comprehensive Plan includes the feature designated as BB5 and titled Dade-Broward Levee/Pennsuco Wetlands. This feature includes water control structures and modifications to the Dade-Broward Levee and associated conveyance system located in Miami-Dade County, including the Lake Belt Area. The purpose of this feature is to reduce seepage losses to the east from the Pennsuco Wetlands and southern Water Conservation Area 3B, to enhance hydroperiods in the Pennsuco Wetlands, and to provide recharge to Miami-Dade County's Northwest Wellfield. The Pennsuco Wetlands comprise the western side of the Lake Belt Area and have been designated in the Lake Belt Plan as a mitigation area that will not be mined.

31. Ensure hydrologic connectivity with the Water Preserve Areas footprint.

Response: The Comprehensive Plan provides hydrologic connectivity within and between the Water Preserve Areas components except where land availability precludes this.

32. The Water Preserve Area concept should be used in other areas such as the Upper East Coast.

Response: The Water Preserve Areas concept is an outgrowth of the East Coast Buffer program which was designed to reduce seepage from and provide a buffer between the Water Conservation Areas and suburban development as well as providing for additional storage capacity. The concept of the Water Preserve Areas was extended north into Martin and St. Lucie Counties under the Indian River Lagoon Feasibility Study. Further, the Comprehensive Plan provides many of these same concepts in all other major planning areas.

33. The S-9/C-11 and Acme Basin B initiatives should be coordinated with the Restudy and remain local funding initiatives.

Response: The water quality elements of both initiatives remain local funding responsibilities; however, both also have regional impacts that qualify for federal funding through the Comprehensive Plan. Thus, both remain components/Other Project Elements within the Restudy.

34. The Comprehensive Plan should ensure that maximum ecological, not maximum mining potential is incorporated into the Lake Belt/C&SF Restudy process.

Response: The two concepts are not mutually exclusive. A review of the Lake Belt storage features reflects this fact.

35. At the onset of the Restudy, site, design and construct and use surficial reservoirs to buffer the effects associated with construction activities. Further, Federal funding should go towards ecosystem restoration first.

Response: An Implementation Plan has been developed to guide subsequent efforts. This Implementation Plan provides a logical sequencing of project features to maximize benefits and reduce disruptions.

36. Utilize adaptive assessment and monitoring techniques to adapt design components to eliminate/minimize adverse impacts while implementing the Comprehensive Plan.

Response: The Implementation Plan, Section 10, includes a discussion of how adaptive assessment and monitoring will be used to support future decision making.

37. Land utilization and subregional planning efforts must be coordinated into the implementation phase of the Restudy.

Response: Coordination and information flow has been an important element of the Restudy since the study was initiated. The make up of the Restudy Team draws from state, local and Water Management District representatives, stakeholder groups as well as Federal agencies. Coordination and information flow will continue to be important throughout all phases of the Restudy. However, coordination and information flow must not be disguised as direction. Land utilization must properly remain a responsibility of state and local governmental entities. Coordination and information flow will remain an important objective of the Restudy, but cannot be utilized as anything more than guidance for the authorities that are charged with decisions on local utilization of land.

38. Reservoirs and retention areas should be managed for multiple purposes, e.g., fish and wildlife, water quality.

Response: During the PIR phase of plan development, opportunities to manage these facilities as multi-purpose projects will be investigated.

39. Use "step down" seepage management techniques where possible.

Response: The Water Preserve Areas concept, formerly the East Coast Buffer, is designed based on this premise.

40. The Comprehensive Plan and future studies should more fully develop the reuse and desalinization concepts.

Response: Reuse has been identified as a component where additional regional water sources are required (components BBB6 and HHH6). Several other reuse projects were proposed as Other Project Elements; however, the high cost of reuse could not be justified for inclusion in the initial draft plan. These additional projects may be able to provide benefits to the regional system should some of the less certain or less costly sources turn out to be impractical. Therefore, these applications should be considered as contingency sources. Two of the contingency applications are in Broward County.

The Comprehensive Integrated Water Quality Plan feasibility study recommended in this report will investigate alternative reuse concepts that were originally proposed by the Water Quality sub-team but were not pursued further. During the initial formulation of components, desalinization was considered but was quickly rejected as a practical option due to the quantity of water needed to achieve the goals and objectives of the Restudy. The use of desalinization or other local water supply options would be best addressed by local governments and utilities.

41. Local and regional governments should review and revise water conservation programs to be consistent with Restudy goals and objectives.

Response: Concur. Water conservation is an important element of the Comprehensive Plan and is best implemented at the state, county, and local levels.

42. The Comprehensive Plan should be revised to include Florida Bay, the Keys and the Keys reef tract. Further, waste water treatment in the Keys should be a feature of the Comprehensive Plan.

Response: The Restudy goal to enhance ecological values in south Florida ecosystems includes Florida Bay, the Keys, and the Keys reef tract, even though structural components of the C&SF Project do not extend into these areas. Actions taken in the Everglades, Lower East Coast, and Lower West Coast have high potential to influence water quality conditions throughout Florida Bay and the Keys. The major focus of the Restudy to date has been to address the impact that the C&SF Project has had on that system. Hydrodynamic and water quality models currently under development for Florida Bay will provide the tools necessary for evaluation of the problems in a holistic manner. A feasibility study is recommended to comprehensively evaluate Florida Bay and the Florida Keys to determine the types of modifications that are needed to successfully restore the bay and the Keys.

Improved sewage treatment is a part of the Florida Keys Water Quality Protection Plan developed as part of the Florida Keys National Marine Sanctuary Program. Restudy conclusions support the need for improved sewage treatment in the Keys. However, while the Corps of Engineers agrees that improved sewage treatment is critical to protect public health and the natural environment, including coral reefs, under existing Federal policy, sewage treatment is the responsibility of county or local government. This report (Sections 3 and 5) has been updated to address the need for additional water quality improvements, including improved sewage treatment in the Florida Keys. The Corps, through the Restudy, will continue to work with federal, state, and private sectors interested in restoring and protecting all south Florida ecosystems.

43. Non-structural storage concepts (conservation easements, lake fringes) should be considered.

Response: The Comprehensive Plan includes a vast number of non-structural solutions to meet the Restudy goals and objectives. As detailed planning progresses, additional/alternative means to achieving these goals and objectives will be sought.

44. Additional water quality features such as stormwater treatment facilities should be considered in future planning and design efforts.

Response: Subsequent planning and design efforts have been programmed into the Restudy to address water quality concerns. Specifically, a study to develop a Comprehensive Integrated Water Quality Plan is included in the Comprehensive Plan recommendation. Additionally, the Implementation Plan, Section 10, provides a mechanism to analyze water quality needs and recommend supplemental water treatment facilities if needed during the PIR phase.

45. An additional 14,600 acres of Reservoir-Assisted Stormwater Treatment Areas (RASTAs) around Lake Okeechobee are needed to achieve water quality targets for the lake.

Response: The S-65E basin Stormwater Treatment Area was designed in the existing footprint of the North Lake Okeechobee Reservoir. The remaining RASTA acreage is included in the discussion of Lake Okeechobee RASTAs but has not been fully evaluated due to the late consideration. The Restudy has committed to include these additional RASTAs in future planning documents.

46. The Comprehensive Plan should include enough flexibility to allow for cost share of the Lake Okeechobee Sediment Dredging Study.

Response: The Lake Okeechobee Sediment Dredging Feasibility Study has been added as a component to be investigated as part of the Comprehensive Integrated Water Quality Plan Feasibility Study.

47. The Comprehensive Plan should identify the Ten-Mile Creek as a Restudy project. Further, an additional five projects identified by the St. Lucie Issue Team should also be included in the Comprehensive Plan.

Response: The Ten-Mile Creek project is a Critical Project and is still being pursued as such. If this proves unsuccessful, the Comprehensive Plan has included it in the component UU C-23/24/25 Storage Reservoirs. The other features identified by the St. Lucie Issue Team will be investigated as part of the ongoing Indian River Lagoon Feasibility Study. This study will include recommendations to Congress for the Comprehensive Plan components in Martin and St. Lucie Counties that are not authorized in the Water Resources Development Act of 2000.

48. The 900-acre Miccosukee Water Quality Treatment Area should be included in the Comprehensive Plan. Further, the Plan was sized to treat nutrient inputs of the Tribal lands. When describing this project, please emphasize that the Miccosukee Tribe plans to treat their own pollution before discharge into the Everglades – not the pollution of others.

Response: Concur. This feature has been added as an Other Project Element and is included in the Comprehensive Plan. Although all other inflows in the area are treated either through the Everglades Construction Project or treatment components in the Comprehensive Plan, this specific emphasis will be included.

49. The Comprehensive Plan needs to ensure an adequate and fair allocation of water to the natural system.

Response: The Comprehensive Plan attempts to capture, store and deliver water to natural and urban areas as efficiently as possible. The goal is to provide the target amounts of water specified by the performance measures to natural and urbanized areas. The objective is to eliminate, to the extent possible, water shortages for both the natural system and urban communities. Although there are no guarantees, this approach minimizes the risk that the natural environment will be shorted its required amount of water in the future. Water allocation is a responsibility of the State of Florida.

50. Discussion of Lake Istokpoga in the report should be modified to include the current condition of the Lake. Further, the restoration of the Lake should be included as an Other Project Element.

Response: Lake Istokpoga's aquatic plant problems have been added to the report. A study to address the Lake's operational plan, which is believed to be the long-term solution to this problem, has been added as an Other Project Element of the Comprehensive Plan.

51. What is the relationship of the Kissimmee River Restoration Project and the Stormwater Treatment Area proposed in the S-65D sub-basin as part of the Comprehensive Plan?

Response: The proposed S-65D sub-basin Stormwater Treatment Area component of the Comprehensive Plan will be upstream of the Kissimmee River Restoration Project. This feature is designed to attenuate peak flows before entering the Kissimmee River and retain phosphorus before entering Lake Okeechobee.

52. Identify agencies responsible for the operation, management and performance of each component. Who will pay for the operation and maintenance costs?

Response: The agency responsible for the operation of a completed component will be determined through the terms of local cooperation executed between the Secretary of the Army and the local sponsor. Performance is normally a direct function of the design and construction of the component and will be monitored through a multi-agency, multi-disciplinary, team utilizing an adaptive assessment strategy, before, during, and after component construction. The cost of operating and maintaining the Comprehensive Plan is recommended to be shared equally between the Federal government and the local sponsor on a 50-50 basis.

53. Why did Restudy not consider "local sources first"?

Response: “Local sources first” concept is derived from a State law which exempts the C&SF Project.

54. The Comprehensive Plan should include the tidal restoration of the Dispatch Creek in the Florida Keys.

Response: The Dispatch Creek has been added to the Florida Keys Tidal Restoration Project under the Other Project Elements of the Comprehensive Plan.

55. Lake Okeechobee must be restored and the water supply and flood control pressures alleviated. Further, all backpumping to Lake Okeechobee must be stopped.

Response: Lake Okeechobee is the liquid heart of south Florida. Besides its ecological importance, the lake provides critical water supply and flood control to all of south Florida. The Comprehensive Plan was formulated to improve the ecological conditions of the lake while providing these other critical needs. Under the Comprehensive Plan, the ecology of Lake Okeechobee is much improved. Backpumping to Lake Okeechobee has been dramatically reduced in recent years. The Comprehensive Plan further reduces the need for backpumping untreated runoff.

56. "Adaptive Assessment" should be included in the Recommended Plan.

Response: Adaptive Assessment is a process by which the Comprehensive Plan will be implemented. It is fully discussed in the Implementation Plan, Section 10, of the report.

57. The report should include a complete list of the Other Project Elements and a discussion of the fate of the Critical Projects.

Response: The Other Project Elements appendix (Appendix A5) has been rewritten to include a complete list of the Other Project Elements. Further, the Critical Projects that have not been approved and funded have been added into the Comprehensive Plan as either components of the plan, Other Project Elements, or incorporated into the recommended feasibility studies or as preconstruction engineering and design activities. A new section has been added to describe the status of the Critical Projects Program.

58. Major project elements should have complete engineering and environmental and economic evaluation before submittal to Congress and before land acquisition.

Response: The Comprehensive Plan serves as a framework for future efforts. Included in the Implementation Plan, Section 10, is a discussion of the subsequent activities necessary before authorization of major project components will be sought.

59. The Restudy focused primarily on areas west of the North-South protective levee in Southeast Florida. An assessment of the urban areas might reveal additional ecosystem restoration opportunities that could ultimately reduce the cost of the Comprehensive Plan.

Response: Studies conducted during the Restudy did investigate the potential of using lands in the developed areas of the Lower and Upper East Coast. Due to the land mass needed to store and convey water, the land suitability analysis revealed that these lands were not appropriate for the projects being considered.

60. The Restudy should include plans that limit residential and commercial development. Further, green infrastructure plans should be developed for all urban areas including southeast Florida, southwest Florida, and the Upper East Coast.

Response: Land use planning is a state, county, and local government responsibility. The Corps and SFWMD can work closely with these agencies to ensure current and future land use practices are consistent with the Restudy objectives.

61. Has a cumulative impact assessment been prepared for the Restudy and what are the impacts to south Miami-Dade County and Biscayne National Park?

Response: A cumulative impact assessment of the Comprehensive Plan is included in Section 8 of this report. The Comprehensive Plan was formulated to achieve both economic and ecologic benefits throughout south Florida. The plan should result in positive effects to both south Miami-Dade and Biscayne National Park.

62. The Restudy should use information gleaned from the Upper St. Johns Project. More specifically, a combination of deep and shallow storage should be pursued.

Response: The design for these features was conceptual in nature. As the Indian River Lagoon Feasibility Study progresses, a range of options, including various operating water levels, will be looked at.

63. The Comprehensive Plan should not depend so heavily on canals and pumps.

Response: The Comprehensive Plan actually eliminates many of the levees and canals and water control structures that presently compartmentalize the Everglades. This includes much of L-29 that separates Everglades National Park from the Water Conservation Areas, all of L-28 that separates Big Cypress National Preserve from the Water Conservation Areas, all of the Miami Canal through Water Conservation Area 3A, and most of the L-67 canals and levees that divide Water Conservation Areas 3A and 3B.

With the loss of much of the water storage capacity that once occurred naturally in the pre-drainage Everglades, it is an unfortunate reality that reservoirs, canals and pumps are required to deliver water to the remaining natural system with the proper volume, distribution, and timing. The Comprehensive Plan creates a flow corridor of canals, pump stations and reservoirs to the east of the remaining Everglades to deliver water to Everglades National Park and Biscayne Bay. This replaces a wetland flow corridor that existed in the pre-drainage system but that is now developed. This flow path is essential to achieving restoration goals in the park without creating high water depths that would damage ecological values in the Water Conservation Areas.

It should be emphasized that as adaptive assessment and detailed modeling and design proceed over the next several years, every opportunity will be explored to utilize passive storage and conveyance in the remaining natural Everglades to the maximum extent possible without damaging ecological values due to excessively high or low-water conditions.

64. Use of regulatory-derived wetland mitigation to fund the purchase and construction of the Water Preserve Areas could accelerate the loss of the remaining peripheral wetlands, thus reducing the already scarce spatial extent of wetland habitat of the eastern Everglades in the lower east coast.

Response: The Corps generally concurs. Mixing of regulatory-derived compensatory mitigation projects and Restudy components presents a number of issues that need careful consideration. If a regulatory mitigation site is located within the footprint of a Restudy component several complications can arise. For example in the Water Preserve Areas:

Reduction of the Spatial Extent of Wetland Habitat: The spatial extent of wetland habitat in the Lower East Coast (between the C&SF protective levee and the coastal urban/agricultural areas) has been significantly reduced and the remaining acreage is under mounting development pressure. The wetlands east of the levee, but not within the WPA footprint, will be either 1) permitted for development, 2) used as compensatory mitigation for permitted losses, or 3) preserved/restored through some other public program. Assuming that item 3) will occur at the same rate regardless of the outcome of the Restudy, the fate of the remaining acreage of wetlands on the WPAs periphery will be determined through the regulatory program. These areas will be either permitted for destruction or preserved/restored as compensatory mitigation sites. When mitigation sites are located within the footprint of the WPAs, the total spatial extent of WPAs "peripheral" wetlands that will be lost to development is thusly increased. This result conflicts with the Restudy goal of increasing the spatial extent of wetland habitat within the study area.

Benefit Allocation: Environmental benefits must be allocated between either the Restudy or the regulatory-derived compensatory mitigation project, <u>but not both</u>. Benefits allocated to the Restudy accrue to the overall public interest and can therefore be used to justify federal participation in the project. Benefits allocated to compensatory mitigation sites are used to offset the wetland losses of the associated permitted development projects. Therefore, if a mitigation site exits within the footprint of a Restudy component, federal participation may be reduced or eliminated.

Operational Compatibility: The operational characteristics of many WPA cells are still being designed. Some hydrologic operational regimes, such as that needed for water storage or flood attenuation, may be incompatible with that necessary for optimum wetland habitat required at compensatory mitigation sites. If a Restudy component adversely affects a regulatory-derived compensatory mitigation site, a separable Restudy component will be needed to offset the loss. This effectively results in Restudy mitigation features for the loss of the regulatory mitigation sites and ultimately increases costs to the Restudy or reduces design flexibility for the WPAs.

Until Congressional approval of the Restudy Comprehensive Plan is received, potential benefits can not be allocated to the Restudy. In the interim, proposals to site regulatory compensatory mitigation sites within the footprint of Restudy components can be expected. Corps of Engineers Regulatory Division personnel are aware of the potential complications listed above and will work closely with Restudy Team members and private sector applicants. The goal will be to develop regulatory mitigation projects that will not be incompatible with, nor supplant potential benefits of, the Restudy. State and local authorities with wetland regulatory responsibility will be encouraged to do the same.

65. The proposed Southwest Florida Feasibility Study should complement the soon to be completed Southwest Florida Environmental Impact Statement. Further, the effect of expansion of agricultural land use in Hendry County needs to be included in the Southwest Florida Feasibility Study.

Response: Concur.

66. Lee County Department of Transportation recommended editorial changes to the Sanibel Island Causeway Other Project Element description. Further, it is premature to recommend the Sanibel Island Causeway Other Project Element at this time.

Response: Concur. The editorial changes have been made. Further, the Restudy recommends that this project be included as an alternative to be evaluated during the Southwest Florida Feasibility Study.

67. The capacity (10mgd) of the Aquifer Storage and Recovery wells exceeds any proven well size presently in operation in Florida.

Response: The capacity of the wells proposed in the Comprehensive Plan is 5 MGD, which is consistent with wells already in operation in Florida.

68. Surface water reservoirs can not retain water over the long term.

Response: Surface storage has two basic functions: to capture flood flows and to help meet water supply needs. If the natural areas are full, a reservoir is the only feature that can catch large flood flows to reduce the floodwater that is lost to tide. Because of evapotranspiration and seepage issues in south Florida, the surface reservoirs are not expected to retain water over the long term. However, by supplying water in the early part of dry seasons, water can be retained in Lake Okeechobee for the longer drought periods. Thus, even short term storage can have significant water supply benefits.

69. Will the seepage management along L-31N be effective and will reductions in flow to Biscayne Bay result from this seepage management and lowering of the south Miami-Dade water table?

Response: The amount of seepage along L-31N is a loss of water in NESRS and greatly diminishes the ability to restore hydroperiods in the ENP. Several management scenarios were modeled for the Restudy including a full “curtain wall.” The curtain wall was created to offset groundwater problems east of L-31N and was eliminated from further consideration. The seepage management component in the Comprehensive Plan represents the best balance between reducing seepage loss and maintaining groundwater stages to the east of L-31. During dry seasons, the seepage is reduced by about 30 percent using a shallow barrier (e.g. subsurface sheet pile wall along the levee); during wet seasons, additional groundwater pumping is included to capture as much seepage as possible.

Modeling for the Restudy showed no adverse problems for the groundwater east of L-31N, but it did show reductions to Biscayne Bay beyond the reductions due to increased water supply demands. In response, reuse water was identified to compensate for the loss of flow to the bay due to reduced both seepage loss and increased water supply withdrawal (2050 Base Case). During January 1999, modifications to D13R were modeled to demonstrate alternative sources for the Reuse water. The wet season groundwater levels can be improved in south Miami-Dade with the seepage management. Dry season levels were not adversely affected because of lesser dry season management and increased availability of regional water for groundwater recharge – improved performances in the saltwater intrusion prevention and water supply were evident.

During the design phase, additional groundwater modeling will be conducted at a higher resolution to evaluate the seepage management components as well as the potential for replacing the reuse water for Biscayne Bay. Given the level of detail and the unrefined demands of Biscayne Bay, the recommended plan represents the best balance possible at this time.

70. The in-ground reservoirs proposed in Miami-Dade County do not appear to be implementable.

Response: Pilot projects have been recommended to address these concerns and assist in the future design and implementation of these components.

71. The Comprehensive Plan should include flood protection.

Response: The Comprehensive Plan includes flood protection as an objective. Due to the scale of the project and the tools used to evaluate alternatives, the flood protection element of the study was not investigated to the level of detail that a typical flood control study would undergo. However, the Restudy Team did investigate potential adverse impacts that could arise from implementing the Comprehensive Plan or opportunities to enhance flood protection in known problem areas. Appendix E includes an inventory of these areas.

72. Canals and backpumping practices should be used where necessary to reduce excessive water depths and to maintain the hydrologic connectivity of the Everglades

Response: The Comprehensive Plan attempts to minimize canals and levees in a manner to promote hydrologic connectivity within the Everglades without causing harm to both the natural system or human system.

73. Reduce nutrient enrichment of Lake Okeechobee by increasing capacity of EAA canals, which will also reduce harmful discharges to the east-west estuaries.

Response: The Comprehensive Plan includes improvement to the major canals in the Everglades Agricultural Area.

74. Institute on-site stormwater treatment for facilities that are hydrologically connected to Lake Okeechobee.

Response: An objective of the Restudy is to improve water quality in Lake Okeechobee. Therefore, components, such as North Lake Okeechobee Storage Reservoir have stormwater treatment areas associated with them.

75. The Restudy should investigate the feasibility of dredging Lake Okeechobee sediments to reduce Phosphorus loads.

Response: The Comprehensive Integrated Water Quality Feasibility Study includes a study to investigate the feasibility of dredging these sediments from Lake Okeechobee.

76. Implement Best Management Practices in the Everglades Agricultural Area.

Response: Best Management Practices are being implemented under the Everglades Forever Act.

77. Improve the performance of the Comprehensive Plan in natural areas including the Water Conservation Areas and Everglades National Park. Further, restore pre-drainage flows, quality and timing via Taylor Slough, Shark River Slough and the C-111 system to provide Florida Bay historical fresh water inputs.

Response: In light of comments made in the draft Fish and Wildlife Coordination Act report, the Corps, along with its partner agencies, have invested considerable effort to identify a process by which key ecosystem features may be further improved through optimization and adaptation of the draft Comprehensive Plan (D-13R). Most notably since November 1998, the study team has developed and run several modeling “scenarios” in which the draft Comprehensive Plan was modified in an effort to improve restoration in key areas of the central and south Florida ecosystem. These scenarios are vital in demonstrating the robust nature of the recommended Comprehensive Plan and its ability to be manipulated to further improve performance.

A major focus for developing these scenarios was to determine if additional water could be captured in the lower east coast urban areas and used to better meet performance measure targets in the Water Conservation Areas and Everglades National Park, as well as investigating alternative sources of water for Biscayne Bay. This effort ultimately resulted in scenario runs $D13R_{1-4}$. Preliminary evaluation by the Alternative Evaluation Team indicates that additional captured water (about 245,000 acre-feet) helps to meet targets for Everglades National Park, Biscayne Bay and some areas within the WCAs. Performance declines relative to D13R in other areas of the WCAs and the Pennsuco Wetlands. In addition, issues relative to treating urban runoff prior to discharge into the WCAs and impacts to secondary canals have not been fully resolved. The Restudy is committed to implementing the final plan in a manner that provides improvements to the operation of the WCAs as well as providing more water for Everglades National Park and Biscayne Bay. Upon resolution of these outstanding issues, the Restudy will incorporate features of $D13R_{1-4}$ or other similar measures that allow for the capture and conveyance of additional water to the southern Everglades and Biscayne Bay. These features will be assessed under the ongoing Water Preserve Areas feasibility study and in subsequent Project Implementation Reports.

78. Utilize the most current local government comprehensive plans or Evaluation and Appraisal Reports to provide a more accurate depiction of future population movement.

Response: The population projections used were based upon the University of Florida Bureau of Economic and Business Research extrapolated to 2050 based on rates of growth projected by the U.S. Department of Commerce Bureau of Economic Analysis. Local comprehensive plans were used to modify these projections, such as in Miami-Dade County, where the evidence to modify was compelling. These choices were basic decisions made by the Restudy Team prior to the start of alternative modeling and were deemed appropriate to provide the most accurate population projections.

79. Include a table that summarizes Comprehensive Plan adoption information throughout the 16-county region to assist local government entities in making local land use decisions.

Response: Future land development is not within the scope of the Restudy. Such decisions shall properly remain a responsibility of state and local governmental entities.

80. If development continues, the Restudy components will be resized based on available land and not performance measures.

Response: While available land is certainly a limiting constraint, proper sizing of components is dependent upon many factors that are not presently based upon the conceptual level of analyses that have been conducted to date. The Restudy will continue to coordinate with responsible local authorities and provide the best information possible upon which to base land use decisions.

81. How will implementation of the Restudy be affected if the Everglades Forever Act deadline is not met, and how will costs be similarly affected?

Response: The Everglades Construction Project construction is on schedule. There is no apparent reason to believe all of the requirements will not be met. The Restudy schedule has been constructed in a manner that provides flexibility to adjust for changes resulting from project implementation. Costs are normally directly affected by market conditions during the time of delay. It is difficult to predict future market conditions.

82. Who pays for costs incurred in the Restudy as a result of the above referenced delays?

Response: Both cost increases and decreases will be shared by the federal government and local sponsors.

83. What environmental effects will result from such delays?

Response: Unfortunately, environmental effects usually are not discernible until long after occurrence of the actions that precipitated the effects. The question is comparable to predictions of the future.

84. Use location specific environmental site assessments prior to initiating land acquisition and construction activities.

Response: Such assessments normally precede construction activities and land acquisition.

85. Continue to model a “biologically” based framework and improve design for the remaining Everglades.

R: Concur; there is every intention of doing so.

86. With the present and massive losses in spatial extent, the primary focus must remain on restoring pre-drainage water flows wherever possible. This can only be supported by land acquisition to restore temporal and spatial extent.

Response: A comparison of flows against the Natural System Model indicated that the preferred alternative, D13R, improved the situation in every instance except one and refinements continue to be reviewed to improve the exception. The preferred alternative requires the addition of over 185,000 acres of land for storage, treatment and wetlands retention across the study area.

87. Restudy biological and hydrological science follow engineering regimes and scenarios that have questionable relevance with the science, biology or needs of a passive ecosystem.

Response: The Alternative Evaluation Team, chaired by Mr. Ogden, ensured that the proper measure of biological and hydrological science was used in evaluating engineering scenarios. Albeit an engineering tool, modeling can be an excellent tool in assisting and supporting decisions "based upon natural science regimes" in selecting components and alternatives, as happened in the Restudy.

88. Of 3500 pages of investigation and modeling, I have found only one page that addresses the most critical aspect from the Science Sub-group report.

Response: Perhaps only one direct reference is made to the Science Sub-group report, but the report was a basis for Restudy goals and objectives and inference to the report is made throughout the plan.

89. Where is the full range of reasonable alternatives for analysis? The Restudy Team should model and analyze population growth interests and impacts – air quality, highway impacts, sprawl and all direct and cumulative impacts.

Response: Perhaps under ideal conditions every possible alternative and impact could be reviewed, modeled and analyzed. Unfortunately, expedited schedule, personnel, budget and sheer magnitude of effort do impose reasonable constraints. The team has utilized available resources to model and analyze six different alternatives, four hybrid alternatives, 13 different scenarios, several revisions and various sensitivity analyses and case studies to develop a Comprehensive Review Study of the C&SF project. The team has fostered consensus development among state, local and federal governmental representatives; concerned individuals; citizen groups and stakeholders in the component development and evaluation and preferred alternative selection. Widespread distribution of developmental information and continued public involvement in the Restudy process are objectives that have far exceeded statutory requirements for a study of this nature. The Restudy is fully committed to achieving the best plan possible and will continue to improve the plan as it goes forward through authorization, further planning, pilot projects, and design and construction phases.

90. Federal taxpayers should not pay for research and testing of Restudy technical enhancement scenarios related to urban water supply and expensive curtain walls to stem seepage through permeable limestone in the West Miami-Dade Lake Belt area.

Response: One of the stated objectives of WRDA 96 is "The comprehensive plan shall include such features as are necessary to provide for the water related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the C&SF Project." The Comprehensive Plan includes components that meet these objectives in addition to restoration.

91. The role of fire should be included in the Comprehensive Plan.

Response: The role of fire in natural systems ecology is recognized in this report. Typically, it is the responsibility of land managers to develop fire management programs. As restoration proceeds, the Restudy believes that the Working Group should develop a system-wide burning program plan to assist land managers.

92. Decisions can not be made until the uncertainties are analyzed.

Response: A more complete uncertainty analysis is included in Appendix O.

93. There does not appear to be a tradeoff analysis among the various C&SF Project purposes.

Response: Some trade-off analyses were done through modeling scenarios by reducing urban water demands in the Lower East Coast. These are described in Section 7 of the report. The objective of the Restudy was to improve the functioning of the natural system, water supply, and other authorized C&SF Project purposes. The initial precept was that it would be necessary to give up water supply or other project purpose to enhance ecological values in the natural system. As planning progressed, it became apparent that all sectors could be improved without detrimentally impacting any particular sector. In fact, the Restudy found through these modeling scenarios that little benefit is achieved by reducing or eliminating one project purpose for the benefit of another. Despite the apparent win-win situation, there could be adverse impacts related to project implementation. Nevertheless, it is the Restudy's intention to do every thing possible to minimize these impacts by working closely with those who could be impacted.

94. The Lake Belt storage areas will require relocation and removal of existing rock mining processing equipment which will interfere with the miner's removal and processing ability. These issues need to be addressed.

Response: The Restudy Team is working with the rock miners to address such issues. The Comprehensive Plan recognizes the need to allow for continued limestone mining in this region. Every effort will be made to integrate ongoing rock mining operations with the proposed project features in order to reduce adverse impacts to the landowners.

95. The 1995 Base condition should not be used to determine potential flood impacts associated with the Comprehensive Plan. The 1995 Base does not reflect the authorized level of flood protection in the C&SF Project.

Response: Whether the 1995 Base does or does not reflect the authorized level of protection in the C&SF Project is immaterial to the analysis. An objective of the Restudy is to minimize flooding of urban and agricultural areas. The information presented in the report regarding flood protection is only meant to point in the right direction in planning and design efforts. It is important to remember that very little can be said about specific areas that will be impacted negatively by flooding as a result of the Comprehensive Plan. This is because the SFWMM is a regional scale model, not a flood routing model. There was considerable discussion during the study process as to whether anything should be said about flooding at all, given the limitations of the SFWMM for this purpose. As a compromise, the study team decided to do what is presented in Appendix E.6 regarding potential flooding impacts.

The general idea of Appendix E.6 was to point out potential areas that may need more examination and evaluation during the details of project implementation, expected to take place over many years. It is an overview, although it is based on voluminous output of selected SFWMM performance measures. It is important to look at both 1995 and 2050 base conditions since project components are anticipated to be put in place over a 20-30 year period expected to begin some time after 1995, and be completed sometime before 2050.

96. The Comprehensive Plan will have a devastating impact on rural communities while encouraging affluent urbanites to devour the east coast.

Response: There could be adverse impacts related to project implementation. It is the Restudy's intention to do every thing possible to minimize these impacts by working closely with those that could be impacted.

97. Additional water storage on privately owned lands should be considered as an alternative to the reservoir options.

Response: Flood attenuation facilities can serve three functions: flooding in developed or natural areas can be reduced, reductions of water lost to tide may occur, and some water supply benefits may be served. The various reservoirs, located throughout the study area, provide these basic functions. In the Comprehensive Plan, there are no flood attenuation “ponds” recommended, only reservoirs. During the design and implementation phase of the Restudy, such ponds may be added for very localized problems but are not likely.

98. Partially degrading levees and filling canals may provide additional habitat benefits at less cost than the Comprehensive Plan.

Response: The concept of pushing in large sections of the levees into adjacent borrow canals and leaving other sections may have merit. By doing this, the hydrologic effect of the levee and canal will be reduced. At the same time, the levee sections that are left will benefit wildlife similar to the existing tree islands which are considered to be an important part of the system's diversity. Additionally, the remaining ponds will provide aquatic habitat. This concept will be further explored during subsequent planning and design efforts.

99. It is not clear from the report whether there will be impacts to existing wetlands or other natural areas as a result of the projects features.

Response: There is a potential for impacts to existing wetlands and other natural areas as a result of the features as presently designed in the Comprehensive Plan. During subsequent phases of this project, the construction features of the Comprehensive Plan will be designed to avoid and/or minimize any impacts to wetlands or other aquatic sites. Unavoidable impacts to existing wetlands or aquatic sites are expected to be offset by the wetland preservation and/or enhancement that results from the overall restoration achieved by the Comprehensive Plan. Accordingly, separate mitigation features are not included in the recommended Comprehensive Plan for these impacts. Separate mitigation features may be included for impacts to unique or critical habitats, mitigation areas for regulatory permits, and historic or cultural resources.

100. Additional storage in the Everglades Agricultural Area is required.

Response: Component G6 includes 360,000 acre-feet of storage area in the Everglades Agricultural Area. Modeling indicated no benefits would result from additional storage in the area.

101. The draft plan contains inadequate contingency planning to guarantee Everglades restoration in the event of a shortfall in long-term funding, under performance of the costly and untested water storage and seepage control technologies and the projected sea level rise.

Response: Response numbers 16 and 41 address ASR, seepage control and contingency plans. Appendix B reflects the results of a modeling scenario to address the sensitivity of the C&SF Project to a sea level rise. The Implementation Plan addresses adaptive assessment and uncertainties. Regarding funding, the purpose of the Comprehensive Plan is to determine the feasibility of modifying the C&SF project to improve the quality of the environment; improving protection of the aquifer; improving the integrity, capability and conservation of urban and agricultural water supplies; and improving other water-related purposes. Funding, per se, is not a direct purpose of the plan. Rather, the plan should address the findings sufficiently to ensure authorization and appropriation of funds by Congress.

102. More study is needed to address impacts of a predicted sea level rise.

Response: The modeling scenario adequately detailed the primary impacts of a sea level rise relating to increased water demands for prevention of salt water intrusion and increased flood protection. A shift in development patterns is outside the responsibility of the Comprehensive Plan. Zoning and land utilization remain the responsibility of local governments. Most local emergency management functions are already equipped to assess the impacts of sea level rise. The description of sea level rise in Section 4 was revised to more accurately describe how the scenario was used.

103. An analysis of the environmental impacts of the population influx predicted for south Florida over the next 50 years is needed.

Response: WRDA 96 states "The comprehensive plan shall include such features as are necessary to provide for the water related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the C & SF Project." The plan meets those objectives. Growth management and land utilization must properly remain a responsibility of state and local governmental entities. Coordination and information flow will remain an important objective of the Restudy, but cannot be utilized as anything more than guidance for the authorities that are charged with decisions on local utilization of land.

104. Include the acquisition, restoration and management of the remainder of "Unit 11" as a part of the Pal Mar and Corbett Hydropattern Restoration OPE.

Response: Purchase will be considered during future studies relating to the acquisition of land for this OPE.

105. Attenuation and treatment facilities should be added for those basins that continue to backpump to the lake consistent with water quality restoration targets for the lake.

Response: With the additional storage facilities south of the lake and improved conveyance capacity of the canals, less backpumping to the lake should occur as a result of the Comprehensive Plan components.

106. Restoration of bays and lagoons requires reestablishing the quantity, quality, distribution and timing of fresh water inputs and the deconstruction of road barriers for establishing connectivity of tidal flushes to coastal bays and lagoons.

Respond: The Restudy includes components for restoration of Biscayne Bay, Lake Worth Lagoon and Indian River Lagoon and a feasibility study for Florida Bay. Either causeways or bridges are used to connect mainland roads to the barrier islands. The success of the Restudy in achieving ecological restoration is heavily dependent on adaptive assessment. The adaptive assessment strategy, as described in the Implementation Plan, will incorporate external scientific peer review at every stage over the next two or more decades. The strategy combined with the listed components should adequately address restoration of bays and lagoons without complete interruption of vehicular traffic patterns.

107. Restoration of Florida Bay must include further return of natural fresh water flow patterns than what is proposed in the draft comprehensive plan.

Response: The time frame of the draft Comprehensive Plan did not permit a thorough investigation of all of the regional water resource problems of south Florida. Subsequent to the completion of this plan, further feasibility studies are proposed. One of these studies is for Florida Bay and the Florida Keys. Details of the feasibility study are included in Section 9 of the main report.

108. Biscayne and Everglades National Parks and other natural areas are entitled to a water allocation that would ensure the parks' ecological integrity; therefore, a discussion of state and federal statutory and regulatory provision governing water use and allocation is needed.

Response: The purpose of the C&SF Project Comprehensive Review Study is to reexamine the C&SF Project to determine the feasibility of modifying the project to restore the south Florida ecosystem and to provide for the other water-related needs of the region. Nothing in the authorization for the original C&SF Project nor the two acts authorizing the Restudy (WRDA 92 and WRDA 96) establishes water allocation rights. The Corps of Engineers is responsible for water deliveries to Everglades National Park. The Restudy has attempted to provide for all water-related needs of the region, environmental, urban and agriculture, and has balanced those needs predicated on modeling results to meet performance measures established by the Restudy Team. Language that describes assurances to water users can be found in the Implementation Plan, Section 10.

109. Deep injection of wastewater is not prudent and should not be utilized in the Restudy as is required by the wastewater reuse components.

Response: Injection of wastewater is an acceptable method of disposal under the Environmental Protection Agency and the Florida Department of Environmental Protection rules provided specified standards are met. As long as the method is viable and acceptable, there is no reason not to include the method in the tool box of solutions. Similar methods of disposal are prevalent in Florida. If the method is deemed unacceptable in the future, the adaptive assessment strategy should adequately address injection concerns. Subsequent to the release of the draft report, the Restudy Team developed additional scenarios to address a reuse concern regarding meeting Florida Bay and Biscayne Bay targets with reuse water. This analysis revealed that additional water could be captured and diverted from upstream urban areas and conveyed into the Water Conservation Areas or in canals adjacent to the Water Conservation Areas to Biscayne Bay by modifying the preferred alternative, reducing the need for wastewater reuse. Decreased performance of the plan in other areas, as a result of these modifications, has not been fully resolved. Upon resolution of these outstanding issues, the Restudy is committed to the using the most effective features of the additional scenarios. If resolution is not forthcoming then continued reliance on wastewater reuse will be necessary as applicable.

110. Bass fishing or other recreational activities should not be a determining factor in the analysis of canal removal, levee removal or ecological restoration.

Response: During at least one of the public hearings, there were concerns expressed regarding canal removal and the consequent loss of bass fishing sites. No formal comments have been received, and this concern was not a factor considered during the alternative design and evaluation of decompartmentalization. However, any such concerns cannot be discounted as frivolous. WRDA 96 states that “The Comprehensive Plan shall include such features as are necessary to provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project.” Providing recreational activities was an objective of the original C&SF Project. In addition, societal sustainability requires the preservation of the rich cultural diversity of the region along with providing and preserving recreational facilities for public use.

111. The USACE should seek an extension to the deadline and use the additional time for peer review, full consideration and response to the public and peer review comments and beneficial modifications to the Restudy.

Response: The success of the Restudy in achieving ecological restoration is heavily dependent on an adaptive assessment plan. That adaptive assessment strategy, as described in the Implementation Plan, Section 10, will incorporate external scientific peer review at every stage over the next two or more decades. Response to public comments are included in this final report. The Restudy Team welcomes an ongoing external review by scientists with the highest level of national and international recognition in their fields. Indeed, the Restudy Team has already taken steps to initiate such a review process; however, that review is more appropriate within the confines of the adaptive assessment strategy which allows timely completion of this report.

112. There is concern that the predicted behavior of the Comprehensive Plan may not be accurate with respect to the Seminole Tribe's lands since the lands are at the edges of or outside the boundaries of the regional computer model used in the Restudy.

Response: While the concern regarding the regional model is reasonable, there is a high degree of probability that the components directly impacting Tribal lands will improve conditions. Component CCC6 improves the water quality of inflow to Seminole lands, reestablishes sheet flow across the natural area, ensures flood protection is either enhanced or not degraded and requires consistency with the Tribe's Water Conservation System master plan. More accurate modeling will occur during detailed design to further ensure the accuracy of regional modeling performance. The success of the Restudy in achieving restoration is also heavily dependent on future adaptive assessment. That adaptive assessment strategy, as described in the Implementation Plan, Section 10, will incorporate external scientific peer review at every stage over the next two or more decades. While the concern is understood, there are also procedures to ensure that such concerns are dealt with in the future.

113. The projected water conservation reductions do not appear to be based on realistic conservation capabilities of the utilities. As a consequence, there is concern of excessive water shortages in Hollywood.

Response: The water use forecasts in this study used IWR-MAIN (Version 6.1), a PC-based software developed by researchers at Johns Hopkins University and improved upon by the U.S. Army Corps of Engineers Institute for Water Resources. The software program is based on observed relationships between water use and causal factors or determinants of urban demand for water. Two projections of future water consumption for the year 2050 were made for the Lower East Coast study area. The two scenarios differ in terms of the assumed level of water use conservation. The higher estimate is based upon the same percentage distribution and usage of conservation flow devices and irrigation restrictions in effect in 2050 as in 1990. The lower estimate is based upon full implementation of existing SFWMD mandatory regulations and programs. The higher projection estimate for the year 2050 is about 1450 MGD. The lower estimated usage for the year 2050 is about 1200 MGD, approximately 18 per cent less than the higher projection. The 2050 Base condition (without project condition) assumes a more moderate application of conservation practices and effectiveness representing a level of consumption about 12 per cent below the higher year 2050 estimate. A full discussion of the water consumption projections and conservation may be found in

Appendix E. The projections were most assuredly not selected simply because they eliminated excessive water shortage declarations in southeast Broward County.

114. The draft report does not specify the portions of the L-28 and L-28 Tieback levees will be removed. Clarification is required.

Response: Concur. Water Conservation Area 3A Decompartmentalization and Sheetflow Enhancement should also specify component QQ in addition to AA and SS. This will be corrected in the final plan. Component QQ in Appendix A indicates that the levees and canals will be removed from the L-28 Tieback south to L-29.

115. Rehydration of the northwest corner of WCA-3A may be insufficient to restore this area and relocating pump station S-140 may impact flood protection for the eastern portion of the Big Cypress Reservation.

Response: More accurate modeling will occur during the detailed design phases of the components to further ensure the accuracy of component performance. The success of the Restudy in achieving restoration is also heavily dependent on future adaptive assessment. Should the more detailed engineering analyses and adaptive assessment reflect the need for changes, such changes will be made.

116. As component CCC6 provides flood protection for the majority of the Big Cypress Reservation, remove only the portion of the L-28 Interceptor south of the Big Cypress Reservation.

Response: Concur. The complete description of CCC in Appendix A (p. A4-45) indicates that the L-28 Interceptor Canal shall be backfilled at a point south of the Big Cypress Reservation boundary with the Big Cypress National Preserve Addition. This point was added after previous coordination with Tribal representatives.

117. What is the operation and maintenance cost of the Comprehensive Plan?

Response: The current estimated annual operations and maintenance cost for the Comprehensive Plan is $165,000,000. It should be noted that this cost is not realized until all features are fully implemented, which is not expected until 2037. Further, the estimate includes the two wastewater reuse projects which make up more than 50 percent of the annual operating costs. If these projects do not become necessary due to less costly alternatives, then the annual operations and maintenance cost would be considerably less.

118. How will the Restudy affect the ownership and management of our local water utility?

Response: The Comprehensive Plan will not affect the ownership or management of local water utilities. The implementation of the Comprehensive Plan will assure that there will be an adequate quantity of water to meet future demands.

119. There does not appear to be any direct economic benefit to Cypress Grove Community Development District.

Response: All localized impacts are important. It is anticipated that the implementation of the Comprehensive Plan will have positive effects to local economies. The resolution of the economic impact estimating model and methodology is not at a level of detail that would explicitly include this specific concern.

120. Critical Projects that fail to be implemented under the WRDA 96 authority should be included in the Restudy. Further, implementation of these projects should not be delayed until the associated feasibility study is completed.

Response: Funded Critical Projects by definition follow a different, expedited schedule than the Restudy. Critical Projects that have not been approved and funded have been added as Other Project Elements (OPEs). The OPEs will be phased as outlined in the Implementation Plan, which provides a logical sequencing of project features to maximize benefits and reduce disruptions.
Feasibility studies do precede components in the areas under study. The feasibility studies are early in the sequencing process for that reason.

121. Maintain compatibility between the restoration plan and agriculture.

Response: The purpose of the Restudy is to reexamine the C&SF Project to determine the feasibility of structural or operational modifications to the project essential to restoration of the Everglades and south Florida ecosystems while providing for the other water-related needs of the project. Water supply for agricultural uses falls within the other water-related needs of the project. Section 5 of the Report indicates that increasing the availability of fresh water to meet agriculture, urban and environmental needs is an objective of the Restudy.

122. The Restudy should support local efforts toward implementation of Eastward Ho.

Response: Although zoning, growth management and land utilization remain the responsibility of local governmental authorities, nothing in the Restudy precludes or impedes implementation of the program.

123. For environmental restoration, some of the 400,000 acres of sugar cane land is needed while insuring that agricultural runoff is treated to strict water quality standards.

Response: Best Management Practices by land owners and stormwater treatment areas constructed under the Everglades Construction Program, a separate program funded primarily by the SFWMD from agricultural privilege and a special ad valorem tax assessments, will ensure that runoff is treated to required water quality standards. Over 44,000 acres of farmland has been purchased to accommodate the stormwater treatment areas. The Restudy designates another 60,000 acres of Everglades Agricultural Area land for use as surface water storage areas. Thus, nearly 100,000 acres of agricultural land will be purchased to meet water quality cleanup and water storage requirements.

124. Improve the ecological conditions of Water Conservation Area 2B.

Response: The Restudy Team is committed through the implementation process to improve the operation of all the conservation areas.

125. D13R should move forward as the recommended plan. Make diversions of water from the urban areas as a contingency and possible design refinement during the implementation. The Miami-Dade Reuse component should be less specific in location and schedule so that it would remain as a contingency to be used as needed.

Response: The recommended plan is D13R plus the Other Project Elements. Further refinement to the recommended plan will take place during the Project Implementation Reports, which are the next phase of the project.

126. Suggest watershed based approach to solving Biscayne Bay and Florida Bay starting with the Analytical Tools necessary.

Response: Next generation models are being developed for the Miami-Dade County area.

127. Ensure that a process will be funded to identify alternative sources of water for Biscayne Bay and if another source of water is found, re-diverting water from the reuse to this source will not require reauthorization. Costs associated the construction, operation and maintenance, and monitoring for the South Miami-Dade County Reuse component should be eligible for 50/50 cost sharing.

Response: The Draft Implementation Plan released 25 January 1999 identified a Reuse Technology Pilot Project which included studies to address the ecological effects of reuse, design the pilot, construct the pilot and monitor the pilot. It has been the intention of the Restudy to cost share the reuse facility 50/50.

128. Ensure that new facilities are reliable, before switching the supply.

Response: For each major component or series of components that is developed, a Project Implementation Report and supplemental EA or EIS will be prepared. The EIS will contain the operational rules and the impacts on water supply. The process of component development, as well as developing the EIS, will be open to public involvement. Thus, the various stakeholders in the region can actively participate throughout the transition period. Section 10, Implementation Plan contains assurances to water users.

129. Ensure a minimum of 1 in 10-year flood protection.

Response: The Comprehensive Plan provides good performance for agriculture in south Miami-Dade; this view is borne out by evaluations done by the Florida Department of Agriculture and Consumer Services. There exists apprehension by local agricultural concerns about how the conditions may change between current conditions and implementation of the recommended plan. The 2050 Base Case (without the Restudy), unless altered favorably for flood control, will cause worse conditions than today. The Restudy modeling demonstrated favorable groundwater management guidelines.

130. Lower East Coast Utility Water conservation should be broad enough to allow for alternative means to reduce urban water demands and be Federally cost shared.

Response: Concur; water conservation is an important element of the Comprehensive Plan and is best implemented at the state, county, and local levels.

131. The report should be modified to identify a process to resolve areas of deficiency in the performance of the Comprehensive Plan.

Response: The Implementation Plan, Section 10, has been revised to include a process to modify the Comprehensive Plan in the future to affirm, reformulate or modify a component, or group of components, address uncertainties, knowledge learned from pilot projects, and further design the components. This process is the development of Project Implementation Reports (PIR). As the Comprehensive Plan is being formulated in the PIR, significant changes will be evaluated by the Restoration, Coordination and Verification Team (RECOVER). The RECOVER Team will be established to provide system-wide evaluation and analyses and perform program tasks. This team will be similar in function to the Restudy's Alternative Evaluation Team (AET) and the other ad hoc Everglades teams used to formulate and refine the Comprehensive Plan.

132. The components, C-111 North Spreader and the Biscayne Bay Wetlands should not be considered for authorization, until the land is sited.

Response: The Restudy is not seeking authorization on the Biscayne Bay Coastal Wetlands at this time. Authorization is being sought on the C-111 North Spreader Canal to accomplish as part of the C-111 project construction. This canal will provide water to the Model Lands area. More detailed modeling will be accomplished during the design phase of its construction and if warranted, a supplemental NEPA document will be prepared.

133. The Restudy does not provide adequate cost/benefit analysis.

Response: The cost/benefit analysis is contained in Section 7 of this report.

134. Protect coral reefs and public health from sewage.

Response: Although the scopes of the studies have not yet been developed, it is envisioned that the Florida Bay feasibility study and Comprehensive Integrated Water Quality feasibility study contained in the recommended plan will address in detail the issues of nutrient sources and loads, impacts to reef ecosystems, appropriate restoration targets, and remediation programs (including wastewater treatment) to protect and restore reef ecosystems.

135. The results of the Sensitivity Analysis indicate only limited benefits are produced by the North Lake Belt Storage Area. Do the benefits of this component justify its cost?

Response: To the contrary, the sensitivity analysis conducted by the Restudy revealed that eliminating the North Lake Belt Storage Area from the Comprehensive Plan would cause adverse conditions throughout south Florida. Namely, it would result in a significant increase in water deliveries for Lake Okeechobee and Water Conservation Area 3A to the Lower East Coast Service Area 3 to maintain water levels in the canals. As a result lake stages were lower, and there were increases in water restrictions in Lower East Coast Service Area 2 with reduced ability to maintain coastal canals, and a redistribution of flows to Biscayne Bay.

136. How much can a component be changed after the plan goes to Congress?

Response: Subsequent to the submittal for approval of the Comprehensive Plan to Congress, a detailed planning effort in the form of Project Implementation Reports (PIRs) will be developed for each component or a logical group of components. Each PIR will then be submitted to Congress for project authorization. Upon project authorization, the detailed design and real estate activities would commence followed by construction and operation of the component.

137. Additional formulation of the best configuration of the in-ground reservoirs is needed during the subsequent phase of this project.

Response: During pilot projects, the Water Preserve Areas Feasibility Study and future design work for the recommended plan, both groundwater modeling and technical evaluations will be conducted to further explore the feasibility of the underground barriers associated with the Lake Belt storage areas. The Restudy presented the initial design, but a lot of additional studies are required. Technical evaluations will include core-boring studies that will clarify the depths and spatial extents of the clay layers underlying the areas. These layers are critical elements of the in-ground reservoirs. Technical reviews of existing barrier technologies will be completed. Technical evaluations will include discussions with experts familiar with the substrate and the barrier techniques. Modeling evaluations will be conducted at a greater resolution to ensure the reservoirs would not adversely impact groundwater flows in the region. Although years of evaluations will proceed possible implementation of the component, the recommended plan has demonstrated the importance of pursuing in-ground lakes for several reasons: hydrologic restoration of NESRS, water management flexibility, water supply, and prevention of saltwater intrusion.

138. The Restudy is not consistent with the Dade County Lake Belt Plan Committee.

Response: Recommendations of the Lake Belt Committee were considered during the formulation of the Comprehensive Plan. Implementation of this component will require continued communication with the Lake Belt Committee and landowners. It has been the intent of the Restudy to build these components, after mining in the area is through. The Restudy presented the conceptual design, but a lot of additional studies and pilot projects are required, including the timing and construction schedule.

139. Ensure that the Pennsuco wetlands are preserved and enhanced.

Response: The Miami-Dade County Lake Belt Plan Implementation Committee is currently developing a detailed master plan for the northwest portion of the county that includes public ownership and restoration of the Pennsuco wetlands. A draft Programmatic Environmental Impact Statement was released by the U.S. Army Corps of Engineers, Jacksonville District in February 1999, which discusses rock mining and its effects on the region, including the Pennsuco wetlands. The draft Programmatic Environmental Impact Statement includes a proposed funding source and process for the acquisition and restoration of the Pennsuco wetlands.

140. Ensure that maximum ecological, not maximum mining potential is incorporated into the Lake Belt/C&SF Restudy process.

Response: The Comprehensive Plan includes features that would utilize existing and future rock mining lakes as in-ground storage reservoirs. A pilot test of this component will be conducted prior to final design to determine construction technologies, storage efficiencies, impacts on local hydrology, and water quality effects. The purpose of these features is to store damaging excess water from Water Conservation Areas 2 and 3 and then provide environmental releases to Northeast Shark River Slough, Water Conservation Area 3B and Biscayne Bay as needed. The utilization of existing mining lakes will maximize the ecological benefits of this resource with the resources of the Everglades ecosystem as a whole.

141. An expanded discussion on the issue of the Restudy including separable compensatory mitigation features for adverse impacts to existing compensatory mitigation sites established by wetland regulatory permits is recommended. In addition, it is suggested that the Corps commit to promptly identify the location and acreage of existing regulatory compensatory mitigation sites located within the currently sited components of the recommended Comprehensive Plan.

Response: The editorial comment is noted; the section will be rewritten for easier comprehension and an expanded discussion on Restudy impacts to regulatory derived compensatory mitigation sites. As the Project Implementation Report process is initiated for each component, or set of components, the identification of regulatory derived mitigation sites as well as unique and critical habitats will be an early action.

142. Only the Critical Projects that have been approved by HQUSACE and are expected to be funded through the Critical Projects program should be in the Without Project Condition.

Response: Concur. In the Final Report, the approach to Critical Projects will change so the Without Project Condition will only include the Critical Projects that have been approved by Headquarters and are anticipated to be funded through the Critical Projects program. All the remaining Critical Projects will be accounted for in the recommended Comprehensive Plan.

143. The evaluation of the Other Project Elements (OPE) by the interagency team was not in-depth.

Response: Concur. Many of the proposed OPEs were very conceptual in nature and the interagency evaluation team was tasked with the evaluation responsibility with very little time remaining in the plan formulation process. In the final report the conceptual nature of the OPEs will be emphasized.

144. Regarding the OPE evaluation matrix. The “significance” criterion should be eliminated and the factoring of the “geographic extent” criterion should be modified.

Response: There has been no time to reassemble the interagency team to "reevaluate" the OPEs. Even so, reevaluation will occur during the detailed design phases for the OPEs included in the recommended plan. Most of the other OPEs are recommended for additional study through one of the recommended feasibility studies.

145. The OPE evaluation matrix used by the interagency team has the potential for bias due to the ranking method developed by the Corps.

Response: Concur. The ranking method described in the draft report was not used as a basis for selection of the OPEs recommended for inclusion in the Comprehensive Plan. In the final report, the evaluation matrix will not be used to comparatively rank the OPEs.

146. How will the OPEs recommended for inclusion in the Comprehensive Plan be implemented?

Response: The Implementation Plan (Section 10), which will be included in the final report, includes scheduling for the recommended OPEs.

147. Evaluation of the effects of the Restudy were limited to the Caloosahatchee Estuary when the entire Charlotte Harbor Estuary Complex should have been evaluated.

Response: The Restudy's major strategy to improve the ecological health of south Florida's coastal estuaries is to modify both the timing and quantities of freshwater deliveries to the coast in order to produce conditions favorable to aquatic life. Development of the recommended Comprehensive Plan involved evaluation of an array of "alternatives" using a variety of tools. The South Florida Water Management Model (SFWMM) provides the best tool currently available for evaluating the effect of a given alternative on the entire ecosystem influenced by the C&SF Project, including the estuaries.

The Restudy's effect on the Charlotte Harbor Estuary is dependent upon flows down the Caloosahatchee River. The most relevant output from SFWMM simulations is river flow at the Franklin Lock and Dam (S-79). A multi-agency, multi-disciplinary Alternative Evaluation Team (AET) evaluated the various alternative plans using a set of performance measures. The performance measures for the Caloosahatchee Estuary are based on known relationships of various flow rates, and the response of estuarine organisms to those flows. Desirable average monthly flows for S-79 were first developed by SFWMD scientists and then reviewed and approved by the AET. Average monthly flows were determined to be the most appropriate "time slice" for measuring the performance of an alternative because the hydraulic residence time of the Caloosahatchee Estuary averages about one month.

Moderate variation in salinity is one characteristic of a healthy estuary. To account for this desirable variation, both low and high average monthly flows were selected to form a favorable "salinity envelope". Selection of these flows was based on a recent study that estimated the optimum freshwater flows to the estuary for the area from S-79 downstream to Shell Point. The AET evaluated the performance of a given alternative by counting the number of times during the 31-year period of the SFWMM simulation that the desirable average monthly flows were either; not met on the low side, or were exceeded on the high side. The recommended Comprehensive Plan does extremely well at staying within the desirable monthly flows for the Caloosahatchee Estuary. Even so, the Restudy recognizes that the domain of the model used to develop the estuary salinity envelope does not encompass the total Charlotte Harbor Estuary complex. Additional study is needed to confirm that improvements to the Caloosahatchee Estuary will not have unintended adverse effects on the greater Charlotte Harbor Estuary. A coupled circulation and water quality model for the greater Charlotte Harbor Estuary is currently being developed by the SFWMD with completion expected in December 2000. This model of the entire Charlotte Harbor Estuary will allow the Restudy to refine, in consultation with the CHNEP, the desirable average monthly flows for the Caloosahatchee.

The Restudy Implementation Plan includes several pathways to update the Comprehensive Plan as new and better information becomes available. The Implementation Plan (Section 10) also includes many opportunities for continued public review and input. The implementation schedule for the project features proposed for the Caloosahatchee Basin (i.e. Surface Reservoir(s), Aquifer Storage and Recovery systems, and Lake Okeechobee Backpumping facilities) contains ample time to include results from more refined modeling and public input, prior to final design and construction. Construction of Restudy features will provide the management capabilities necessary to attain many of the CHNEP hydrologic objectives related to the Caloosahatchee.

N.2.2 Water Quantity and Modeling

148. What assurances are there concerning the reliability of water supply (for urban, agriculture, and the natural system) during the transition period?

Response: For each major component or group of components that are developed, a supplemental EA or EIS and a project implementation report will be prepared. The EIS will contain operational rules and the impacts on water supply. The process of component development, as well as preparation of the EIS, will be open to public involvement. Thus, the various stakeholders in the region can actively participate throughout the transition period. Study planners will strive to meet or exceed current water supply. Language on assurances to water users can be found in Section 10 of this report.

149. What assurance is there that backpumping Caloosahatchee River water will not degrade the water resources within the Caloosahatchee Basin or estuary?

Response: According to current water allocation rules, the Caloosahatchee Basin receives water supply from Lake Okeechobee without any backpumping to the lake. However, the river will back-flow to the lake when the lake stage is below about 11.2 feet, which happens only rarely. The only new concept in the Restudy is that water only when it is “in excess” of the basin needs would be backpumped to the lake. The only time water is considered to be “in excess” is when (1) water amounts are greater than what is required by the estuary, (2) storage is not available within the basin, and (3) it would otherwise be lost to tide. Once the water is backpumped into Lake Okeechobee, it would be available to the Caloosahatchee Basin if it later needs the water. Under the D13R plan, about 50 percent of the backpumped water is returned to the basin, the rest goes to environmental improvements. Because backpumping only occurs during the events that would send the excess water to tide, it does not cause additional drainage from the basin. During low flow periods of the river, about half of the backpumped water is returned to the basin for water supply and minimum flows to the estuary; the other half of the water is used to support Everglades restoration.

150. Does the Alligator Alley Turnpike cause a hydraulic/hydrologic impediment the flow of water in Water Conservation Area 3A?

Response: A review of headwater and tailwater data shows that Alligator Alley does not impede the flow of water in WCA 3A. There are two reasons why this is likely: (1) there are extensive borrow canals along the road, both north and south, that act like collection ditches; and (2) there are numerous bridges that allows the water to pass from the north side to the south side.

151. Will additional refinements in hydrologic models be done to reduce uncertainty?

Response: Improvements in the NSM and SFWMM (the primary models used to develop targets and alternatives) are expected to continue in the future. One source of uncertainty comes from a lack of precision in land elevations in both the historical and current landscape. Studies and data collection, leading to improved land elevations, are being conducted at this time. Additionally, other models with higher resolution and more suitable for developing detailed information will be used for the design and implementation of components.

152. Does the storage area north of Lake Okeechobee have significant environmental benefits and will it have water quality problems if agricultural lands are used?

Response: The storage area, identified as being north of Lake Okeechobee (about 200,000 acre-feet of capacity), serves to reduce the flood flows coming into the lake. This reduces both the damaging high stages of the lake and the destructive releases to the estuaries. As the lake levels lower, the water is released from the storage area to the lake where the water has several benefits: water quality improvement, environmental releases, water supply, and in-lake low level improvements. Numerous flood reduction features in the Kissimmee Chain of Lakes area have resulted in higher and more rapid flood peaks in the Kissimmee River. The storage feature will be used to ameliorate that effect as well as reduce water that would otherwise be lost to tide.

153. Are the flows to Florida Bay substantially increased by D13R, if not what modifications can be done to increase the flows?

Response: The flow pattern to Florida Bay was not increased by D13R so much as improved. The timing and distribution was improved in the recommended plan, however subsequent scenario modeling that substantially increased the flow to the ENP was successful at increasing the flows to Florida Bay as well.

154. Why were flowways not included in the recommended plan?

Response: A flowway is generally described as a broad, shallow marsh area that is used to freely-flow water from Lake Okeechobee to one or more of the WCAs. The evaluation of the concept shows a number of problems concerning its feasibility, including soil subsidence, evapotranspiration, seepage management, vegetation, timing of flows, and lack of flow events. Additional EAA issues include numerous roads, bridges, and railroad relocations would be required if a flowway cuts through and divides the entire area.

Soil subsidence in the EAA has substantially reduced the hydraulic head that would drive the southward flow of water; hence, velocities and flow rates would be greatly reduced. By spreading the water over shallower areas (as opposed to reservoirs) and because a marsh habitat would have to be kept hydrated, the evapotranspiration loss could easily be doubled. A long, rectangular configuration would have a 75 percent longer levee than a more square area, thus increasing seepage management features. Because nutrient-laden soil would be flooded for the flowway, the vegetation most likely to dominate would be cattails and not desirable Everglades habitat. Flowways would not “hold back” water going the WCAs and the delivery of that water would exacerbate the already high stages in the northern parts of the WCAs. Thus, the timing of flows from flowways would not be manageable or beneficial for the remaining Everglades. Perhaps the most crucial element, water flowing from the lake to the WCAs, is not present in dry or even normal years! For example, during long periods from 1970-1982 or 1985-1994, no significant excess lake water was available for the flowway. Only demand releases to the Everglades were made from the lake during those periods. Water delivered to the Everglades on a demand basis, through a flowway, would not be effective with increased travel times and increased evapotranspiration losses. The only years where water could flow for long duration are wet periods like 1969-1970, 1982-1983, and 1994-1995. In those years, the stages in the WCAs are already too high and additional flow from flowways would be damaging, not beneficial.

155. Can ASR replace the function of surface reservoirs and eliminate the need for large tracts of land?

Response: Reservoirs provide two basic functions: flood storage and subsequent water supply. ASR wells can provide the water supply function, but they cannot provide significant flood storage. ASR wells have a relatively small pumping rate – about 5mdg or 7cfs. Structures designed to handle flood flows have the capacity to pump several thousand cfs. A surface storage area can receive up to 10,000-acre feet per day (at the S-5A capacity) whereas an ASR well can only pump about 14-acre feet per day. Because flood flows require high flow rates on a daily basis, ASR wells – even when clustered – cannot catch flood surges. However, when ASR wells are used in conjunction with reservoirs, the wells can free up reservoir storage over time, which allows the reservoir to catch additional flood surges. Although ASR wells have some loss to the aquifer (assumed to be 30 percent in the Restudy), there are no evapotranspiration losses as in surface storage. Therefore the ASR wells have a superior long-term drought management ability. In the recommended plan, most of the ASR wells are associated with reservoirs so that both flood control and water supply is maximized. In the case of the in-ground storage areas (in the Lake Belt area) no additional evapotranspiration would occur since the area already has open-surface losses. Hence there is no additional water supply benefit with ASR wells used with those storage areas. The land covered by reservoirs may lose natural hydrology, plant communities and wildlife habitat values; judicial placement of reservoirs should be considered as well as the overall benefit to the system.

156. Has the “saturation point” been reached in the LEC with regard to water supply?

Response: No. Under the current conditions, any additional water supply required in dry years by the LEC comes from the WCAs, which reduces water in the natural system. Under the recommended plan, a 50 percent increase in LEC demands can be met while lowering the withdrawals from the natural system. Using water that is currently lost to tide along the LEC allows not only more water to be available for water supply, but also can increase the water to the natural system by about 300,000 acre-feet on average each year.

157. Can the current drainage system furnish restoration flows to the Everglades?

Response: The current drainage system was designed primarily to remove floodwaters from the system while supporting water supply deliveries from the lake. In order to furnish water to the Everglades for restoration, the current system requires extensive changes. Simply routing floodwaters to the Water Conservation Areas does not enhance ecological values because the timing of the flows would not be ecologically beneficial.

158. Will the water levels in the WCAs have the proper fluctuations for restoration?

Response: With the exception of WCA 2B and the southern part of WCA 1, the water levels in the WCAs will be fluctuated to mimic natural system patterns. The damaging over-drainage and ponding effects currently experienced in WCA 2A, 3A, and 3B will be nearly eliminated by the recommended plan. In WCA 1, hydropattern restoration could be accomplished, but it would require using water of a different quality that could adversely alter the landscape in WCA 1. Improvements to hydropatterns in WCA 1 were limited to the northern end (reduced over-drainage). Although several configurations were attempted to return WCA 2B to natural fluctuations, additional efforts are needed to improve performance in the area.

159. Will the westward movement of wellfields in Broward County adversely effect wells in the tribal reservation?

Response: Modeling shows that the groundwater along the LEC will be maintained by the recommended plan, thus protecting against saltwater intrusion. The westward movement of wells does not put other wells at risk as long as more water is delivered to the area. Broward County is the only LEC area that receives greater deliveries from the regional system in the recommended plan. Then too, some well fields will receive water from additional canal works. To ensure the plan is sound, groundwater modeling at a high resolution will be accomplished during the continuing Water Preserver Areas Study.

160. Will site specific ASR pilot tests and aquifer modeling be conducted prior to implementation of the ASR components? How will the amount of recoverable water be determined in ASR wells? Have contingencies been identified if the ASR component is not as effective as modeled?

Response: ASR wells will be evaluated in several ways. Aquifer studies will be conducted that will include data collection and groundwater modeling of regional and local effects. Test wells will be constructed and used to develop feasibility and design information. Operational criteria will be developed based on aquifer performance and water quality data. A multi-agency committee addressed the major unresolved issues in a report to the Working Group in January 1999.

ASR wells were included in the recommended plan because they can provide a water supply function that is superior to reservoirs in long-term drought management. If ASR wells will not function to the level envisioned in the recommended plan, then several contingencies will be explored. The most likely contingency will be to make existing storage areas more hydrologically effective by making the areas deeper. The overall performance of the recommended plan may be reduced if ASR does not perform as well as expected. However, the loss of water resources would be relatively small (less than 5 percent), but without ASR, Lake Okeechobee stages would exceed target levels more often.

161. What are the water supply benefits/impacts of the recommended Lake Okeechobee regulation schedule (component F3)?

Response: The change in Lake Okeechobee regulation schedule, as noted in component F3, was used in the recommended plan D13R. Essentially, the new regulation schedule eliminates all regulatory release schedules except Zone A releases (that are required for levee protection). Zones for operation of the ASR wells around the lake and operation of the storage area north of Lake Okeechobee were identified. Additionally, a zone for passing water to the EAA storage area was defined.

162. Is the amount of storage in the EAA (360,000 acre-feet) sufficient and will the Holey Land and Rotenberger areas be used for storage?

Response: The amount of storage in the EAA is considered sufficient. In most years, 120,000 acre-feet of storage could handle any excess runoff from the EAA without adversely impacting water levels in the WCAs. In wetter years, an additional 120,000 acre-feet of storage is needed to catch the excess runoff plus some releases from Lake Okeechobee. In all but 2 of the 31 years modeled in the Restudy, a third 120,000 acre-feet of storage was needed to capture all excess runoff and releases from the lake. Additional increases in storage size results in some loss of water to the Everglades as modeling results demonstrate. Modeling of 480,000 acre-feet shows a clear reduction of flow to the Everglades although there is an improved ability to handle the two extreme flood events over the period of record. Both Holey Land and Rotenberger are areas to be restored and are not used as storage areas. As Holey Land and Rotenberger represent the last significant portion of the sawgrass plains that historically covered most of the EAA, water levels in those areas will be managed in a way to promote the sawgrass landscape while discouraging cattail dominance.

163. Will the storage area in the Caloosahatchee River Basin be used to improve water supplies to other areas?

Response: No. Water stored in the Caloosahatchee River Basin would be released back to the basin to help meet water supply and estuary demands. In many years, the releases from the storage area will be sufficient to meet the needs of the basin; however, in drier years, there will still be releases from Lake Okeechobee needed to help meet basin demands. Overall, the water supply in the Caloosahatchee River Basin will improve by about 40 percent in addition to meeting most estuary minimum flow needs.

164. The urban water supply need from the Caloosahatchee River Basin (about 50cfs) for Lee County and the City of Ft. Myers was not mentioned in the recommended plan; was this need identified and included in the Restudy?

Response: A 40 percent increase in total water supply demand was assumed by the Restudy. In the recommended plan, that increase would be more reliably met in the year 2050 than current demands are met. Because water allocation is a state responsibility, the federal plan does not reallocate or permit water resources, but rather increases the available water supply. The request for an additional 50 cfs for water supply to Lee County and Ft. Myers was noted, but it cannot be permitted by the Restudy. The permit for the 50 cfs should be considered under state law by the SFWMD.

165. Can pumping be minimized through water management options?

Response: If excess water is to be captured in the Caloosahatchee Basin, it can be either put into storage areas that allow for early dry season deliveries (by gravity feed) or held in smaller retention areas throughout the region. If water is held in the smaller retention areas (such as existing marshes), there is a flood control benefit but the water supply benefit would be greatly reduced (when compared to a single, deeper reservoir). Whenever water is transferred across hydrologic regions, the pumping requirements tend to be high. However, in the case of backpumping excess water into Lake Okeechobee, deliveries can be made to the Everglades or back to the Caloosahatchee River with the same pumping requirement that would be required for reservoir storage within the basin.

166. Does the recommended plan send sufficient water to Biscayne Bay? Furthermore, could another source of water be identified to replace the reuse water?

Response: In the southern Biscayne Bay region, the recommended plan exceeds target flows. In the central regions, flows to Biscayne Bay are below the target; however the excess in the southern region could be used to meet the needs in the central region. In the recommended plan, reuse water was identified as a source of water to augment the flows from the south Miami-Dade drainage basin. At the time alternative plans were formulated, this was the only source readily available for meeting target flows. Alternative sources are being investigated and may be used to replace reuse water if feasible. In modeling conducted in January 1999, modeling scenarios were able to increase the flow to the ENP by about 245,000 acre-feet per year while replacing the need for reuse water in Biscayne Bay. About 75,000 acre-feet per year increase in deliveries to the bay was achieved through the capture of excess water from both Broward and Palm Beach counties.

167. Will all research conducted on hydrology, modeling, and water quality be peer reviewed by experts outside the agency?

Response: The hydrologic models used in the Restudy were peer reviewed. There are extensive peer review efforts associated with water quality (especially as related to the Everglades Forever Act). The Restudy process has been open and available for review throughout the entire study process. The study team included experts from all agencies (state and Federal). Presently, the South Florida Ecosystem Restoration Task Force is proceeding to select a peer review panel to perform ongoing review as part of the implementation process.

168. Does the recommended plan provide an adequate quantity of water to the natural system including Shark River Slough, Taylor Slough, Model Lands, and Florida Bay to ensure a sustainable and diverse ecology within the Everglades ecosystem? Can the recommended plan be modified to increase the amount of flow to the ENP in order to improve various flow targets?

Response: The performance measures for the Shark River Slough, Taylor Slough, Model Lands and Florida Bay all indicated a great improvement over existing conditions, but also showed targets based on NSM were only about 75 percent successful. As a result of a desire to be closer to NSM flow and stage characteristics, additional modeling of the recommended plan was conducted in January of 1999. The modeling effort sought ways to increase the flows to those areas as well as Biscayne Bay. The water identified as excess to tide from C-51 (from West Palm Beach) and southward was captured and routed for that purpose. Water quality issues will require additional evaluations. The modeling effort demonstrated the flexibility of the recommended plan with minor modifications to D13R facilities. As a result, an additional 77,000 acre-feet per year was identified for Biscayne Bay (which could eliminate the need for reuse water) and an additional 245,000 acre-feet per year was delivered to the ENP. There was a dramatic improvement to the Shark River Slough, Taylor Slough, and Florida Bay. Almost 90 percent of NSM flows were delivered to Shark River Slough and essentially 100 percent was delivered to Taylor Slough and southward to Florida Bay. The most extreme deviation for the NESRS stage duration curve showed less than 0.2 foot from the NSM duration curve. There were “pros” and “cons” through the rest of the system that requires additional modeling, but the effort clearly demonstrated the flexibility and robustness of the recommended plan. Improvements to all areas are still possible with more data collection, more modeling, and newer operational scenarios. The recommended plan creates the features necessary to capture and use resources currently lost to tide and therefore remains the basis for restoration of the Everglades while meeting other project purposes.

169. Was the water budget for the recommended plan identified and did it consider the need for groundwater recharge?

Response: The water budgets for all areas have been available on the Restudy web site for public review of the recommended plan as well as for all other alternative plans evaluated. The surficial groundwater component was modeled both in the NSM and SFWMM (the models used for alternative development and evaluation). Groundwater recharge was evaluated along the LEC because of the critical nature of both water supply and prevention of saltwater intrusion.

170. How was the amount of water considered to be “excess to tide” in the Caloosahatchee Estuary determined and were the greater needs of the Charlotte Harbor area considered?

Response: The flow regime necessary for a suitable salinity in the Caloosahatchee Estuary was modeled and evaluated in the mid-1990s and was published by the Charlotte Harbor National Estuary Program in 1997. The evaluation considered the estuarine environment from the mouth (at Shell Point) to just downstream of the Franklin Locks. The Restudy used the available information to determine the amount of “excess flow to tide” for the recommended plan. A modeling study of potential influences of changes in the Caloosahatchee River on the entire Charlotte Harbor was proposed by the SFWMD in the summer of 1998. Modeling results should be available prior to the design and implementation of any components of the recommended plan in the Caloosahatchee Basin. In the recommended plan, dry conditions are improved (not degraded) by the delivery of a minimum flow of 300 cfs; currently there is zero flow to the estuary during dry conditions.

171. Does the recommended plan propose to keep the Caloosahatchee storage area full during the wet season and are the reductions in flow to the Caloosahatchee River from Lake Okeechobee detrimental to the health of the river?

Response: The operation of the storage reservoir in the Caloosahatchee Basin does not include a rule that is designed “to keep” the reservoir full. Under the recommended plan, the reservoir fills upon availability of “excess water”. If sufficient water is available, the reservoir will fill. In years when excess water is less plentiful, the reservoir does not fill. If the water in the river is needed for either water supply or estuarine health, it is not put into storage. Regardless of how much water is in the reservoir, if there is a water supply need in the Caloosahatchee Basin, water would be released from storage. The reductions of flood flows from Lake Okeechobee are highly desirable for the health of the Caloosahatchee River and Estuary, especially because they are not annual events but rather are occasional and destructive.

172. Are the long-term average flow needs of the Caloosahatchee River met and can the water that is identified in the recommended plan for backpumping into Lake Okeechobee be kept in the Caloosahatchee Basin instead?

Response: In the Restudy, 31 years of daily flows were used to determine how much water could be held in storage that would be consistent with the health of the river and estuary. There are only three options for capturing the excess Caloosahatchee River water: in one or two large storage reservoirs, many small and shallow retention areas, or in Lake Okeechobee (via backpumping). Many small and shallow retention areas will not have the water supply benefits (because of large increases in evapotranspiration) of one or two large reservoirs. There are no additional evapotranspiration losses associated with backpumping to Lake Okeechobee. In the recommended plan, backpumping to the lake was preferred over a large increase in surface storage. Half of the water backpumped to the lake is returned to the Caloosahatchee Basin either for water supply or estuary minimum flows. The rest is associated with environmental benefits of the lake and the Everglades.

173. Can the proposed 110mgd ASR capacity in the Caloosahatchee Basin reduce the destructive high flows to levels below 2800 cfs without storage in the basin? Further, if the average river flow is greater than the 300 cfs low target, is river diversion needed?

Response: ASR by itself cannot substantially reduce the destructive flood flows of the Caloosahatchee River. While ASR can store large amounts of water, it can only do so at a slow rate (e.g. 110 mgd). Flood flows are typically short term and large quantities (several thousand mgd). The only way for ASR to capture a flood is by first catching it in a reservoir with suitable inflow capacity and then pumping it into ASR wells. Even if the average flow target is met, flow can be excess at times or deficient at times. Daily averages must be used in determining the flow requirements of the river and whether or not flow is available for capture.

174. How were future changes in basin flows from Fisheating Creek accounted for in the recommended plan?

Response: In absence of definitive changes in the water that flows from Fisheating Creek to Lake Okeechobee, the same flow pattern was assumed. Before substantial changes to the pattern (new water demands or basin development resulting in changes) would occur, the changes would be reviewed and permitted by the SFWMD. Future changes from any watershed, including Fisheating Creek, would be incorporated into the design and implementation of the recommended plan.

175. What is the functional value of the attenuation ponds in the recommended plan?

Response: Flood attenuation ponds can serve three functions: reducing flooding in developed or natural areas, reducing water lost to tide, and providing some water supply benefits. The various reservoirs, located throughout the study area, provide these basic functions. In the recommended plan, there are no flood attenuation “ponds” recommended, only reservoirs.

176. What is the extent of capturing water currently lost to tide (water conservation) in the recommended plan, who gets it, and is it adequate?

Response: In the Caloosahatchee Basin, the amount of water captured is considered to be equal to, or possibly greater than what is identified as “excess”. More refined studies are needed to determine if more or less is available. In the UEC area, additional sources of water may be available for capture and use. Modeling continues in the area to more clearly define the water needs. Currently, there are no excess flows to tide in Miami-Dade County, along the Biscayne Bay inflow area. Only along Service Area 1 and 2, were flows to tide still considered to be “excess to tide.” In modeling conducted in January 1999, almost 350,000 acre-feet of water on an average annual basis was captured and rerouted to both Biscayne Bay and ENP. That represented the most aggressive plan for the capture of water currently identified to be excess. Minor modifications to the recommended plan were necessary to capture and deliver the water. In the design and implementation phase of the Restudy, the plan can be modified as necessary to incorporate new information with regard to capturing and using all excess flows to tide.

177. How was the Everglades Screening Model used in the Restudy?

Response: In the initial stages of modeling, water budget models were used to identify potential sources of water and the features that could be used to catch and distribute the available water. In addition to the Everglades Screening Model, the Object-Oriented Screening Model, and the Prescriptive Reservoir Model were used for the evaluations. Information from the screening phase was helpful in starting the alternative development phase; however, the SFWMM was used in the formulation and evaluation of alternative plans and in the evaluation of environmental impacts. The use of ESM was both proper and valuable in the Restudy.

178. Are high water events eliminated in the WCAs?

Response: While the high stages in the WCAs are improved by the recommended plan, they were not eliminated. The reasons why high stages persist in some areas vary across the region. In some cases the reduction in the spatial extent causes the original flow lines to be severed, especially in WCA 2A and 2B, and along the eastern protective levee in WCA 3A and 3B. Simply putting the original amounts of flow back into the northern borders of the WCAs does not always recreate the desired stages. In some cases, subsidence has caused water to flow more slowly with higher stages for historical flow rates. As the detailed design and implementation of the recommended plan occurs, additional modeling will be conducted to further improve the high stage characteristics of the WCAs.

179. Will Biscayne Bay models (hydrodynamic and ground water) be completed in time for use in the recommended plan design and implementation?

Response: The Biscayne Bay Feasibility Study is currently underway. As part of that effort, a model of the bay, which will include hydrodynamics and water quality is being developed. Findings from that Feasibility Study will be included into the future design and implementation of the Restudy recommended Comprehensive Plan.

180. Do all the major features of the recommended plan have significant environmental benefits?

Response: Yes – either directly or indirectly. For example, storage and use of water to meet environmental targets has a direct benefit, such as in the majority of the EAA storage component. Features that capture and release water that is then used to meet urban and agricultural dry season demands provide an indirect benefit to the environment by reducing high discharges to estuaries as well as reducing the dry season demands on the Water Conservation Areas and Lake Okeechobee.

181. Will computer models be used to simulate "next steps" during the construction of the recommended plan?

Response: Computer modeling has been used extensively throughout the Restudy in the reconnaissance phase, initial screening and alternative selection and refinement phase, and will continue to be used during adaptive assessment and when modeling can assist and support proper decision making. For each major component or series of components, a supplemental EA or EIS and a project implementation report will be prepared that includes the quantified impacts of the component. Modeling will be conducted for each component in order to quantify the impacts. The modeling will not only include the component itself, but will also include the interactions of all existing features.

182. Does the recommended plan protect Miami-Dade County from saltwater intrusion and reduction of flows?

Response: The recommended plan provides protection of the aquifer water levels and there are clear improvements over the 2050 Base Case. Both water supply and prevention of saltwater intrusion are enhanced by the plan. The principal components in the recommended plan that sustains groundwater levels in Miami-Dade County are the North Lake Belt storage area and wastewater reuse facilities.

183. Does the recommended plan provide appropriate flood control for the Miami-Dade agricultural areas?

Response: The recommended plan provides good performance for agriculture in south Miami-Dade County, this view is borne out by evaluations performed by the Florida Department of Agriculture and Consumer Services. There does exist apprehension by local agricultural concerns about how the conditions may change between current conditions and implementation of the recommended plan. The 2050 Base Case (without the Restudy), unless altered favorably for flood control, will cause worse conditions than today. The Restudy modeling demonstrated favorable groundwater management guidelines. The concern is not that the recommended plan will not be better, but that the plan will not be implemented in time. Additional ground/surface water modeling will be conducted at a higher resolution to better define the flood protection issue.

184. Can flood control discharges from Lake Okeechobee, when absolutely necessary, be proportioned according to potential damages throughout the system?

Response: The C&SF project has flexibility, but was not designed to operate in this fashion. Typically, the system operated to minimize damages, not to proportion the damages across the system. The information needed to proportion damages would require that everything (property, businesses, lives, natural habitat, endangered species, etc.) be valued on the same scale. For example, an estuary harmed by large freshwater releases will recover over time and the business losses can be quantified. If an endangered species is lost, there can be no recovery and the economic losses are difficult to identify. Since many impacts are not monetary, this type of analysis was not considered or included in the recommended plan.

185. Can the C-44 Basin flows for stages up to 15.5 feet (instead of 14.5 feet) be returned to Lake Okeechobee until WPAs are constructed in the basin? Additionally, can the stored water be returned to the basin for low flows?

Response: Potentially, making the 15.5 feet rule for backflows would result in more water being sent to Lake Okeechobee. The additional flow to the lake would have to be treated to reduce nutrient loads, probably through a STA, and therefore could not simply backflow. The recommended plan includes storage in the C-44 basin that could be altered to catch the additional flow and use it for water supply in the C-44 basin. Additional modeling, in conjunction with the Indian River Lagoon Study, is ongoing and will address this and other possibilities. If the 15.5 foot rule could be implemented without water quality problems, it could be done separately from the Restudy.

186. Can water supply continue if the destruction of the Everglades is imminent?

Response: Under current state allocation rules, water can be taken from the WCAs and Lake Okeechobee as long as minimum stages are met. If the water levels are at or below minimum levels in those areas, water cannot be taken out for water supply. Water supply is not taken directly from ENP

187. Does the recommended plan meet the timing, delivery, quantity, and quality requirements of the natural system through passive system management?

Response: The recommended plan has included a number of passive management features. WCA 3A was decompartmentalized to allow sheetflow into ENP. To protect the high-quality habitat of WCA 3B, L-67 was degraded to include weirs, considered to be passive structures, so that sheetflow will pass from WCA 3A to 3B and ENP without damage. Most of the natural areas have boundaries with agriculture and urban areas, and many features are necessary that are not passive (e.g. pumps). To the extent possible and for protection and enhancement of habitat within the natural areas, passive features such as weirs and sheetflow features were considered.

188. Why does the recommended plan include the relocation of the S-140 pump to a more southern location?

Response: Water delivered to the WCAs is greatly increased by the recommended plan. In order to deliver water at the right time and place, the S-140 pump was relocated southward. This was done to reduce high damaging stages in the northern boundary of WCA 3A as well as supply water to a high-quality habitat in the central part of WCA 3A. Decompartmentalization of WCA 3A would have adverse low water effects without relocating the S-140 pump. Exact location of the S-140 pump will be evaluated during the implementation phase.

189. Why wasn't full decompartmentalization for all WCAs included in the recommended plan?

Response: Decompartmentalization was the single most-modeled feature of the Restudy alternative development and evaluation process. The evaluation included full decompartmentalization as well as many lesser configurations. Ultimately, the reason full decompartmentalization was not selected was because of the unintended adverse consequences of decompartmentalization. The reduced size of the remaining Everglades does not allow water to flow through the system in its historic way. The eastern protective levee causes those historic flow lines to be severed. The best example can be seen in WCA 2A and 2B where water once flowed southeastward; water must currently flow southwestward to leave the areas, nearly 90 degrees from the original flowlines. That water, when combined with the southeasternly flow of WCA 3A, causes extreme high stages inside the WCAs along the eastern protective levee. The high stages also result in faster flow velocities. The net effect is that higher wet season stages occurred, which are damaging to tree islands, and lower dry season stages occurred, in which flow passed through the system too quickly. Most of the ecologists involved in the evaluations were not willing to cause significant damage to existing high-quality habitat for the sake of full decompartmentalization. Ultimately, a more balanced approach was determined which allowed all of WCA 3A and 3B to be decompartmentalized, including filling in the Miami River Canal through the area. The lower end of the L-67 canal was filled in, but the upper part was needed to help prevent high stages in the northeast part of WCA 3A. The L-67 levee was degraded in places to allow passive flow into WCA 3B without causing high stages and environmental damage to WCA 3B. The hydrologic boundary of the ENP was essentially moved to the northernmost reach of WCA 3A with the resulting sheetflow. The problem in creating sheetflow across WCA 1 was related to water quality concerns. Currently, the center part of WCA 1 is pristine because it is hydrated by relatively pure rainwater. Under a sheetflow scenario, water of a different nature would cover the pristine areas causing changes to the existing communities and therefore were not included in the recommended plan. The problems associated with the severed flowlines of WCA 2A and 2B were not solved during the alternative development process. If future modeling efforts resolve the issues, the information can be used in the design and implementation of the recommended plan.

190. Why didn't the recommended plan restore (raise) Lake Okeechobee to historical levels and create a new littoral northwest of the lake?

Response: One of the major hydrologic characteristics of a littoral zone is that it is underwater most of the time. Zones that are over-flooded for a long period will die because of diminished light penetration. Zones that become dry are in danger of burning as well as converting to more terrestrial species. In order to support a littoral zone in the northwest corner where land elevations are high, the lake would have to be relatively stable (about 3 feet of fluctuation) at around 20 feet above sea level. For the lake to remain stable there can be no water supply taken from it and floodwaters would have to be moved through a smaller system. In the Everglades, the constrained floodwaters would result in depths that are too deep for the remaining natural system. If the lake is to continue providing both flood control and water supply, the lake fluctuation will be about 6 or more feet. Under that scenario (the most likely case), a littoral zone at 18 to 20 feet in the northwest corner would be underwater about once out of every 4 or 5 years. The function of a littoral zone cannot be met in an area that is dry most of the time.

191. Have the flows to the Model Lands, Card Sound, Barnes Sound, and Manatee Bay been addressed in the recommended plan?

Response: Yes. A number of features intended to increase the connectivity and sheetflow in the south Miami-Dade area were included as component WW in the recommended plan. The features include backfilling the lower part of C-111 and creating a spreader canal in the Model Lands. Groundwater models of a higher resolution are being developed that will guide the future design and implementation of the features in that area.

192. Why wasn't the NOAA meteorological modeling work being incorporated into the recommended plan and the hydrodynamic modeling of the Florida Bay?

Response: A hydrodynamic model of the bay is currently being developed. The results of that modeling effort will be incorporated into the Florida Bay and Florida Keys feasibility study recommended in the Comprehensive Plan. The meteorological modeling work conducted by NOAA can be included, if applicable, into the hydrodynamic modeling of Florida Bay.

193. Can existing hydrologic models be refined to provide more reliable predictions of flows into Florida Bay, Biscayne Bay, and across the southwest Florida coast?

Response: The existing models can be refined by the inclusion of more detailed topography, an ongoing activity. Newer ground/surface water models that have higher resolution are needed to not only improve the predictions of flows but to improve the target flows and patterns necessary to restore these areas. The ground/surface modeling of the area upstream of Biscayne Bay is underway. An extension of the Everglades Landscape Model may be possible to increase the resolution of the hydrology associated with flows into Florida Bay on the south of the ENP. The modeling requirements of the southwest coast of Florida will be identified in the Southwest Florida Feasibility Study.

194. What basis, other than using the P33 gage, was used to determine hydrologic improvements to Florida Bay?

Response: The statistical relationships associated with P33 were helpful in the development of performance targets for Florida Bay, but in addition other targets for improvements of flows to Florida Bay were included. Flow lines were developed to evaluated the flow patterns to Florida Bay as the water flowed southward through ENP. NSM patterns were used as the target pattern for the flow lines. Because there are only a few water management features within the ENP, restoration of flow into the ENP dominates the flow patterns into Florida Bay.

195. Is it possible to quantify the amount of flow adjustments to Florida Bay that can be achieved through flexible operation of the C&SF system?

Response: Some model runs could be evaluated to determine the amount of flexibility the C&SF Project has on the flows to Florida Bay. There are, however, only a few water management features within the ENP that can affect deliveries to the bay. To the extent that the flexible flow patterns are acceptable within the ENP, the evaluations could be made.

196. What is the effect of public water supply on the natural system?

Response: In the 1995 Base condition, the LEC receives about 173,000 acre-feet per year from the WCAs and Lake Okeechobee, in addition to rainfall and seepage. Without the Restudy, the amount increases to 252,000 acre-feet from the natural areas by the year 2050 unless some water allocation rule (e.g. minimum flows and levels) prevents it. In the recommended plan, the LEC <u>reduces</u> its dependence on the natural system to 135,000 acre-feet while receiving more water supplies from increased local resources identified in the plan.

197. How is the S-316 structure affected by the recommended plan?

Response: The S-316 structure acts as the hydrologic divide in the L-8 basin. The operation of the structure was not changed by the recommended plan. More flood protection capability downstream of the structure is anticipated as the result of several components of the recommended plan. As part of the ongoing modeling for the Water Preserve Areas, the flood protection benefit will be quantified.

198. Will additional modeling having more accurate predictions be included in the design and development of the LEC areas?

Response: As part of the Water Preserve Areas Feasibility Study, ground/surface water models are being developed at a higher resolution than the SFWMM used in the Restudy. Additional modeling, if necessary, to support the design and implementation of the components identified in the LEC will be done.

199. How will reservoirs be sized and will they have associated “surge tank” areas?

Response: The reservoirs identified in the recommended plan have the basic purposes of flood control and water supply, for natural areas as well as urban and agriculture. Accordingly, the reservoirs will be designed to enhance the capture and distribution of water. The most efficient water supply reservoir would be deep with a small footprint; however, in South Florida, seepage issues tend to limit the depth to which water can be stored effectively. As potential storage sites are identified, data collection and evaluation will be used to determine the maximum depth. The Restudy identified the total amount of storage needed at each site. Once the maximum depth is determined, the actual footprint, or acreage, can be determined. The reservoirs are not expected to require surge tanks. If site inspection and detailed modeling reveal the need for associated surge tanks, they will be included.

200. Will the excessive flood releases from Lake Okeechobee to the estuaries be reduced by the recommended plan?

Response: One of the most dramatic improvements by the recommended plan is the reduction of flood releases from Lake Okeechobee to the estuaries. All but one release was eliminated in the Caloosahatchee Basin and all but two releases were eliminated to the St. Lucie Estuary. The remaining releases would only be about one-tenth the magnitude of the past regulatory releases. As detailed planning and implementation proceeds, there is a chance that all releases can be eliminated. Not only are the damaging releases from the lake nearly eliminated but also damaging local flows are also greatly reduced. Local basin improvements come from reservoirs located within the basin that catch flood waters and then release the stored water to improve low flows to the estuary.

201. Will the excessive flood releases from Lake Okeechobee, as well as some LEC areas such as C-6 and C-9, to the various estuaries be reduced by the recommended plan?

Response: Both the C-6 and C-9 flows to tide are reduced by the recommended plan. Additional modeling of D13R modifications shows that a further reduction in the C-9 basin is possible. The North Lake Belt storage area is instrumental in the capture of the excess water in those basins. In the recommended plan, the water is released to support groundwater levels for the preventing of saltwater intrusion as well as water supply.

202. What evaluations will be conducted to determine the necessary depths of seepage barriers around the Lake Belt storage areas?

Response: During the Pilot Projects, Water Preserve Areas Feasibility Study and future design work for the recommended plan, both groundwater modeling and technical evaluations will be conducted to further explore the feasibility of the underground barriers associated with the Lakebelt storage areas. Technical evaluations will include core-boring studies that will clarify the depths and spatial extents of the clay layers underlying the areas. These layers are critical elements of the in-ground reservoirs. Technical reviews of existing barrier technologies will be completed. Technical evaluations will include discussions with experts familiar with the substrate and the barrier techniques. Modeling evaluations will be conducted at a greater resolution to ensure the reservoirs would not adversely impact groundwater flows in the region.

203. Were discharges from C-23, C-24, and C-25 modeled for the recommended plan?

Response: Yes. As part of the Indian River Lagoon Feasibility Study, C-23, C-24, C-25, and other tributaries to the St. Lucie Estuary were modeled. The C-44 Basin was modeled in the SFWMM, but that model treated all other tributaries to the St. Lucie Estuary as a lumped sum. To ensure the best answers possible, the tributaries were modeled with a higher resolution model and then the results were included into the SFWMM for alternative development and performance evaluations.

204. The 2050 Base Case condition for the C-111 area shows ground water levels that are considered too high; should the base case be corrected by the Restudy?

Response: The base case conditions used in the Restudy represented the best available information. The future operation of the C-111 area was not clearly defined in existing documents and was open to some interpretation. The ongoing C-111 Project will be developing operational rules for that project.

205. How was the role of the permitting process included in the recommended plan? Should the comprehensive plan allow for a watershed-based approach for water allocation?

Response: Water allocation is a State of Florida responsibility. The recommended plan assumed no changes in the way water is allocated in south Florida. The SFWMD, as a Restudy partner, has access to all data and modeling results that could be used in future permitting or in the development of new guidelines; it would not be a Federal activity. If modifications in Florida law change the way water is allocated, any such changes could be incorporated into the recommended plan during the design and implementation phase. It is the responsibility of water management district regional water supply plans to permit for water supply.

206. Should the recommended plan ensure that the 1-in-10 drought criteria are met for all water supply regions?

Response: Florida law requires Water Management Districts to plan for the 1-in-10 year drought. The 1-in-10 drought criteria were accepted as a goal in the Restudy. In some areas of south Florida the 1-in-10 goal was met. In other areas the goal was not quite met although there is clear indication that the recommended plan greatly improves the amount and reliability of water supply while providing for the environment.

207. Because surface storage areas will not supply water throughout long-term droughts, should they be relied upon?

Response: In the recommended plan, surface storage has three basic functions: to capture flows currently lost to tide, provide flood control, and to help meet water supply needs. If the natural areas are full, a reservoir is the only feature that can catch large flood flows to reduce the floodwater that is lost to tide. Because of evapotranspiration and seepage issues, the surface reservoirs are not expected to provide water throughout droughts. By supplying water in the early part of dry seasons, water can be retained in Lake Okeechobee for the longer drought periods. Thus, even short term storage can have significant water supply benefits.

208. Are there any unintended consequences on natural system water demands in the urbanized areas of Broward County – especially related to the capturing of wet season flows?

Response: Under the recommended plan, there is no significant increase in capturing excess water, that is water lost to tide, in Broward County. Some changes in the way seepage and floods are managed in the western part of the county would be changed. Some additional modeling investigations during January 1999 did evaluate the possibility of catching water currently being lost to tide in the county during wet seasons. As part of all modeling efforts, both the groundwater levels and water supply levels are improved and “natural system” demands in the county are dependent upon the groundwater levels. Under the recommended plan, the urbanized area of Broward County is the only LEC area that receives more water from the WCA and Lake Okeechobee rather than less.

209. Was storage provided in the recommended plan for the C-44 Basin?

Response: In the recommended plan, a storage area of about 10,000 acres was included for the purposes of flood attenuation to the estuary, water supply including environmental releases to the estuary, and water quality benefits from reduced nutrient and better salinity control. The maximum storage was set at 4 feet deep so that marsh conditions can exist in the facility. If farmland is ultimately used for storage, deeper depths may be considered.

210. Currently, the western side of WCA 3A is too dry; will it be improved?

Response: In the recommended plan, natural stages and fluctuations will be restored to the northwest side of WCA 3A. On the west-central side of WCA 3A, the S-140 structure will be relocated southward to improve the flows from the west to the central part of WCA 3A. Although some improvements can be expected from the Everglades Forever Act, the recommended plan delivers enough water to restore natural stages.

211. Does the recommended plan include elimination of the diking effect, if any, within Everglades National Park along Flamingo Road?

Response: According to ENP, the Flamingo Road does not create a hydrologic barrier although there are clearly impacts to vegetation. According to ENP, recent flow studies show there to be no hydrologic diking effects. The Restudy Team did not evaluate Flamingo Road and the recommended plan did not include any changes to Flamingo Road.

212. What was proposed for the Southern Golden Gates Estates area in the recommended plan?

Response: As part of the recommended plan, restoration of part of the Southern Golden Gates Estates area was included as an Other Project Element. The details of the OPE were developed as part of a feasibility study conducted by the SFWMD.

213. What modifications were included for the Big Cypress National Preserve?

Response: Changes in the Big Cypress National Preserve identified in the recommended plan primarily affect the eastern side of that Preserve. In the northeast, the L-28 Interceptor will be partially degraded to increase the flows directly into Mullet Slough. Stormwater treatment areas upstream of the interceptor will improve water quality as well. North of Tamiami Trial, the L-28 levee and the L-29 levee will be degraded allowing for natural sheetflow across those areas.

214. Did the recommended plan address conveyance and connectivity along US Route 1 and in the Model Lands areas?

Response: The recommended plan contains a component to extend the C-111 spreader canal east of Card Sound Road. If the conveyance problems are not solved by some other project prior to implementation of the recommended plan, for instance through a mitigation project, then the issue will be addressed as part of the recommended plan.

215. Were underwater structures in the canal along the western edge of Card Sound Road evaluated for the recommended plan?

Response: The regional extent of the models used in the development of the alternatives (NSM and SFWMM) does not accurately predict hydrologic characteristics of the areas near the coastline. This effect, as many other existing drainage features, was not modeled. However, an OPE was included in the recommended plan to incorporate several features to improve the flows to southern Biscayne Bay. As part of the future design work, many existing ditches in the area will be evaluated to see if filling or blocking is warranted.

216. Should S-197 be removed for ecological/hydrological purposes?

Response: S-197 would be removed and the lower end of the C-111 Canal will be back-filled (component WW) as part of the recommended Comprehensive Plan.

217. Can the 8.5 Square Mile Area be used in restoring flows to Northeast Shark River Slough?

Response: In the current system, flood concerns within the 8.5 Square Mile Area (as well as other private lands to the north of the area) tend to restrict the flows to Northeast Shark River Slough. As part of the Modified Water Deliveries Project, the stage restriction due to the 8.5 Square Mile Area will be removed so that natural stages can be restored to the slough. The recommended plan assumes that stage restrictions currently imposed by the 8.5 Square Mile Area will be resolved (either through levee construction or buyouts) prior to the implementation of the plan.

218. Should the flows through L-5 be increased in the recommended plan?

Response: Some flow improvements can be expected from the Everglades Forever Act; however the recommended plan delivers enough water with the correct timing to restore natural stages. There is some speculation that too much water is added to the northern part of WCA 3A. Because the recommended plan sends so much more than the Act, most of the flows have to be routed around the northern part to the western side of WCA 3A to prevent too high stages. Additionally, flows added along L-5 tend to “stack up” along the eastern side of WCA 3A. To help reduce this effect, the recommended plan removes some of the flows along the eastern side of WCA 3A and routes them down to NESRS via the Central Lakebelt storage area.

219. Did the recommended plan adversely effect the water flowing to tribal lands?

Response: Flows to tribal lands were altered slightly as part of the operation of two new stormwater treatment areas included in the recommended plan for water quality improvements. The flow changes are likely to include some flood benefits for the tribal lands, but more refined modeling will be conducted to quantify the benefits. No adverse impacts are known or anticipated.

220. Were the connections between Florida Bay and the Atlantic Ocean addressed in the recommended plan?

Response: A hydrodynamic model of the bay is currently being developed. The issues of connectivity between Florida Bay and the Atlantic Ocean will be investigated as part of the Florida Bay and Florida Keys feasibility study.

221. Did the recommended plan have specific water conservation program suggestions for the LEC?

Response: The 2050 Base in the Restudy assumed the current SFWMD water conservation rules would remain in place, but the success of the program would be similar to the success in UEC areas. That resulted in about a 12 percent reduction in future water demands, as compared to no specific water conservation program. In the recommended plan, full compliance with the rules was assumed, which lead to an additional 6 percent reduction.

222. This number was inadvertently skipped and therefore not used for a comment.

223. Should flow predictions from models be used as restoration targets?

Response: According to the USGS and others, the accuracy of flow predictions by the NSM and SFWMM is one of the least accurate parameters – stages are far more predictable. Stages are often a more important indicator of ecological health. When the aerial extent of the natural system is considered, a modeling error in stage of 0.1 feet can result in large changes in flow-rates and flow-volumes.

N.2.3 Ecological (Including Targets and Fish and Wildlife)

224. The question is since estuarine systems exist because of fresh water and saltwater mixing, are their target salinity ranges that are currently not being met?

Response: Salinity targets were developed based on how much fresh water would be required to achieve the target salinity range, based on the salinity preferences of selected estuarine plant and animal communities. During plan development, each estuary was evaluated as to how well its fresh water needs were met. For existing conditions, many of the targets are frequently violated. The recommended plan makes marked improvements in achieving many of the targets. The Caloosahatchee and St. Lucie estuaries salinity targets were met over 90% of the time.

225. Due to uncertainty of modeling results the Corps should verify modeling limitations for the PEIS. The Corps should also consider further model review / verification / refinement, and field monitoring results as needed.

Response: Concur. In an attempt to acknowledge the uncertainties and develop strategies to resolve them, the final report includes an Uncertainty Appendix (Appendix O) and a more detailed Implementation Plan.

226. There is concern that optimal fresh water be delivered to Florida Bay, particularly the Taylor Slough/panhandle area. Additional concern is that regression equations used to predict salinity at coastal locations based on inland stations (P33 gage) are not adequate. It is recommended that due to uncertainties in the reliability of this method that the recommended plan remain flexible to accommodate these uncertainties in flows as well as water quality requirements.

Response: The Florida Bay sub-team of the Alternatives Evaluation Team developed the regression equation used to evaluate salinity in this area of Florida Bay. It was critiqued, revised, and accepted by the Alternative Evaluation Team as being an acceptable method to evaluate project alternatives effect on the bay. Members of the Florida Bay subteam also participated on the Marl Prairie (Taylor

Slough) subteam of the Alternative Evaluation Team. This was valuable due to the relationship of rehydration of the marl prairie to flows entering Florida Bay. Plan implementation will include developing and using more accurate modeling and evaluation tools. Furthermore, the Florida Bay Program Management Committee has in their response letter dated 1 December 1998, pledged to develop a detailed set of ecological performance measures and restoration targets for Florida Bay in the next twelve months (see below).

227. The regression equations for relating salinity at coastal locations to water levels at P33 should not be relied on for detailed planning. The PMC will develop a detailed set of ecological performance measures and restoration targets for Florida Bay in the next twelve months.

Response: Concur. Development of performance measures and targets by the PMC would be of great benefit to planners involved with developing restoration plans for Florida Bay during the implementation phase.

228. The relationship between water levels in P33 and salinity in Florida Bay are based on the hypothesis that water flows and levels in Shark Slough influence the entire hydrological conditions in the entire region including Florida Bay. There is uncertainty in this assumption. The evaluations of the alternative D13R should take into account these uncertainties in the salinity predictions, in particular the benefits to Florida Bay suggested in Tables 7-12 and 7-13.

Response: There is uncertainty associated with the models used in the analysis. An uncertainty analysis, Appendix O, has been added to the final Report/PEIS to acknowledge the magnitude of uncertainty of the models and evaluation tools used to develop the Comprehensive Plan.

229. There is disagreement with the Restudy response to #13a of the draft Fish and Wildlife Coordination Act Report Recommendations on using a variety of different hydrologic targets rather than on using the single parameter flow volume. The ecological restoration of Florida Bay depends most directly on restoring freshwater flow volumes. The use of hydroperiod and stages at inland locations are only indirectly and imperfectly related to flow in Florida Bay.

Response: Concur that the performance measures used for Florida Bay are imperfect. However, the approach used to evaluate different plans was successful in identifying improved hydrologic conditions for Everglades National Park and Florida Bay.

230. Biscayne Bay performance targets are based on providing a slight increase over current flow rather than based on research of what flow is best for the bay. This research is needed to more appropriately determine benefits to the bay.

Response: Concur. The Implementation Plan includes a strategy that will allow research findings to be incorporated in project planning and implementation as they become available.

231. The “river of grass” image and focus of the Restudy needs to be replaced with a perspective that recognizes the diverse ecological complex of pre-drainage southern Florida, including uplands. The Restudy does not or inadequately addresses the restoration of all biologically significant community types, including pine and cypress forests, the pond apple forest located south of Lake Okeechobee, and high sawgrass plains.

Response: The Restudy attempted to consolidate as much scientific information as was available on the communities that comprised the historic wetland system of central and southern Florida. Concur that the major focus of the Restudy is on wetlands impacted by the C&SF Project in accordance with the authorization for the study. Although the Corps has jurisdiction over activities which effect wetlands, rather than uplands, the Corps does consider the impact of its activities on upland areas, usually with assistance of other agencies such as U.S. Fish and Wildlife Service and the Florida Game and Fresh Water Fish Commission. Concur that not all historic communities, such as the pond apple forest historically located along the southern boundary of Lake Okeechobee, are recreated in the recommended plan. The forms and functions of these historic communities were analyzed to the extent possible, based on existing information, and appropriately included in the plan. As more information on these communities becomes available and as these systems become better understood and documented in the Conceptual Ecological Models, then actions can be taken to include these additional areas into subsequent planning, as appropriate. The Implementation Plan explains this process.

232. More natural patterns of water flow should be provided to western cypress forests, through mangrove forests and other coastal areas.

Response: Concur. Plan D13R includes the removal of L-28 Interceptor and increasing flows through Tamiami Trail in order to achieve more natural water flows in these areas.

233. Containing the natural process of ground water flow through curtain walls or other barriers may have unintended adverse ecological impacts.

Response: Concur. A seepage management pilot project is one of the pilot projects that are recommended. The effect of seepage control on coastal resources, including such areas as Biscayne Bay, was evaluated in the plans. An important aspect of subsequent studies and the pilot projects will be to address these concerns.

234. The Restudy does not guarantee or assure biologically based water allocation for Florida’s natural systems.

Response: Biologists and ecologists, when asked how much water is needed for the natural system could not answer definitively. The Restudy Team agreed early in the study, based on the draft Ecological Conceptual Models, that the best available tool to help evaluate the water needs of the natural environment was the Natural System Model. The Restudy Team also acknowledges that the water needs of the natural system may change as more is understood about the needs of the biological systems. An Adaptive Assessment approach to the study will be used as discussed in Section 10: Implementation Plan for the Restudy.

The Restudy's Comprehensive Plan attempts to capture, store, and deliver water to natural, agricultural and urban areas as efficiently as possible. The goal was to provide the target amounts of water specified by the performance measures. The idea behind this has been to eliminate to the extent possible water shortages for both the natural and built communities. Water allocation in the State of Florida is governed by Florida water law, Chapter 373, F.S.

235. The NSM targets should not be used where there is compelling ecological reasons why these targets should not be met.

Response: Concur. The draft Ecological Conceptual Models and the special needs of some species were used to identify targets other than NSM where appropriate.

236. The final EIS and preferred alternative need to describe the hydrologic regime in sufficient detail for Congress to approve the Restudy.

Response: The final PEIS will contain sufficient detail for Congressional approval. The final PEIS contains an Implementation Plan (Section 10) that specifies details about the project development process, future detailed studies and other pertinent information that was not addressed in the draft report.

237. What are the existing and proposed canal operations of the L-31N and C-111?

Response: The current operating rules for L-31N and C-111 were used to model the 1995 Base, referred to as the existing condition. The 2050 Base or future without project condition was based on information taken from the current C-111 Project. The C-111 Project is an on-going project which will define the operating rules of the South Dade Conveyance System. Component OO4 provides linkage between the C-111 Project and the Restudy.

238. Restoration ecological performance measures should be developed that are flexible enough to incorporate ecological responses to hydrology, should be enforceable, and encompass long-term operations.

Response: Concur. The Implementation Plan addresses these recommendations.

239. The Restudy must address the four main requirements of the Everglades ecosystem: timing, delivery, quantity, and quality of water.

Response: Concur. These were the premises upon which the Restudy was carried out.

240. The St. Lucie Estuary and Indian River Lagoon have permanent problems with shoaling and flocculent organic sediments which must be reduced in order for recovery to begin.

Response: Concur. The Indian River Lagoon Feasibility Study is investigating these problems.

241. The evolution and use of the salinity envelope deserves accolades and deserves more serious consideration in regulatory matters. The approach toward managing salinity should be included in regulatory matters at state and federal levels.

Response: Concur.

242. Regarding the Programmatic Section 404 (b)(1) Evaluation (Annex C), it is suggested that the details of the analysis that quantifies the potential impacts of construction features be presented in the report.

Response: The discussion of the analysis has been revised accordingly. As the Service is aware, the siting of the construction features is only conceptual at this point in time. However, not withstanding the current uncertainty, the Corps attempted to analyze the approximate extent of potential impacts. This analysis supports the need to conduct land suitability analysis during the Project Implementation Report process to avoid or minimize the potential effects on native habitat types in favor of disturbed sites.

243. Water quality warrants close consideration in Big Cypress, particularly since the Restudy will restore natural sheetflow in the northeast portion of the Preserve.

Response: Concur that the impacts on water quality from increased water deliveries to Big Cypress must be carefully evaluated. The potential to degrade water quality by bringing in “outside” water was identified during the study and is being carefully considered by the water quality team.

244. Discharges to estuaries should be based on their ecological requirements and salinity levels managed to restore benthic habitat. Water reservoirs should be managed to accept regulatory discharges from Lake Okeechobee in a way that will minimize the harmful effects of regulatory discharges to coastal waters.

Response: Concur. The salinity envelopes used to identify target discharges to the estuaries are based on their ecological requirements.

245. The Restudy goals and objectives have been diluted from what was presented in the Science Sub-Group Report and replaced with schematics to enhance economic growth. The Restudy should refocus on restoration goals and objectives rather than on ecosystem enhancement.

Response: The goals and objectives presented in the Science Sub-group report were used to develop and to evaluate Restudy plans. An important aspect of the study was to better understand the importance and reason behind each of the goals and objectives. Many of the authors of the Science Sub-Group Report participated on the Restudy. The theories and ideas presented in the book The Everglades: the Ecosystem and its Restoration (Davis and Ogden, 1994) were heavily relied on to understand the form and how the historic Everglades functioned. The Restudy Team worked together to try to solve critical issues such as how areas could be added to increase the spatial extent of natural areas so they could be restored, and how to restore hydrologic structure and function for the system. The Restudy meets the objectives and goals necessary to provide for a sustainable Everglades and sustainable south Florida ecosystem.

246. Restudy biological and hydrological science follows engineering regimes and scenarios that have questionable relevance with the science and biology or needs of a passive ecosystem.

Response: The Restudy looked at a more natural "less managed" plan to restore the form and function of the Everglades. A number of scenarios to decompartmentalize more of the WCAs were modeled and showed some benefits to Everglades National Park but indicated severe adverse effects on the Water Conservation Areas and Loxahatchee National Wildlife Refuge. The recommended plan removes as many impediments to flows as was possible to result in favorable conditions for the entire natural system.

247. The Restudy doesn't meet all the hydrologic targets for the Everglades.

Response: Concur, not all targets were totally met (100%) for all areas. It is anticipated that in more detailed planning and modeling, performance will continue to be enhanced.

248. In LEC areas the Restudy should use urban run-off to maintain canal stages rather than water from natural areas. There are conflicts between providing water to natural areas and to urbanized areas that are tied to the lack of needed land for spatial expanse recommended in scientific studies.

Response: The Water Preserve Areas study will further refine sources of water needed to maintain canal stages and prevent saltwater intrusion. Some urban runoff has been utilized; recent case studies have shown the potential to add more.

249. Water levels in Lake Okeechobee should be regulated to protect the lake's littoral zone.

Response: The recommended plan protects the resources of Lake Okeechobee through a regulation plan which eliminates damaging high and low water levels.

250. Ensure sheetflow in the Water Conservation Areas while protecting ecosystem diversity.

Response: Concur. The recommended plan includes a number of passive management features to enhance sheetflow. WCA 3A was decompartmentalized to allow sheetflow into ENP. To protect the high-quality habitat of WCA 3B, L-67 was degraded to include weirs, considered to be passive structures, so that sheetflow will pass from WCA 3A to 3B and ENP without damage.

251. Maintain water levels in WCA 1 to provide for optimal wildlife management and habitat diversity.

Response: The water levels requested by Loxahatchee National Wildlife Refuge (WCA 1) managers were used as the restoration target for this area.

252. For Florida Bay and the estuaries of Shark River Slough (SRS), the differences between D13R and the restoration target defined by NSM are significant. Alternative D13R proposes to provide 70% of NSM flow volumes to Shark Slough estuaries, which is not adequate to restore or sustain keystone species in Shark Slough estuaries. Water in Shark River Slough is not as deep for as long a period of time under D13R as the target suggests it should be. While Alternative D13R can be described as moving in the right direction, it still appears to fall short of restoration.

Response: The findings of the Alternative Evaluation Team are that D13R would provide hydrologic conditions for a sustainable ecosystem in these areas. Although the targets were not completely achieved it was believed by the Alternatives Evaluation Team that substantial improvements would result from the plan, capable of resulting in sustainable ecosystems. The 70% flow volumes used by ENP was a different performance measure for the Shark Slough Estuary (flow-volume) then was used by the AET. The merits of the different performance measures will be reviewed in future workshops, and improved measures developed and used during detail designs.

253. Greater water depths will be needed in SRS, beyond those predicted by D13R, to encourage development of deep water, water lily-dominated communities that were part of the historic southern Everglades.

Response: Work will continue on the recommended plan to further improve conditions within Shark River Slough. However, the only sure way to determine what effects the plan will have on Shark River Slough vegetation is through monitoring activities within the slough.

254. Alternative D13R may not provide needed conditions for the alligator. An appropriate simulation model for alligators in the southern Everglades is not currently available. An alligator model will be available in 1999 that will provide better information for the alligator.

Response: Concur that additional ecological models are needed. Development and use of additional ecological models is discussed in Section 10: Implementation Plan.

255. D13R predicts higher frequencies of dry downs in the Rocky Glades than the targets warrant and will result in negative consequences for vegetation. D13R falls short of targets in Rocky Glades.

Response: While targets were not completely met, the recommended plan greatly improves conditions within this area. Continued work on restoration plans and evaluation tools, including the conceptual ecological models will be conducted and ultimately should result in further improvements for the natural resources occurring within this area. Subsequent to implementation of any restoration activities, monitoring will be required to determine vegetative responses to such activities.

256. Hydrological conditions for aquatic communities are not adequately improved under D13R.

Response: The findings of the Alternative Evaluation Team for D13R are that hydrologic conditions are greatly improved but that additional improvements may be desirable. Additional work will be accomplished on the conceptual ecological models which should better define and reveal the linkages and relationships between hydrologic conditions and ecological responses. Until this work is completed and the project is implemented no one will really understand the effects of partial or even full achievement of target hydrologic conditions on the natural communities of the Everglades.

257. D-13R does not represent a restoration scenario for the southern, central and northern Everglades.

Response: There is considerable evidence to the contrary, including that of a broad cross-section of scientists, planners, resource managers, and concerned individuals who participated fully during a lengthy inter-agency planning effort. In detailed comments, there is repeated reference to the plans' inability to attain 100% of NSM predicted values. There is a certain degree of uncertainty in conditions predicted under any model, including NSM, and uncertainty as to the precise optimal hydrologic and ecological targets for ENP. It is of dubious value to insist on attaining 100% of a target (in this case NSM) that is constantly being revised, for which there is not an equal degree of certainty that the target will result in optimal ecological conditions.

While the accuracy of NSM may be questionable, it is not the reference by which the Corps evaluates the environmental impacts of its proposed projects. The Corps civil works planning guidance requires the Corps to compare a reasonable array of alternatives to the future without project condition that is predicted to exist should the proposed plan not be implemented (2050 Base in this case). The Corps assesses the ecological "lift" of conditions under the Comprehensive Plan relative to those conditions predicted under the 2050 Base, not the attainment of an as yet undefined and still unclear hydrologic target predicted under the NSM and not compared to existing conditions.

Modeling results have shown very similar hydroperiods predicted by D13R and that of NSM throughout much, but not all, of Everglades National Park and without creating conditions that may jeopardize listed species such as the Cape Sable seaside sparrow.

Scenario $D13R_4$ largely corrects all the shortcomings of previous model output with respect to hydroperiod in the Rocky Glades. Nearly every measure of water depth and duration match NSM for that area. The development of scenarios $D13R_{1-4}$ demonstrate the robust nature of the Comprehensive Plan and the ability to manipulate water flows to different regions of the system to meet demands based on information expected to arise during detailed planning and design.

258. D13R provides a relative improvement of about 10% over the 2050 Base for flows into the Everglades' estuaries. D13R delivers about 70% of the target flows, as compared to about 60% under the 2050 Base no-action alternative.

Response: For a discussion of targets, see response above. Under D13R, and more so under $D13R_4$, for the Florida Bay estuaries, mean salinity, the range of salinity variation and frequency, magnitude and duration of hypersaline conditions would decrease compared with the 1995 or 2050 base. D13R conditions could stabilize conditions and allow the development of a significant vegetative community. $D13R_4$ demonstrated an even better probability of producing a sustainable submerged aquatic vegetation community within the estuaries. This conclusion was reached during the preparation of the inter-agency Alternative Evaluation Team's

Everglades Issue paper, which is reproduced, in part, in the Final Fish and Wildlife Coordination Act Report (see Annex A). Lorenze (1997) has correlated increased flow with increased productivity of prey fish. D13R and $D13R_4$ have greater flows than either 1995 or 2050 bases. $D13R_4$ flows are approximately 80-85% of NSM estimated flow. The Corps has committed to investigating features of $D13R_{1-4}$ which may, in the future, be incorporated into the Comprehensive Plan in order to convey additional flows to ENP and Biscayne National Park, assuming outstanding environmental issues (notably in the WCAs) can be satisfactorily resolved.

259. The reason for the shortfall (in target flows) is that wet season water level targets in Shark Slough are not met.

Response: When compared to D13R and the 1995 and 2050 bases, $D13R_4$ has greater possibility for increased peat accretion and restoration of the historically dominant slough communities. Compared with the base conditions, D13R should improve overall aquatic productivity in Shark River Slough, benefiting the American alligator. The number of drying events, although fewer than predicted historically, are probably within the uncertainty of the model. The mean number of weeks of a drying event is decreased from D13R to $D13R_4$ further improving conditions for aquatic prey production in Shark River Slough. It must be noted that the Restudy AET/ADT process has largely shown the difficulty in implementing incremental project features into the Comprehensive Plan without incurring some negative consequences elsewhere in the system. These issues need to be further investigated and resolved through the inter-agency coordination and planning process before the incorporation of the project features proposed in $D13R_{1-4}$.

260. D13R does not show improvements in ponding depth and duration adequate to sustain fish populations in the southern Everglades.

Response: The above comment refers to attainment of ponding depths as predicted by NSM relative to those by D13R. As mentioned above, the reviewer assumes there would be detrimental environmental impacts incurred due to the implementation of the Comprehensive Plan relative to NSM. The NSM should be used as a reference point, and not as a tool to assess environmental impacts. Attainment of 80% of NSM flows for instance, does not result in a net negative environmental impact when compared to future conditions, it is quite simply 80% attainment of a reference point. Hydroperiods and flow predicted under D13R and $D13R_4$ are an improvement in the environmental conditions as they exist today and as they are predicted to exist in the year 2050. One result of the scenario development process resulting in $D13R_{1-4}$ is that the Comprehensive Plan has demonstrated a robustness and flexibility that would allow for further improvement.

261. D13R largely retains the fragmented management and compartmentalization characterizing today's Everglades.

Response: D13R proposes the removal of a number of levees, canals and structures, particularly in and around the Big Cypress National Preserve, Everglades National Park and within WCA-3. Specifically D13R proposes total removal (including all associated water conveyance structures) of the southern L-28, L-29, L-68, significant parts of the L-67 and nearly all of the Miami Canal within the Everglades Protection Area. Also, the L-67 Extension is assumed to be removed as a part of the future without project condition. These levees and canals are mostly within the central and southern Everglades and directly effect flows to and within the Park. Although restoration of more natural sheet-flow is a priority of the Restudy, this must be balanced against other performance indicators such as hydropattern and ponding depths.

262. On page 7-12, Item 2 asks what was the basis for prioritizing hydrologic targets. Details on how they were prioritized are not presented in Appendix D. Because the models are conceptual the process is subjective. The basis for choosing one hydrologic characteristic over another should be described.

Response: Each subteam on the AET was asked to prioritize the measures and document why one measure was considered more important than another. In many cases the subteams did this; some were unable to. In these instances, the teams were requested to continue work on their appropriate conceptual models with the intent that the linkages that the teams intuitively believed to be valid would become better understood and documented as a result of this continued investigation. The scientific team that developed the slough model agreed that hydroperiod equaled duration of uninterrupted surface flooding and represented the highest priority hydrological target for addressing the major ecological problems of the region.

263. On page 7-12, the Everglades Protection Area should be evaluated on a system level. A conceptual model for the natural system should be developed.

Response: Concur that a total system conceptual model would greatly benefit the evaluation. A Total System Conceptual model will be developed in subsequent phases of the study as described in Section 10: Implementation Plan.

264. On page 7-26, the ENP disagrees with the assessments on how well D13R does in the Everglades Protection Area. The final evaluation matrix is only a small subset of the total set of performance measures used during the model evaluations.

Response: Concur that the final evaluation matrix was a subset of the performance measures used. Each subteam of the AET was requested to conduct a final evaluation of how well each of the plans performed to achieve sustainable ecosystems and provide supporting documentation for the evaluations. The subteams' final evaluations are included in Appendix D.

265. The citation referring to the number of miles of canals and levees removed is incorrect and misleading.

Response: The Alternative Evaluation Team focused its attention on reducing the number of canals and levees in the natural areas. The Total System Performance Measure for Fragmentation: Miles of Canals and Levees uses only the number of miles of canals and levees within the Everglades Protection Area, Big Cypress National Preserve, Holey Land, and Rotenberger Wildlife Management Areas. The list of which structures were included can be found on the web site under “View Maps and Tables”, “Individual Maps and Tables” and the last category “Model Inputs”. The above comment mixes figures from within this selected area with figures from the entire system.

The lengths used in the Fragmentation performance measure are as they are modeled by the SFWMM. Model miles are useful for comparative purposes but are unlikely to exactly match the number of miles actually implemented.

Within the “natural” area, the 1995 Base condition had 330 miles of canals and 400 miles of levees. The 2050 Base condition had 311 miles of canals and 400 miles of levees. Alternative D13 and the D13R scenario have 184 miles of canals and 318 miles of levees. There were 146 fewer miles of canals and 82 fewer miles of levees in D13R. New canals and levees were outside this area so were not counted. The correct number of miles of canals and levees removed in Alternative D13R (and D13R4) within the natural areas is: 146 + 82 = 228.

266. The development of targets for Biscayne Bay is critical in determining the desired flow quantities to be delivered from the C&SF Project and in the future design and implementation of the Restudy's Comprehensive Plan. The feasibility report should identify the process for developing the targets as an early action item. Costs should also be identified.

Response: The Corps and Miami-Dade County are presently conducting a feasibility study for Biscayne Bay. At this point, the study involves development of an hydrodynamic model and related water quality inputs. This model as well as other ongoing efforts are essential to the development of these targets. The Implementation Plan shows "Establishing Biscayne Bay Performance Targets and Alternative Sources” to begin July 1, 1999 and continue through June 26, 2002. Required funds identified for this task are $100,000.

267. Referring to page D-127, this page states that there is a discrepancy between assessments conducted by a Corps contractor and that of Everglades National Park regarding the effect of the southern L-28 levee on NSM-like hydroperiods within the Big Cypress. The sub-team conducting the assessment was unable to comment on how this information may effect the outcome of Restudy modeling of the L-28, since sub-team members had not seen the information. Discrepancies such as this should be eliminated by obtaining and assessing pertinent information from ENP, a cooperating agency.

Response: Concur. Note that Everglades National Park (ENP) was not a Cooperating Agency at the time the Corps contractor was conducting the initial L-28 modifications study. The U.S. Park Service, including ENP, was a Cooperating Federal Agency for the Restudy. The Corps as lead agency regularly requested information, data, technical assistance, and staff expertise of ENP as well as the other Cooperating state and Federal agencies. Due to other exigencies on staff time and resources, these requests, at times, met with mixed results.

268. In reference to the Summary, page viii, how will water level stabilization of Lake Okeechobee make it a healthy, productive lake? Stabilization is the one activity that is most damaging to lake ecosystems in Highlands County.

Response: It is unclear where this information originated from, because the cited information is not present in the summary. The Restudy recommended plan does not propose to stabilize lake levels, rather to restore them to a more natural hydrologic regime with more, not less moderation facilitated through the retention of high water events in storage facilities north of the lake. See Section K.4.4 in Appendix K.

269. Include and provide for invasive / nuisance plant control for, but not limited to, air potato, Japanese climbing vine, melaleuca, Brazilian pepper and cattail.

Response: The recommended Comprehensive Plan does not include measures to *directly* combat exotic plant infestation. Direct measures to control exotic and nuisance plants, such as field treatment with herbicides, mechanical removal, and biological controls are managed by operational elements within the responsible agency (e.g., Army Corps of Engineers, Water Management District, or Everglades National Park). Three Critical Projects involving biological control of Melaleuca were nominated by the Working Group. These include the following: constructing a new quarantine facility, upgrading and retrofitting the current quarantine facility in Gainesville, Florida, and large-scale rearing of approved biological control organisms (e.g., *Oxyops vitiosa*) with release and monitoring at multiple sites in the South Florida Ecosystem. The new quarantine facility is expected to be implemented through the Critical Projects program. The other two projects are included in the Comprehensive Plan as Other Project Elements.

The South Florida Ecosystem Restoration Task Force and Working Group established the Exotic Pest Plant Task Team to develop a statewide strategic plan for managing exotic pest plants. This group recently renamed the Noxious Exotic Weed Task Team (i.e., NEWTT) is composed of scientists and plant management experts from Federal, State, and local government agencies who will deal with current invasive and future invasive plant species. The plan would improve conditions for native plant communities by restoring more natural sheet flow and hydroperiods throughout much of the system, improving water quality, and restoring more natural timing and distribution of flows, hydrologic and ecological conditions. However, care most be taken so that the new structures associated with the restoration (i.e., new canal systems and water retention areas with their associated levees) would not become new areas for invasive plant colonization. While increased hydrology may help control some of the currently known invasive plant species, increased hydrology will have little effect on certain life stages of others. Although the plan would improve hydrologic conditions in the area, invasive plant management would be a challenging problem. Management strategies are being developed by the NEWTT for current invasive plants and it would be the task of the operational elements to develop plans to execute these strategies.

270. The Restudy has not succeeded in advancing the goal of increasing spatial extent of natural areas as described in the report. In reference to Table 7-21, top row, DOI does not agree that Alternative D-13R and the OPEs will increase the total spatial extent of natural areas by 2,370,000 acres. The explanation of this entry in the table was based on the total number of acres judged to be “green” by the AET subteams. Speaking strictly of the spatial extent of natural areas, it is inappropriate to count the acreage of areas classified as “green” as equating to a corresponding increase in spatial extent.

Response: Concur in part. It is true the recommended Comprehensive Plan makes little significant progress in increasing the spatial footprint of the historic Everglades to the degree that would have been (ideally) preferred. The Restudy plan focuses on restoration of existing natural areas that are degraded, usually as a result of a lack of proper volume, timing, distribution and quality of fresh water flows. The Restudy Comprehensive Plan ensures that the functions and values of these degraded areas will be restored providing sustainable habitat for native plant and animal populations. The recommended Comprehensive Plan is expected to restore conditions that provide for a numerous and diverse array of quality habitat “options” that allow necessary habitat to be available during an extreme or catastrophic event such as a hurricane, extreme drought or freeze. This, in a sense, may be viewed as increasing the spatial extent of functional natural areas, although as acknowledged in the comment, the definition of “natural area” is debatable. A broad definition of the term “natural area”, it may be argued, may include those areas within the Water Preserve Areas, some of which will be restored as natural marsh, others converted to impoundments. In either scenario, they will prevent urban sprawl westward from the Lower East Coast, thus, increasing the spatial extent of natural areas relative to the 2050 Base. These areas will certainly provide some wetlands function and value within their footprint, as well as ensuring hydroperiods are maintained west of the protective levee during dry cycles.

271. Effects of the recommended Comprehensive Plan are less clear for Biscayne Bay and the Florida Keys National Marine Sanctuary than for Florida Bay.

Response: Modeling results, and empirical studies have shown there to be no conclusive effects on the Keys National Marine Sanctuary due to freshwater flows from the C&SF Project. Therefore, it was not unexpected when modeling conducted during the feasibility phase of the Restudy, showed that none of the alternatives studied showed substantive impacts (positive or negative) to the Keys. Effects on Biscayne Bay were addressed in the Draft PEIS, although there may be further beneficial impacts which require further study, given the presence of two Other Project Elements expected to benefit Biscayne Bay that are outside of the model domain.

272. Given the uncertainties of the method used to assess the impacts on Florida Bay, the report may overstate the differences among the various restoration alternatives with respect to their expected effects on Florida Bay.

Response: Concur, in part, although in using this line of reasoning the report may have equally understated differences among the alternatives. The current best science was employed in developing and using meaningful performance measures by an inter-agency sub-team during the alternative development and evaluation process. The performance measures that the PMC expects to provide in the upcoming year will be helpful.

273. The proposed restoration plan must be sufficiently flexible to accommodate the remaining uncertainty in the freshwater flow and water quality requirements of the marine ecosystems of south Florida.

Response: Agreed. A process actually occurred beginning in November 1998 and extending through January 1999, which explored several alternative scenarios ($D13R_{1-4}$) which identified possible new flows to the southern Everglades and marine ecosystems of south Florida in addition to those in D13R. An initial assessment of $D13R_{1-4}$ by the Alternative Evaluation Team demonstrated some promising results, however, not without negative effects to other parts of the system. The Corps is committed to exploring elements of these scenarios during detailed planning and design assuming they do not result in unacceptable trade-offs elsewhere in the natural system.

274. The draft fails to provide a flow-way to Loxahatchee National Wildlife Refuge (Water Conservation Area #1).

Response: The assumption is that the comment refers to the lack of a flow-way project feature in the recommended Comprehensive Plan. A flow-way component was evaluated by the interagency study team during the alternatives screening process. The proposed component was intended to divert excess treated water south through the J.W. Corbett Wildlife Management Area, to the Everglades Construction Project and ultimately into WCA-1. The inter-agency team set a condition that there be no adverse impact to Corbett Wildlife Management Area by the backpumped water. The study team determined that a flow-way would result in unacceptable negative impacts to existing high quality wetlands and cause further fragmentation of the regional ecosystem. Furthermore, a flow-way regains little of the water storage that is required to deliver adequate quantities of water to the remaining Everglades. It was also found that the flow-way greatly exacerbates evapotransporation water losses, seepage losses, and dry-season water demands of the flow-way to maintain it as a viable wetland system. Reference Appendix A, Table 5, page A1-42 for a summary of the screening results.

275. Urban natural areas, especially lands set aside for conservation, natural parks/reserves and mitigation are not addressed in the draft document. Urban natural areas should be specifically listed in the Executive Summary as a “Major Feature of the Recommended Plan”.

Response: Under the current system of management, water from urban natural areas does not contribute a significant amount of flow back to the natural system. The focus of the ecosystem restoration component of the Restudy is to address those resources, which are part of and contribute to the natural system of protected wetlands and the Everglades. The C&SF Project Restudy is therefore a regional study with a broad perspective on larger scale water resource issues. Urban natural areas, while valuable in and of themselves, are not specifically targeted within the Restudy for restoration, although they should not be adversely affected by the Restudy. Urban water supply under the Comprehensive Plan is expected to greatly benefit, in many instances surpassing 2050 Base demand targets. This water, though targeted mainly for consumption, protection of well fields, and prevention of saltwater intrusion, may also benefit local urban wetlands and natural areas. Under the Comprehensive Plan, the system will have greater capability to maintain higher canal stages, which may have beneficial effects to localized wetlands, ponds, lakes and natural areas.

276. The increasing hyperinsularity of the remnant Everglades wetland mosaic, if not addressed, will further erode the already declining species richness, biodiversity and vitality of these remaining wetlands.

Response: Concur. Although this is more of a rhetorical statement, it provides the very foundation and justification for the Restudy. It is debatable that the remnant Everglades are “hyperinsular”, surely there are significant problems associated with the many drainage canals and levees which obstruct sheet-flow, thus impacting the natural timing, volume and distribution of flow to large areas. A large number of these canals and levees within the Everglades Protection Area are targeted to be removed from the system under the recommended plan which, it is predicted, will restore more natural hydroperiods to the natural system. All of the

L-29, L-68, the southern portion of L-28, significant parts of the L-67, and the Miami Canal within the Everglades Protection Area will all be removed or filled in. The L-67 Extension is assumed to be removed as a part of the future without project condition. This, in concert with other related project features, will restore more natural hydroperiod conditions to the natural system and allow for a more dynamic system, which should support a sustainable and diverse assemblage of plants and animals and of greater abundance. It will further remove physical barriers for native plants and animals, allowing greater freedom of movement and migration around the system from which they had been heretofore largely restricted.

277. Federal and State Threatened and Endangered fish and other species, as well as their recovery, need to be addressed in the report.

Response: There are no Federally listed threatened or endangered fish species within the project area. Any state listed species or species of special concern present in the study area will be coordinated with the Florida Game and Fresh Water Fish Commission (GFC) under authority of the Fish and Wildlife Coordination Act, of 1959 as amended. This Act requires the Federal agency taking action to coordinate project plans with the U.S. Fish and Wildlife Service, as well as the state agency responsible for management of fish and wildlife. The Endangered Species Act requires action agencies to consider only Federally listed species, although the Corps routinely considers state listed species before proceeding to construction of a project.

278. Project component sequencing as it relates to fish and wildlife, including federal and state threatened and endangered and species of special concern and watchlist species as listed on the Audubon web site must be included in the report. Precautionary measures should be taken to ensure that hydrologic alterations occur at a rate that will not adversely effect fish and wildlife diversity or abundance.

Response: The Restudy Implementation Team is coordinating closely with state and Federal wildlife agencies to ensure that project sequencing will minimize adverse affects to all fish and wildlife species during the implementation phase. Watchlist species do not necessarily have protection under the ESA, so including a list of these species within that portion of the report that discusses Threatened and Endangered species is not appropriate. In an effort to maintain a brief and concise document for an immense study area, with minimal redundancy, and avoid reproducing long lists of plant and animal species which may or may not be affected by the project, the Corps decided to include detailed information in the appendices. All plant and animal species considered, particularly those considered threatened, endangered, of special concern or sensitive, whether protected under the ESA or not will receive consideration and evaluation by an inter-agency study team throughout the detailed planning and design, as well as through the monitoring and adaptive assessment process.

279. ATLSS models, which are used heavily in the document, should not be used as a surrogate for actual field collected data.

Response: The Comprehensive Plan includes substantial monitoring and adaptive assessment components that will collect and interpret field collected data and ensure that those data are used to improve project implementation. These data will also be used to continuously update and improve modeling tools, including the ATLSS models, which will continue to be an important part of detailed design and planning.

280. The effects of predicted hydrologic changes should be assessed with respect to how they affect threatened and endangered species and fish and wildlife throughout their entire life cycle.

Response: The U.S. Fish and Wildlife Service's Preliminary Biological Opinion on the Restudy includes an analysis of the Comprehensive Plan's expected effects on all aspects of affected threatened and endangered species' life cycles. This document is included in the report as Annex B.

281. The implementation of the C&SF Restudy should not adversely affect critical and/or endangered habitat, the health and/or quantity of listed threatened or endangered species, nor shall individual listed species or their habitat be irretrievably lost.

Response: The U.S. Fish and Wildlife Service's Preliminary Biological Opinion on the Restudy includes an analysis of the Comprehensive Plan's expected effects on all aspects of affected threatened and endangered species' life cycles and designated critical habitats. The Biological Opinion recognizes that while many listed species are expected to benefit from implementation of the Comprehensive Plan, some other listed species and some individual animals and specific portions of their habitat may be adversely affected. In most cases, these relatively minor adverse effects are necessary in order to provide a greater overall benefit to listed species and their habitats.

282. In reference to the Summary, page viii, animal populations "should markedly increase" but not as a function of restoration, rather as a function of increased surface water storage for water supply.

Response. Do not concur. A marked increase in animal population numbers is a key objective of the Restudy and will be accomplished largely through restoration of the remaining natural wetland features and characteristics which comprise the Everglades, including more natural volumes, timing, distribution and quality of freshwater flows. The water storage features included in the recommended plan are a means to an end, not an objective in themselves to create more available wetlands in the form of a reservoir.

283. The Integrated report leaves out a number of Federally and state-listed species that fall within the project area, and provides little or no information as to which species may be expected to occur within each region.

Response: It was the intent of the Corps to provide in the draft report, those listed species which were determined to be present within the study area and “likely to be affected” by the Restudy alternatives. This determination was made in consultation with USFWS under Section 7 of the ESA. Listed species expected to be present and likely to be affected were identified for each physiographic region in Appendix J. In following guidance under NEPA, the Corps has endeavored to prepare a report that is complete, yet brief and concise, focusing on those issues which are most applicable. This input will be considered and used in future evaluations. It does not, however, appreciably alter the description of the existing environment. Nonetheless, the information presented is incorporated into Appendix J.

284. In reference to page ii, Major Conclusions, is the sentence describing declining fisheries true for recreational fishing in fresh water, or is this more true of saltwater fisheries?

Response: Since there is no citation next to the statement, it is difficult to know the source of the information. It is reasonable to assume though, that it may equally apply to fresh water, near shore marine and estuarine fisheries. All three fisheries have been documented to have experienced some negative effects of man including Lake Istokpoga, Lake Okeechobee, Florida Bay, the St. Lucie Estuary and other fisheries receiving pollutants or excess freshwater flows from the C&SF Project. Offshore salt water fisheries may have received less of an environmental impact to their fisheries due to the limited effect of the C&SF Project offshore.

285. Implementation of D-13R will result in better deer foraging conditions in WCA 3A, south of I-75, but not necessarily for WCA 2B or WCA 3B.

Response: The final report has been edited accordingly. Reference Appendix K, Section K-101-104. The Corps acknowledges and agrees with GFC assessment that not all areas of the WCA system will benefit by improved deer habitat. This information will be used in future assessments of localized impacts where ecological lift in one part of the ecosystem may result in ecological damage to another.

286. The Table J-1.6.4-1 “List of Common Resident and Migratory Avifauna of South Florida (After USACE Wildlife Survey of Lake Okeechobee 1998”, page J-33 may be more suitable for the section describing the resources of Lake Okeechobee.

Response: Undoubtedly there are more complete lists of avifauna for south Florida. The intention here was to provide a flavor for the types of avifauna typically observed and indicative of the south Florida ecosystem. The table provides recent field collected data and, while certainly not a complete list of all avifauna, is representative of south Florida avifauna.

287. Given the aim (restoration) and scope (south Florida ecosystem) of the Restudy, the GFC feels it appropriate that state listed fish and wildlife species be included in the description of existing conditions.

Response: For this final report State listed fish and wildlife species were included in Appendix J (Existing Conditions) in a table as requested. This table is provided in the Regional Overview, section J.1.7 as this was the organizational system used for listed species in the report, not on a physiographic regional basis.

288. To ensure that the Restudy projects protect, conserve, and enhance habitat for native species, WWF urges the Corps to coordinate closely with the Multi-Species Recovery Team of the USFWS and with the multi-species recovery implementation working group which is being established by the Fish and Wildlife Service.

Response: Close coordination with the U.S. Fish and Wildlife Service throughout the alternatives design and review phase ensured that the Comprehensive Plan was consistent with the Draft Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida (MSRP). The U.S Fish and Wildlife Service's, Preliminary Programmatic Biological Opinion on the Restudy included an exhaustive list of conservation recommendations taken directly from the MSRP, and the Corps will work to implement as many of these recommendations as possible during the Restudy's detailed design and implementation phases.

289. The Corps must also incorporate biological indicators into its adaptive implementation and management strategy for the Restudy.

Response: The Comprehensive Plan includes substantial monitoring and adaptive assessment components that will collect and interpret field collected data and ensure that those data are used to improve project implementation. These data will also be used to continuously update and improve modeling tools, including the ATLSS models, which will continue to be an important part of detailed design and planning. ATLSS is a complex series of ecological modeling tools, which collectively incorporate biological indicator type data into species models. Several of these models were used for the feasibility study and others, including models for wood storks, crocodile, and Cape Sable seaside sparrow will be utilized during detailed planning and design. The Corps will continue to coordinate with USFWS under the F&W Coordination Act and Section 7 of the ESA, and with the GFC under the Fish and Wildlife Coordination Act to ensure that each Project Implementation Report expected to be tiered from the recommended Comprehensive Plan will receive appropriate consideration for fish and wildlife and threatened and endangered species.

290. The Seminole Tribe of Florida is concerned that the description of its Big Cypress Water Conservation Plan in the Draft Restudy Coordination Act Report (CAR) reflects some confusion about the purpose, benefits and implementation of this project. The Seminole Tribe recommends several changes to the CAR and has submitted extensive edited text which they request be incorporated into the Final CAR.

Response: The Corps coordinates its project planning with the U.S. Fish and Wildlife Service under the Fish and Wildlife Coordination Act of 1959, as amended. Under the Act, the USFWS is obligated (usually with funding provided from the Corps) to prepare a Fish and Wildlife Coordination Act Report (CAR). The USFWS, and not the Corps, is therefore responsible for preparation of the CAR. The Corps forwarded the Tribe's comments, unedited, to the USFWS and suggested the comments be considered for incorporation into the appropriate section of the Final CAR which is included in the Final Integrated Feasibility Report and Programmatic EIS as Annex A.

291. The Restudy is currently inadequate in providing for the recovery of dangerously threatened populations. The Cape Sable seaside sparrow requires 80 days without disruptive water flows for breeding. In 1999 the Restudy only provides 45 days and 60 days in 2003.

Response: This comment seems to confuse information published in the current draft of Reasonable and Prudent Alternatives (USFWS) for the Experimental Program of Water Deliveries to Everglades National Park project. These results do not apply to modeling done for the Restudy. According to the USFWS staff member on the Restudy Team responsible for endangered species coordination, the recommended plan does not endanger the continued survival of the Cape Sable seaside sparrow and *will* provide sufficient nesting habitat to significantly improve the sparrow's chances for survival and recovery. Furthermore, the Cape Sable seaside sparrow nesting cycle is not 80 days but rather is 40-50 days.

N.2.4 NEPA / Compliance with WRDA

292. The main report includes insufficient information regarding Lake Istokpoga, environmental issues on the lake, and current restoration efforts. Maps of the project area do not include approximately 300 square miles of the Kissimmee River watershed in Highlands and Polk Counties that is on the Highlands Ridge.

Response: Due to the desire to explain the existing conditions of the study area in a brief and concise manner, and concentrate on those resources "ripe" for discussion, many details were remanded to the appendices. During the preparation of the draft report, there were no project features proposed for the Lake Istokpoga, Lake Wales Ridge area, therefore under NEPA there was no need to discuss existing conditions for an area not expected to be affected. The draft Fish and Wildlife Coordination Act Report, part of the overall draft Integrated Feasibility Report and Programmatic EIS, and required as a part of the coordination process under the Fish and Wildlife Coordination Act of 1959, describes in detail the Lake Istokpoga existing conditions (reference Annex A).

293. The draft report failed to include the Lake Wales Ridge in project maps.

Response: There were no project features proposed for this area in the draft report. The Lake Istokpoga Regulation Schedule, incorporated in the recommended plan as an Other Project Element since coordination of the draft, is addressed in the comment/response above. The resource issues mentioned in this comment will be considered as a part of this report, and future individual project implementation reports, although not reproduced in the main report.

294. The Upper St. Johns River was specifically excluded from the study.

Response: Yes. The St. Johns River is outside of the Central and Southern Florida project boundary, is part of a separate watershed, and is hence, outside of the Restudy study area. Moreover, issues associated with the Upper St. Johns River are currently being addressed in a separate feasibility study.

295. Localized adverse effects are all north of Lake Okeechobee, while the "overall benefit to the regional system" occurs south and east of the lake. Were cumulative effects quantified? Or merely discounted?

Response: Not all localized adverse effects occur north of Lake Okeechobee. The report cites that there are expected to be localized adverse effects throughout the system in order to achieve an overall, system-wide restoration. Most of the benefits of the proposed plan do occur from Lake Okeechobee southwards and east of the lake. Benefits are also expected to occur west of Lake Okeechobee, within the Caloosahatchee River Basin and estuary and within the northern Big Cypress Basin. The Kissimmee River watershed is currently being addressed by the Kissimmee River Restoration project that is ongoing. A Lake Istokpoga Regulation Schedule study has recently been included within the Restudy as an OPE. An assessment of cumulative impacts to the study area is required in the draft EIS by NEPA, and was not "discounted". The total area expected to be impacted by construction of reservoirs and STAs was quantified and is cited in the report. A qualitative assessment of cumulative impacts was done for each of the physiographic sub-regions, although no quantitative cumulative impact assessment was done, nor any reliable methodology known to be available at this time for a study area of this magnitude.

296. It is recommended that location specific NEPA review be conducted prior to land acquisition and Restudy component installation.

Response: Given the size and complexity of the Comprehensive Plan, by necessity the plan will be divided into smaller projects for implementation. Refer to the Implementation Plan, Section 10 of the Final Integrated Feasibility Report and Programmatic Environmental Impact Study for details on the plan and need for location specific NEPA review as the components are implemented.

297. EPA believes that it is imperative that water quality be fully (if not equally) addressed in the Restudy together with water quantity. EPA is pleased that inputs (Appendix H, pg. H-2) were wholly incorporated into the Draft PEIS as follows:

Water quality concerns have been identified for several of these (water quality) parameters (listed in Draft PEIS). Accordingly, both water quantity and water quality actions will be fully considered in the hydrologic restoration of south Florida via the Restudy PEIS.

EPA requests that the above paragraph be included in the main document of the Final PEIS for emphasis.

Response: Concur. The paragraph has been added to the Final PEIS.

Note: The Corps, as lead agency, for the preparation, editing and publication of the Draft and Final PEIS, is charged with decision making over the data, information, and written text submitted by Cooperating Agencies, including EPA. In editing the report, the Corps tries to determine what information is most relevant, adds substantive information and value to the decision maker. In addition, NEPA guidance is explicit in instructing the preparer to write clearly, concisely, and in terms the average reader can understand. In that light, the Corps judiciously edited inputs to the main report received from its partner agencies, in an attempt to make the document easy to read and understand, while providing a complete comprehensive “story” of the project planning process to date.

298. Because the air quality section in the main volume is very brief, a reference to appended detailed information (Appendix I) is critical and should be added in the Final PEIS.

Response: In reference to Section 3.0, paragraph 5 of Draft PEIS, there are references to both Appendix H (water quality) and Appendix I (air quality) in the main report. A further reference to Appendix I was added to Section 3.3, air quality existing conditions for emphasis.

299. For the environmental effects information submitted, it appears that the air quality section was drastically reduced to a one-paragraph summary in the main document. Again, the summary in the main document did not reference that detailed information was appended as Attachment D of Appendix I.

Response: It was generally agreed in coordination between the Corps and EPA, that there would be no effects to existing air quality due to the array of alternatives presented in the C&SF Restudy. According to NEPA guidelines, preparation of an EIS should address issues at a level of detail commensurate with the anticipated significance of the impact on the human and natural environment. Therefore, the detailed information regarding air quality received from EPA was edited and reduced for the main document to reflect the anticipated lack of significant impacts, and incorporated by reference the air quality appendix. In Section 8.0, paragraph 2, Appendix I is so referenced in the Draft PEIS. Reference has also been incorporated in Section 8.4, air quality for the Final PEIS.

300. A point of contact for NEPA comments should have been provided on page i. For an extensive document such as the Restudy Draft PEIS (nine volumes), EPA concurs with the extension of the public review time to well beyond the NEPA set minimum of 45 days. Greater use of conventional NEPA language in the draft PEIS would have been preferred.

Response: A point of contact was provided on page i. of the draft report. It is generally the Corps policy not to include two points of contact for one document, as it tends to confuse the public. Comment noted regarding review period. This is not a “conventional” study, therefore extraordinary language, outside of the traditional NEPA framework was appropriate.

301. The C&SF Project Comprehensive Review Study, Feasibility Report and draft Programmatic Environmental Impact Statement does not consider the “unconstrained alternative” as required under the National Environmental Policy Act (NEPA). This alternative would provide the basis for evaluating restoration system integrity for comparison to other alternatives and enhancement. Include an analysis of secondary and cumulative impacts of the recommended plan.

Response: The National Environmental Policy Act does not require the consideration or evaluation of an “unconstrained alternative”. However, NEPA does require an evaluation of alternatives that fulfill the objectives and goals of the study, plus the “no action alternative” or the without plan condition. The “no action alternative” for this study is defined as the 2050 condition, the condition one would assume to be in place if none of the Restudy’s alternative plans are implemented. Refer to Section 4, Future Without Plan Condition, of this Final Integrated Feasibility Report and Programmatic Environmental Impact Statement for a description of this condition. The without plan condition provides the basis for evaluating other alternative plans. The difference between the without plan condition and an alternative plan’s condition are the effects or impacts resulting from that plan. The formulation of alternative plans is described fully in Section 7, Formulation and Evaluation of Alternatives. Secondary and cumulative effects were assessed for each physiographic region throughout the study area and were presented in Appendix K, as well as Section 8 of the main report.

302. There is unequal consideration given to upland wildlife as opposed to wetland-dependent species in the Draft PEIS. Section 8 should be revised to include more upland wildlife issues, particularly as they relate to impacts associated with construction of water storage reservoirs.

Response: Section 8 of the draft report was revised with a view to providing more balance to upland and wetlands issues and addressing more fully those upland habitat issues of concern. Note: The C&SF Restudy is by and large a proposed plan for restoring wetland ecosystems and the native plant and animal life that once thrived there. The Restudy also proposes to provide a sustainable water supply to agriculture and urban users, flood protection, and water based recreation within natural areas. Although upland species are important components of these ecosystems, and potential impacts to upland habitat were discussed in the draft report, most discussion in the draft report focused on water resources and restoration of desirable volume, timing, distribution, and quality of fresh water flows.

303. In reference to page 3-1, the statement “the Big Cypress region is less impacted by human activities and is in relatively good condition as an ecosystem”, does not adequately account for major man caused disturbances such as logging, oil and gas exploration, residential development, recreational uses, and agriculture.

Response: The above statement, as presented, is somewhat out of context. It actually read as “In contrast (to the Everglades), the Big Cypress regions is less impacted”. This statement is true and not misleading. The point regarding long-term impacts of human activities, and growth and associated development increasingly impacting the region is well taken. The referenced statement has been enhanced to include these concerns.

304. NEPA requires the Corps to fully analyze and disclose in the Final PEIS how the proposed action would result in increases in criteria and hazardous air pollutants. In addition, the Corps should disclose alternatives to the proposed action that would address restoration goals without increasing air pollutants that would result from the doubling of human population.

Response: Air quality concerns related to the recommended Comprehensive Plan were fully and appropriately assessed by the U.S. Environmental Protection Agency, Air Quality Division, a Cooperating Federal Agency under NEPA on the Restudy. The Environmental Protection Agency determined, with Corps concurrence, that there were no significant impacts to air quality as a result of the implementation of the recommended Comprehensive Plan relative to the without plan (2050 Base) condition, which is our basis of comparison of alternatives. The results of the air quality assessment are available in detail in Appendix I.

305. The Comprehensive Plan facilitates future population growth, therefore the Final Integrated Feasibility Report and Programmatic Environmental Impact Statement should consider the direct, indirect and cumulative effects of such growth, as required under the National Environmental Policy Act.

Response: The Comprehensive Plan does not facilitate future population growth within the 16 county area covered by the Restudy. Future population estimates were projected by the Bureau of Economic and Business Research, University of Florida, State of Florida (BEBR) and the U.S. Department of Commerce for use in establishing the “Future Without” condition (refer to Section 4 of the Final Integrated Feasibility Report and Programmatic Environmental Impact Statement for a detailed description of this condition). The future population estimates are then used to project future urban and agricultural water supply demands. Knowing these demands it would be irresponsible if the Comprehensive Plan did not moderate the projected impacts on this resource.

306. Extend the comment period for the Restudy due to the voluminous text and the holiday season.

Response: Although the concern is understandable, the comment period is longer than required under the NEPA process. The expedited schedule imposed by WRDA 96 to submit the report to Congress by July 1, 1999 did not allow an extension beyond December 31, 1998.

307. The Restudy is not consistent with the intent of the Water Resources Development Act of 1992 and 1996 which authorized the Restudy and appears to have changed its course since the Reconnaissance Study.

Response: The purpose of the Restudy is to review how well the C&SF Project is functioning and determine what modifications may be needed to achieve a new set of objectives. The precursor to the feasibility phase of the Restudy -- the reconnaissance study -- identified a set of regional-scale planning objectives based on the work conducted by the Science Sub-Group of the South Florida Ecosystem Restoration Working Group as well as input form the public. The Governor’s Commission for a Sustainable South Florida also developed a set of regional-scale objectives for the Restudy. A synthesis of these has resulted in an inclusive set of objectives to achieve two general goals for south Florida’s ecosystem: enhance ecological and economic values and social well being.

The Restudy planning objectives were developed as the result of public participation and scientific knowledge of south Florida. Through workshops conducted during the reconnaissance phase of the Restudy, it is evident that the C&SF Project must continue to provide valuable services to developed areas as originally intended. Therefore, many of the economic and social objectives are similar to those of the original C&SF Project. However, unlike the original project purposes of the C&SF Project, the Restudy includes objectives that recognize the importance of the natural system in achieving sustainability of the region.

308. The definition of the South Florida Ecosystem should be consistent with that in WRDA 96 and that used by the South Florida Ecosystem Restoration Task Force.

Response: The south Florida ecosystem as discussed in the Restudy coincides with the 16 county region of the South Florida Water Management District. These 16 counties contain the most significant structures of the 18 county region identified by the original C&SF Flood Control Project.

309. Ecosystem enhancement is not Everglades restoration and does not meet the stated goals of restoration required under WRDA.

Response: Recognizably, the Restudy is not a perfect plan and will not please every concerned individual and stakeholder. The Restudy is a solid, feasible plan that meets the objectives established by WRDA 96. The plan process fully involved state, local and Federal governmental representatives; concerned individuals; citizen groups and stakeholders in the component development and evaluation and preferred alternative selection. Widespread distribution of developmental information and continued public involvement in the Restudy process are objectives that have far exceeded statutory requirements for a study of this nature. The Restudy is fully committed to achieving the best plan possible within the constraints imposed and will continue to improve the plan as it moves forward through the authorization, feasibility study, pilot project and design and construction phases.

N.2.5 Socio-Economics

310. It is not accurate to state that agricultural encroachment has taken place in the floodplain in the areas east of the levee (pg. E-117). The area is flat, sits on top of an extremely porous aquifer and water management in the area is ground water driven. The area has not received a floodplain designation from any governmental entity.

Response: A floodplain designation has not been established for the area. Although the area is flat and sits on top of an extremely porous aquifer, ground water hydrology does affect the types and locations of agricultural production. The primary project purpose of the South Dade Conveyance System is to provide flood protection to the south Miami-Dade County area. One effect of project implementation was to reduce flood risk to the agricultural area by channel improvements and establishing authorized water levels in the canal system. Shortly after implementation of the project, authorized stages were reduced in the canal system to benefit the farming community. During this period, increased agricultural production has occurred in the area due to the reasons sited in the Economic Appendix. Agriculture has not *encroached* upon wetlands in a traditional sense. Nevertheless, additional agricultural development is damage-susceptible given that the current canal water levels are now higher because of increased deliveries to Everglades National Park. The higher stages during the winter months can adversely affect truck crops, and root zones of fruit trees can be affected year around. It is this increased agricultural production with its consequent resulting damage susceptibility that is referred to as encroachment in the report. Section E.6.5.2.2.6 will be revised to generally substitute the phrase “increased agricultural production” for “agricultural encroachment”. This should clarify the fact that agriculture has not encroached upon wetlands in a traditional sense.

311. The original design of the C&SF System was such that the northern (approximately) third of the EAA discharged into Lake Okeechobee. When the Interim Action Plan (IAP) went into effect, the stormwater that was designed to go to the lake was diverted south, affecting the ability of the EAA canals to protect the adjacent farmland. Section E.6.5.2.2.13 (pp. E-119-120) should state that the IAP reduced the original flood protection level of service provided by the original C&SF design. It is not possible to determine with the SFWMM if the recommended plan components have improved this situation.

Response: The recommended plan will reduce flooding problems in the EAA relative to what they would be without the plan. The SFWMM is not the appropriate tool to analyze these effects in detail.

312. The derivation of the tables in the “Beneficially Affected Areas” section is unclear. According to the text, the same information as the “adversely affected areas” was used to generate a list of beneficially affected areas. In many cases, the same nodes show up as both adversely affected and beneficially affected. More information, in general, about how the flood control benefits and adverse impacts were calculated is essential.

Response: The methodology for determining which areas are adversely impacted is discussed on page E-124 of the appendix and illustrated in the tables that follow. The methodology for determining which areas are beneficially affected is discussed on page E-157 but the tables that describe the process are abbreviated. The determination of problem areas that might be beneficially affected use the same methodology as the determination of problem areas that might be adversely impacted. Tables 6.6.2.1-2, 6.6.2.1-3, 6.6.2.1-4, and 6.6.2.1-5 in Appendix E display increases and decreases in depth expected with alternatives A, B, C, D, and D13R for May and October compared to the 1995 and 2050 bases. Flood depth increases recorded in these tables indicate potentially adversely affected areas; flood depth decreases indicate potential beneficial affected areas.

Table 6.6.2.1-6 and Table 6.6.2.1-7 are also used to determine possible adverse affects that could occur during months other than May and October of the year. As stated in the appendix, a potential adversely affected area was defined as an area where the peak stage difference was at least 0.25 feet higher for an alternative than the appropriate base condition for more than 0.0% of the years. Beneficial affects were attributed to an area where the peak stage difference for an alternative was at least 0.50 feet less than the appropriate base condition for more than 0.0% of the years. Using this approach, many of the same nodes show up as both adversely affected and beneficially affected. This is to be expected since there are beneficial and adverse affects that occur under the recommended plan to the same areas at different times of the year or in different years of the period of analysis (1995, 2050).

As noted above, the discussion of beneficial and adverse affects is limited to the areas designated as problem areas. It should also be noted that additional areas that do not have existing problems may also be beneficially or adversely affected by alternatives to the extent flood problems may be created or alleviated. The identification of these areas, though, is beyond the scope of the models used for the Restudy.

313. Encourage appropriate development, and discourage western sprawl, but with care to address minority concerns of gentrification, displacement, and contamination.

Response: Land use planning is largely a matter of local government planning, and wise planning is encouraged in support of, and consistent with, a healthy Everglades south Florida ecosystem. Such planning should include concerns about particular impacts on any one group, especially minorities.

314. A more accurate depiction of where future populations will be located is desirable. A table should be included in the report with details for all of the study area counties concerning county comprehensive plan dates of adoption and revisions and the exact year land use data stems from.

Response: Concur that details concerning population location will be important as plan implementation takes place gradually through time. Such details are beyond the scope of the Restudy. The Comprehensive Plan's focus is on developing and recommending a framework for improving the ecosystem and other water resource needs in south Florida. Such a table would provide interesting information, but is more pertinent to a land use planning document.

315. Worker retraining should be part of the plan for dislocated workers. There must be a preferential hiring program for dislocated workers via clauses in all publicly awarded contracts. The socio-economic part of the report must include provisions to minimize impacts on working families.

Response: Populations at risk have been profiled in Section 12 of Appendix E, “Other Social Effects”. During detailed implementation of the recommended plan, facilities will be sited with care regarding low income, minority and other at-risk populations. Undue impacts on any particular group or individual will be minimized, as a part of compliance with laws and regulations, to include Executive Order 12898 (Environmental Justice).

316. Hendry County population estimates are too low, and should be revised upward.

Response: Population estimates for larger areas tend to be more reliable than for smaller parts of the total; the Restudy is no exception. These observations about Hendry County represent perhaps a case in point. The main purpose of the population projection estimates is to generally describe the economy and demography of the study area, and to assist in estimating municipal and industrial water use in the service areas covered by the South Florida Water Management Model. For purposes of evaluation of large scale planning concepts in this study, adjusting Hendry County estimates due to the cited observations will not likely materially affect regional water demand results enough to alter conclusions and recommendations. Reasonable consistency in estimating study area population 50 years into the future required adherence for the most part to the comprehensive statewide Bureau of Business and Economic Research and U.S. Department of Commerce projections. It will be necessary to adjust this plan as more improved and detailed knowledge during the implementation process, expected to take place over many years, becomes known. Adjustments to relevant planning parameters to the extent affected by departures from the report’s estimates of population can and should be made as necessary in the future. This will be acknowledged in the final report, to include the point that Hendry County’s population estimates could be understated.

317. Water supply needs for Southwest Florida agriculture should be examined.

Response: Caloosahatchee Basin agricultural water demands have been accounted for. Water needs outside the current C&SF project area will be considered in a separate study for Southwest Florida. This will be the proper place to comprehensively address the rest of these Southwest Florida water supply issues.

318. Local economic impacts are callously disregarded in Restudy, and payment-in-lieu-of taxes programs should be addressed to assist Hendry County in counteracting the detrimental impact of taking productive agricultural lands from the tax roll.

Response: Local economic impacts are important, and can be significant for some communities. Economic impact evaluation was limited to the study area on a region-wide scale, about which more could be said with certainty than for individual small areas such as counties. Nevertheless, the recommended plan does acknowledge the potential for significant impacts, especially in the case of small rural communities that are dependent on agriculture for their prosperity, when large amounts of farm land are converted to a reservoir (Section E.12.2). The complexity and uncertainty involved in calculating detailed effects on a county by county basis is such at this level of analysis that it fell outside the scope of this study. Consideration of specific programs such as payment-in-lieu-of taxes has not been a part of this aspect of the Restudy's planning process, but can be incorporated into detailed implementation of specific plan features and components when that activity takes place.

319. Why must livelihoods and daily lives be utterly destroyed for this project? No amount of money can buy lives and homes.

Response: Adverse impacts will be minimized wherever possible.

320. Why don't we deal with the number one reason why things got this way in the first place – i.e., the ultimate exotic invasive species, humankind? We must begin the dialogue of how to control the growth of our human population.

Response: Growth management is not a Restudy issue. The impact of humans on the natural system is important. There is a linkage between anthropogenic stressors and ecological values. A major responsibility and authority of the Corps is with regard to the control and movement of water in the C&SF Project, not population control. The goal of the Comprehensive Plan is to find ways to adjust the functioning of that system to satisfy the public's desire for water for the Everglades ecosystem and for urban and agricultural activities.

321. There's not enough detail to make an informed decision. The plan is too conceptual.

Response: This is a regional scale study, and there is enough detail to make informed decisions at this level.

322. Population projections are too low, and there should be more focus on regulatory approaches, rather than just conservation effects on demand. Users should operate within their own resources, rather than importing additional hydrological resources from elsewhere.

Response: The population projections are adequate for purposes of the regional system issues that the Restudy addresses. Restudy population projections represent a middle ground approach. A number of alternative scenarios for future population and future water consumption were considered, and the future scenario for the Restudy rests in the middle. Unrealistically high or low projections can encourage inappropriately sized project feature recommendations. There is not a one to one proportional correspondence between projected population and recommended project components. The region wide management of water resources has been in place for many years and helps to dampen what would otherwise be significant impacts of too much water in one locality and not enough in another at different points in time. This has been an efficient system; the recommended plan continues this approach. The new water that will be made available for future users would in the absence of this plan be lost to tide, as it is now. The alternative of no action would result in an Everglades ecosystem that would be inferior and not likely sustainable. Part of the monitoring of the system's performance over time will include a monitoring of actual growth in population and its consequent use of water, which will account for any significant departure that may be necessary from the comprehensive plan.

323. It is particularly curious that Glades and Hendry Counties have such low projected populations, and are the locations of large storage lakes are to be built.

Response: These two counties were not singled out and targeted for low growth in the Restudy. Their projections are part of a regional scale estimate of future growth trends. One of the reasons for Corps policy and practice of using a large area (State BEBR, US Department of Commerce) system of internally consistent projections is to avoid bias. Departure from such area wide projections would be ignoring official estimates that take into account state and national control totals. It is important to recognize that the large scale conceptual plan, even though it includes suggestions for specific detailed components, will certainly of necessity be subject to changes over the many years during which implementation is expected to take place.

324. The economic impact of reservoirs proposed for Glades, Hendry, Lee, and Collier Counties is discounted as a local problem (p.E-329).

Response: The discussion in Section E.13.4., titled "Regional Economic Effects," states that these features, if constructed, could eliminate jobs and have adverse effects on local communities and economies. It also states that the detailed locations of such features are not known yet, and that a more detailed assessment of the vulnerability of such communities to the project would be possible when such details become known. While it is true that such effects would likely be localized, this acknowledgment does not equate to discounting such effects as being insignificant.

325. There is a startling lack of empathy for localized collateral community economic and social impact damage, and that there is no component to help the local economy recover or even be stable during the construction effort.

Response: Impacts to the local economies are important, and there is great empathy for those who might feel they will be negatively affected. Such impacts could in certain areas be significant, but they may not be. Negative impacts will be avoided as much as possible.

326. The Restudy report doesn't include specific details regarding Seminole Tribe expectations for economic development in the Fisheating Creek Basin.

Response: All localized negative impacts are important and will be either avoided or minimized. The resolution of the economic impact estimating model and methodology is not at a level of detail that would explicitly include this specific concern.

327. A socioeconomic impact study of the local, regional, and State levels must be conducted by a consortium of State university faculty.

Response: Concur that such a study would be a valuable contribution to the body of knowledge about this issue.

328. We are willing to work with you for the betterment of all concerned, but we are very concerned about the potentially significant economic and physical impact to our citizens and our government.

Response: The impacts to Glades County's people, government, and economy are important. Any negative effects will be minimized to the greatest possible extent.

329. The Restudy plan is heavily weighed in favor of environmental restoration, and should be more balanced, as directed by the original authorization and as restated in WRDA 96. The Corps' economic analysis estimated only 6% of the benefits are attributable to M&I water supply and only 1% to agricultural water supply, and that the remaining 93% are undefined.

Response: The Comprehensive Plan is a balanced plan. Almost if not virtually all water using sectors will have more water with the plan than without the plan. Disagree with the comment about the percentage figures cited; they are incorrect, or at the least misleading. The estimated annual costs in the draft report are $402 million, and the estimated annual M&I water supply benefits are $27.2 million, or about 6.8% of the costs, not 6% of the total benefits, as the comment states. Similarly, the annual agricultural water supply benefit estimate is about $1.9 million, or about ½ % of the costs, not of the total benefits. The total benefits are not all quantified, for reasons discussed in the report. There are likely to be significant other "non-environmental" benefits, especially for fishing and recreation. There has been no attempt to express the natural system environmental benefits per se in economic dollar values.

Disagree with the premise that this project favors the environment vs. the economy in a way that is out of balance. There can be no meaningful separation of the intrinsic value of environmental restoration from benefits associated with other water management needs. A healthy and functioning natural system is the very infrastructure upon which the economic system is built, within which it functions, and upon which it absolutely depends. The economic system and all of its water management needs do not exist separate from the environmental system whose health the Restudy will improve with this plan; they exist *in* the environment. Spending on fishing and recreation activity (including tourism and eco-tourism) in the region is in the hundreds of millions of dollars per year. Agricultural production exceeds $4 billion annually. Total sales in the study area exceed $200 billion per year. All participants in this economic and social environment deserve a clean, healthy natural environment, without which the qualitative and quantitative aspects of the economy and society of south Florida would be endangered.

330. Acceptance of future growth and development should be conditional on the sustainability of environmental systems to accommodate such growth. Just because a current rate equates to some future figure does not mean that is the smartest number to plan for or that it is inevitable.

Response: Growth has an important bearing on ecosystem sustainability. Planning for the most likely future growth is a realistic position that the Restudy has taken. The future projection figures do not equate to current growth rates. Study area population growth projections are characterized by significantly declining growth rates throughout the period of analysis used in the Restudy.

331. Water conservation is an extremely important component of a successfully implemented Restudy plan. Serving unlimited water supplies to unlimited growth must not be a guarantee. It should be the firm resolve of the Corps and the SFWMD to not divert water from the natural system in the future, to the detriment of that natural system, to serve whatever needs arise in the future. Otherwise we will wind up right back where we are, and all this planning will have been for naught.

Response: Concur. All stakeholders have to work together to achieve a sustainable partnership between the needs of a sustainable natural system and the needs of the economy which ultimately depends on the natural system for its very survival.

332. Economic development and water supply will not survive the continued destruction of the Everglades.

Response: Concur. The Restudy plans to reverse the destructive decline in the ecological values of the Everglades system, which will benefit the health of the natural system itself, as well as the health of the economy and its water supply.

333. Population projections should be done in concert with land use analysis, considering zoning and alternative future buildout scenarios. The construction of ASR facilities could wind up being the fuel to fire further future population growth. There should be an entire section devoted to the interrelation of population, landuse, and ecosystem functions. Such information and analysis would be critical for guiding land use acquisition, and for mitigating the effects of population growth.

Response: The Restudy has not followed the analytical procedures suggested with regard to population analysis. The Restudy recommended plan is designed to allow for shifts as implementation proceeds over the many years necessary. One of the issues of ongoing review and adjustment will be population growth – where and how it will in fact be taking place, compared with the general growth scenario used in the Restudy. A most likely middle ground future growth scenario has been considered, based on a state and national control total growth concept. With such a process, the danger of basing regional projections on detailed micro-area analysis is avoided, which can result in the individual parts adding up to more than the total could realistically be. Detailed small area resolution of future growth estimates would have been inconsistent with the regional scale of the hydrologic modeling tool (the South Florida Water Management Model) whose outputs provided the basis for most of the Restudy recommendations. Population projections used in the Restudy are generally characterized by a continued decline in growth rates over time.

334. Population figures should include a projection of where the populations are locating, to aid in appropriate siting and sizing of water storage areas.

Response: The Restudy has chosen to keep the officially reported projection estimates general at the region wide level. Appropriate sizing and siting of storage areas are some of the many implementation details that will necessarily take place throughout the many years of project implementation. Population location is one consideration that will be considered; others will include site suitability, willing sellers of available land and its price.

335. Using the most current local government comprehensive plans, vested development approvals, and future buildout plans, would help to provide a more accurate depiction of where populations are moving.

Response: At this level of detail, the Restudy did not make micro-area-specific projections. Such considerations will be important in the decisions to be made during project implementation. Local government comprehensive plans are generally consistent with the State of Florida Bureau of Economic and Business Research projections, which were used.

336. Were any water supply uses not included in the IWR-Main modeling? If so, how do they affect the findings?

Response: Yes, there were some water uses not covered by IWR-MAIN. IWR-MAIN was used to estimate municipal and industrial water use. This covers commercial, residential, industrial, public, etc., both through utilities and self-supplied by user wells. It covers all of this but the estimates do not identify supply source (user-owned wells vs. utility supplied); they only focus on demand (consumption/use). IWR-MAIN estimated use was by service area, which was disaggregated into well-specific withdrawals, necessary for input into the SFWMM. As a part of this process, there were some adjustments to account for water estimated to be withdrawn from the Floridan aquifer for reverse osmosis (RO) treatment. There were some other similar minor adjustments, in order to make the input for the SFWMM make sense.

IWR-MAIN does not include agricultural use or environmental deliveries. IWR-MAIN estimates were developed to be used as one of the inputs necessary for running the SFWMM. It represents part of the water use "pie."

337. The Restudy report should mention some of the state-managed lands that are used for recreation that are managed by the FGFWFC.

Response: This concern was addressed by adding mention of the Lake Harbor Waterfowl Area and Terrytown (both in the EAA), Rocky Glades WEA, and the Everglades Management Area to Section E.8.2, Recreation Resources, in Appendix E, including the recognition that they also comprise significant recreational resources. Text was also added to direct the reader to seek additional information in the F&W Coordination Act Report, which can be found in the Restudy document in Section A2 of Annex A.

338. The Restudy geographic scope includes the entire SFWMD managed watershed, but the report discussion (Section E.8.2) seems to focus only on Everglades-related recreation.

Response: The study area includes areas that are not part of the Everglades, such as the Kissimmee River basin. The focus, though, tended to concentrate on the areas that most likely will be affected by the ecosystem restoration actions of the Restudy.

339. The Restudy (Section E.8.2) focuses on five main areas for Everglades-related recreation. Why wasn’t the Everglades WMA (WCAs 2 and 3) included?

Response: The five principal areas were selected on the basis of geographic area, designation as nationally significant (i.e., National Park), and available information on visitation. Based upon what could be determined, the Everglades Wildlife Management Area is relatively difficult to access and is not a magnet for state, national, and international visitors to the extent of the five selected areas. Mention of this resource was added to the discussion.

340. Catfish should not be considered by-catch since it is commercially fished in Lake Okeechobee. Bullhead, shad, and gar are technically not by-catch either (in the sense that they are thrown away) since they are sold as crab bait.

Response: In Section E.9.2.1.1 of the report, it is stated that the haul seiners are trying to catch bream when they catch the by-catch. It is recognized that the catfish have some commercial value and could therefore be included with target species. The use of the word “by-catch” is from a 1990 GFWFC paper entitled “Use of a Subsidy to Compensate Commercial Haul Seine Fishermen for By-Catch of Nongame Species in Lake Okeechobee”. The term “incidental” will be used instead of “by-catch.” This sentence will be followed by: “Some of the incidental catch is sold as crab bait and some is given away.”

341. It is hard to believe that only 27% of the visitors that were engaged in recreation on Lake Okeechobee were involved in fishing. This seems inconsistent with our Okeechobee Division of Fisheries staff.

Response: The 27% figure is cited in the document as having come from the Corps’ Natural Resource Management System (NRMS). Since the NRMS information is collected for the entire project, which includes visitation to the St. Lucie and Caloosahatchee rivers, the percentage of fishermen may seem small. But the absolute number of fishermen identified by the NRMS (27% x total visitors) still suggests a significant recreational fishery.

342. Recreational fishing, unlike commercial fishing, is very sensitive to hydrologic changes due to the structural complexity of the vegetation of the spawning grounds.

Response: According to personnel in the GFWFC Division of Fisheries field office in Okeechobee, recreational fishing is also not extraordinarily sensitive to low water, and fishermen can wade from shore rather than fish from their boats, the changes in vegetation of the spawning grounds notwithstanding.

343. Not enough emphasis on snorkeling and diving as economic impact activities.

Response: As discussed on page E-185 of the draft report (Section E.8.1) in the paragraph beginning with “This chapter is concerned with…”, this section focuses on landside Everglades-related recreation, which includes recreation on Lake Okeechobee. However, the subject of snorkeling and diving is also mentioned as part of the description of Biscayne National Park in Section E-8.2. Snorkeling and diving are addressed in Section 9 (Recreational and Commercial Fishing). The prominence of these subjects was expanded in the final report.

344. It is confusing in the discussion on p. E-185 of the draft report that the chapter supposedly deals with land-based recreation, but then goes on to include fishing, swimming, and boating, and defines Lake Okeechobee as a principal recreation area.

Response: Most of the visitors to the lake engage in passive recreational activities (e.g., sightseeing, picnicking, etc), which are often related to visiting the Everglades. For this reason, lake-related recreation was split between Section 8 (Recreation) and Section 9 (Recreational and Commercial Fishing).

345. Florida Keys National Marine Sanctuary should be included as one of the principal south Florida recreation areas.

Response: The FKNMS was not included as a "principal recreation area" because its visitation levels and relationship to the Everglades does not push it into the top category of "principal".

N.2.6 Real Estate

346. Should condemnation procedures be necessary, federal rather than state condemnation processes should be used.

Response: Acquisition of lands required for the implementation of the C&SF Restudy will be based on further study. The lands required will be identified as future Project Implementation Reports are completed. The C&SF Project is a cost shared local cooperation project and as such it is the responsibility of the non-Federal Project sponsor, the South Florida Water Management District, to acquire all lands, and interests in land required for the Project. While it is the intention of both the U.S. Army Corps of Engineers and the South Florida Water Management District to acquire lands from willing sellers, if condemnation of lands becomes necessary, the condemnation action would normally be handled by the non-Federal sponsor.

347. Acquire all lands in the park expansion boundary and all land within the 8.5 Square Mile Area to ensure full ecological and hydrologic restoration of the ENP and Florida Bay. The C&SF Restudy should maximize the utilization of the 8.5 Square Mile Area in restoring flows to ENP.

Response: For purposes of the Restudy Comprehensive Plan, it has been assumed that acquisition of all lands within the Everglades National Park Expansion boundary had been accomplished prior to implementation of plan components. The acquisition of lands within the Everglades National Park Expansion boundary is the responsibility of the National Park Service, Department of Interior. Acquisition of all lands within the 8.5 Square Mile Area was approved by the Governing Board of the South Florida Water Management District in November 1998. The 8.5 Square Mile Area will become a part of the Modified Water Deliveries to the Everglades National Park Project as the locally preferred option, after approval of a Post Authorization Change. The South Florida Water Management District has begun acquisition of portions of the 8.5 Square Mile Area. The Governing Board approved this project subject to a firm financial commitment from the Federal government and Miami-Dade County to cost share this project.

348. Acquire the Model lands and other southern lands designated under EEL and other acquisition programs (i.e.: areas between Everglades and Biscayne National Parks) for conservation purposes.

Response: Acquisition of the Model Lands and other southern lands designated under EEL and other acquisition programs is ongoing by the South Florida Water Management District and Miami-Dade County under state and local land acquisition programs. Portions of these lands may be required for the C&SF Restudy.

349. Accelerate the acquisition of all lands within the WPA footprint to restore hydrologic functions in the Everglades system.

Response: Acquisition of lands from willing sellers within portions of the lands required for the Water Preserve Areas by the South Florida Water Management District has been ongoing for some time and will continue as state or other funding is available. However, under current Corps procedures, until the Comprehensive Plan is approved by Congress, a separate Project Implementation Report is completed and approved, and a Project Cooperation Agreement executed, land acquisition will continue under state land acquisition programs or with funding provided through other sources.

350. Ensure that quarry pits, as they are mined-out, become public property at no additional cost to the public.

Response: Until the Comprehensive Plan is approved by Congress, and a Project Implementation Report is completed and approved, and a Project Cooperation Agreement is executed, land acquisition will accomplished under state land acquisition programs. Acquisition of these mined out quarry pits would be at appraised fair market value as required by law.

351. Acquisition of the lands within the north and central lake belt storage areas involved difficult issues and may delay implementation if issues related to acquisition of these lands cannot be resolved.

Response: Lands required for the North Lake Belt Storage Area and Central Lake Belt Storage Area will be among the last project lands required and these will be among the last components constructed. As described in the Implementation Plan, it is proposed that Phase I lands would be required in 2015 and Phase II lands in 2031. This would allow private landowners a sufficient period to mine and remove the minerals, limestone, rock, sand, etc. The period of time for the removal of the materials will be dependent on when the lands are required for construction of the storage areas.

352. Approval of the plan will cause a loss of private property rights and bypasses elected officials.

Response: Private property will be required to complete construction of Restudy project; however, it is the intent, where practicable to purchase required lands from willing sellers. Approval of the plan will be by Congress and the Florida Legislature. Affected residents, businesses and landowners will continue to be informed of project developments, and provided opportunities to provide input to project design and implementation. The Corps and the SFWMD will continue to evaluate project designs to minimize real estate needs, and work with affected residents and land owners to arrive at mutually acceptable solutions. In any event, Federal laws and regulations require that property owners be paid fair market value, any severance damages, and allowable relocation assistance payments. Further, mitigation of effects on real estate will be developed in accordance with the requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as Amended.

353. The Real Estate acquisition cost for Component FF4 (construction of S-356 A&B structures in Miami-Dade County) seriously underestimated the worth of the land with three miles of major highway frontage and does not account for land and building improvements or equipment.

Response: Land acquisition costs were estimated based on available information and data obtained from various sources. A gross appraisal of the land was not completed, but will be accomplished at the time a Project Implementation Report is processed. At that time, more detailed information would be obtained regarding the building improvements, equipment, and land values in the area. Lands required for the construction of the S-356 A&B structures in Miami-Dade County are projected to be acquired by 2005. On only a portion (approximately 1,082 acres) would the landowner be allowed to retain the rights to extract the minerals and limestone. However, the landowner would be given a specified period of time after the lands were acquired and the component constructed in which to mine and remove the minerals, limestone, rock, sand, etc. This period of time for extraction of the minerals and limestone has not been determined and would be factored into the ultimate land valuation.

354. All land purchases must be justified based on engineering, science, and socioeconomic impact for each specific project. The 3.2 million acres of public lands should be utilized as the first alternative in any project or part of a project before private lands are considered, which would bring down the costs of project implementation. The acquisition of 248,000 acre of private land should be a last resort alternative.

Response: All land purchases will be justified based on engineering, science, and socioeconomic impact for each specific project occurring during preparation of the Project Implementation Reports. The use of the public lands was considered during the planning process and use of these lands was determined not to be feasible, and inconsistent with study goals.

355. Undertake land acquisition efforts on a willing seller basis and only using Florida's state eminent domain procedures, if necessary. Projects should be completed on a whole as funds are available.

Response: The C&SF Project is a cost shared local cooperation project and as such it is normally the responsibility of the non-Federal project sponsor, the South Florida Water Management District, to acquire all lands, and interests in land required for the project. While it is the intention of both the U.S. Army Corps of Engineers and the South Florida Water Management District to acquire lands from willing sellers, if condemnation of lands becomes necessary, the condemnation action would normally be handled by the non-Federal sponsor. Lands purchased for the project will required an independent fair market appraisal prior to purchase.

356. Ensure that Florida Power & Light (FP&L) is adequately compensated for all costs of relocation of electrical lines.

Response: FP&L would be compensated for modifications to existing electric facilities or utility rights-of-way.

357. Component A6 provides for a regional storage reservoir north of Lake Okeechobee. The Tribe supports increased regional storage in this basin, but does not support the use of Tribal lands for storage of water for others.

Response: The location of this storage reservoir has not been determined. It could be located in any of three counties (Glades, Highlands, or Okeechobee). The use of Tribal lands for the storage reservoir has not been considered.

358. Local governments should deny land use amendments that increase the intensity or density of land uses within the WPAs.

Response: Neither the U.S. Army Corps of Engineers nor the South Florida Water Management District can control the actions of local governments on land use amendments. Restudy Team members have been working with local governments during the planning phases of the study and will continue to work with local governments during plan implementation.

359. Immediately acquire all lands necessary for the C&SF Restudy.

Response: It is not feasible to acquire all lands necessary for the C&SF Restudy immediately. Until the Restudy Comprehensive Plan is approved by Congress, a Project Implementation Report is completed and approved, and a Project Cooperation Agreement executed, land acquisition will continue under state land acquisition programs or with funding provided through other sources.

N.2.7 Water Quality

360. A comprehensive, systematic pollution prevention program is needed in urban areas of south Florida. The program should include enhanced emphasis on best management practices (BMPs) and greater participation in the National Pollutant Discharge Elimination System (NPDES) program for urban stormwater facilities.

Response: The recommended Comprehensive Plan includes a Comprehensive Integrated Water Quality Plan feasibility study to ensure that water quality restoration in south Florida is achieved. Although the scope of the feasibility study has not yet been developed, the feasibility of BMPs in specific urban areas should be investigated as well as identifying those urban areas where participation in the NPDES municipal stormwater program is needed.

361. Recent studies indicate that water in quarry lakes is of good quality. Lake Belt water could be pumped directly underground for aquifer storage without additional treatment. ASR should be evaluated as an element of the Lake Belt storage components.

Response: Present regulations require that underground (aquifer) injection of water which meet primary and secondary drinking water standards. If future planning and detailed design work indicates that ASR is viable and necessary as an element of the Lake Belt storage components, and the water to be injected is of adequate quality, ASR could be incorporated into the overall design of those components.

362. The recommended plan should identify strategies to reduce phosphorus and nitrogen loading to coastal waters to assure protection of reef tracts.

Response: Although the scopes of the studies have not yet been developed, it is envisioned that the Florida Bay feasibility study and the Comprehensive Integrated Water Quality feasibility study included in the Comprehensive Plan will address in detail the issues of nutrient sources and loads, impacts to reef ecosystems, appropriate restoration targets, and remediation programs (including wastewater treatment) to protect and restore reef ecosystems.

363. There are water quality issues such as potential treatment system failures, contaminants in the sanitary sewer system, and pollution loads to Biscayne Bay associated with discharging treated reclaimed wastewater into Biscayne Bay/Biscayne National Park as proposed in the South Miami-Dade Wastewater Reuse component.

Response: Future planning and detailed design work necessary to construct and operate the South Miami-Dade Wastewater Reuse component would involve a comprehensive evaluation of potential treatment train methodologies, reliability and dependability of treatment methodologies (including the extent of and controlling and minimizing contaminant inputs to the sanitary sewer system), and designated uses and water quality criteria of receiving water bodies necessary to assure compliance with water quality standards.

364. The Report/PEIS indicates that urban water quality is degraded and not expected to improve. These statements should be reconsidered to reflect the results expected from the federal NPDES Program and local water quality improvement initiatives. Urban stormwater which is returned to the Everglades should continue to be improved.

Response: Statements about future water quality conditions in the Report/PEIS are based on current conditions and trends as summarized in FDEP's 1996 Section 305(b) Report to USEPA and predicted population increases during the planning period for the Restudy (through 2050). While many water quality remediation programs are expected to be planned and implemented during the planning period, for planning purposes, the increase in population is expected to result in a net increase of (legal) point and non-point sources of pollution, delivering a net increase in pollution loads to urban water bodies in the Lower East Coast. Water quality conditions in some secondary and tertiary drainage systems are expected to remain “degraded” compared to designated uses (particularly for Class III water bodies) contained in state water quality standards. Urban stormwater that is returned to the Everglades through operation of recommended plan components will be improved to meet the water quality standards for the Everglades Protection Area. The recommended plan results in a significant decrease in urban stormwater returned to the Everglades, particularly at the S-9 pumping station in Broward County.

365. The draft "Reuse Issue Paper" discussing water quality concerns associated with the wastewater reuse components inappropriately concludes that adverse environmental impacts will occur. There are several benefits that result from incorporating reuse into the recommended plan, including perpetual fresh water supply and a net water quality improvement compared to urban runoff.

Response: The issue papers were prepared by subteams of the Alternative Evaluation Team to resolve issues raised by U. S. Department of Interior agencies prior to finalizing the Fish and Wildlife Coordination Act report for the Final Report/PEIS. Water quality concerns raised by environmental resource management agencies, including BCDNRP, will be addressed in detail during future planning and design work.

366. At present, there is a great deal of uncertainty about the concept of injecting raw (untreated) surface water into aquifers (surficial, Biscayne, Floridan). Issues of concern which have not been clearly resolved include the chemical make-up of potential source water (Lake Okeechobee Basin, Caloosahatchee River Basin, etc), chemical and biological effects of aquifer storage, and the quality of recovered water and its subsequent long-term effects on receiving surface waters. Specific constituents of concern in waters to be potentially injected into ASR facilities in the draft recommended plan include coliform bacteria, several pesticide compounds, mercury and nitrates.

Nearly all surface waters in the greater Everglades ecosystem are contaminated with pesticides, herbicides, and coliform bacteria. To meet federal Safe Drinking Water Act standards, surface waters would have to be treated with chlorine prior to injection into an aquifer at ASR facilities. Treating surface water with chlorine prior to injection may increase the potential for formation of tri-halomethane compounds (THMs).

Other forms of pretreatment should be employed to prevent the injection of bacteria, viruses, and other microbial contaminants into the underground reservoir. Moreover, the effectiveness of treatments under consideration (e.g., microfiltration, reverse osmosis) should be proven to be effective prior to pilot testing.

Response: Current regulatory standards require that any substance to be injected into potential underground sources of drinking water (USDWs) must meet primary and secondary drinking water standards. In addition, FDEP has developed guidance concentrations for many substances for which there are no primary or secondary standards. With regard to aquifer injection of surface waters containing coliform bacteria, USEPA has agreed to adopt a flexible, risk-based approach for ASR components of the recommended Comprehensive Plan. USEPA has oversight authority over FDEP's implementation of the federal Safe Drinking Water Act. This flexible, risk-based approach would allow aquifer injection of water without chlorine treatment, provided that coliform bacteria is the only problematic parameter in the water to be injected, and further providing that there is a demonstration that USDWs will not be endangered in any way that could adversely affect the health of humans.

Full implementation of the ASR facilities contained in the recommended plan depends upon pilot projects, including water quality monitoring work and follow-up assessments, to determine the effect of the injectate on the USDW. The cost for chlorination at ASR facilities, if required to prevent bacteriological contamination of USDWs, is included in the estimated costs for the recommended plan. If future monitoring work indicates that chlorination causes or contributes to the formation of THMs, alternative remediation methods or alternative water storage methodologies will be considered to provide the necessary storage. Technical information about the effectiveness of various treatment technologies for ASR facilities is presently available and will be reviewed during future detailed planning and design work. Pilot testing, possibly including different treatment technologies, is necessary to determine the best combination of technologies for full-scale implementation of the proposed ASR facilities.

367. Water stored in the Floridan aquifer may be contaminated by existing levels of radioactivity.

Response: Levels of radioactivity and the potential for contaminating aquifer stored water will be further evaluated during future detailed planning work. The ASR pilot projects described in the Implementation Plan are key to determining the long term water quality effects on aquifer stored water. Radiation levels would be monitored routinely as part of future operation and maintenance activities, if determined to be necessary as a result of the proposed pilot projects.

368. The protocol for injecting and withdrawing water into confining layers of the aquifer should be better defined to maximize the efficiency of ASR facilities. ASR wells should be designed to compliment surface storage reservoirs and canals. An issue team should be established to evaluate design and operations options. Pilot test results should be peer-reviewed.

Response: The South Florida Ecosystem Restoration Working Group has established an interagency ASR issue team to work through these and other issues associated with ASR. Future detailed planning and design work will address issues of optimal configuration and operation to maximize efficiencies at ASR facilities during the implementation phase of the Restudy. The interagency process will continue to be utilized during implementation of the recommended plan. Peer review of ASR pilot test results will be considered if necessary for objective interpretation.

369. There is a lack of reliable and verifiable water quality data in south Florida. A non-biased, reliable water quality data base should be compiled and continually updated and reviewed.

Response: A number of Federal, state, regional, tribal and local entities collect samples and use water quality data for research recommendations and management decisions in the study area. Although the scope of the feasibility study has not yet been developed, it is envisioned that the Comprehensive Integrated Water Quality Plan feasibility study contained in the recommended plan would address the issues of fragmented sampling, data quality, and climatological effects and trends.

370. Ultimate sources of water and receiving water bodies are not yet known. Future detailed design work to meet regulatory water quality criteria may necessitate design changes. Construction of plan components without the necessary permits could result in the inability to operate those facilities. Plan components requiring water quality treatment facilities should not be authorized until more detailed design is completed.

Response: Future detailed design work will take into account water quality conditions of source waters and designated uses of receiving water bodies, and will include appropriate treatment facilities to assure that designated uses and water quality standards are achieved. Water quality certifications from the State of Florida and the Miccosukee and Seminole Tribes will be obtained as required by federal law. By involving those entities in the planning and design process, it is intended that instances where additional detailed design necessary to assure compliance with water quality standards are completed at the appropriate time and water quality certification is obtained. The project implementation process contained in the Implementation Plan includes additional planning, engineering, and design to assure that water quality problems and permitability issues which could preclude future construction and operation are avoided or dealt with appropriately.

371. Water quality costs have not been included in the project cost estimates. The draft Report/PEIS contains no explanation as to how compliance with the Clean Water Act is to be achieved. Water to be supplied to fruit and vegetable growers must be of adequate quality. A comprehensive water quality feasibility study is necessary. The study should identify costs and cost-sharing.

Response: The estimated costs for the recommended plan include costs for construction, operation, and maintenance of water quality treatment features included in the recommended plan. Compliance with the Clean Water Act is a without project condition (State, Tribal, and local responsibility), except in the case that the recommended plan creates new discharges that potentially conflict with designated uses of receiving water bodies established under water quality standards. In that case, water quality treatment features will be included in future detailed design to assure that designated uses are maintained. Water quality features included in the recommended plan, together with ongoing (without project) programs to improve and maintain water quality, assures that water to be supplied for agricultural purposes will be of adequate quality to meet that designated use.

The recommended plan does include a feasibility study to develop a comprehensive integrated water quality plan to assure that water quality restoration targets in south Florida are achieved. Although the scope of feasibility study has not yet been developed, it is envisioned that the water quality feasibility study would include cost estimates for monitoring and data evaluation, construction and implementation and operation of treatment facilities and other remediation programs, and recommendations for cost sharing.

372. The draft Comprehensive Plan does not address water quality issues in Florida Bay and the Florida Keys. The Florida Keys Water Quality Protection Plan, including wastewater elements, should be included within the Restudy.

Response: The recommended plan includes a feasibility study to evaluate environmental restoration issues, including water quality, in Florida Bay and the Florida Keys. Although the scope of that study has not yet been developed, it is envisioned that the plan which would result from the study will include the Florida Keys Water Quality Protection Plan. The Florida Keys Water Quality Protection Plan includes measures for improving wastewater and stormwater treatment within the within the Keys. Implementation of this plan is critical for ecosystem restoration in the Keys.

373. A discharge standard of 10 ppb total phosphorus should be established and implemented for the EAA. Backpumping of EAA runoff into Lake Okeechobee should be eliminated. Water quality in the Holey Land and Rotenberger Tracts should be restored by the Restudy.

Response: The Florida Department of Environmental Protection has responsibility under state law (the Everglades Forever Act; "EFA") to develop a numeric phosphorus criterion for the Everglades Protection Area. The default concentration in the EFA is 10 ppb; however, a final numeric criterion is not required to be set by FDEP until December 31, 2003. Discharges from the EAA will be treated by the Everglades Construction Project (ECP), including supplemental treatment technologies, if necessary, to achieve compliance with the numeric phosphorus criterion. The ECP significantly reduces, but does not completely eliminate, backpumping of EAA runoff to Lake Okeechobee. Hydrologic modeling results for the recommended plan indicate that, on average, backpumped volumes are slightly increased with the recommended Comprehensive Plan. The hydropattern restoration features of the ECP, continuation of BMPs in the EAA, acquisition of additional lands for storage in the EAA (Component G), and the revised regulation schedules for the Holey Land and Rotenberger Tracts should result in water quality restoration in those areas.

374. There is significant uncertainty about the ability of STA technology to treat urban stormwater runoff to meet restoration water quality goals. It is imperative that the recommended plan seek to eliminate the regulatory flood control function of the S-9 pumping facility.

Response: On average, the recommended plan reduces the volume of water discharged via the S-9 pump station to WCA 3A from 193.6 k ac. ft. per year in the 2050 Base condition to 7.8 k ac. ft. per year with the recommended plan (see Appendix H, p. H-F-27). Most of the remaining 7.8 k ac. ft. is seepage return flow; flood control discharges are virtually eliminated with implementation of the recommended plan. The Non-ECP requirements of the EFA require that all discharges from S-9 to WCA 3A comply with all water quality standards, including the phosphorus criterion, by December 31, 2006.

375. Martin County requests that the Final Report/PEIS contain language assuring that water quality criteria will be included in design scopes for all Restudy projects.

Response: The Implementation Plan (Section 10) describes how existing and yet-to-be-developed water quality criteria (TMDLs, PLRGs,) will be integrated into future detailed planning and design activities as part of the Project Implementation Report process.

376. Estimated costs for treating water prior to aquifer injection may make other alternatives to ASR such as recycling and desalination more economically and environmentally attractive. Once an aquifer is contaminated, it will remain contaminated. This is a concern, in terms of future treatment costs, for those municipalities withdrawing water supplies from contaminated aquifers.

Response: Contamination of underground drinking water supplies is prohibited by underground injection control (UIC) regulations. Routine monitoring associated with ASR operations will be performed to continuously evaluate waters to be injected and the response of the aquifer into which water is injected to prevent aquifer contamination. Local initiatives to develop alternative water supplies will supplement the regional system.

377. The Restudy must address the four main requirements of the Everglades ecosystem: timing, delivery, quantity, and quality of water.

Response: The recommended plan should significantly improve water quality in the study area through optimal design and operation of the components to achieve water quality restoration targets. The recommended plan also includes a feasibility study to develop a comprehensive integrated water quality plan for south Florida. Although the scope of the feasibility study has not yet been developed, it is envisioned that the comprehensive integrated water quality plan will involve the development of additional water quality restoration targets where needed, recommendations for remediation programs to achieve those targets, and recommendations for synchronizing water quality restoration programs with the implementation schedule for the components of the recommended plan.

378. Reductions in Caloosahatchee River flow volumes resulting from the recommended plan should be recognized as part of the reduction in pollutant loads required by FDEP total maximum pollutant load (TMDL) limits.

Response: Establishment of total maximum daily loads (TMDLs) of pollutants for impaired water bodies is a responsibility of FDEP for state waters. FDEP is represented on the interagency Restudy Team, and will continue to be represented during plan implementation and other subsequent studies in south Florida. The TMDL process takes into account the assimilative capacity of water bodies and ongoing and planned water management and environmental restoration projects.

379. Construction and operation of the Caloosahatchee Backpumping with Stormwater Treatment component (Component DDD5) requires treating water discharged from Lake Okeechobee into the Caloosahatchee River before it is returned to Lake Okeechobee. The same water quality requirements should apply for water discharged from the lake to the river as those which apply for water to be pumped from the river back to the lake. The stormwater treatment area for this component should be reconsidered based on this criterion.

Response: Component DDD5 is designed to treat runoff from the C-43 basin and return treated water to Lake Okeechobee, providing a net increase in fresh water captured and stored within the regional system. The stormwater treatment area is included in the conceptual design and cost estimate for this component to assure that designated uses of Lake Okeechobee (Class I – potable water supply) continues to be met as a result of hydrologic changes contemplated by the Comprehensive Plan. The recommended plan also includes several components specifically included to improve water quality in Lake Okeechobee; however, fully restoring water quality in Lake Okeechobee depends on actions outside of the recommended Comprehensive Plan (e.g., establishment of total maximum daily pollutant loads (TMDLs) and development of pollutant load reduction programs to meet Lake Okeechobee water quality targets). The recommended feasibility study to develop a comprehensive integrated water quality plan for south Florida will investigate water quality issues associated with implementing recommended Comprehensive Plan components, including ecological effects of Lake Okeechobee releases on downstream waterbodies.

380. The Comprehensive Plan does not address how the huge volumes of water that will be stored and diverted to the Everglades will meet the soon-to-be-established stringent numeric phosphorus criterion. The costs associated with the necessary treatment should be included in the estimated costs for the Comprehensive Plan.

Response: The increased volume of water delivered to the Everglades from areas to the north (EAA, Lake Okeechobee) will be routed through the Everglades Construction Project (ECP) stormwater treatment areas (STAs). The ECP STAs are a without project condition for the Restudy. An evaluation of the effect of the recommended plan on the ECP STAs was performed by William Walker, Ph.D., for the Corps of Engineers and the Department of Interior during the plan formulation and evaluation phase of the Restudy. Dr. Walker's evaluation indicated that the recommended plan was not expected to adversely affect the projected overall performance of the STAs. This was due primarily to the beneficial effect of the EAA storage reservoir (Component G6) on STA 3/4. A summary of Dr. Walker's results is included in Appendix H.

However, that evaluation was performed without any assumptions about future (Phase 2) treatment requirements necessary to meet the final phosphorus criterion. Once the technology or technologies have been determined which will supplement the ECP STAs, a subsequent evaluation of the effect of the recommended plan on the performance of the ECP will be performed during future detailed design activities.

The Water Quality Subteam of the AET also evaluated other new discharges to the Everglades contemplated in the recommended plan. The most significant new discharges identified were: the increase in flows through the modified S-140 pump station (Component RR4) and the new discharge into the L-31N Canal through the proposed S-356 pumps. Using water budget data, the Water Quality Team determined that the increased flows through the S-140 pump originated in ECP STAs (STAs 3/4 and 6), natural areas (Holey Land and Rotenberger WMAs), and the L-28 Interceptor Canal basin, runoff from which is to be treated by whatever strategy/facility is developed for that basin as part of the Non-ECP requirements of the EFA (also a without project condition for the Restudy). The source of the increased flows through the proposed S-356 pumps is seepage water from WCAs 2 and 3 stored in the Central Lakebelt storage area and is assumed to meet the water quality criteria for the Everglades.

381. The Water Quality Sub-team of the AET's evaluation of the alternative plans for the Caloosahatchee watershed does not include the effects of ASR.

Response: Average volumes of water discharged from ASR facilities to the Caloosahatchee watershed and Lake Okeechobee was considered by the Water Quality Subteam as a potential performance indicator. The performance indicator was rejected because of uncertainties about the quality of the stored water withdrawn from the aquifer and the effects, if any, of aquifer stored water on receiving water bodies. Discharges from ASR facilities to surface waters will be required to meet applicable surface water quality standards.

382. Routing of water around the northern portion of WCA 3A is likely to lead to water quality problems. The recommended plan proposes a 285,000 acre-feet per year increase through the modified S-140A pump station. This creates a new point discharge into the Everglades. Adequate water quality treatment is not provided. This operation could neutralize the hydropattern restoration and water quality objectives of the Everglades Construction Project.

Response: Structural flows into northwestern WCA 3A were increased specifically to achieve preferred hydroperiods and hydropatterns in northwest WCA 3A. Component RR4 includes a spreader canal in the initial design and cost estimate to re-establish sheetflow into WCA 3A. It is not intended that discharges from the modified S-140A pump station would create a new point source discharge into WCA 3A.

According to water budget data from the SFWMM, the upstream sources of the flows through S-140A in the Comprehensive Plan break down as follows:

	2050 Base	Draft Comp. Plan
Holey Land	0.0	20.0
Rotenberger	77.0	99.0
STA 3\4	5.0	228.0
STA 6	0.0	11.0
S140A	93.0	102.0*
SUBTOTAL	175.0	460.0
Difference:		285.0 increase

Note: All flow volumes indicated are 31-year averages, in k ac. ft.

Thirty-one year average flow volumes were compared to the projected future (2050) Base condition flow volume for S-140A. During plan formulation and selection, it was concluded by the Water Quality Subteam (which included Everglades National Park) that increased flows through S-140A would not adversely affect water quality conditions in WCA 3A. This conclusion is based on the future without plan condition for the Restudy, i.e. full implementation of the State of Florida's Everglades Program contained in the Everglades Forever Act (F.S. 373.4592) by December 31, 2006. This condition includes construction and operation of the Everglades Construction Project (ECP) STAs and any supplemental treatment technologies necessary to achieve compliance with the yet-to-be-determined numeric phosphorus criterion, and implementation of the Non-ECP discharge structures requirements of the EFA (Section 373.4592(9), F.S.).

Non-ECP structures are those water control structures within the control of the SFWMD, which are not associated with the Everglades Construction Project discharging "into, within, or from the Everglades Protection Area." The S-140 pump station was specifically identified as a water control structure discharging into the Everglades Protection Area in the Non-ECP discharge structures permit issued by FDEP to the SFWMD. The EFA requires that schedules and strategies be identified and implemented for all Non-ECP structures to achieve compliance with all water quality standards in the Everglades Protection Area by December 31, 2006.

From the table above, it can be seen that all flows delivered through the modified S-140A pump station as contemplated in the Restudy Comprehensive Plan originate from STA 3\4, STA 5, STA 6, the Rotenberger and Holey Land WMAs, or via whatever water quality treatment strategy is developed for the S-140 basin. It should be noted that the average annual volume of runoff originating from the S-140A basin directed to WCA 3A increases approximately 9.0 k ac. ft. (from 93.0 k ac. ft. to 102.0 k ac. ft; see "*" in above table). If it is determined in future detailed planning and design work that the increased volume and proposed operation would adversely affect whatever treatment strategy is developed for the S-140 basin in accordance with the Non-ECP requirements of the EFA, modifications necessary to assure that the water quality requirements of the EFA are achieved would be incorporated into the final design and operation of Component RR4.

383. Reducing water levels in northwest WCA 3A will likely cause soil oxidation and more subsidence and will degrade downstream water quality.

Response: Water depth and duration of flooding performance indicators were established for specific grid cells in WCA 3A. The recommended plan was formulated to meet those targets to the maximum possible extent consistent with all of the other performance measures developed / approved by the AET. Projecting with certainty the ecological responses to alternative water management scenarios was not possible during plan formulation and evaluation due to the scale of the models used (two mile by two mile grid cells), uncertainties about final locations, and uncertainties about antecedent conditions in the vicinity of water control structures and appurtenant features to be constructed. Ecological responses, including potential releases of phosphorus from enriched soils, will be further evaluated in future detailed planning and design actions as described in the Implementation Plan (Section 10). It is anticipated that future improved versions of the Everglades Landscape and Everglades Water Quality (phosphorus) Models will simulate soil phosphorus releases and affects on water column phosphorus concentrations.

384. Restoration of sheet flow in the northern Everglades will create a water quality benefit by reducing the rapid, long-distance transport of aquatic pollutants into wetlands.

Response: Concur. To evaluate the alternative plans, the Water Quality Sub-Team of the AET utilized structural flows into the Everglades Protection Area (including the northern Everglades) as an indicator of potential pollution loads. High structural flows (loads) received low scores in the team's ranking matrix for the Everglades Protection Area.

385. Lake Okeechobee Water Quality Model results indicate that phosphorus enriched sediments provide a high rate of internal loading to the lake. Dredging of phosphorus enriched sediments is necessary to fully restore the lake and decrease phosphorus loads discharged to downstream ecosystems.

Response: The final recommended plan now includes all of the reservoir assisted stormwater treatment areas (RASTAs) recommended by the Lake Okeechobee Issue Team to reduce external phosphorus loading to the lake to target levels. A discrete task already identified to be performed as part of the recommended feasibility study to develop a comprehensive integrated water quality plan for south Florida involves evaluating the environmental and economic costs and benefits of dredging phosphorus enriched sediments in Lake Okeechobee.

386. Isolating deep storage reservoirs (e.g., North and Central Lake Belt storage areas) from ground water flows by constructing curtain walls may cause water quality problems in those reservoirs. The potential for poor water quality in these lakes must be thoroughly investigated.

Response: Future detailed planning and design work for the Lake Belt storage components would include evaluating the effects of the proposed designs on water quality, including thermal stratification and the migration of pollutants.

387. Two twenty thousand-acre storage reservoirs are insufficient to cleanse runoff from an area of 550,000 acres (the EAA). The proposed areas for the six STAs in the Everglades Construction Project are insufficient. Acreages of Storage (sic) Treatment Areas (STAs) must be expanded to fully address water quality.

Response: The initial design of Component G6 includes three 20,000-acre storage reservoirs, totaling 60,000 acres of storage in the EAA. Evaluation and modeling of the six stormwater treatment areas (STAs) presently included in the design of the Everglades Construction Project during Restudy plan formulation and evaluation work indicated that the interim performance target for the STAs was not likely to be adversely affected by the recommended plan (see Appendix H). In particular, the performance of STA 3/4 improved due to the upstream storage and attenuation provided by the EAA reservoir (Component G).

388. The interim (Phase 1) water quality target (50 ppb of phosphorus) for the STAs does not assure adequate protection of Everglades marshes. The Phase 2 target will become a “Herculean” task without providing vastly expanded STA acreage. Failure to provide guaranteed clean water with a maximum of 10 ppb of phosphorus will further impact the ecosystem and the costs of cleanup. Other pollutants such as mercury and pesticides need further review.

Response: The water quality treatment requirements of the Everglades Forever Act (EFA), including potential supplemental treatment (Phase 2) technologies are a without project condition for the Restudy. Modifications to those facilities necessary to accommodate recommended plan components will be evaluated during future detailed planning and design work, included as appropriate, and are eligible for federal cost-sharing. Due to the many uncertainties about potential Phase 2 treatment technologies, assumptions about the sizes, locations, and costs of Phase 2 technologies were not incorporated into the evaluation of the alternative plans and the selection of the recommended plan. Modeling work performed during plan formulation and evaluation indicated that increasing the area of storage proposed for the EAA greater than the 60,000 acres proposed did not significantly improve overall plan performance. Impacts of pollutants other than phosphorus will be evaluated during future detailed planning and design work to the extent that pollution load reduction targets and total maximum daily loads (TMDLs) for pollutants causing impairment of receiving water bodies are established by USEPA, FDEP, Tribal, and local water quality regulatory agencies.

389. The Corps should insure that all Restudy components are designed so that water outflows meet restoration standards for water quality. The federal share for water quality features of the recommended plan should be fifty percent, provided that state, regional, and local interests have done all they can to implement BMPs and appropriate water quality regulations.

Response: The Implementation Plan (Section 10) contains steps to assure that water quality restoration targets developed by state and tribal agencies (e.g., total maximum daily loads (TMDLs) and pollution load reduction goals (PLRGs)) are considered during future detailed planning and design work. The Water Resources Development Act of 1996 contains provisions authorizing fifty- percent federal cost sharing for water quality features determined to be essential to Everglades restoration. All of the water quality features of the recommended plan are recommended for fifty- percent federal cost sharing.

390. Sewage treatment in the Florida Keys should be improved to protect public health and coral reefs.

Response: Improved sewage treatment is a part of the Florida Keys Water Quality Protection Plan developed as part of the Florida Keys National Marine Sanctuary

Program. The final Report/PEIS (Sections 5, 8, and 9) has been revised to acknowledge the need for water quality improvements, including improved sewage protection, in the Florida Keys.

391. Water quality issues associated with aquifer storage should be addressed to protect and preserve the quality of underground drinking water sources.

Response: Regulatory criteria are in place to assure that water to be injected by future ASR facilities would meet drinking water standards. Underground injection regulations prohibit the injection of substances (including raw surface water) which could potentially adversely impact underground sources of drinking water.

392. Restoration of the Everglades is critical to improving the ecological health of coral reefs in the Florida Keys. Strategies for reducing agricultural runoff containing pesticides, herbicides, and fertilizers (including phosphorus and nitrogen) should be identified in the Restudy restoration plan.

Response: The State of Florida's Everglades Program contained in the Everglades Forever Act is the primary strategy for reducing agricultural pollution, including phosphorus and nitrogen compounds, entering the Everglades Protection Area. State and tribal agencies are also responsible under the federal Clean Water Act for developing total maximum daily loads (TMDLs) and pollution load reduction goals (PLRGs) for phosphorus and nitrogen where those pollutants are impairing water bodies other than the Everglades. Achieving water quality restoration targets in the Everglades and other water bodies will benefit downstream water bodies (Florida Bay, Florida Keys). In addition, the Florida Bay/Florida Keys feasibility study included in the recommended plan will address ecological and water quality restoration targets and remediation programs in Florida Bay and the Florida Keys.

393. The quality of water in canals that discharge into Biscayne Bay needs to be drastically improved to ensure ecological restoration in the bay. Cleanup priority should be given to highly contaminated canals, such as the Miami River, Military and Mowry Canals. Reduce nutrient loading.

Response: Under the federal Clean Water Act, the State of Florida is responsible for identifying impaired water bodies (not meeting water quality standards), including canals flowing into Biscayne Bay. For pollutants (including nutrients) causing Biscayne Bay canals to not meet water quality standards, total maximum daily loads (TMDLs) will be developed, along with remediation programs (including canal cleanup, if appropriate) to achieve TMDLs and compliance with water quality standards. It is envisioned that the Restudy Comprehensive Integrated Water Quality Plan feasibility study included in the recommended plan will contribute to expedited development of TMDLs for south Florida impaired water bodies by FDEP as well as expedited remediation programs for water bodies where TMDLs are implemented. The Restudy Implementation Plan (Section 10) assures that plan features (where located in or adjacent to impaired water bodies) will be designed and located to improve water quality conditions to the maximum extent possible.

394. The recommended Comprehensive Plan should ensure that all water entering Biscayne Bay meets or exceeds applicable water quality standards.

Response: The State of Florida, through its statewide, regional, and local agencies is responsible for assuring compliance with applicable water quality standards for existing discharges and sources of pollution. The Restudy Implementation Plan assures that plan features (where located in or adjacent to impaired water bodies) will be designed and located to improve water quality conditions to the maximum extent possible. It is expected that implementation of those components of the Restudy affecting Biscayne Bay will be located and designed to improve water quality conditions in the bay.

395. Establish numeric water quality standards for Outstanding Florida Waters (OFWs) as soon as possible.

Response: Numeric criteria already exist for many specific water quality parameters listed in the State of Florida's water quality standards. In addition, an anti-degradation provision, based on conditions at the time of OFW designation, applies to all OFWs designated by the State of Florida. Numeric interpretations of the OFW anti-degradation requirement for specific water quality parameters are the responsibility of the state or tribal agency having jurisdiction over the water bodies to which the OFW and anti-degradation provisions apply. Under the federal Clean Water Act, USEPA has an oversight and approval authority when states and tribes undertake such actions.

396. Rigorously enforce state and federal water quality standards. Moreover, establish and enforce standards that address both concentration and cumulative loading. All standards must be established to meet restoration objectives and maintain the integrity of the ecosystem.

Response: Enforcement of water quality standards is the responsibility of USEPA and state and tribal agencies. The establishment of new or additional water quality standards and criteria is the responsibility of states and tribes, over which USEPA has oversight and approval authority under the federal Clean Water Act. Existing, new or additional water quality standards and total maximum daily pollution loads (TMDLs) for impaired water bodies will be considered during future detailed planning and design work undertaken to implement components of the recommended Comprehensive Plan with the goal of maintaining or restoring ecosystem integrity.

397. Water from non-natural sources (e.g., urban, agricultural, industrial sources) should be treated to meet the most stringent of federal and state water quality standards prior to being discharged to the Kissimmee River and Lake Okeechobee.

Response: Existing and future discharges from urban, agricultural, and industrial sources are required to meet water quality standards established by state and tribal agencies regulating water quality, over which USEPA has oversight authority. The stringency of water quality standards depends upon the designated use of receiving water bodies and other special designations to which additional criteria apply. At present, several water bodies within the Kissimmee River watershed are designated "Outstanding Florida Waters" (OFWs) by the State of Florida, affording the most stringent water quality protection; however, most of the Kissimmee River watershed is not designated as OFW. Such designations, if appropriate, are the responsibility of the State of Florida through the Department of Environmental Protection, and are subject to review by USEPA. The designated use for most of the Kissimmee River watershed is Class III (recreation and propagation and maintenance of a healthy, well-balanced population of fish and wildlife), to which general and specific criteria particular to that classification apply. Lake Okeechobee is classified by the State of Florida as a Class I water body (potable water supply). The criteria for Class I water bodies are the most stringent for surface waters. Lake Okeechobee is not designated an OFW. Water quality remediation goals and targets for Lake Okeechobee have been set through the Lake Okeechobee Surface Water Improvement and Management (SWIM) Plan process developed by the SFWMD and approved by FDEP.

398. A maximum total phosphorus concentration of 10 ppb should be established for all water that is discharged into the environment from developed and or cultivated sources to help ensure the chemical, physical, and biological integrity of Florida's interior and coastal waters. An EAA maximum total phosphorus discharge criterion of 10 ppb or less should be established. Monitor changes in WCA 3B and ensure that discharges into WCA 3B meet all applicable water quality criteria.

Response: The State of Florida has responsibilities for enforcing water quality standards within its jurisdiction. Under the Everglades Forever Act, the State of Florida is presently engaged in research to numerically interpret the phosphorus concentration for the Everglades Protection Area. The default phosphorus concentration is 10 ppb in the event that no alternative numeric criterion is adopted through administrative rule making by December 31, 2003. USEPA must approve the numeric interpretation of the phosphorus criterion for the Everglades Protection Area. For other water bodies not meeting designated uses, the State of Florida or the Seminole and Miccosukee Tribes, as appropriate, are required under the federal Clean Water Act to develop total maximum daily loads (TMDLs) for pollutants, including phosphorus, causing impairment of water bodies. The recommended Comprehensive Plan's Comprehensive Integrated Water Quality Plan feasibility study will address accelerating FDEP's efforts to numerically interpret the total phosphorus and other water quality criteria for other south Florida waterbodies outside of the Everglades Protection Area.

For Restudy planning purposes, it was assumed that the State would enforce applicable water quality standards through BMPs and other regulatory and non-regulatory programs governing point and non-point sources of pollution. To compliment regulatory and non-regulatory water quality programs by the state and local governments, the Implementation Plan (Section 10) provides that plan components will be planned and designed to the maximum extent practicable to augment basin pollutant load reduction and total maximum daily loading targets. Under the Everglades Forever Act, flows to WCA 3B will be treated to meet all applicable State water quality standards.

399. Alternative methods of water treatment, such as periphyton-based STAs (PSTA) should be investigated. To the extent possible, “natural” methods of stormwater treatment (i.e. PSTA) should be used in the C&SF Restudy. Chemical dosing, if utilized, should not adversely affect the environment.

Response: The Corps and the SFWMD are presently investigating PSTAs as possible supplemental treatment technologies. Other natural technologies (e.g., submerged aquatic vegetation and limerock) are also being investigated by the SFWMD. The most appropriate technology for achieving low phosphorus concentrations has not yet been determined. Future modifications of Restudy water storage and water quality treatment components, including PSTAs, necessary to accommodate plan components and operations will be included in future detailed planning and design efforts.

400. Committees such as ETAC and TOC should continue their efforts to develop methods for effectively monitoring water quality.

Response: The Everglades Technical Advisory Committee (ETAC) was formed by FDEP to assist the Department in future decisions regarding research, monitoring, and the establishment of the numeric phosphorus criterion for the Everglades Protection Area. The Technical Oversight Committee (TOC) was formed pursuant to the settlement agreement for the federal lawsuit regarding pollution of Loxahatchee National Wildlife Refuge and Everglades National Park. The Corps of Engineers and SFWMD participate on both of those committees. Although the functions of those committees is outside the scope of and the authority for the Restudy, it is expected that those committees will continue to meet and make recommendations regarding water quality, including monitoring, during implementation of the recommended plan.

401. Agencies involved in best management practices (BMPs) for agricultural activities should monitor international BMP developments, particularly those

BMPs which increase nutrient and mercury uptake. Such practices should be evaluated for applications in south Florida, where feasible.

Response: The development of agricultural BMPs is the responsibility of those state, tribal, and local agencies responsible for protecting water quality and regulating agricultural and water management activities. USEPA provides financial assistance to state and tribal governments through the Clean Water Act's Section 319 grant program to develop and implement agricultural BMPs which result in reducing non-point source pollutant loading to receiving waters. Improved BMPs are expected to be implemented in south Florida, where feasible. The effects of BMPs will be incorporated into future detailed planning and design work undertaken to implement components of the recommended plan. The Restudy's recommended feasibility study for developing a Comprehensive Integrated Water Quality Plan will assist in development/implementation of agricultural and urban BMPs designed to reduce pollutant loading into south Florida receiving waters.

402. Existing water quality monitoring programs should remain in place. However, adaptive assessment should be used to reexamine existing water quality monitoring programs on a regular basis and/or when development/construction is about to occur.

Response: Although the scope of the study has not yet been developed, it is envisioned that the Comprehensive Integrated Water Quality Plan feasibility study, which is included in the recommended Comprehensive Plan, will include evaluating existing monitoring programs in order to make recommendations for modifying and integrating those programs to more effectively monitor water quality changes and ecological responses to water quality conditions. The adaptive assessment process contained in the Implementation Plan assures that monitoring is adjusted throughout the implementation process to provide meaningful information regarding the water quality and ecological effects of implementing the recommended plan.

403. To date, water quality monitoring in the Everglades has focused on phosphorus and the development of a phosphorus water quality standard. Water quality standards should be developed for other chemicals that are commonly used at industrial and agricultural facilities (e.g., nutrients, pesticides, herbicides, and metals). Furthermore, numerical Outstanding Florida Water standards should be developed and used as applicable standards for all waters that are discharged to designated natural areas and/or sensitive ecosystems.

Response: The Everglades Forever Act requires FDEP to evaluate all existing water quality standards (including non-phosphorus parameters) applicable to the Everglades Protection Area. Establishing and/or revising water quality standards is the responsibility of the state or tribal entity having jurisdiction over those water bodies where such actions are proposed. The USEPA has authority to approve or disapprove proposed water quality standards or revisions to water quality standards pursuant to the federal Clean Water Act. The recommended Comprehensive Plan includes a recommended feasibility study to develop a comprehensive integrated water quality plan that will assist with the expedited development of numeric water quality criteria for other, non-phosphorus water quality constituents. Also see response #402.

404. Provide increased flow through the L-5 canal and ensure water quality improvements.

Response: The recommended Comprehensive Plan increases the volume of water routed through the L-5 canal into WCA 3A. Water quality improvements to EAA runoff are a without project condition for the Restudy (i.e., full implementation of Everglades Forever Act requirements by December 31, 2006). Any Restudy related flows to WCA 3A via the L-5 canal above and beyond future without project flows will be treated to meet all applicable state and tribal water quality standards.

405. Ensure that water discharged from the C-11/S-9 system meets all water quality standards.

Response: The recommended plan diverts urban runoff from the C-11 west basin presently discharged via the S-9 pump station to WCA 3A to storage and water quality treatment facilities in Broward and Miami-Dade counties. Remaining discharges from the S-9 to WCA 3A are required to meet water quality standards, including the phosphorus criterion, by December 31, 2006, pursuant to the Non-ECP requirements of the Everglades Forever Act.

406. Site-specific investigations of potential ASR sites, including chemical analysis of the geologic formations of aquifers proposed for storage, water contained within those aquifers, potential contaminant plumes, and simulated leaching and dissolution rates to characterize the quality of water recovered from storage aquifers should be undertaken to aid future design and monitoring activities.

Response: The suggested investigations will be undertaken as part of the ASR pilot projects included in the recommended Comprehensive Plan and initial authorization request.

407. Existing (and proposed future) injection facilities in the vicinity of proposed ASR sites should be subjected to in-depth evaluation, including the confining geologic formations, to determine the long-term risks of locating ASR facilities in the vicinity of potential sources of aquifer contamination.

Response: Inventories of existing and known-proposed injection facilities will be developed during future detailed planning work undertaken for implementation of ASR components. Monitoring data and technical information, including information describing confining geologic formations, will be reviewed. Part of the ASR Pilot projects proposed in the Restudy initial authorization package is an extensive literature review of existing Florida ASR operations, including chemical composition of ASR injectate and Floridan aquifer chemical composition at the ASR well. It will be completed prior to detailed design of any Restudy ASR facilities.

408. After suitable sites for ASR facilities are identified, pilot tests should be undertaken to obtain additional hydraulic and aquifer chemistry data. Actual data should be compared to previously modeled results. Adaptive assessment principles should be applied to subsequently determine appropriate locations for ASR facilities. Laboratory analytical results from all Florida wells and exploratory borings into the Floridan Aquifer should be obtained to assess the chemical properties of the aquifer at the well location. These data should be used to look for potential contaminant plumes that might affect ASR reservoirs.

Response: The process suggested is generally that which is described in the Restudy Implementation Plan. Pilot testing of ASR facilities is included in the recommended initial authorization package.

409. Are there water quality data describing pre-drainage conditions for WCAs 2B and 3B?

Response: In describing pre-drainage water quality conditions for the Everglades, Section 2.5.4 erroneously referred specifically to Water Conservation Areas 2A and 3A; the statement has been corrected in the final report to refer more broadly to WCAs 2 and 3.

410. DOI supports the proposed modifications to the L-28 Interceptor Canal and levees (Component CCC). However, DOI is concerned with the quality of the proposed sheetflow entering Big Cypress National Preserve as a result of implementation of this component. It is unclear whether proposed treatment techniques included in the plan will adequately reduce this contamination risk.

Response: Flows directed into Big Cypress National Preserve through modifications to the L-28 Interceptor Canal would be required to meet applicable water quality standards. The Preserve is designated an Outstanding Florida Water by the State of Florida, to which more stringent water quality requirements apply. The initial design of this component included STAs designed consistent with the criteria used to size the STAs for the Everglades Construction Project. Future detailed planning and design work for that component will involve reviewing current water quality conditions, applicable water quality standards and criteria, and designing appropriate treatment technologies.

411. Water quality performance (of the recommended plan) was not ranked for Big Cypress National Preserve. The Preserve is increasingly affected by degradation of water quality to the north. Existing and future water quality of flows entering the Preserve warrants closer consideration.

Response: The Water Quality Subteam of the Alternative Evaluation Team determined that water quality performance of the recommended plan could not be ranked for the Big Cypress area, due to a lack of quantitative tools (e.g., modeling results) and performance measures with which to perform a comparative evaluation. Water quality models are under development which will augment future detailed planning and design work of components affecting hydrologic the Preserve. Under the State of Florida's Everglades Program, flows from the C-139 and Annex Basins which could adversely affect ecological conditions in the Preserve will be directed to STAs 5 and 6 of the Everglades Construction Project. A BMP program is also under development for those basins. The Seminole Tribe's Water Conservation Plan, when implemented, should also improve water quality in the northeastern area of the Preserve. The Seminole Water Conservation Plan is included in the recommended plan as an OPE.

412. The Restudy should provide adequate quality of water throughout central and southern Florida's natural areas.

Response: The State of Florida and the Miccosukee and Seminole Tribes, through their appropriate agencies, have responsibilities for enforcing water quality standards within their jurisdictions. For Restudy planning purposes, it was assumed that those entities would enforce applicable water quality standards through BMPs and other regulatory and non-regulatory programs governing point and non-point sources of pollution. All flows from Restudy facilities will meet applicable state and tribal water quality standards. To compliment regulatory and non-regulatory water quality programs by state, tribal, and local governments, the Implementation Plan for the Restudy provides that plan components will be planned and designed to the maximum extent practicable to augment basin pollutant load reduction and total maximum daily loading targets. The recommended plan also includes a feasibility study to develop a Comprehensive Integrated Water Quality Plan for south Florida.

413. Water that is lost to tide via the C&SF project as a result of urban stormwater runoff should be captured, treated to meet the most stringent of federal and state water quality standards, and stored in reservoirs.

Response: The recommended Comprehensive Plan includes numerous components that capture freshwater flows currently "lost to tide" and utilizes these water resources for ecosystem restoration and improved urban and agricultural water supply. Approximately 1.9 million acre feet per year (31 year average) of freshwater currently lost to tide is captured by over 180,000 acres of surface water storage facilities and extensive ASR facilities. Additionally, the Restudy proposes approximately 36,600 acres of water treatment facilities to reduce pollutant loading of Restudy flows entering surface water bodies throughout south Florida. Restudy water flows to surface and ground water receiving bodies will be treated to meet existing and future state and tribal water quality standards.

414. Efforts to identify "control areas" characteristic of historical Everglades water quality should continue. Once defined, the characteristic of the water quality "control area" should be defined for use as a restoration standard.

Response: Research to characteristic "pristine" Everglades water quality conditions is an ongoing requirement of the Everglades Forever Act. Field sampling sites remote from surface water pollution sources are being monitored in an effort to assist the State of Florida with establishing numeric water quality criteria for the central Everglades region. Restudy water quality monitoring programs will be designed utilizing existing unimpacted areas of the Everglades to assist with establishment of ecological restoration standards.

415. Phosphorus laden sediments in lakes, canals, and the Kissimmee River should be mitigated by removal and/or through the use of drawdowns wherever possible.

Response: The existing headwater revitalization program of the Kissimmee River Restoration project includes lake draw-down activities to improve water quality and habitat conditions in the Kissimmee Chain of Lakes area. These activities are not operational components of the Restudy but they are considered in the future without project planning analysis. In the lower Kissimmee River basin, the recommended Comprehensive Plan includes the Lake Okeechobee Tributary Sediment Dredging Other Project Element (OPE) component. This OPE includes dredging of sediments from 10 miles of primary canals within an 8-basin area to remove phosphorus from canal sediments and reduce nutrient loading to downstream receiving waters in an effort to improve water quality conditions in the primary canals and in the downstream Lake Okeechobee.

416. Restoration efforts should protect the river corridor and associated prairies from nutrient rich runoff generated by adjacent agriculture and pasturelands.

Response: In the lower Kissimmee River area, the Restudy final recommended plan now includes several OPEs that will result in water quality improvements via construction and operation of reservoir assisted stormwater treatment areas (RASTAs) to reduce nutrient loading to the downstream Lake Okeechobee. Additionally the North of Lake Okeechobee reservoir (Component A) has been modified to include a 2,500-acre STA. Cumulatively, these lower Kissimmee River RASTAs total approximately 6,900 acres. Additional RASTAs in the recommended Comprehensive Plan in the Fisheating Creek and C-41 Basins totaling approximately 14,600 acres will be subject to further evaluation in the next phase of the Restudy. All of these facilities will significantly reduce nutrient loading to their respective river corridors.

417. Provide proper quality of water to the St. Lucie River/Estuary and the Caloosahatchee River/Estuary.

Response: The State of Florida has responsibilities for enforcing water quality standards within its jurisdiction. For Restudy planning purposes, it was assumed that the State would enforce applicable water quality standards through BMPs and other regulatory and non-regulatory programs governing point and non-point sources of pollution. All flows from Restudy facilities will meet applicable state and tribal water quality standards. To compliment regulatory and non-regulatory water quality programs by the state and local governments, the Implementation Plan for the Restudy provides that plan components will be planned and designed to the maximum extent practicable to augment basin pollutant load reduction and total maximum daily loading targets.

Within the St. Lucie River/Estuary watershed the recommended Comprehensive Plan proposes approximately 45,500 acres of water storage areas, with additional acreage for storage areas and reservoir assisted stormwater treatment areas (RASTAs) in tributaries of Lake Okeechobee. These Restudy water storage/ treatment facilities should substantially reduce non-point source pollutant loading to the St. Lucie River/Estuary.

Within the Caloosahatchee River/Estuary watershed the Restudy proposes approximately 20,000 acres of water storage areas and a 5,000-acre stormwater treatment area (STA), with additional acreage of storage areas and RASTAs in tributaries of Lake Okeechobee. These Restudy water storage/ treatment facilities should substantially reduce non-point source pollutant loading to the Caloosahatchee River/Estuary. The recommended plan also includes a feasibility study to develop a comprehensive integrated water quality plan for south Florida.

418. Eliminate/minimize sediment loading to the St. Lucie Estuary and the Caloosahatchee Estuary from all sources to ensure ecological restoration of estuary ecosystems.

Response: Restudy water storage/treatment facilities should substantially reduce sediment loads being delivered to the lower St. Lucie River and Estuary and to the Caloosahatchee Estuary. The recommended water quality feasibility study is expected to address reduction of sediment loading to the Caloosahatchee Estuary and the St. Lucie River/Estuary systems.

419. As part of the C&SF Restudy, all of the Holey Land and Rotenberger areas should be designated as OFW.

Response: The Rotenberger Wildlife Management Area is currently designated as an Outstanding Florida Water (OFW) by the Florida Department of Environmental Protection (FDEP). Designation of the Holey Land Wildlife Management Area as an OFW is not an action that the Restudy has statutory authority to accomplish, however, implementation of the Restudy Comprehensive Integrated Water Quality Plan may result in FDEP designating the Holey Land as an OFW.

420. Restore proper water quality to the Holey Land and Rotenberger. Enforce and strengthen water quality standards for water sent to these areas.

Response: The State of Florida has responsibilities for enforcing water quality standards within its jurisdiction. For Restudy planning purposes, it was assumed that the State would enforce applicable water quality standards through BMPs and other regulatory and non-regulatory programs governing point and non-point sources of pollution. To compliment regulatory and non-regulatory water quality programs by the state and local governments, the Implementation Plan provides that recommended plan components will be planned and designed to the maximum extent practicable to augment basin pollutant load reduction and total maximum daily loading targets. Under the Everglades Forever Act's Everglades Construction Program (ECP), future Phase 2 water flows to Rotenberger will be routed through STA 5 as part of the ECP's hydroperiod restoration activities. Operation of STA 5 will also result in reduced pollutant loading in flows directed to the Holey Land. The recommended Comprehensive Plan includes a recommended feasibility study to develop a comprehensive integrated water quality plan that will address water quality issues relating to the Holey Land and Rotenberger.

421. Restoration of pre-drainage water quality should be restored to the southern BCNP by modification or, where feasible, elimination of the L-28, S-343, and the S-344 structures.

Response: The recommended plan would result in the removal of the L-28 and L-28 Tieback levees and borrow canals. Existing structures S-343/S-344 would also be eliminated with removal of the L-28 levee/borrow canal. Water quality conditions in this region should be restored to pre-drainage conditions with the Big Cypress/L-28 Interceptor modification, which would treat water in the L-28I basin via two STAs totaling 1900 acres, and would degrade the lower portion of the L-28I levee and backfill this portion of the L-28I canal. These activities would reestablish surface water sheetflow across the eastern portion of the BCNP, with pollutant loads from the L-28I system being adequately treated to meet applicable state and tribal water quality standards.

422. The C&SF Restudy should not adversely alter the quality of water flowing into tribal lands. Moreover, efforts by tribal, federal, state, and local governments to monitor water quality should continue.

Response: The primary strategy for improving water quality in the Everglades is the activities undertaken by the State of Florida pursuant to the requirements of the Everglades Forever Act (EFA). All structural discharges to the Everglades are required to meet applicable water quality criteria, including the yet-to-be-determined State phosphorus criterion, by December 31, 2006 (see Section 4.8.5 of the Final Report/PEIS). Restudy features that discharge into or alter discharges into the Everglades will include appropriate treatment facilities to meet applicable water quality criteria. Future detailed planning and design activities undertaken during implementation of specific components will consider all applicable state and tribal water quality standards, and will be designed to achieve maximum water quality performance consistent with those standards and the overall performance objectives of the Restudy. The Restudy Team is aware of and acknowledges the Miccosukee and Seminole Tribe's adopted water quality standards, including the phosphorus criterion. The recommended plan features discharging into Tribal waters (e.g. the proposed modifications to the S-140 pump station and the L-28 interceptor modifications) will include appropriate treatment necessary to comply with applicable water quality standards. Water quality certification from the Miccosukee Tribe and Seminole Tribe will be sought when appropriate as required by federal law.

423. Provide the proper quality of water entering Everglades National Park to ensure a sustainable and diverse ecology within the Everglades ecosystem.

Response: The State of Florida has responsibilities for enforcing water quality standards within its jurisdiction. For Restudy planning purposes, it was assumed that the State would enforce applicable water quality standards through BMPs and other regulatory and non-regulatory programs governing point and non-point sources of pollution. To compliment regulatory and non-regulatory water quality programs by the state and local governments, the Implementation Plan for the Restudy provides that components will be planned and designed to the maximum extent practicable to augment basin pollutant load reduction and total maximum daily loading targets. Under the Everglades Forever Act flows to Everglades National Park (ENP) will be treated to meet all applicable State water quality standards. Additionally, water quality of freshwater flows to ENP is subject to the Everglades lawsuit settlement agreement, which ensures that waters of adequate quality to fully protect the ecology of ENP are delivered to the park.

424. The C&SF Restudy should provide the proper quality of fresh water to Biscayne National Park while making every effort to reduce or eliminate reliance on wastewater reuse.

Response: Biscayne National Park (BNP) is currently designated as an Outstanding Florida Water (OFW) by the Florida Department of Environmental Protection (FDEP). An anti-degradation provision applies to all OFWs designated by the State of Florida. For Restudy planning purposes, it was assumed that the

State would enforce applicable water quality standards. Several Restudy components would result in reduction of pollutant loads currently being delivered to BNP via the C&SF primary canal system. Relative to wastewater reuse concerns, the recommended Comprehensive Plan includes a pilot project to evaluate the feasibility of treating wastewater to sufficient quality to be discharged to BNP. Due to the anticipated high costs of potential wastewater reuse treatment technology, a thorough evaluation of alternative, less costly, potential supplies of freshwater to BNP will be completed prior to any detailed design initiated relative to directing wastewater reuse flows to BNP.

425. What are the regulatory and monitoring requirements for agricultural runoff to be relatively free of pollution?

Response: Agricultural runoff is exempt from National Pollutant Discharge Elimination System (NPDES) permitting requirements administered by USEPA and FDEP. However, discharges from agricultural facilities can not cause violations of applicable water quality standards. Ambient monitoring programs are in place to assess pollutants in water bodies, including those contributed by agricultural runoff. Where necessary (based on ambient monitoring data), best management practices (BMPs) and other regulatory and non-regulatory programs are in place or will be instituted to minimize the contribution of pollutants in agricultural runoff to receiving water bodies.

426. There are water quality issues associated with directing wastewater reuse flows to Biscayne Bay as proposed in the recommended plan.

Response: The Implementation Plan for the Restudy includes pilot testing of wastewater reuse facilities prior to full-scale implementation. Pilot testing will include detailed investigation of water quality issues, including applicable water quality standards and criteria, treatment requirements, and the ecological suitability of wastewater reuse discharges to Biscayne Bay. It should be noted that the cost estimates for wastewater reuse components included in the recommended plan include treatment facilities necessary for discharges to comply with water quality standards.

427. The preferred alternative (recommended plan) contains insufficient measures to ensure that the water quality needs of the Everglades system are met.

Response: The principal measure for achieving the water quality needs of the Everglades is the Everglades Construction Project and the Non-ECP elements of the Everglades Forever Act. Full implementation of the requirements of the EFA is a without project condition for the Restudy. An evaluation of the effect of the recommended plan on the ECP indicates that the performance of the ECP will not be adversely affected by the Restudy.

Other areas of the greater Everglades ecosystem lack specific water quality restoration targets at this time. State and tribal agencies are responsible under the federal Clean Water Act for developing total maximum daily loads (TMDLs) and pollution load reduction goals (PLRGs) for impaired water bodies within their jurisdictions. The Implementation Plan ensures that components of the recommended plan will be designed and operated to achieve TMDLs and PLRGs consistent with the overall Restudy performance objectives.

428. The Restudy preferred alternative does not meet water quality requirements with flows to the St. Lucie estuary.

Response: The recommended Comprehensive Plan had the best performance, from a water quality perspective, of all the alternatives evaluated in terms of beneficial water quality effects on the St. Lucie River estuarine system. This determination was based primarily on salinity targets for the estuary, but also included a consideration of the effect of the proposed water storage areas on pollutant settling and load reduction. Future detailed planning and design work currently underway as part of the Indian River Lagoon feasibility study will lead to further refinements in plan components located in the St. Lucie Estuary watershed.

429. EPA recommends that water quality considerations be made more explicit in the Final Report/PEIS.

Response: Several sections of the Report/PEIS were revised to more specifically describe water quality problems and opportunities in the study area (Section 5), water quality effects of the recommended plan (Section 8), water quality elements of the recommended plan (Section 9), and water quality considerations during future implementation actions (Section 10). The Summary section prefacing the Report/PEIS and the water quality portion of Appendix H was also revised to more explicitly address water quality. As a cooperating agency under NEPA, EPA was involved in the drafting of those revisions.

430. EPA proposes a multi-agency south Florida "water quality initiative" under the auspices of the South Florida Ecosystem Restoration Task Force to review water quality features of the recommended Comprehensive Plan, consider water quality standards, criteria, and restoration targets, and to address areas of south Florida (e.g., Florida Keys) not addressed by the recommended plans.

Response: The recommended plan includes a feasibility study to create a "Comprehensive Integrated Water Quality Plan" which would address all of the above issues. As an element of the recommended Comprehensive Plan, the feasibility study and future recommendations would involve consultation with the federal Task Force and Working Group, and the Florida Governor's Commission for a Sustainable South Florida.

431. As basin-specific total maximum daily loads (TMDLs) are developed, Restudy facilities should be designed to maximize reduction of pollutant loads to downstream receiving water bodies.

Response: The Implementation Plan describes how water quality considerations will be integrated into future detailed planning studies. TMDLs will be considered in future detailed planning and design work for specific components/projects. It should be noted that TMDLs have not yet been developed for any of the impaired water bodies identified in south Florida, with the exception of the ongoing process to determine the numeric phosphorus criterion in the Everglades. Development of TMDLs is the responsibility of the State of Florida and tribal entities having jurisdiction over impaired water bodies. Development of TMDLs is a “critical path” item necessary to design and operate Restudy components to achieve maximum water quality benefits.

432. EPA recommends that the interagency Restudy Water Quality Subteam focus efforts on the development of basin-specific TMDLs, re-evaluation of existing water quality criteria, and set priorities and schedules as well as funding strategies for accelerating water quality improvements in south Florida. Efforts should be integrated with the regulatory and enforcement responsibilities of federal, state, and local agencies.

Response: Although the scope of the study has not yet been developed, it is envisioned that the feasibility study included in the recommended plan to create an Integrated Comprehensive Water Quality Plan will address all of the above issues including continuing involvement by the interagency Restudy Water Quality Subteam. It is expected that EPA will play a key role in the development and preparation of the feasibility study and subsequent recommendations.

433. EPA wishes to emphasize that the Future “Without Plan” condition alternative assumes full compliance with the Everglades Forever Act, including timely implementation of a numeric phosphorus criterion to be proposed by FDEP and approved by USEPA or the default criterion of 10 ppb in the Everglades Forever Act.

Response: The above-described condition is the without project or without plan condition for the Restudy; that is, full implementation of the requirements of the Everglades Forever Act by December 31, 2006.

434. The Restudy does not provide reasonable assurances that water quality will ensure the health of natural systems and meet water quality standards.

Response: The State of Florida and the Miccosukee and Seminole Tribes, through their appropriate agencies, have responsibilities for enforcing water quality standards within their jurisdictions. For Restudy planning purposes, it was assumed that those entities would enforce applicable water quality standards through BMPs and other regulatory and non-regulatory programs governing point and non-point sources of pollution. To compliment regulatory and non-regulatory water quality programs by state, tribal, and local governments, the Implementation Plan for the Restudy provides that plan components will be planned and designed to the maximum extent practicable to augment basin pollutant load reduction and total maximum daily loading targets. The recommended plan also includes a feasibility study to develop a Comprehensive Integrated Water Quality Plan for south Florida.

435. Planning for water quality improvements in south Florida should not be limited to nutrients; a variety of other pollutants should also be addressed (e.g. pesticides and mercury).

Response: The State of Florida and the Miccosukee and Seminole Tribes are required under the federal Clean Water Act to identify impaired water bodies within their respective jurisdictions, identify the pollutants causing impairment, develop total maximum daily loads (TMDLs) for those pollutants, and develop remediation programs to improve impaired water bodies. Although excessive nutrient loading is the primary cause of impairment in many such water bodies, other contaminants are known to be contributing to impairment. TMDLs and remediation program will be developed to address all pollutants causing impairment.

436. Regarding the proposed wastewater reuse components, it is not clear in the draft Report/PEIS whether it will be effective, much less cost effective, to treat the proposed level of sewage to acceptably low phosphorus and coliform bacteria levels for discharges to National Park Service waters.

Response: The wastewater reuse components were included in the overall plan because they provided a ready source of additional water to areas where additional flows were needed. Wastewater reuse is also consistent with the State of Florida's water management planning efforts required under Chapter 373, F.S. The technology to treat to low phosphorus and coliform bacteria levels presently exists, and is included in the estimated cost of those components (see Appendix C, Section 3.5.3.2; and, pages C-A-51 and 58). Cost effectiveness will be re-evaluated during future detailed planning and design work undertaken during the implementation phase of the recommended plan.

437. How will the explosive growth projected for south Florida affect water quality? The projected increase in population will increase the amount of hazardous and toxic chemical releases into groundwater and sewage systems to the detriment of the ecological health of south Florida.

Response: Federal planning regulations require a 50-year planning horizon for water resource development projects. Future population projections were based on current trends and growth management plans for south Florida. Recommended plan components will be designed and located to provide maximum water quality protection benefits consistent with the overall performance objectives for the recommended plan. As such, it is expected that without the Restudy, water quality conditions in the study area will decline, particularly in those areas expected to experience a significant increase in population. A notable exception to this prediction is the Everglades. Water quality in the Everglades is expected to improve between now and 2007 as the requirements of the Everglades Forever Act are completed.

438. Everglades restoration plans should include steps to ensure that agricultural runoff containing harmful contaminants is not discharged to Florida Bay and the downstream coral reefs of the Florida Keys. The recommended plan should identify strategies for reducing both phosphorus and nitrogen loading to waters of Florida Bay and the Florida Keys in recognition of the fact that the nutrient thresholds for coral reefs are lower than previously acknowledged.

Response: The State of Florida's Everglades Forever Act (EFA) is a comprehensive plan for water quality improvements in the Everglades. The EFA includes the Everglades Construction Project (designed to clean-up agricultural runoff from the EAA) and a requirement that all other discharges into the Everglades meet all water quality standards by December 31, 2006 (the so-called Non-ECP requirements of the EFA; see Sections 373.4592(9) and (10), F.S.). The Non-ECP element of the EFA addresses agricultural non-point source runoff entering the Everglades from areas other than the EAA. Full implementation of the EFA is a without project condition for the Restudy. Restudy components that alter or increase discharges to the Everglades will be designed to meet applicable Everglades water quality standards, regardless of the source of the water stored and discharged by those components.

State and tribal agencies are also responsible under the federal Clean Water Act for developing total maximum daily loads (TMDLs) and pollution load reduction goals (PLRGs) for phosphorus and nitrogen where those pollutants are impairing water bodies other than the Everglades. Achieving water quality restoration targets in the Everglades and other water bodies will benefit downstream water bodies (Florida Bay, Florida Keys). In addition, the Florida Bay/Florida Keys feasibility study included in the recommended plan will address ecological and water quality restoration targets and remediation programs in Florida Bay and the Florida Keys.

439. The draft Report/PEIS falls short of identifying those features which will result in improved water quality in the Everglades. It should be noted that the EAA Storage Reservoirs were not designed with improved water quality in mind. By "stacking" water to maximize storage depth, storage components of the recommended plan fail to take advantage of additional wetland treatment benefits that would be available.

Response: The primary strategy for improving water quality in the Everglades is the activities to be undertaken by the State of Florida pursuant to the requirements of the Everglades Forever Act (EFA). All structural discharges to the Everglades are required to meet applicable water quality criteria, including the yet-to-be-determined phosphorus criterion, by December 31, 2006 (see Section 4.8.5 of the Draft Report/PEIS). Recommended plan features that discharge into or alter discharges into the Everglades will include appropriate treatment facilities to meet applicable water quality criteria. Future detailed planning and design activities undertaken during implementation of specific components will consider all applicable water quality standards, and will be designed to achieve maximum water quality performance consistent with those standards and the overall performance objectives of the Restudy.

440. The Restudy fails to recognize that a more stringent (than the State of Florida's current interim criterion) for phosphorus already exists. The water quality criterion for total phosphorus in surface waters on the Miccosukee Reservation is 10 ppb.

Response: The Restudy Team is aware of and acknowledges the Miccosukee Tribe's adopted water quality standards, including the phosphorus criterion. Plan features discharging into Tribal waters (e.g. the proposed modifications to the S-140 pump station) will include appropriate treatment necessary to comply with applicable water quality standards. Water quality certification from the Miccosukee Tribe will be sought when appropriate as required by federal law.

441. The Restudy calls for an annual increase of 285,000 acre-feet of water (above the 2050 Base condition) to be routed through the S-140 pump station. This additional water has no water quality treatment component to ensure that the water is treated to Tribal water quality standards prior to discharge. The Miccosukee Water Management Plan will treat Tribal waters to 10 ppb total phosphorus, but is not designed to treat the additional 285,000 acre-feet of water from upstream areas. Previous assurances that elements of the Everglades Forever Act (assumed to be in place in the 2050 Base condition) will adequately address this issue are unsatisfactory to the Tribe.

Response: Planning assumptions for the Restudy include full implementation of the requirements of the Everglades Forever Act, including those facilities/strategies necessary to achieve compliance with the State of Florida's phosphorus criterion in the Everglades for discharges from the S-140 pump station. The sources of the proposed increase in the average annual volume of water discharged through the S-140 are upstream treatment areas designed to achieve compliance with State of

Florida water quality standards, including the yet-to-be-determined phosphorus criterion for the Everglades. Also, see response #382.

442. The draft Restudy Report/PEIS falls short of meeting water quality requirements of the Water Resources Development Act of 1996 because it fails to mention NPDES Permit requirements. At a minimum, the final Report/PEIS should include a discussion of the federal Clean Water Act (CWA) as it applies to discharges into the Everglades in general and the S-9 pump station in particular, designated uses of the Everglades, CWA 305(b) requirements, CWA 303(d) (total maximum daily load) requirements, the permitability of the Restudy, and applicable State and Tribal Water Quality Standards.

Response: The Report/PEIS was revised to more specifically address water quality issues in several sections. NPDES, 305(b), and 303(d) requirements of the federal Clean Water Act are addressed in Section 5.3 (Water Quality Problems and Opportunities), Section 8.10 (Water Quality), Section 9.1 (Construction Features), and Section 9.7.3 (Comprehensive Integrated Water Quality Plan). Permitability (sic) is addressed in the revised Implementation Plan (Section 10). State and Tribal water quality standards are discussed in Appendix H.

443. The Florida Department of Environmental Protection (FDEP) is aware that a significant risk to aquifers exists with ASR as proposed in the Restudy but has asked the U. S. Environmental Protection Agency (EPA) to relax the requirements of the federal Safe Drinking Water Act to allow contamination of aquifers.

Response: FDEP has not asked USEPA to relax the requirements of the Safe Drinking Water Act. In a letter dated October 1, 1998, the Chairman of the Governor's Commission for a Sustainable South Florida, the Secretary of the Florida Department of Environmental Protection, the Executive Director of the South Florida Water Management District, and the Commander of the Jacksonville District Army Corps of Engineers requested the Administrator of the U. S. Environmental Protection Agency to consider a "risk-based" approach for allowing injection of water containing coliform bacteria into saline aquifers in the implementation of Restudy ASR facilities. Current EPA and FDEP underground injection control (UIC) regulations require primary drinking water standards must be met prior to injection into an underground source of drinking water. The primary drinking water standard for coliform bacteria is zero; none can be present. The request to use a risk-based approach when reviewing future UIC permit applications was based on the assumption that "microorganisms do not present a public health threat when stored underground in a saline aquifer." USEPA responded to the request to use a risk-based approach in a letter dated February 9, 1999. EPA agreed that a flexible, risk-based approach was appropriate to consider, provided that coliform bacteria is the only problematic parameter in the water to be injected, and further providing that there is a demonstration that underground sources of drinking water (USDWs) will not be endangered in any way that could adversely affect the health of humans. Copies of the letters were provided to the Miccosukee Tribe.

444. The recommended plan includes a 2,600 acre water quality treatment facility in the S-65D sub-basin (Pool D) of the Kissimmee River in Highlands and Okeechobee Counties. Is this of the same scope and location of current Kissimmee River Restoration projects in that basin, or is this additional water storage derived from channel restoration?

Response: Completion of the Kissimmee River Restoration Project is a without project condition for the Restudy; that is, it is assumed that Kissimmee River Restoration will be completed as authorized. The proposed Pool D water quality treatment area is not part of the Kissimmee River restoration project. Future planning and design work for the proposed treatment facility would consider hydrologic conditions created by the completed Kissimmee River Restoration Project.

445. It is possible that additional water quality problems may potentially be created through implementation of the draft recommended Comprehensive Plan. There should be an explicit recognition in the Restudy report/PEIS of the critical need to deal with all remaining water quality issues at the most appropriate stages of project planning, design development, permitting, and construction of the recommended plan components.

Response: Several sections of the Report/PEIS were revised to more specifically describe water quality problems and opportunities in the study area (Section 5), water quality effects of the recommended plan (Section 8), water quality elements of the recommended plan (Section 9), and water quality considerations during future implementation actions (Section 10). The Summary section prefacing the Report/PEIS and the water quality portion of Appendix H were also revised to more explicitly address water quality. The recommended Comprehensive Plan facilities will be designed to meet applicable state and tribal water quality standards. To compliment regulatory and non-regulatory water quality programs by state, tribal, and local governments, the Implementation Plan provides that plan components will be planned and designed to the maximum extent practicable to augment basin pollutant load reduction and total maximum daily loading targets. The Comprehensive Plan includes a recommendation for a feasibility study to develop a comprehensive integrated water quality plan for south Florida.

446. According to Florida environmental rules, water discharges to OFWs cannot cause water quality conditions to be degraded and must be clearly in the public interest. The proposed restudy wastewater reuse projects must also comply with the requirements of chapter 62-610, F.A.C., which governs the reuse of reclaimed water, and Chapter 62-611, F.A.C. which contains the provisions for discharges of reclaimed water to wetlands.

Response: Biscayne National Park (BNP) and Everglades National park (ENP) are currently designated as an Outstanding Florida Waters (OFWs). An anti-degradation at the time of OFW designation provision applies to all OFWs designated by the State of Florida. Relative to wastewater reuse concerns, the Restudy includes a pilot project to evaluate the feasibility of treating wastewater to sufficient quality to be discharged to BNP and ENP. Due to the anticipated high costs of potential wastewater reuse treatment technology, a thorough evaluation of alternative, less costly, potential supplies of freshwater to BNP and ENP will be undertaken in future planning and design efforts prior to beginning detailed design work relative to directing wastewater reuse flows to BNP and ENP.

447. The Department understands that the cost for treating raw surface waters to be injected into aquifers has been included in the overall estimated cost for the recommended plan. While the Department supports consideration of revised underground injection regulations to allow underground injection of raw surface water in some cases to achieve ecological restoration and water supply objectives, protection of ground water resources and drinking water supplies is of paramount importance to the Department. Aquifer stored water must be treatable to meet designated uses upon recovery.

Response: In a letter dated October 1, 1998, the Chairman of the Governor's Commission for a Sustainable South Florida, the Secretary of the Florida Department of Environmental Protection (FDEP), the Executive Director of the South Florida Water Management District (SFWMD), and the Commander of the Jacksonville District Army Corps of Engineers requested the Administrator of the U. S. Environmental Protection Agency (USEPA) to consider a "risk-based" approach for allowing injection of water containing coliform bacteria into saline aquifers in the implementation of Restudy ASR facilities. Current EPA and FDEP underground injection control (UIC) regulations require primary drinking water standards must be met prior to injection into an underground source of drinking water. The primary drinking water standard for coliform bacteria is zero; none can be present. The request to use a risk-based approach when reviewing future UIC permit applications was based on the assumption that "microorganisms do not present a public health threat when stored underground in a saline aquifer." USEPA responded by letter dated February 9, 1999, indicating that it will work with the Corps, FDEP and SFWMD to develop a risk-based flexible approach to constructing and permitting ASR wells proposed by the Restudy provided that the risk-based analyses of Restudy ASR projects "demonstrate that the USDW will not be endangered in a way that could adversely effect the health of humans" or the environment.

448. An additional concern regarding ASR is the quality of the recovered water to be reintroduced into the natural system to achieve ecological objectives. Aquifer-stored water is likely to be low in temperature, low in dissolved oxygen, and have a different pH than receiving waters. Other chemical changes may occur which have not been identified. Recovered water would have to be treated to meet surface water quality standards prior to discharge if it were subsequently determined that aquifer storage water created water of unacceptable quality for surface discharges.

Response: Full implementation of the ASR facilities contained in the Restudy depends upon pilot projects, including water quality monitoring work and follow-up assessments, to determine the effect of the injectate on the USDW as well as the potential effect of the recovered ASR waters on the receiving surface water bodies. The recommended Comprehensive Plan includes aeration treatment of recovered ASR waters. If ASR pilot projects indicate that other water quality treatment is required to treat ASR recovered waters in order to be in compliance with applicable state and tribal water quality standards, then modifications will be made to the appropriate ASR components prior to initiation of detailed design and construction.

449. Modeling performed during plan formulation and evaluation indicates that already planned diversion of 80% of the drainage discharge from the four 298 Drainage Districts and Closter Farms identified in the Everglades Forever Act to the Everglades Construction Project does not fully occur in the draft recommended plan. Instead, only about 40% of the discharge is diverted and 60% continues to be pumped to Lake Okeechobee. An explanation should be provided for this modification of a major and expensive pollution reduction component required by the Everglades Forever Act.

Response: The comment is accurate; however, no deliberate effort was made to increase backpumping to Lake Okeechobee. Water budget data from the SFWMM for the EAA/298 Districts and Lake Okeechobee in the recommended plan are summarized below (in k as. ft.):

298s to Lake Okeechobee:	23.80
S-236 to Lake Okeechobee:	10.90
298s to STA 2:	10.79
298s to STA 3\4:	5.94
S-236 RO South:	7.37
TOTAL, 298s + S-236:	58.80 (Total flows for 298s)

The percentage of runoff from the 298 Districts/Closter Farms diverted for treatment by the ECP is calculated as follows:

298s to STA2:	10.79
298s to STA 3\4:	5.94
S-236 RO South:	7.37
SUBTOTAL:	24.10 (Combined 298s RO to STAs)

(Combined 298s RO to STAs) ÷ (Total flows for 298s) x 100% = (Percentage of RO Treated)

(24.10) ÷ (58.80) x 100% = 41.0%

The modeling results indicating that the diversion of runoff from the 298 Districts and Closter Farms is reduced in the Restudy compared to the target in the Everglades Forever Act are likely to be an artifact of the overall operational triggers and routing mechanisms in the model. There was no deliberate effort made to increase backpumping to Lake Okeechobee. There is sufficient conveyance and storage capacity provided in the plan, particularly with the inclusion of the EAA storage area (Component G), to manage the target volume of 80 percent, if not more. This apparent operational and routing problem will be more fully investigated in future detailed planning and design work undertaken for the construction and operation of the EAA storage area.

450. The recommended plan significantly increases flows at several existing Non-ECP structures, including the proposed modified S-140 structure (Component RR). Although it is understood that most of the increased flow through the proposed S-140A pump station is to be diverted from the STAs, approximately 9,000 acre feet (average annual volume) of additional runoff (greater than future base conditions) from Seminole and Miccosukee tribal lands is to be directed through the structure into WCA 3A. If it is determined that this increased volume were to cause whatever treatment strategy/facility is to be developed for that basin to fail to perform adequately, the recommended plan should assure that additional modifications to assure that water quality standards would continue to be met will be implemented as part of the overall design, construction, and operation of the applicable recommended plan components.

Response: The planning assumptions for the Restudy include full implementation of the requirements of the Everglades Forever Act, including those facilities/strategies necessary to achieve compliance with the State of Florida's phosphorus criterion in the Everglades for discharges from the proposed S-140A pump station. The sources of the proposed increase in the average annual volume of water discharged through the proposed S-140A pump station are upstream treatment areas designed to achieve compliance with State of Florida water quality standards, including the yet-to-be-determined phosphorus criterion for the Everglades. If it was determined in future detailed planning and design work that the increased volume and proposed operation would adversely affect whatever treatment strategy is developed for the S-140 basin in accordance with the Non-ECP requirements of the EFA, modifications necessary to assure that the water quality requirements of the EFA are achieved would be incorporated into the final design and operation of Component RR4.

451. The draft recommended plan includes at least two new structures (S-356 A&B, Component FF) which would be considered new discharges into the Everglades Protection Area (EPA). If future investigations indicate that water to be directed through the new structures would not meet water quality criteria for the EPA (including the yet-to-be-established numeric phosphorus criterion an the phosphorus concentration targets mandated by the federal Settlement Agreement), additional treatment measures would have to be incorporated into the overall design and operation of this component by the Corps and the SFWMD to assure that water quality standards are met

Response: The planning assumptions for the Restudy include full implementation of the requirements of the Everglades Forever Act, including those facilities/strategies necessary to achieve compliance with the State of Florida’s phosphorus criterion in the Everglades. The source of water to be discharged by the S-356 A & B structures is the WCAs 2 and 3. Seepage and surface waters from WCAs 2 and 3 will be directed to the Central Lake Belt storage area. Under certain conditions, the stored water is returned to the L-31 N canal bordering Everglades National Park. It has not yet been determined that water quality treatment facilities will be necessary to operate Component FF as conceptually planned. However, water quality treatment facilities, if necessary, associated with the proposed Central Lake Belt storage area and discharges from the S-356 A&B structures will designed to achieve compliance with State of Florida water quality standards, including the yet-to-be-determined phosphorus criterion for the Everglades.

N.2.8 Public Outreach

452. Counties north of the lake did not participate in the Restudy process.

Response: The Restudy is committed to an open public process and the participation of all 16 counties within the study area. The Restudy Team highly encourages participation by county and local governments and will actively seek enhanced involvement in the future as the Restudy moves into more detailed design and planning.

453. The USEPA wishes to continue its involvement in the Restudy and requests to be advised of Restudy progress.

Response: Concur. USEPA’s continued involvement in the Restudy is seen as being crucial. Restudy progress will be reported regularly.

454. There was not adequate exposure of different alternatives and inadequate time for public input.

Response: The Restudy process has been ongoing in South Florida since the beginning of the Reconnaissance phase in 1993. As described in Section 11: Public Involvement, the Restudy Team has held numerous public meetings throughout the study area to apprise the public on the study's progress and to solicit input. As the study moves into the more detailed stages, continued public involvement will be sought.

455. The comment centered around increased efforts to educate and work with the public regarding local, regional, state, and Federal issues.

Response: The Restudy Team, since its beginning, has been committed to understanding the issues within the study area and at larger scales. This commitment will continue as more detailed study and planning progresses.

456. There should be full coordination between partnering agencies and different levels of government.

Response: Concur. The Restudy Team is made up of individuals from a wide variety of Federal, state, local, and tribal governments and the study has been carried out in a spirit of cooperation and collaborative problem-solving.

457. The concern regards project impacts on minority communities.

Response: Concur. As the study moves into more detailed design, the Restudy Team will actively work within the communities where project works will be sited.

458. The Department expects to continue to be fully involved in the Restudy.

Response: Concur. The Department's continued involvement in the Restudy is seen as crucial.

459. The public comment period for the Comprehensive Plan was inadequate and additional review time is necessary.

Response: The Restudy Team appreciates the fact that the Comprehensive Plan contains a great deal of information. However, the entire plan formulation process of the Restudy was posted on a public web site over the formulation period of September 1997 through August 1998. The comment period for the draft programmatic environmental impact statement was one month longer than that required under NEPA.

460. The comment regarded the technical feasibility of ASR and whether it would be practical to go to Manatee County to visit ASR facilities there.

Response: Pilot projects to test the technical feasibility of ASR are slated for early authorization; indeed, the SFWMD is drilling monitoring wells at the Site 1 location (Hillsboro Canal) at the present time. Information gleaned from operating ASR wells is helpful, however, the more site-specific data gathered from the Restudy pilot projects will be the most valuable to the Restudy.

461. It was recommended that education be one of the features of the recommended plan.

Response: Education is typically is not a formal activity of the Corps of Engineers, although it is concurred that pollution prevention and water conservation are important items for the public to understand. In conjunction with the November 1998 public meetings, however, an environmental education component was developed for grade school and high school levels. Public outreach activities, which by their nature include education, will be ongoing in all future Restudy planning.

462. The comment was a commendation on the interagency efforts of the Restudy and the commitment to work collaboratively in the future.

Response: Concur. All efforts will be needed to further the goals of the study.

463. Environmental needs were an afterthought in the study.

Response: The Restudy is about restoration of the south Florida and Everglades ecosystems while continuing to provide for the other water-related needs of the region. Restoration goals have always been at the forefront of the study.

464. The Restudy seems to favor a management approach that will shortchange the ecosystem.

Response: Current operation of the C&SF Project has had adverse effects on the natural system. The philosophy of the Restudy is that in addition to structural changes to the project, operations must also change such that degradation does not continue to occur.

465. Stakeholders need to have a better understanding of the PIR process and their points of entry.

Response: Five public workshops were held during the development of the Implementation Plan, which was released January 25 for a review period of ten days. The entire PIR process is explained in the Implementation Plan.

466. The level of detail available in the Comprehensive Plan is not sufficient to answer specific questions. When such detail becomes available, will there be sufficient time for the commission to respond?

Response: The more detailed or site specific resolution of issues will come in this next phase of Restudy planning, the Project Implementation Report process. The Implementation Plan explains this process and points of entry for comment / public input. There will be continuing opportunities for stakeholders and the public to be involved in the implementation process.

467. There was a lack of straightforward information presented at public meetings.

Response: Information presented at the public meetings was consistent with the level of detail of the Comprehensive Plan. There was an open house at each of the meetings so that the public could have questions answered by team members. The more detailed or site specific resolution of issues will come in this next phase of Restudy planning, the Project Implementation Report process. The Implementation Plan for the Restudy explains this process and points of entry for comment / public input.

468. The Corps is applauded for the initiation of a minority outreach program. The effort should involve the multi-agency working group.

Response: Concur.

469. NOAA recommends that Restudy implementation plans include multi-agency education and outreach efforts.

Response: As the Restudy continues on through its successive phases, the commitment has been made to continue the multi-agency approach. Public outreach will be an integral part of all future work.

470. The same level of public participation that occurred throughout the Restudy should continue.

Response: Concur. Public outreach will be an integral part of all future work.

471. There has been no real effort to inform the public about the Restudy.

Response: The Restudy public outreach program actively sought ways and means of informing the public about the study and will continue to do so. Section 11: Public Involvement describes all of the public outreach activities conducted during the study.

N.2.9 Implementation Plan and Monitoring

472. What guarantees are there that the project will be operated to achieve hydrologic regimes for the entire remaining Everglades?

Response: The Comprehensive Plan was formulated to address issues and problems currently facing the south Florida ecosystem. The plan attempts to strike an important balance in the system's needs. Hydrologically, initial assessments indicate that all areas and users reap benefit from implementation of the plan. Formulation of operational criteria will include coordination with involved stakeholders and agencies.

473. How will operational changes affecting Everglades National Park be handled?

Response: Interim operation criteria will be developed as part of the next phase of component development. Formulation of any interim operational schemes stemming from the Restudy will include coordination with involved stakeholders and agencies.

474. NRDC recommends the immediate acquisition of the Model Lands.

Response: The C-111N Spreader Canal component will enhance connectivity and sheetflow in the Model Lands area. This feature, which includes acquisition of the Model Lands, is one of the features recommended for initial authorization.

475. What is the status of South Miami-Dade Agricultural and Rural Land Use and Water Management Plan and Biscayne Bay Coastal Wetlands Critical Projects?

Response: In an effort to advance this work, these projects will be addressed in the ongoing Biscayne Bay Feasibility Report.

476. Why is the L-28 Interceptor Canal Backfill component not implemented earlier?

Response: The Implementation Plan schedule was developed to implement each component as soon as possible under reasonable and prudent constraints. The L-28 Interceptor Canal Backfill component must be implemented in conjunction with the decompartmentalization of WCA-3 and has been scheduled accordingly.

477. How can the WCA-3A Decompartmentalization and raising Tamiami Trail components be implemented faster?

Response: It is currently anticipated that certain features could be advanced under the authority of the Modified Water Deliveries to Everglades National Park Project.

The first phase of decompartmentalization, which includes raising the eastern portion of Tamiami Trail, is recommended for initial authorization.

478. How is surface water storage maximized and what assurances do water users have?

Response: The formulation of the Comprehensive Plan included analyses of the use of surface water storage. The recommended Comprehensive Plan attempts to balance known and existing sources with new sources and sources that may be contributed through the implementation of high technology. Assurances to water users are addressed in the Implementation Plan, Section 10 of this report.

479. What commitment exists in this report to address water quality needs and how will water quality features be included in future component design?

Response: The Implementation Plan schedule, Section 10 of this report, provides a level of detail consistent with the Comprehensive Plan. General design that includes water quality needs will be accomplished during the project implementation process. Water quality considerations will be included during this process, as described in the Implementation Plan. Additionally, a feasibility study to develop a comprehensive integrated water quality plan for south Florida is being recommended.

480. Why are expensive reuse facilities being considered?

Response: The Implementation Plan recognizes the high cost of constructing and operating reuse facilities along with the potential issues involving the operation of such facilities. For that reason, components involving reuse have been scheduled as last orders of work, so that alternatives can be considered that may preclude the need to rely on this source of water.

481. When and how will optimization of design, sizing, and siting be accomplished to maximize water quality benefits?

Response: General design will be accomplished during project implementation studies and reports. Detailed design will follow authorization of each component. These considerations can be included as design considerations and the development for construction. Optimization for each component's designs, performance, and operation will be considered as part of future component development.

482. The EAA Storage component should be phased.

Response: Concur. The Implementation Plan reflects a phased approach.

483. What level of management of the system will be required?

Response: The Comprehensive Plan was formulated to address issues and problems currently facing the south Florida ecosystem. The plan attempts to strike an important balance in the system's needs. Hydrologically, initial assessments indicate that all areas and users reap benefit from the implementation of the plan. During the implementation process, formulation of operational criteria will include coordination with involved stakeholders and agencies. The level of system management will be in accordance with the efficient and effective functioning of the system.

484. Why is the schedule for implementation of the Comprehensive Plan biased towards building water supply and flood control components.

Response: The scheduling of components have been made in such a manner as to attempt to achieve project goals in the most efficient way possible. It is inappropriate to attribute or assign the function of an individual component to urban, agricultural, or environmental water supply. The premise of the plan is that restoration can only be achieved through the full implementation of the recommended Comprehensive Plan with each component contributing to the overall goal of ecosystem restoration. Initial authorization recommendations clearly recognize the need to provide ecological benefit as soon as possible, while maintaining a broad range of water supply sources until additional studies are performed.

485. The Restudy should recognize the need for peer review, evaluation of pilot projects prior to construction, distribution of research funds, a Florida Bay Feasibility Study, accurate and comprehensive topographic data, monitoring program provided should provide the procedure of how monitoring data will be disseminated to interested parties, and avoidance of single species management.

Response: The Implementation Plan schedule, Section 10 of this report, provides a level of detail consistent with the Comprehensive Plan. The Restudy Team recognizes the importance of peer review, which has been addressed in Section 10. Pilot projects have been identified and the current schedule reflects the dependencies of certain components on the completion of the pilots and analysis of performance. The recommended plan includes a Florida Bay and Florida Keys Feasibility Study. Ongoing efforts will be integrated into this study. The recommended plan does include obtaining the necessary data to complete design of project components. The dissemination of adaptive assessment data and analysis will be part of the commitment to continue to do business in an open and public manner. Use of the internet and other publicly accessible outlets will be used for all project information to the maximum extent possible. As additional formulation is performed, and as details for the design of each component progresses, the Project

Team will coordinate the refined plan with the necessary agencies to insure appropriate implementation occurs in regards to environmental concerns.

486. How does the plan address the issue of future funding uncertainties?

Response: The Implementation Plan has been constructed to provide a “technical solution” for execution of work. Applying funding constraints (such as the $400 million annual guideline) reflects a prudent and reasonable expectation for Federal and local sponsor annual appropriations and capability. The Comprehensive Plan must be completely implemented to achieve project goals. The schedule has been built to allow for changes in the implementation of the components due to funding shortfalls or accelerated funding.

487. How can the St. Lucie and Martin County (Indian River Lagoon and St. Lucie River) components be expedited? What is the ability of local governments to participate? The implementation schedule should assure that all Lake Okeechobee storage will be completed to stop damaging freshwater discharges into the St. Lucie Estuary.

Response: The Implementation Plan schedule was developed to implement each component as soon as possible. The feasibility report for the Indian River Lagoon is ongoing and in recognition of the opportunity for immediate benefit, the component for the C-44 Storage Reservoir will be recommended for initial authorization. Additionally, as a result of recent discussions, the Implementation Plan will be revised to reflect a phased approach that will allow the Indian River Lagoon components to be initiated sooner.

488. What interim improvements will be made in St. Lucie and Martin Counties and what impacts will there be to the St. Lucie Estuary?

Response: The St. Lucie River Issue Team of the Working Group identified four main project types that could be made in the interim before Restudy projects are implemented. The four categories of interim projects include stormwater retrofits, water storage areas, restoration, and programs.

489. What assurance is there that backpumping of Caloosahatchee River water will not degrade the water resources within the St. Lucie Basin or estuary?

Response: The backpumping facility includes a 5,000-acre stormwater treatment area for water quality treatment prior to discharge into Lake Okeechobee.

490. Why is the implementation and funding scheduled so late, how were priorities of individual components determined, and what has been done to expedite the implementation of the Comprehensive Plan?

Response: The schedule was developed using the "best professional judgement" of a broad multi-disciplinary team to identify the linkages between components. In this way, each component is implemented as soon as possible using reasonable and prudent constraints. Prior to implementing any component of the Restudy (except for the WPA's and IRL feasibility studies which are on-going), agreements outlining the roles and responsibilities for the Federal government and the local sponsor during pre-construction engineering and design phase. No Federal funds may be expended on the construction prior to congressional authorization and execution of terms for local cooperation.

491. How does project component sequencing relate to threatened and endangered species?

Response: General design will be accomplished during the project implementation phase. Detailed design will follow authorization of each component. Implementation of projects will include endangered species considerations to prevent negative impacts.

492. The WPA Feasibility Study should be expedited.

Response: The WPA Feasibility report is currently underway and scheduled to be completed in 2001.

493. Hydrological transitions should be staged and timed to encourage fish and wildlife to move toward safe habitat.

Response: General design will be accomplished during the project implementation phase. Detailed design will follow authorization of each component and can include the stated design considerations. Refer to the adaptive assessment strategy in the Implementation Plan.

494. Sensitive periods for aquatic life should be identified, and changes in hydrological conditions and other disruptive activity timed to avoid negative impacts.

Response: Component design and system-wide analyses can include these considerations during future planning and design efforts.

495. How was the Phase A analysis [2010 Scenario] used and how will the concerns contained in the National Park Service's conclusions on Phase A be addressed?

Response: As part of the development of the Implementation Plan schedule, a list of Comprehensive Plan components that could be expected to be operational by the year 2010 was developed. This scenario represents approximately the first 10 years of implemented projects using an estimated capital expenditure of approximately $400 million per year. The components were then modeled using the South Florida Water Management Model to simulate the performance of the C&SF Project at this point in time. The Alternative Evaluation Team, to help understand and determine the ecological and water supply effects that would occur, evaluated the output as a result of incrementally implementing the Comprehensive Plan. The goal of this analysis was to improve conditions over the base cases and at a minimum not to have performance inferior when compared to the base cases. No attempt was made during the analysis to optimize operations. It was not expected that modeling the 2010 components would attain the hydrologic or ecological performance of the Comprehensive Plan. The focus was to identify any areas where performance was worse than the 1995 Base Case or 2050 future without project condition. Sub-groups looked for and suggested corrections for sequencing. These types of scenario-based analyses will be used during future component development to refine the Implementation Plan.

496. The details of the Implementation Plan need to be completed and go through a process of peer review and public input prior to the submission to the Chief of Engineers. Funding sources, methods, and justifications must be included in the Implementation Plan. Federal matching funds must be guaranteed annually before commitment and expenditure of state and local funds. Florida legislative support for the plan is critical and must include public hearing at the local level.

Response: The level of detail contained in the Implementation Plan is consistent with that contained in the Comprehensive Plan. The current Implementation Plan addresses the lack of detail by identifying processes that will be used for future project development. A revised Implementation Plan was released for public review on 25 January 1999, and addressed the guidelines for implementation and schedule development. Appropriate peer review will be addressed during advanced formulation portion of the Project Implementation study and report. Financial analyses are contained in Appendix G. The Federal funding of water resource projects are subject to development by the administration and review and modification by Congress annually. Historically, Congress has chosen not to provide full funding on these types of projects. It is expected that local cost sharing will be handled programmatically with the SFWMD using a combination of District, state, and local government funds. The details of this effort are being formulated and will be solidified as detailed information is developed during the Project Implementation Report period. The Corps and the SFWMD have continually worked with the state and local governments to provide an understanding of the proposed project. This process will continue throughout the implementation period.

497. Why does the plan not schedule early acquisition of land? It is recommended that the Restudy's land acquisition program be a top priority during the first implementation phase. The Restudy should maximize the spatial extent of functional wetlands by prioritizing land acquisition since lands continue to be lost to development. The Implementation Plan is weighted towards building expensive water supply components early which may leave funding shortfalls for future land acquisition. Adaptive management should be used to determine if a more passive surface storage system responds better that "high tech" components [contained in the Comprehensive Plan].

Response: The scheduling of components has been in such a manner as to attempt to achieve project goals in the most efficient way possible. The Implementation Plan has been structured to address land acquisition concerns using current policy and law. The schedule has been constructed with flexibility that would allow for any changes that would advance work in any area, like real estate acquisition (once authorized). The Implementation Plan was developed with the input of Federal, state, local, and tribal input; as well as stakeholders and the public. It is inappropriate to attribute or assign the function of an individual component to urban, agricultural, or environmental water supply. The premise of the plan is that restoration can only be achieve through the full implementation of the recommended plan with each component contributing to the overall goal of ecosystem restoration. Initial authorization recommendations clearly recognize the need to provide ecological benefit as soon as possible, while maintaining a broad range of water supply sources until additional studies are performed. Federal funding will be subject to Congressional review on an annual basis and would be exposed to their appropriation equally in any one budget year. The use of Adaptive Assessment is an inherent part of the implementation of the Comprehensive Plan.

498. Provisions should be included in the Restudy plan to ensure that secondary impacts are considered and addressed.

Response: The next phase of the project development includes more detailed planning, engineering and design. These efforts will be contained in a Project Implementation Report for each component or groups of components. The studies conducted in preparation of this report will include advanced formulation, general engineering and design, real estate analysis, and socio-economics analysis. It is expected that coordination with adjacent and impacted users will occur through this process as well as through the public involvement process that will be conducted prior to the approval of the Project Implementation Report.

499. Provisions should be included in the Restudy plan to ensure that future co-location of electrical facilities with the Restudy's components are made as compatible as possible.

Response: See response # 498 above. Coordination with FPL and other entities is expected to occur during the Project Implementation Report and Detailed Design phases.

500. It is essential that the Implementation Plan provide a process that ensures that water quality or any other requirement that could prevent implementation of a component, be identified, fully addressed, and equitably funded by both the Federal government and the local sponsor before the components are authorized and public resources are irrevocably committed. The period of review for the revised Implementation Plan (25 January 1999 release) is too short.

Response: The Implementation Plan is consistent with the level of detail contained in the Comprehensive Plan. Project development process discussion has been included in the Implementation Plan. The next phase of project development includes detailed planning, engineering and design. These efforts will be contained in a “Project Implementation Report” for each component or groups of components. The studies conducted in preparation of these reports would address most issues contained in the comment. The Federal funding of water resource projects are subject to development by the administration and review and modification by Congress annually. Historically, Congress has chosen not to provide full funding on these types of projects. The comment period and public meeting was held after a series of public workshops conducted to improve the Implementation Plan for release for public review on 25 January 1999. In order to meet the legislatively directed submission date for the Comprehensive Plan, adequate time is required for the processing of comments received as part of the latest public input of the Implementation Plan. The maximum allowable time for further review was made available that would allow for completion of the report. A final state and agency review will occur as part of the Corps approval process prior to the submission of this report to Congress on 1 July 1999.

501. What provisions have been made for future public input to decision making? There has not been enough time allotted for adequate review of the Comprehensive Plan. Components should be subjected to an appropriate level of technical analysis prior to congressional action.

Response: One of the guidelines for the development of the Implementation Plan (see Section 10 of this report) is the continuation of outreach and public involvement. In addition, public review and input has been ongoing even prior to the October 1998 release of the draft Comprehensive Plan. The next phase of the project development includes detailed planning, engineering and design. These efforts will be contained in a “Project Implementation Report” for each component or groups of components. The studies conducted in preparation of these reports will address technical issues contained in the comment, including the agency and public review prior to preparation of detailed design.

502. The Implementation Plan should address: integration of other ongoing efforts (Federal, state, regional, and local planning efforts), adaptive management, assurances for the natural system, expediting feasibility studies, integration with parallel planning processes and restoration projects, and contingency planning.

Response: Integration of other ongoing efforts has been occurring throughout the Restudy. The Implementation Plan contains an explanation of the integration of the recommended components of the Restudy with ongoing projects and programs (Section 10) and provides an explanation of how adaptive assessment will be used throughout the project development lifecycle. The Implementation Plan contains language dealing with assurances. The schedule and recommended initial authorization include both pilot projects and additional feasibility studies as part of the first order of work. The next phase of each component's development would include detailing the features in preparation for detailed design. This process will include specific integration with on-going projects and programs. In addition, public and stakeholder review and input will occur. The level of detail contained in the Comprehensive Plan required that the cost estimate for the recommended features contain contingency funding. If the analysis of the performance of pilot projects should reveal a significantly less reliability than is expected in the Comprehensive Plan, then the plan will be modified.

503. Revisions to the Implementation Plan contained in the October draft report should have some mechanism for review and comment. Additional work is required to determine how the Comprehensive Plan will be implemented.

Response: Concur. A revised Implementation Plan containing stakeholder and public input was released for additional public review on 25 January 1999. Additionally, the Implementation Plan will be revised as new and better information becomes available.

504. Given that so much of the report's basis is meeting the speculative growth, why does the Restudy plan not employ more prudent uses of public money by staging certain components.

Response: The revised Implementation Plan, Section 10 of this report, does stage (phase) a number of components over a 37-year implementation period.

505. The report states that the Caloosahatchee Basin and Estuary and the Big Cypress Basin have been under-assessed by the EIS. That being the case, the timing [scheduling] of some of the projects components should be delayed pending the conclusion of the [Southwest Florida] feasibility study. An assessment of the basin's water supply needs and the greater estuarine salinity level needs must be completed and accepted before the Restudy Plan can be approved.

Response: Due to the recognized need, a feasibility study for Southwest Florida was authorized and is currently being pursued. This study will investigate the water resources of this portion of the south Florida ecosystem. Plans arising from this study will be integrated into, and must be consistent with the plan of improvement of the Restudy. To the extent possible, Restudy components were developed to address system-wide concerns. These components will undergo further formulation and once reviewed and if approved, constructed. Currently, with the exception of an ASR pilot project, facilities proposed for the area are anticipated to begin construction in 2005 and so will be able to incorporate the findings from the feasibility study.

506. It is recommended that a streamlined permitting process be established with the approval of the Governor and Cabinet for features in the Comprehensive Plan.

Response: Concur. The Restudy will continue to identify areas to improve the efficiency of the implementation process. Currently, the Corps meets with state agencies on a quarterly basis to discuss these types of matters.

507. The implementation of the components of this project must include adequate assurance to existing water users that their source of water will not be taken or reduced prior to installation of proven alternative sources. The implementation strategy must include provisions for assurances to existing water users and provisions requiring adequate facilities to be in place before any re-allocations of water that would adversely affect existing users. Costs must be distributed equitably. Restoration and preservation must be undertaken in accordance with state water law and must be balanced with the needs for water supply and flood protection.

Response: The revised Implementation Plan, Section 10 of this report, addresses in greater detail assurances to water users. The plan does recognize the need for a reasonable and prudent implementation in regard to replacing water sources. Details for individual components will be developed and/or refined during the Project Implementation Report process.

508. For those more speculative components of the Comprehensive Plan about which there continues to be much technical debate and concern, the Corps and the SFWMD should undertake detailed, yet accelerated feasibility analyses in order to eliminate uncertainties.

Response: The current plan recommends early authorization of pilot projects and additional studies to address uncertainties as rapidly as possible. Project Implementation Studies and Reports will be conducted and will consider these types of issues. Formulation of operational criteria will include coordination with involved stakeholders and agencies.

509. The Council has serious concerns about the potential for delays or slippage in the implementation plan in light of a 20 year implementation projection. The Council supports the development of a detailed Implementation Plan. The Council is concerned that the revised Implementation Plan will not receive public review.

Response: Revisions to the Implementation Plan provide an aggressive, but more realistic implementation period. The level of detail contained in the Implementation Plan cannot be greater than that contained in the Comprehensive Plan. The current Implementation Plan addresses the lack of detail by identifying processes that will be used for future project development. The revised Implementation Plan was released to the public on 25 January 1999, with a 12 day review period.

510. The Council believes that Federal and state agency review and certification should occur prior to authorization.

Response: Prior to the submission to Congress, the plan will receive a final state and agency review. Each Project Implementation Report will include a supplemental NEPA document and will undergo full public and agency review.

511. The process for prioritizing and packaging elements [components] under the Implementation Plan remains unclear. The Corps should provide information on how the Restudy components are prioritized and packaged for authorization.

Response: The Implementation Plan, Section 10 was revised with input from stakeholders and the public. It addresses the guidelines for implementation and schedule development.

512. The implementation of the Seminole Tribe Water Conservation Plan Other Project Element is critical for full restoration of the south Florida ecosystem. This component should be one of the first funded in the Restudy.

Response: The Seminole Tribe Water Conservation Plan Other Project Element is scheduled for early implementation. It is also included as a component that would be pursued under the recommended Programmatic Authority for the Restudy.

513. The feasibility study did not allow a thorough investigation of Southwest Florida. A feasibility study of this area is recommended as soon as possible. A pilot project for ASR is recommended. When would this pilot project be underway?

Response: The Southwest Florida Feasibility Study is included in the Comprehensive Plan and will be initiated in 1999. Pilot projects have been recommended for initial authorization and will be initiated as soon as possible. The design of the ASR pilot projects is currently scheduled to be initiated in fiscal year 1999 and 2000.

514. The Corps and the SFWMD must commit to providing adequate modeling and monitoring support for the implementation process. Computer models should be used to simulate “the next step” prior to making alterations to the existing infrastructure. There should be a continuous effort to refining and improving models.

Response: Concur. The Implementation Plan, Section 10 of the main report, provides an explanation of how this comment will be addressed through adaptive assessment, future component development, and continuation and improvement to models and tools throughout the implementation lifecycle. The Implementation Plan can be utilized as a model that provides insight to the affects of changes to the implementation schedule.

515. The Implementation Plan should including monitoring, research and performance evaluation. The authorization should be broad enough to accommodate “adaptive management.”

Response: Concur. The current plan addresses the use of an adaptive assessment program throughout the implementation period. The Implementation Plan, Section 10 of this report, provides an explanation of the project’s Adaptive Assessment strategy.

516. It is imperative that the Implementation Plan adequately characterize the benefits of the components so that appropriate funding strategy can be developed and supported by stakeholders.

Response: The formulation process followed by the Restudy precludes a strict use of cost effectiveness and incremental cost analyses in optimizing the recommended plan. The individual components were combined during formulation in recognition of their synergistic effects that extend throughout the ecosystem. The schedule developed for the Implementation Plan reflects a logical sequencing that has been reviewed by a wide sector of stakeholders and the public. This schedule constrained to an annual funding target of $400 million provides a basis for funding the effort over a 37-year program. The schedule has been constructed so that increases or decreases in annual funding can be evaluated and the schedule revised accordingly. Section 7: Plan Formulation and Evaluation describes the benefits of the recommended Comprehensive Plan. SFWMD’s financing plan for the non-Federal share of project costs is contained in Appendix G: Local Cooperation and Financial Analysis in this final report.

517. How are Biscayne Bay Estuary Targets addressed?

Response: The Implementation Plan schedule addresses the need to complete the Biscayne Bay Estuary targets prior to initiation of certain features.

518. The Restudy report should be modified to provide a process for obtaining policy-level review and input throughout the development and implementation of the project.

Response: The Implementation Plan, Section 10 of this report, provides discussion of the guidelines that will be used throughout the implementation of the recommended plan. Included in the guidelines is the commitment to continue interdisciplinary and interagency teams throughout the project's lifecycle. Further project development (project implementation studies and reports) would include formal and informal consultation with stakeholders.

519. What is the process for designing and implementing pilot projects and DERM's role?

Response: The Implementation Plan schedule provides a level of detail consistent with the Comprehensive Plan. It is currently recommended that pilot projects receive early authorization. Upon the execution of appropriate cost sharing agreements, design is expected to be initiated as early as fiscal year 2000. The plan recognizes the commitment to continue interdisciplinary and interagency teams throughout the project's lifecycle, of which, DERM would have a role.

520. The Implementation Plan must include process descriptions for dealing with uncertainties, contingency planning, and assurances to water users, as well as, the ability to assess the effectiveness of these processes.

Response: The Implementation Plan schedule, Section 10 of this report, addresses the issues contained in this comment.

521. There should be utilization of local funding sources in combination with Federal and SFWMD funds to advance the implementation of the project.

Response: Concur. It is expected that throughout the period while the Project Implementation Report is being developed, dialogue will continue with state and local governments to maximize and leverage funding to advance the implementation of the project.

522. How will future land use planning be addressed in the Restudy.

Response: The Implementation Plan schedule has been structured in such a manner that allows for adjustments that will be necessary over the implementation lifecycle. As land use plans are modified and as land use decisions are being analyzed, the Implementation Plan schedule can be used to analyze the effects on the schedule of actual and proposed changes.

523. Will the Restudy plan require immediate acquisition of all required lands.

Response: Expenditure of Federal funds for lands recommended in a pre-authorization decision document is a matter of law. Once a project is authorized, Federal cost sharing may be applied to the acquisition of necessary lands once terms of local cooperation are agreed to. The scheduling of components have been made in such a manner as to attempt to achieve project goals in the most efficient way possible. The Implementation Plan has been structured to address land acquisition concerns using current policy and law. The schedule has been constructed with flexibility that would allow for any changes that would advance work in any area, like real estate acquisition.

524. Model output should be used to eliminate/minimize adverse environmental conditions throughout the implementation of the Conceptual Plan.

Response: General design will be accomplished during the Project Implementation study and report. Detailed design will follow authorization of each component. These considerations can be included as design considerations and the development of construction period and interim water regulation schedules.

525. The Restudy plan should require the establishment of operational standards and minimum operational requirements prior to construction.

Response: General design will be accomplished during the Project Implementation study and report. Detailed design will follow authorization of each component. As part of these design efforts, the details for construction and post-construction interim operations will be developed. A Detailed Design Report requires approval prior to construction.

526. Local outreach programs should be expanded to ensure that qualified local contractors have access to the bidding process. Consideration should be given to establishing local procurement programs, including local preferences where appropriate, to maintain contract dollars locally.

Response: Contracts procured by the Federal government must follow the Federal Acquisition Regulations. Experience has shown that awards made to the large contractors have resulted in the contractor choosing to use local labor and sub-contractors. Additionally, the Corps has several other procurement programs intended to provide opportunities to all sectors of the community. The Corps will develop a comprehensive Small Business and 8a set-aside program. Under the 8a program, local certified contractors would be utilized on a priority basis. As a normal part of establishing a Small Business and 8a plan for a project, the Jacksonville District's Small Business Officer would coordinate the Corps efforts with the project's local sponsor and local community.

527. The importance of establishing a baseline water quality and ecological monitoring program that monitors performance and measures water quantity and water quality improvements should be emphasized and such a program should be developed. The program must include appropriate monitoring to assess performance of the individual project components and impacts/benefits to the overall water resources in south Florida.

Response: Concur. The Corps with its cooperating agencies is in the process of establishing a standing multi-disciplinary, interagency coordination team to oversee the development of a regional monitoring program. The objectives of the monitoring program and monitoring program planning guidelines are contained in Section 9.5 of this Final Integrated Feasibility Report and Programmatic Environmental Impact Statement for the C&SF Project Comprehensive Review Study. These objectives and guidelines will guide the coordination team in developing a regional monitoring program that will have a dual focus on the biological and hydrological restoration objectives in the natural system, and water supply and flood protection objectives in the urban and agricultural regions. The program will be tailored so that it will detect change as a result of the implementation of Comprehensive Plan features. This information, in turn, will guide the adaptive management strategy by becoming the basis for improving the design of the Comprehensive Plan and the next incremental step in the restoration program.

528. The monitoring program should include baseline information on the Floridan Aquifer. The obtained data should serve as a tool to assess the success of the component and the affect of ASR activities on local and regional ground water flow in the Floridan and surficial aquifer systems.

Response: Concur. In addition, see response #527.

529. Regional monitoring should occur throughout the simultaneous testing of all ASR pilot test facilities.

Response: Concur. In addition, see response #527.

530. The comprehensive monitoring program should include methods for effectively monitoring water quality.

Response: Concur. In addition, see response #527.

531. The comprehensive monitoring program should include research on the relationships between native biological species and water quality. Such research should attempt to identify individual and/or communities of species that are sensitive to varying nutrient concentrations. If a relationship can be established the identified biological indicator should be used for regional scale monitoring of nutrient levels within the Everglades.

Response: Concur. In addition, see response #527.

532. The comprehensive monitoring program should utilize as much of the existing water quality monitoring programs as possible. These programs should be reexamined to determine if the matrices and sampling protocols are sufficient to provide the spatial and temporal information necessary to implement an adaptive management strategy on a project component basis as well as at the Everglades regional level.

Response: Concur. In addition, see response #527.

533. The water quality component of the comprehensive monitoring program should sample other water quality constituents in addition to phosphorus.

Response: Concur. In addition, see response #527.

534. Monitor changes in WCA-3B and ensure that discharges into WCA-3B, at minimum, meet all applicable water quality standards.

Response: Concur. In addition, see response #527.

535. Current monitoring of water quantity/quality budgets by tribal, Federal, state, and local governments should continue.

Response: It is not the intent of the proposed monitoring program contained in the Comprehensive Plan to discourage or supplant any tribal or governmental agency from continuing with their current water quality monitoring programs. It is the hope of the Corps and its planning partner, the SFWMD, that the existing programs would serve as a framework from which a base condition could be established for a region wide system that would monitor water quality conditions as individual project components are constructed and operated.

536. The monitoring program should ensure that hydrological alterations occur at a rate that will not negatively affect fish and wildlife species abundance or diversity, or threatened and endangered species.

Response: Concur. In addition, see response #527.

537. The comprehensive monitoring program should include specific Restudy project component monitoring to ensure that hydrological alteration results in the correct biological responses.

Response: Concur. In addition, see response #527.

538. Northeast Shark River Slough, Taylor Slough, and Florida Bay should be used as output indicators of the entire system and continue to be closely monitored for water quality and water flow measurements. As the Comprehensive Plan is implemented these downstream areas need to be monitored to ensure the success of the restoration program.

Response: Concur. See response #527.

N.2.10 Authorization / Funding

539. EPA believes that the potential exists that water quality features proposed in the Restudy may not be fully realized if implementation of the Restudy is in someway abbreviated. Accordingly, EPA recommends that Congress authorize improvement and protection of water quality for natural system protection and restoration as an authorized purpose of the C&SF Project.

Response: The water quality features included in the recommended Comprehensive Plan are an integral part of the Implementation Plan. Congress may consider adding water quality improvement as a purpose of the C&SF Project as part of an upcoming Water Resources Development Act.

540. There is much concern that if funding is cut in the future, the water supply components will be built but the restoration components will be abandoned or will be insufficient.

Response: Implementation of all of the components of the recommended plan is necessary to achieve the full level of benefits of the plan. Water storage is needed to achieve restoration as well as to meet regional water supply needs. The Implementation Plan sequencing recognizes the need to have storage facilities available as soon as possible.

541. Editorial changes in Section 11 of the report.

Response: Concur. Some of the requested changes have been made. While NOAA personnel have been valuable members of the study team, NOAA was not a contributing agency in the preparation of the PEIS.

542. The South Florida Water Management District should work closely with the State of Florida to ensure that the local share of the project (50%) should not be born solely by local residents, property owners, and water users.

Response: South Florida Water Management District's financing plan for the non-Federal share of project costs is contained in Appendix G: Local Cooperation and Financial Analysis in this final report.

543. Will funding to implement the plan be available?

Response: Implementation of the recommended plan will require appropriations by Congress as well as funding from non-Federal sources.

544. Who will pay for cost overruns and at what percentage? How much is this going to cost in new taxes (Federal and local)?

Response: All costs for the recommended Comprehensive Plan will be shared 50-50 between the Federal government and the non-Federal sponsor. Federal funding will be determined by Congress in future Appropriation Acts. The South Florida Water Management District's financing plan for the non-Federal share of project costs is contained in Appendix G: Local Cooperation and Financial Analysis in this final report.

545. The Restudy lacks sufficient funding to complete immediate purchase of East Coast Buffer/Water Preserve Lands.

Response: The initial authorization recommendations include a number of components in the Water Preserve Areas. The remaining components for the Water Preserve Areas will be included in the Water Preserve Areas Project Implementation Report, which is scheduled for completion in 2001.

546. The plan is conceptual and Congress should not be asked to approve any significant element of this plan until detail is provided to judge the costs and benefits of this action.

Response: It will be recommended that the Comprehensive Plan be approved as a framework for modifications to the C&SF Project. Authorization will be sought for pilot projects and for some components of the Comprehensive Plan as described in Section 10: Implementation Plan. If authorized, these components would still undergo more detailed planning and design before construction.

547. The C-111 North Spreader and the Biscayne Bay Wetlands would require purchase of more than 26,000 acres. These components should not be presented to Congress for approval until the land that will be taken and the benefits that will be contained are known.

Response: The C-111 North Spreader component is recommended for initial authorization so that it can be implemented as part of the ongoing C-111 Project. The Biscayne Bay Wetlands component will be developed further in a Project Implementation Report before authorization is sought.

548. A process should be developed whereby the acquisition of critical lands can occur prior to the execution of a Project Cooperation Agreement without jeopardizing the 50% Federal cost share.

Response: Section 528 of the Water Resources Development Act of 1996 provides for crediting of lands acquired for the Comprehensive Plan regardless of the date of acquisition. Some lands needed for the project have already been acquired under various state and Federal programs.

549. Provide more definition on the Federal cost share for operation and maintenance prior to the end of the public comment period.

Response: Concur. Section 9: Recommended Comprehensive Plan has been revised for the final report to describe the rationale for recommending Federal cost sharing of operation and maintenance costs.

550. In light of possible funding shortfalls, there needs to be careful attention paid to the sequencing of projects. Land acquisition must be prioritized and it is important to establish interim restoration targets.

Response: Sequencing of projects was developed based on a number of factors, including utilizing lands already acquired for restoration. The RECOVER team, described in Section 10: Implementation Plan, will establish interim targets as part of the adaptive assessment process.

551. Inclusion is requested in the initial authorization of all Restudy components in the Martin and St. Lucie Counties watershed.

Response: The C-44 Basin reservoir is recommended to be included in the initial authorization package. The remaining components in Martin and St. Lucie Counties are currently being developed in more detail as part of the ongoing Indian River Lagoon study, which is scheduled for completion in 2001. Those components are expected to be authorized after completion of that study.

552. The voters of Martin County agreed to implement an additional 1 cent sales tax for the next three years in order to clean up the estuary. A provision should be added in the final report that when local taxpayers contribute directly to Restudy projects, those projects are assured of priority funding at the Federal and state levels.

Response: Funding decisions for implementing the components of the Comprehensive Plan will be made by Congress and the appropriate non-Federal entities.

553. The Ten-Mile Creek Water Preserve Area must be funded and accelerated.

Response: The Ten Mile Creek project has been approved and is currently awaiting funding under the Critical Projects Program. Should the Ten Mile Creek Project not be funded under that program, it can be implemented under the programmatic authority being requested for the Restudy.

554. The state and Federal government should ensure that Restudy projects are not approved as an unfunded mandate requiring local governments to fund these projects.

Response: A Project Cooperation Agreement, which includes provisions and details about how the local share of project costs will be provided, must be executed by the Corps and the non-Federal sponsor before any project can be implemented.

555. St. Lucie and Palm Beach Counties have passed bond referendums for purposes of purchasing environmentally sensitive lands. There may be ways to use these funds in ways that will benefit specific Restudy projects.

Response: Funding sources for the non-Federal share of project costs will be developed in more detail during the implementation phase of the project.

556. Concern was expressed that emphasis has been placed more heavily on Everglades restoration, not a balance between restoration and water supply. It is recommended that the authorization bill include language to insure the dual purposes.

Response: The components of the recommended Comprehensive Plan provide water for both restoration and regional water supply. Authorization for the recommended plan will be the result of Congressional action.

557. Primary concerns about the Implementation Plan are in regard to the lack of specific information about funding. It is recommended that a detailed funding plan be prepared for public comment.

Response: In response to public comment, a draft Implementation Plan was developed and released for the public to review in January 1999. The South Florida Water Management District's financing plan for the non-Federal share of project costs is contained in Appendix G: Local Cooperation and Financial Analysis in this final report.

558. The Florida Water Council strongly supports the need for a thorough analysis of the technical and economic feasibility of any plan submitted to Congress for authorization. The Council strongly supports Congressional authorization and implementation of only those components for which general consensus exists.

Response: Approval of the Comprehensive Plan as a framework for modifications to the C&SF Project is recommended as well as authorization of pilot projects and an initial set of components. The remaining components of the Comprehensive Plan will be authorized subsequently after completion of Project Implementation Reports. As described in Section 10: Implementation Plan, more detailed analyses will be conducted prior to project implementation.

559. It is imperative that the Governor and Legislature be formally and directly involved as the Comprehensive Plan is developed, in reviewing authorizations of the Comprehensive Plan and in determining how they will be funded.

Response: Implementation of the recommended Comprehensive Plan will require a partnership with the state of Florida. The Governor and Legislature will determine their role in this process.

560. As part of the Corps criteria for a feasibility-level study, the project sponsor must be able to submit assurances that it has the capacity to commit its share of the project funding. It is not understood how this will be possible by the time the comprehensive plan is scheduled to go to Congress.

Response: South Florida Water Management District's financing plan for the non-Federal share of project costs is contained in Appendix G: Local Cooperation and Financial Analysis in this final report.

561. The amount and sources of funding for construction and long term operation of the Restudy improvements need to be established through public debate. Another issue is how big should the authorization be for Restudy implementation. The Restudy results and cost estimates can be adjusted before the full plan is authorized.

Response: South Florida Water Management District's financing plan for the non-Federal share of project costs is contained in Appendix G: Local Cooperation and Financial Analysis in this final report. Approval of the Comprehensive Plan as a framework for modifications to the C&SF Project is recommended as well as authorization of pilot projects and an initial set of components. The remaining components of the Comprehensive Plan will be authorized subsequently after completion of Project Implementation Reports.

562. The Implementation Plan was designed with the assumption that resources will be unlimited. There is encouragement to look for less expensive ways to accomplish the goals of the Restudy plan throughout the process.

Response: The Implementation Plan has been revised with a guideline of $400 million per year funding. Value engineering analyses to optimize components and reduce costs will be conducted as part of Project Implementation Reports.

563. Concern was expressed about how the local sponsor / State of Florida and Florida taxpayers will be able to pay the cost of operation, maintenance, and monitoring.

Response: Section 9: Recommended Comprehensive Plan has been revised for the final report to describe the rationale for recommending Federal cost sharing of operation and maintenance costs.

564. Congress will inquire why water conservation measures are not included in the Plan to reduce project costs. In addition, a more passive system could eliminate the need for expensive components such as ASRs, seepage barriers, and pump stations, and thus save billions.

Response: Water conservation measures are included as part of the recommended plan (Component AAA6). Value engineering analyses to optimize components and reduce costs will be conducted as part of project implementation studies.

565. The Seminole Tribe's interpretation of Section 528(e)(2)(B)(I) of the Water Resources Development Act of 1996 is that water quality aspects of the Restudy should be cost-shared by the Federal government at the rate of 50%.

Response: The water quality components included in the Comprehensive Plan have been found to be essential to Everglades restoration and are recommended for 50-50 cost sharing.

566. The scope of work being authorized is not clear. It is stated that the scope of requested authorization will be provided in the final report. However, this timing does not allow for public comment on the chosen project elements.

Response: In response to public comment, a draft Implementation Plan, which included a list of projects recommended for initial authorization, was developed and released for the public to review in January 1999. Approval of the Comprehensive Plan as a framework for modifications to the C&SF Project is recommended as well as authorization of pilot projects and an initial set of components. The remaining components of the Comprehensive Plan will be authorized subsequently after completion of Project Implementation Reports.

567. The draft report is based on the success of the pilot projects, which are not yet proven to be technically feasible. If the technologies prove infeasible, will further authorizations be necessary?

Response: Authorization for components that depend on the results of the pilot projects is not being sought at this time. Project Implementation Reports will be completed for these components after assessment of the results of the pilot projects.

568. Given the many uncertainties associated with the draft Comprehensive Plan, it cannot be supported either as a final decision-making document or as a blanket authorization in its present form by Congress.

Response: Approval of the Comprehensive Plan as a framework for modifications to the C&SF Project is recommended as well as authorization of pilot projects and an initial set of components. The remaining components of the Comprehensive Plan will be authorized subsequently after completion of Project Implementation Reports.

569. Congressional authorization for those features that were included specifically to enhance the ecological indicator regions should automatically include a 50-50 cost share for water quality treatment features that may be needed in order to redirect the water where it is desired. Currently, operation and maintenance costs for most of the C&SF Project are the responsibility of South Florida Water Management District. It is recommended that the authorization request includes 50-50 cost sharing for operations and maintenance associated with the plan components.

Response: The water quality components included in the Comprehensive Plan have been found to be essential to Everglades restoration and are recommended for 50-50 cost sharing. Section 9: Recommended Comprehensive Plan has been revised for the final report to describe the rationale for recommending Federal cost sharing of operation and maintenance costs.

570. Utilize local funding sources in combination with Federal and SFWMD funds to advance the implementation of the project.

Response: It is expected that throughout the period when Project Implementation Reports are being developed, dialogue will continue with state and local governments to maximize and leverage funding to advance the implementation of the project.

571. The entire Comprehensive Plan should not be authorized.

Response: Careful attention was given to developing an initial authorization recommendation for pilot projects and key specific components. This recommendation is based on the need to expedite project development to ensure consistency with ongoing Federal, state and local programs.

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APPENDIX O

UNCERTAINTY ANALYSIS

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APPENDIX O
UNCERTAINTY ANALYSIS

This Appendix was written by a consultant for the U.S. Army Corps of Engineers as part of a contract to investigate uncertainty issues concerning the Recommended Comprehensive Plan. This Appendix accurately reflects the commitments that the Restudy Team has made to address key uncertainty issues in subsequent planning and design activities and recommends additional studies to help resolve outstanding uncertainty issues including a qualitative risk assessment.

O.1 INTRODUCTION

The Central and Southern Florida Project Comprehensive Review Study (the Restudy) was initiated in the face of gargantuan uncertainty about the future of the Everglades and south Florida. There was uncertainty about complex ecosystems that embodied physics, chemistry, and all the biological sciences. There was uncertainty about engineering systems and their function. There was uncertainty about social and political values large and small. Economic systems and values were also uncertain. There was uncertainty everywhere one looked.

The Restudy marks a watershed event in the investigation of ecosystem restoration projects. The hundreds of people involved in this effort have provided decision makers with an unprecedented quantity and quality of useful information for a study of this scale, complexity, and importance. Unparalleled progress has been made in reducing the uncertainty attending the problems and solutions addressed in this effort. Despite this tremendous progress, study managers recognized there was still much that remained uncertain. Hence, this uncertainty analysis was undertaken.

The study has been extremely successful in generating more and better data than has ever before been available for this kind of study. There is a clear consensus that the quality of the models, databases, and the general information developed for the Restudy are extraordinary for a study of this scale. However, is it enough? No. Do we want more? Yes.

This study has been examining the forest, not the trees. Direction is the forest, details are the trees. The Restudy, to date, has set direction; the details will come in time. Doctors make life and death decisions on a daily basis, while medical research continues to improve the quality of those decisions in the future. That is the situation in which this study finds itself.

Those who do not address resource planning issues on a regular basis, look at the remaining uncertainties they are able to see for the first time and they may feel uncomfortable. Perhaps they have less feel for just how great the uncertainties were before this study began. The uncertainty they see now, great though it may be, is a fraction of what it once was.

To an extent, we have different orientations among some study interests. People who must live and die with the details of their decisions look at the certainty in this study's glass and see it is only half full. Planners and many analysts look at the certainty in the glass and are pleased that it is already half full.

If we're not sure, we're uncertain. This summary of the uncertainty analysis begins with a few facts and opinions.

- Fact: Uncertainty is a fact of life, it cannot be avoided.
- Fact: Uncertainty never disappears, although it can be diminished.
- Fact: Uncertainty describes a range of situations from a complete lack of specific knowledge to knowing everything but the exact outcome of an action.
- Fact: Different uncertainties warrant different responses.
- Opinion: The existence of uncertainty is no excuse to avoid making decisions about Florida's future.
- Opinion: Deciding not to proceed with the Restudy because uncertainty exists is foolish as long as the key uncertainties are recognized, acknowledged and are being addressed in a rational and appropriate manner.
- Opinion: To take no action, to make no decisions because the Restudy is not free of uncertainty may doom central and south Florida to a far more uncertain future than they might face in a well-reasoned and carefully monitored new direction.

O.2 PURPOSE OF THIS UNCERTAINTY ANALYSIS

The primary purpose of this uncertainty analysis was to identify which of the remaining uncertainties are most significant. That is, which uncertainties have the most potential to affect the effectiveness of the project that will eventually be implemented. A secondary purpose of this analysis was to identify broad strategies that can be used to address or reduce the remaining uncertainties. It was not the purpose of this analysis to quantify or resolve the uncertainty that remains.

A few words about significance may help the reader understand why some things are discussed here and others are not. We define three categories of uncertainties: perceived uncertainties, routine uncertainties, and unique uncertainties. Perceived uncertainties are things that some one or more persons might not know but which are known by other people. For example, many people do not know the basic workings of aquifer storage and recovery technology (ASR). To those unfamiliar with this technology, the perceived uncertainties are many. To experts who understand the technology, they are fewer. Perceived uncertainties are not addressed here. The importance of perceived uncertainties should not be overlooked, however. The cure is simply more and better two-way communication. Those who perceive the uncertainties have to ask more questions, and experts need to answer them. This can be handled in the normal planning process.

Much of the uncertainty that attends this study effort is what we call routine uncertainty. Planning is an iterative process. The iterations are distinguished by an increasing quantity and quality of information and a corresponding decrease in uncertainty. In any planning study there are things that are unknown at one point in time that must and will be known before the project can be implemented. That includes such things as specifically where project elements will be located, how much they will cost, and who will pay for them, among many other issues. Planners are well aware of these uncertainties, and they will be resolved. There is a great deal of routine uncertainty attending this stage of the planning study.

All of the routine uncertainties will be answered in due time as the study proceeds and the required information becomes available. Time and more analysis will reduce these important uncertainties. In the meantime, there is sufficient information to begin to make decisions. As important as the answers to the types of questions raised above are, their articulation is the very work of a planning study. For that reason, this analysis did not concentrate on the resolution of questions that we know will be answered in time.

The problem seems to be that experienced planners understand and accept the existence of these routine uncertainties while those who must rely on planners for information are anxious for answers, sometimes wondering if they will ever come. Well established planning, engineering and scientific practices will resolve the routine uncertainty issues at an appropriate time, and these uncertainties are not further addressed in this analysis.

The Restudy effort has been marked by an extensive effort to communicate effectively and in a timely fashion with a broad array of public and private interests. Anxiety about routine uncertainties may be best addressed through the continuation of this communication effort and by focusing some public involvement resources specifically on the task of addressing routine uncertainties of particular concern to the public. For example, compiling the types of questions people are raising and perhaps even publishing them on the Restudy Web site so they become part of the public record, would go some distance in easing anxiety. The list enables concerned parties to see that their concerns have been heard. It also facilitates communication among stakeholders, while simultaneously serving as a "To Do" list for the study team. As answers are found or as investigations to find answers are scheduled, this information can be published as well.

Although much of the uncertainty that remains in the Restudy is routine and will be addressed in time, there are some uncertainties that are too unique to ignore. For example, although the basic workings of ASR technology are a perceived uncertainty, there are some unique uncertainties associated with their application on a magnitude of this scale. These key and unique uncertainties were the focus of this analysis. The remainder of this appendix describes these uncertainties and the manners in which they are being or could be addressed in the future.

O.3 HOW THIS ANALYSIS WAS CONDUCTED

This analysis began in the summer of 1998 in a conversation with the study's managers in order to identify the objectives of this uncertainty analysis. That conversation was followed by an extensive review of the available planning documents related to the Restudy effort. These included the November 1994 Reconnaissance Report and Appendices, as well as numerous reports and memoranda generated as part of the current Restudy effort.

A brief survey of all the Restudy team members (in excess of 150 people) was circulated via e-mail. The survey asked respondents to identify: 1) three things in the study of which they were most sure; 2) three things of which they were least sure; 3) the one thing more time could be spent on to improve the study; 4) the aspect of the study within the respondents' expertise that makes them feel least comfortable; 5) the aspect of the study outside the respondent's expertise that makes them feel least comfortable; and 6) an acceptable level of uncertainty. The purpose of the survey was to explore potential consensus on major uncertainties and to guide the more intensive interviews that would follow. Forty-nine useable responses were obtained from this initial survey effort.

The results of the survey were used to identify both broad areas of general concern and specific examples. A meeting was held with representatives of the U. S. Army Corps of Engineers and the South Florida Water Management District following the survey to identify a subset of study team members who would best be able to provide more detailed information about major areas of uncertainty as identified from the survey. Face-to-face interviews were held during the week of July 6-10, 1998 with 25 study team members identified from a broad cross section of interests and disciplines.

The information gleaned from these meetings, study documents, surveys, telephone conversations and interviews were combined with a little common sense, information from a literature search and the author's experience to produce this analysis.

O.4 KEY UNCERTAINTIES

Four key uncertainties were identified in this analysis that are unique enough to warrant special attention in the future. They are:

- Uncertainties about major Restudy models;
- Uncertainties about the linkage between hydrologic change and ecosystem restoration;
- Uncertainties about new technologies; and,
- Uncertainties about the risks associated with the recommended Comprehensive Plan.

There are other uncertainties that, while not routine, are not considered key uncertainties. For example, some study participants have suggested the evaluation process that relied on performance measures and often subjective judgments was fraught with uncertainty. We draw a distinction between subjectivity in a decision process, which we consider inevitable and appropriate, and uncertainty. Each of the key uncertainties is discussed in turn below.

O.4.1 Models

A large portion of the Restudy's success to this point in time is attributable to the many state-of-the-art models employed in the study's numerous investigations. Models are uncertain by nature because they are simplifications of reality. Some of the uncertainty may reside in the models' basic structures, i.e., are we thinking about this system correctly? Some uncertainty will reside in the values of select decision variables and value parameters used in the models. Other uncertainties can arise because of the quality of the input data and other empirical quantities used in the models.

The Natural System Model (NSM) and the South Florida Water Management Model (SFWMM) are the two most important models used in the Restudy (see Appendix B). The NSM attempts to depict the hydrologic response of the pre-drained system to the rainfall and other hydrologic conditions of the period 1965 through 1995. The resulting hydrologic responses were to serve as approximate targets or goals to be achieved by alternative water management scenarios. There is a widespread and mistaken impression that the NSM is intended to describe the conditions of the pre-drained Everglades system. It is not. The SFWMM was used to characterize the expected hydrologic response of the existing system under various water management scenarios in the future.

Because changes in the hydropattern are viewed as the key to ecosystem restoration, the outputs of the NSM and SFWMM model investigations were used as inputs to numerous calculations and other model runs throughout the Restudy analysis. The results of these various analyses have been used in or have contributed to countless decision processes and subsequent analyses including plan formulation, ecosystem response, project cost estimates and the like. Because of their keystone position in the Restudy, the NSM and SFWMM are the models of primary concern here.

The NSM and SFWMM are state-of-the-art models. The SFWMM has been calibrated and verified. The NSM cannot be. They are the best available models for this analysis. They have been peer reviewed. Their limitations are well understood by their developers and the modelers who use them. A great deal of work has been directed to identifying and addressing uncertainties associated with these models.[1] Nonetheless, there are unique and significant uncertainties that remain with these models and their applications.

O.4.1.1 Topographic Data

There are little if any reliable elevation data for the pre-drained Everglades system. In addition, some of the existing condition topographic data are not as current and accurate as desired. Specifically, there are concerns about topographic data in some parts of the study area. If actual ground elevations differ significantly from the elevations used in the model, outputs could be misleading. Areas might actually be wetter or dryer than model runs indicate. Actual flows could also differ from model predictions. The result could be plan impacts quite different from what is expected. In turn, ecosystem responses to these impacts could be unexpected.

Improved topographic data has been identified as a high priority need for future study efforts, and it will be collected. Improving the quality of key data inputs is an appropriate way to address this uncertainty. Changes would subsequently be made to the Comprehensive Plan as warranted by the improved information. Efforts to gather information about the pre-drained system continue. These efforts represent a

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[1] For example, see Trimble, Paul J. *An Evaluation of the Certainty of System Performance Measures Generated by the South Florida Water Management Model.* A Thesis submitted to the faculty of the College of Engineering in partial fulfillment of the requirements for the degree of Master of Science in Engineering. Florida Atlantic University, Boca Raton, Florida, August 1995 and Lal, A.M. Wasantha, Jayantha Obeysekera, and Randy Van Zee. A Sensitivity and Uncertainty Analysis of a Regional Simulation Model for the Natural System in South Florida. From *Coping with Scarcity and Abundance, Proceedings of Theme A, Water for a Changing Global Community.* The 27th Congress of the International Association for Hydraulic Research, Water Resources Engineering Division/ASCE. Held August 10-15, 1997, San Francisco, CA.

reasonable and appropriate response to this uncertainty.

O.4.1.2 Resolution of Model

The current versions of the NSM and SFWMM use two-mile square grids. This resolution was based on the available spatially distributed data. A concern has been raised by some that at that level of resolution it is not possible to consider impacts of plans on smaller areas of particular interest to stakeholders. Although the models are more than sufficient for making decisions about regional water management plans, there are uncertainties about plan impacts on smaller areas.

The NSM and SFWMM were never intended to be used to develop specific plans for smaller critical areas of special interest. Uncertainty about the plan's effects on these areas will be reduced through the use of finer resolution grids, as small as 500 feet square. In critical areas, where site specific analyses are desired, other models better suited to local analysis will be used. The finer resolution and specialized models are appropriate means of reducing this uncertainty in the future.

O.4.1.3 Rainfall Sequence

The major data inputs for both the NSM and SFWMM include the daily rainfall data for the most recent 31 years of record. This database represents a phenomenal amount of spatially and temporally distributed data. The 31-year period presents stretches of dry years and wet years and is generally regarded as representative of the region in modern times. The database may not be perfect but it is surely the world's best data for this region, and it is far better than what is available for most studies of this magnitude. Because both the NSM and SFWMM use the same rainfall database for making relative comparisons, the relative rankings of the various plans' performances are considered reliable and reasonably robust.

Despite the unprecedented quantity of data, some uncertainty remains. As good as these data are, they represent only one 31-year sequence of rainfall patterns from among an infinite number of possible 31-year sequences of rainfall. The likelihood that the next 31 years of rainfall will have the same spatial and temporal distribution as the 1965 - 1995 period is effectively zero. The likelihood that the available data will be *representative* of the next 31 years is pretty high.

Ideally, it would be advisable to test the sensitivity of the recommended Comprehensive Plan to significant changes in the rainfall sequence. *Significant* changes could be defined by qualified experts. To illustrate the idea, suppose we took the driest year from the 31-year period of record and assumed it will be the wettest year in the next 31 years.[2] How, if at all, might such a sequence change the

[2] We do not suggest there is any reason to do so other than to illustrate the point we are making. Clearly a better recommendation would be to develop a stochastic model for rainfall and use it to develop synthetic traces.

recommended plan? How would the recommended plan perform under this scenario? If we chose the wettest year and repeated the exercise how might the ranking of plans change? At the current time, we do not know the answers to these or related questions.

Uncertainty concerning the performance of the recommended Comprehensive Plan under rainfall patterns different from that of recent history could be reduced by using alternative sets of rainfall data that depict scenarios of most interest to analysts, such as extremely dry and extremely wet sequences. No one really argues this point, but it is not yet possible to perform this kind of analysis. Hence, the uncertainty remains.

The NSM and SFWMM models are the best in the world for this analysis. They are state-of-the-art. The simple truth is that art has not yet advanced to the point that it can accommodate the kind of sensitivity analysis we might like to see. There is no known, practical method that can be employed with these models to generate meaningful and useful synthetic databases. The data requirements for these models are huge. The spatial and temporal dependencies in hydropatterns are exceedingly complex. The capability does not currently exist to develop alternative databases for sensitivity analysis in a practical manner.

Although some uncertainty remains, the NSM and SFWMM are more than adequate for current decision making purposes. Hydrologists and modelers alike would agree that *the* best 31-year sequence of rainfall data to have for an analysis like this would be the modern historic record, i.e., the most recent 31 years.[3] This is standard engineering practice. The modern historic record is the database that is available and it is an excellent one.

The uncertainty that results from the limited sequence of rainfall patterns can be addressed in several ways as the study proceeds. First, research can be initiated to develop a stochastic model for the space-time rainfall structure in the study area and then use the Monte Carlo technique to simulate future possible realizations of rainfall patterns. In view of the state-of-the-art of stochastic hydrology, this may be a difficult task.

Second, the period of record used by the current model includes droughts and wet periods. The performance of alternatives has been investigated by carefully analyzing the modeling results for these extremes within the period of record. Efforts are also underway to extend the period of record to include earlier years spanning back to the 1920s. This will include even more drought and wet periods. Careful analysis of these will provide further sensitivity analysis of the plan's response to extreme patterns of rainfall.

[3] There is nothing magical about a 31-year period of record. There just happens to be 31 years of data available. As more data become available they will be added to the database and used. The point made here is invariant with respect to the number of years of recorded data.

Third, because the NSM and SFWMM are and will, presumably, remain state-of-the-art models, there is a desire to expand their capability to include the type of sensitivity analysis described above. So, although the capability for such analysis does not yet exist, it may in the future. If and when it does, it will be used to improve the formulation of more refined plans for central and south Florida.

If the capability for such evaluation does not become available in a timely or cost effective manner, it should be noted that the Recommended Comprehensive Plan will not likely be inadequate for any resulting rainfall sequence. Operations may be modified to adjust to future situations in much the way that gates on existing structures are opened and closed to adjust to current hydrologic conditions. The worst case is expected to be that, through hindsight, it may have been possible to have designed a somewhat more efficient and cost effective system. Eliminating hindsight is never going to happen. If the study team continues to do whatever sensitivity analysis it can to explore the Recommended Comprehensive Plan's sensitivity to the assumed rainfall sequence; and if the NSM and SFWMM models take advantage of advances that can produce synthetic databases; and if the water management system is managed effectively; this uncertainty will be properly addressed.

O.4.1.4 Amplification and Dampening of Uncertainty

Another unique model-related uncertainty concerns the manner in which the uncertainty in one model combines with the uncertainty in another model to produce greater cumulative uncertainties (amplification) or to cancel one another out (dampening). This is a reasonably possible impact that has not yet been formally investigated. It should be.

NSM and SFWMM outputs are used in many study activities and analyses. This is important because errors in these models can be amplified as uncertain outputs from one model become inputs to subsequent models that add their own uncertainties and errors in ways that are not yet well understood. There are countless points in the various models in the Restudy where small changes or errors, for example in the NSM or SFWMM, could have potentially large impacts on decisions if those errors are magnified in subsequent analysis.

Some Restudy team members have raised concerns about the NSM's empirical sufficiency, primarily because there were little or no data available to describe natural system conditions.[4] Many of the values had to be approximated or even guessed. An example is the previously mentioned elevation data. Reliable topographic mapping of the pre-drained condition in central and southern Florida does not exist. Hence, the

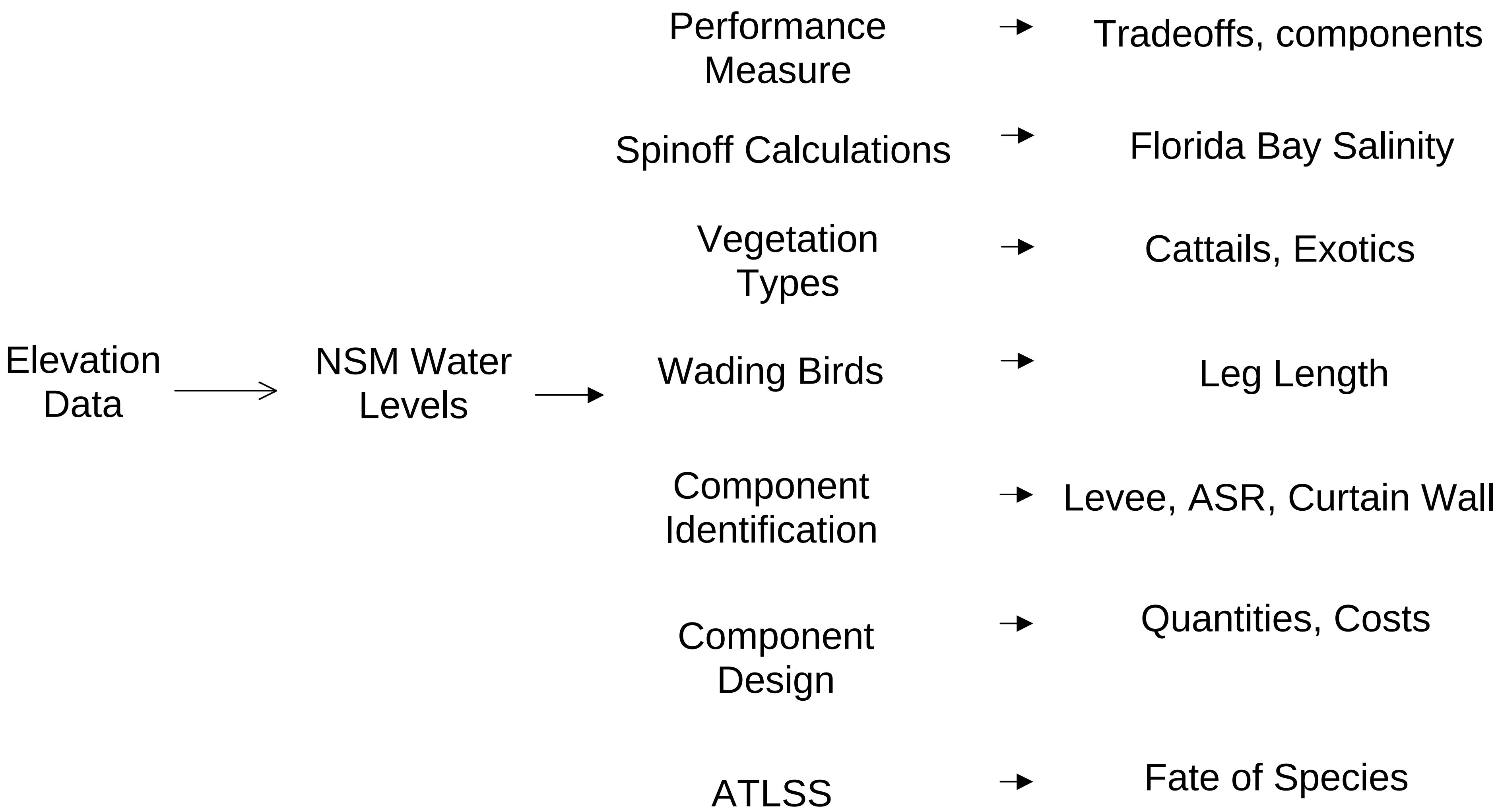
[4] A thorough effort to document historical conditions has been and continues to be undertaken. A draft report entitled, ASoil-Based Estimation of Historic Hydrology of the Everglades, Florida 1840-1880; Comparison with the Natural System Model,≅ by C. W. McVoy, W. A. Park, and J. Obeysekera, dated 1996 is currently being updated and revised.

elevation variable values are uncertain. Figure 1 shows some of the ways elevation data might impact the plan formulation process via the NSM and subsequent models, although the subsequent models are not specifically identified.

Elevation data affect numerous NSM outputs, including water levels, water depths, water flows, and water volumes. Figure 1 addresses only the water levels. Water levels may be used in some areas as performance measure targets. These targets are used to define and make plan trade-offs. For example, if a water target indicates depths that could present a problem for the Cape Sable seaside sparrow (an endangered species), the planning team could decide to lower the depths to aid the sparrow at the cost of some adverse impact to other species. Thus, any uncertainty in the elevation data could ultimately affect trade-offs in plan formulation. There are countless other examples that could be used here as well. There are many calculations that use NSM water levels to estimate other values of interest. For example, salinity levels in Florida Bay have been used with NSM water level estimates at gage P33 in Shark River Slough to develop a simple linear regression relating water levels and salinity. These salinity estimates are critical to the Bay ecosystem. The ecosystem's response to the changes in hydrology depends directly on water levels. Vegetation and animal species that result in the restored ecosystem will depend directly on water depths. Cattails or exotic vegetation could replace sawgrass if depths are more favorable to the former. Whether and which wading birds inhabit an area depend on the depth of water and the length of the birds' legs.

Water levels will help to dictate whether a levee, ASR system, reservoir or other plan component is used to effect the desired hydrologic change. Water levels will have a strong influence on the design of a plan component. For example, the length, top height, width of top and side slopes of a levee depend on the water levels. Levee quantities and costs depend on levee design, which depends on water levels, which depends on elevation data. And so it goes.

Figure 1: Role of Sample NSM Data in Plan



Water levels are inputs to other models. The Across Trophic Level System Simulation (ATLSS) model takes SFWMM water levels and uses them as an input to its own algorithms. When water levels that might be considered indicative and accurate within plus or minus a half foot are used as precise estimates of water levels in another model, the uncertainty attending water levels might be amplified or dampened. Without a more formal and structured investigation of the cumulative effects of uncertainties, we simply do not know. [5]

ATLSS outputs might include a population viability analysis for an endangered species. An analyst might then take the ATLSS outputs, which are very precise in appearance, and offer an opinion about the species' relative risk of extinction. Thus, uncertainty attending the elevation data combines with the model uncertainty of three models (NSM, SFWMM, and ATLSS), all of which are used in a subjective decision process to make a judgment about a species' potential viability in a specific area. These combined uncertainties could, in the worst case, be disastrous for the species. In the best case, they might be negligible or they might cancel one another out. They should not, however, be overlooked.

The cumulative effects of uncertainty are unexamined sources of potentially significant uncertainty in the Restudy. It is reasonable, given study resources, the cutting edge nature of the analysis required, and the existing tight schedule that requires decisions be made at this time while these uncertainties remain. It is equally reasonable to expect that a formal effort to address this remaining source of potentially significant uncertainty be initiated in the Implementation Plan.

One way to begin to address the problem is to conceptually map the potential cumulative uncertainties. As a practical matter, this begins with the NSM and SFWMM. Study team members can identify the ways they have or will use these model outputs in their own work. Thus, this map or flowchart would show the connections among the various models used in the analysis. If ATLSS uses NSM and other model outputs as inputs, these can be simply sketched. Similarly, it should be a straightforward matter to identify the models, analyses and decisions that employ ATLSS outputs. Each analyst and modeler involved in the study should be able to sketch their part of such a map or flowchart.

Armed with the map, the second step would be to rank the potential amplification and dampening from least to most concern, perhaps using a simple criteria-based ranking technique.[6] Step three would be to systematically investigate

[5] A naive example of a sensitivity analysis might be to increase then decrease water levels by one-half foot, as indicated, in coordination with NSM modelers and see if the ATLSS results are significantly different. If not, then we can safely assume the uncertainty in water levels is not a factor worthy of further consideration.

[6] For example as found in Yoe, Charles AUse of Criteria-Based Rankings in Risk-Based Analysis of Ecosystem Restoration Projects,≅ in *Risk-Based Decision Making in Water Resources VIII*, Yacov Haimes, et al eds. American Society of Civil Engineers, Reston, 1998.

the sensitivity of important decisions to these cumulative uncertainties. Step four would be to modify the plan as necessary or, alternatively, to identify potential outcomes for monitoring and assessment during implementation. The last step would be to disseminate the findings of such an effort as widely as appropriate.

This discussion has used the NSM and ATLSS models for example purposes. The potential for cumulative uncertainties exists wherever diverse models have been linked through "outputs as inputs" uses. It should be formally considered, if not investigated, wherever it exists. Although it may not yet be feasible to vary the input data for the NSM and SFWMM, that may be an entirely reasonable expectation for some other models. If varying key inputs changes a decision, then further effort is warranted. That could be reducing the uncertainty in the input by collecting additional data, using better models, or doing more research. Alternatively, it could mean closely monitoring the input sensitive outcome in the adaptive assessment program. In any case, each study team analyst should make a concerted effort to identify and address as appropriate the potential for cumulative uncertainty in their areas of responsibility.

O.4.2 Linkage Between Hydrologic Change And Ecosystem Restoration

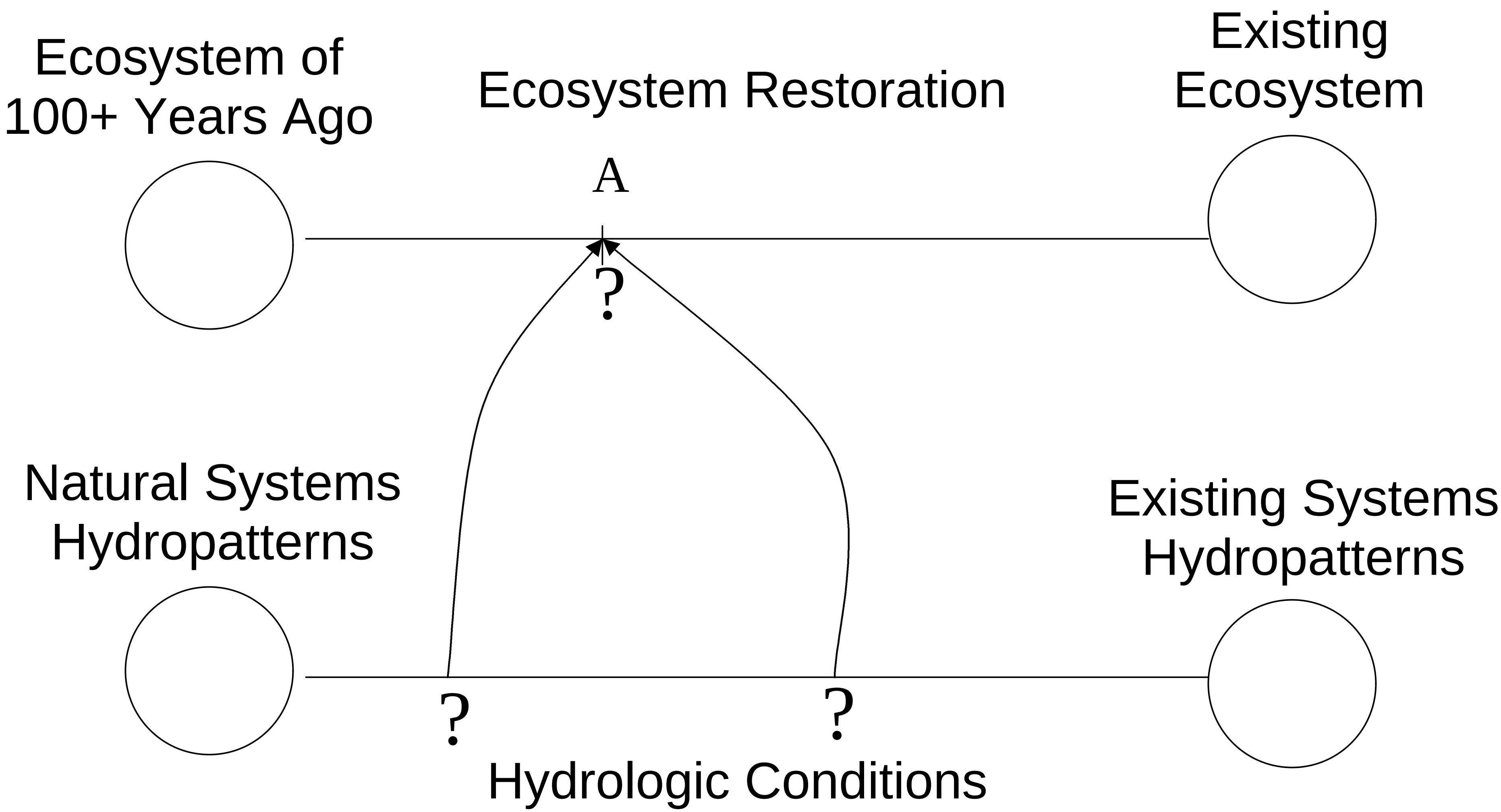
Linkage, as used here, refers to the way that things are connected or united. Perhaps the most important remaining uncertainty is the manner in which the ecosystem of the Everglades will respond to the planned hydrologic changes. It bears noting that most people are well aware of this uncertainty, and it is the principle focus of the adaptive assessment component of the Implementation Plan.

O.4.2.1 Endpoints

There is very real and, to a great extent, unresolvable uncertainty about what the new ecosystem will look like. Because no one knows for sure what the ecosystem will look like, no one knows for sure what the hydropattern required to produce it will look like. This is, in our view, the greatest uncertainty in the entire study. Moreover, we do not know with certainty what the linkages between hydropatterns and the ecosystem are.

Figure 2, an adaptation of an idea offered by a study team member, suggests the conceptual nature of this uncertainty. The bottom line shows that the existing hydrologic system differs from the NSM over a continuum. The top line shows that the existing ecosystem differs from what it was 100 years or more ago, an arbitrarily chosen time frame, also through a continuum.

Figure 2: Hydrology - Restoration



What is known with certainty is that the existing ecosystem is not what we want. We don't even know if the existing ecosystem can be sustained by current hydropatterns. It is important to bear in mind that not all uncertainties are associated with the Recommended Comprehensive Plan. The status quo has its own considerable uncertainties.

Conceptually, we want the ecosystem to move leftward toward a healthier, more predictable and persistent ecosystem. It is certain that we will not achieve the ecosystem conditions of 100 or more years ago. The past is used here to represent a conceptual ecological ideal. The farther to the left on our continuum we move the ecosystem, the more desirable it is. What we don't yet know are the answers to two very important questions. Where do we *want to be* on the line? Where on the line *will we eventually be*? These are major remaining uncertainties.

Now suppose that for argument's sake we decide we want the ecosystem to be at point A. The linkage uncertainty now takes center stage because at large, regional scales we do not know what hydropattern will sustain the ecosystem at point A.[7] We do not know with certainty the water levels, locations, depths and duration that will be needed to get the ecosystem to point A. But that is not even a particular problem yet, because we do not know where point A is or what it will look like.

The desired environmental endpoints have not yet been clearly identified. That does not mean there are not plenty of ideas about what they might be, however. Now that broad consensus on goals and plans has been reached, the study team is working on developing a consensus view on a number of ecological fronts. For example, when this analysis was initiated in the summer of 1998 there was not a consensus definition or understanding of what ecosystem restoration meant in the current context. The Alternative Evaluation Team (AET) has subsequently defined ecosystem restoration as follows: "In its original meaning, and when used with reference to a natural system under anthropogenic stress, 'restoration' means a return to a system that is not under anthropogenic stress. When used in the context of the south Florida wetland system, ‘restoration’ has come to mean the recovery of sustainable wetland systems at some higher level of ecological health than characterizes the current, impacted systems. The broad goal is to recover and sustain the major defining ecological characteristics of the pre-drainage south Florida wetland systems over as large an area of the remaining wetlands as possible."[8]

What this definition means in specific terms for the Everglades still remains a matter of debate and discussion. There are legitimate professional disagreements

[7] Our understanding of linkages between ecological targets and hyrdological patterns at much smaller scales is much sharper. For example, we know fairly well what hydrological patterns are needed to recover healthy alligator ponds.

[8] "Defining Restoration - I, A Restudy Alternative Evaluation Team White Paper,≅ dated 16 November 1998.

about what to emphasize when specifically characterizing a restored ecosystem. Some might prefer nutrient levels, plant community mosaics, food chains, and endangered species or other characteristics. There is broad agreement in qualitative terms, however, about most of the biological and physical characteristics that describe restoration.

The strategy for the coming months and years is to refine the definition of what restoration will look like, i.e., by identifying specific endpoints at finer levels of specificity and detail. Workshops and other consensus building activities are planned for the spring and summer of 1999 to formally begin the process of reducing the uncertainty concerning what restoration *should* look like. Only implementation will reveal what restoration *will* look like.

There is a widespread and robust consensus belief that water is *the* essential ingredient for ecosystem restoration. Each conceptual ecological model, developed to guide restoration planning, identifies hydrologic stressors as primary factors in the ecosystem. So, there exists both popular and science-based support for and agreement with the statement that we are sure that restoration is impossible without changes in the hydropatterns.

Once the ecological endpoints have been identified, the specific water targets required to attain them can be better estimated. Much of this work will be the routine and ongoing work of implementing the plan. Whether these water targets can be achieved via the components of the Recommended Comprehensive Plan is uncertain at this point. If better ways can be found to achieve water targets as they become better defined, they will be pursued. This is an example of a routine uncertainty in a planning process. Whether the water targets once achieved will lead to the desired ecological endpoints is another matter of considerable uncertainty.

The conceptual ecological models represent a set of hypotheses about how the ecosystem functions. Plan implementation is, in some respects, like a scientific experiment. The Implementation Plan's "adaptive assessment" function has been created to oversee this experimental process and to assure the plan's ultimate performance and success. The Implementation Plan says with respect to the uncertainty about the link between hydrology and the ecosystem: "If an unexpected response occurs, it becomes the basis for reviewing and revising the operating set of hypotheses, which results in an ever improving focus on the actions required to meet the ultimate restoration objectives. "

The study team is both aware of and open about the major uncertainties that remain in refining the definition of ecosystem restoration. They are equally aware and open about the uncertainties that accompanies the linkage between hydropatterns and ecosystem response. It is clear that water is essential to every endpoint of importance, but it is not yet clear exactly how the hydropatterns must be changed.

There is an honest awareness of major linkage uncertainties that could not have been reduced at this point by any available means. There is a plan in place and underway for reducing the remaining uncertainty about what restoration should look like, i.e., where on the continuum we want to be. A proactive adaptive assessment program will be developed, in part, to reduce the uncertainty about the link between hydrology and restoration. There is little that can be said at a general level to improve on that strategy. Whether this strategy is adequate for reducing the remaining uncertainty or not will depend on the study team’s ability to reach consensus on the specific details of restoration and the quality of the adaptive assessment process. Both bear close and constant scrutiny in the months and years ahead.

O.4.2.2 It Takes More Than Water

Hydrology is not the only requirement for restoration. The conceptual models reveal that more than water is going to be needed to achieve whatever picture of restoration ultimately emerges. An AET white paper has had the following to say about restoration requirements other than hydropatterns. "Ecological restoration cannot even begin to succeed without the successful maintenance or recovery of a number of other conditions, such as: an appropriate fire regime, exotic control, good water quality, and appropriate human use of different parts of the system. A restored system will also require the physical connections among areas of the system to allow for the completion of all parts of organisms' life cycles and to provide for flexibility in their movements about the system to deal with temporal variations in water levels, fire history, and climatic events. The AET recognizes that there will continue to be uncertainties associated with our current understandings of natural responses, which will continue to influence our ability to reach a final definition of a restored system".[9]

The roles of these other stressors in the attainment of desired endpoints will, ideally, be revealed and assessed through the adaptive assessment process, just as the hydrologic linkage will. So there is a mechanism in place for identifying those factors, in addition to hydropatterns, required for restoration. What is not yet in place or accounted for is a process that will assure that these non-water requirements of restoration will be met.

This restoration project is a complex and multi-faceted, one of a kind, first of its kind effort. It presents coordination challenges of unprecedented magnitude. There are multiple levels of government involved; there is inter-agency baggage to consider; and there are many diverse stakeholders involved. If water quality improvements are required, if a fire regime is needed, if control of exotics becomes necessary, it is not yet clear how, or if, the Restudy can marshal the resources to assure that these essential ingredients of a successful restoration will be provided. This seems too important to leave to chance.

[9] "Defining Restoration - I, A Restudy Alternative Evaluation Team White Paper,≅ dated 16 November 1998.

It may be reasonable to assume that should we get close to restoration, the political willpower will somehow be found to effect the additional changes needed. Given the certainty of changing social values, political objectives, economic situations and the like, it seems explicit attention might profitably be directed toward addressing strategies and decision structures for handling these seemingly inevitable situations. Once again, there is no shortage of thoughts on the subject, but they have not yet crystallized into a strategy. Although a reasonable strategy exists for identifying the non-water factors required for ecosystem restoration, the manner in which those needs will be met remains uncertain. It deserves early and explicit attention in the implementation plan.

O.4.3 Technology

The recommended Comprehensive Plan comprises a complex arrangement of components that employ a vast array of technologies to deliver water to a variety of places at the times and in the quantities required by ecosystems and human systems. Although some of the technologies are relatively new, none of them are untested. Much is known about all of them, although more is known about some than others. What is not known is if some of the newer technologies can succeed in producing the desired quantities of water at the scale envisioned in the recommended Comprehensive Plan.

O.4.3.1 Aquifer Storage and Recovery

ASRs have been used in the U.S. for about 30 years. They were first used in Florida in 1982. There are currently seven ASR facilities operating in Florida and eight more are under construction. ASRs are not an unknown and untested technology. An extensive literature has identified and addressed a host of issues associated with this technology. There is a great deal that is known about ASRs. So let us disavow anyone of the notion that ASRs are a great unknown. There is much perceived uncertainty about ASRs. Most people have never heard of the technology and know nothing about it. They have many questions and much uncertainty. They are largely unaware of what is known about ASRs.

Nonetheless, there are substantial unique uncertainties associated with the use of ASRs. Chief among these is the fact that ASRs have never been used on such a large scale in such a variety of geologic conditions before. In addition, because the technology is only 30 years old it has no long-term track record.

There are questions about water storage. Will ASRs be able to provide the quality and quantity of water required at the times they are needed and wanted? Are there likely to be any unintended consequences of this technology? What will it cost?

In the surveys and interviews conducted for this analysis, team members and stakeholders raised many questions about ASRs. Will the Floridan aquifer be able to handle the volume of water to be injected? Will the injected water simply dissipate in the aquifer? Might the injected water flow to the ocean in underground rivers? What will retrieval rates be like in the many different geologic conditions? Could water injection raise the water table and affect subsurface flows in as yet unknown ways? What effect would the increase in underground storage have on fractures and weak spots in the aquifer's dome? How might untreated water affect the aquifer's waters? How might treated water affect the aquifer's waters? Might retrieval of water from multiple wells result in land subsidence or sinkholes? How long will these technologies last? What are its long-term consequences? How might the ecosystem be affected by this unnatural point source intrusion on the aquifer? Could ASRs throw off natural balances we do not yet understand? Might there not be a tremendous temptation to use the ASRs to remove floodwaters from the land during very wet seasons? In what ways could the ASRs be misused?

An Aquifer Storage and Recovery Issue Team was formed in September 1998 explicitly for the purpose of addressing the surface water, hydrogeological and geochemical uncertainties associated with regional ASR facilities. Thus, there is now a deliberative body in place that will explicitly address the uncertainties that attend the use of this new technology on this unprecedented scale.

In a December 1998 report, the ASR Issue Team produced a Draft Assessment entitled "A Report to the South Florida Ecosystem Restoration Working Group." That report identified the following items as the seven most important issues associated with implementing ASR facilities on a regional scale. Addressing them will reduce much of the remaining uncertainty.

- Characterization of the quality of prospective source waters and spatial and temporal variability.

- Characterization of regional hydrogeology of Upper Floridan Aquifer: hydraulic properties and water quality.

- Analysis of critical pressure for rock fracturing.

- Analysis of site and regional changes in head and patterns flow.

- Analysis of water quality changes during movement and storage in the aquifer.

- Aquifer storage and recovery potential effects on mercury bioaccumulation.

- Relationship between ASR storage interval properties and recovery rates and recharge volume.

Implementation of the ASR facilities is expected to take up to 20 years or more and will begin with a pilot program to test ASR feasibility in specific locations around Lake Okeechobee. As a result of the pilot program and future modeling efforts, a decision will be made whether or not to proceed with the technology to provide the 1.8 billion gallons per day of water requirements proposed in the recommended plan. If ASR technology is to be used, periodic evaluations will continue. If ASR use is to be reduced or eliminated, other features will be substituted for them.

Much is known about ASR technology. ASRs have never been applied at the scale proposed. As a result, there are significant uncertainties remaining. There is an Issue Team in place, formed specifically to address these uncertainties as the study moves ahead. The team has identified the initial set of priorities to investigate. A December 1998 plan outlines the Team's plan of approach. The proposed approach is an exemplary effort to identify and reduce project uncertainties in a formal fashion. In fact, it would be wise to emulate the ASR Issue Team model for seepage management technologies as well.

O.4.3.2 Seepage Management

Seepage management measures invite questions similar to those being asked about ASRs, for many of the same reasons. The scale and geologic diversity are again unprecedented. Unlike ASRs, seepage management measures are not new technology. A great deal is known about seepage management measures, and the techniques presented in the Recommended Comprehensive Plan are based on the findings of the Governor's Commission for a Sustainable South Florida Technical Advisory Committee.

In the Restudy, the "bathtub" concept has been used to describe the concept of lining in-ground reservoirs to control seepage. Curtain walls have been proposed to control seepage of water from the Everglades to adjoining aquifers. Curtain walls are not new ideas, but a so-called curtain wall that is almost 100-feet deep would be quite different. It would be difficult to find trenching equipment that could dig and brace a trench to that depth. That it may not have been done before may suggest some uncertainties. What kinds of head will the curtain be working against? Will the gaskets in the plastic sheeting hold at the required depths? If it does not work, can it be removed? There are also questions about the technology's unintended effects.

If we succeed in blocking off sub-surface flows, do we understand what other things are going to be affected? Seepage management presents us with a situation somewhat analogous to that faced by the builders of the existing project. The levees and canals we see today have had far reaching, unintended consequences. We need to try to anticipate every possible consequence of our actions and avoid irreversible courses of action when the range of consequences cannot be anticipated. These and other questions have not yet been adequately identified and discussed.

The ASR Issue Team provides an ideal model to follow in addressing uncertainty associated with seepage management measures. The surface water, hydrogeological, geochemical and construction uncertainties associated with seepage management are complex and technically sophisticated. They require the on-going attention of experts. Forming a Seepage Management Issue Team to emulate the work of the ASR Issue Team could be an effective way to identify and address uncertainty issues.

O.4.4 Risk Assessment

There are some simple, yet extremely important questions that have not yet been asked and answered about the Recommended Comprehensive Plan. They are: 1) What can go wrong? 2) How likely is it to happen? and, 3) What are the consequences if it does happen? We believe these questions need to be asked and answered, at least qualitatively, about each of the major aspects of the plan. The risks associated with the plan are not as well understood at this point as perhaps they should and could be with some formal risk assessment.

The Restudy has, in part, been made necessary by the inability of people decades ago to foresee how the unintended consequences of their canal and levee system, together with changing social values, could result in serious future consequences for society and the environment. We would be wise to learn from that experience and make the best possible effort to avoid placing a future generation in the position we now find ourselves.

We suggest that can best be done by conducting an initial risk assessment of the Comprehensive Plan's recommendations. Risk assessment can help us make general predictions about the potential outcomes of our decisions. The process of conducting a risk assessment can yield information that might subsequently be useful for risk management. If one or more of the actions below are taken, we suggest using the Corps' without and with plan comparison framework to explore risks. There are substantial risks associated with the status quo as well as with the recommended plan.

The cumulative impact of the uncertainties discussed in this analysis, along with the routine uncertainties we have not addressed, leads us to conclude that we have to think about and ask the right questions about this project. Answers are not necessary at this point, but it is absolutely essential that we pose the questions now. What risks do society and the ecosystem face if we take no action? What risks do they face if we implement the Recommended Comprehensive Plan?

What are the risks associated with new technologies? What are the potential unintended effects of this plan? Consider ASRs. If 200 ASRs are installed, what could happen the first time, 10, or 20 years down the road, when they start injecting water into the ground at the same time? What could go wrong in the short run? In the long run?

It is likely that 50 years ago no one was able to anticipate the unintended consequences of the Central and Southern Florida Project that we are now addressing. Do we really have any reason to believe we are more farsighted with our state-of-the-art technologies than our predecessors were with theirs? Problems that we do not expect will arise. Far fewer of them are likely to become threats to society or the ecosystem if we can anticipate as many of them as possible right now.

At a bare minimum, the study team should undertake an effort to ask and answer the right questions about the recommended plan as soon as possible. Identifying the questions, answering those that can be answered and deciding if and how to answer those that cannot be answered now is an important step in assuring the success of the ecosystem restoration.

The purpose of posing the right questions is to raise issues of potential importance for consideration in plan implementation or its adaptive assessment component. Answering the questions may provide invaluable insight into the study's adaptive assessment strategy. Even if specific questions cannot be authoritatively answered, the process of posing the questions should prove invaluable to future study efforts.

A risk assessment goes beyond the minimalist task of asking the right questions about the plan. It answers as many questions as possible by characterizing the answers by likelihood and magnitude. As noted above, a risk assessment answers the following three questions. 1) What can go wrong? 2) How likely is it to happen? 3) What is the magnitude of the outcome should the unwanted event occur? Or, stated differently, how bad might it get?

These questions can be posed and answered using available information. The answers need not be quantitative. For example, if sinkholes are one of the things that could go wrong with ASRs, the next step is to estimate how likely sinkholes are to occur. Initially, that estimate may be a simple statement, e.g., not very likely or highly likely. Next, we would like to know the magnitude or seriousness of the impact. What are the consequences of sink holes? Once we have identified potential risks and their relative likelihood and consequences, we can decide if the risk is worth worrying about or not.

A risk analysis consists of risk assessment, risk management and risk communication. In a risk analysis, once the nature of the potential risks has been identified in a risk assessment, the next step is to determine what is to be done about the risks. Potential risk management measures can be preliminarily identified by posing and answering the following questions (numbered consecutively after the above questions): 4) What can be done, broadly, about the risks previously identified? 5) What options are available and what are their associated trade-offs? 6) What are the impacts of current decisions on future options?

A third set of questions helps us to communicate with others about the nature of the risks and what can be done to manage them. A simple risk communication exercise would require answering questions like the following: 7) With whom do you communicate about the risks you have identified? 8) How do you convey the information? 9) When do you communicate? 10) What information do you exchange?

A qualitative risk assessment, as outlined earlier, could rely on expert opinions, given the available data. No new analysis is needed to do this initial risk assessment. Many elements of a risk assessment have already been prepared as part of the Restudy analysis. The conceptual models showing the relationships among stressors and ecological endpoints are consistent with the conceptual models suggested in EPA's Ecological Risk Assessment Guidelines. ATLSS outputs on population viability include the relative risks of extinction, the risk that a population falls below some threshold, and the probability a population will grow. Some cost estimates are being prepared using Monte Carlo processes, and there has been limited use of sensitivity analysis by some study members. Posing and answering questions 1 through 3 of this section about new technologies and ecosystem responses to hydrologic changes would be a valuable tool to help guide plan implementation and its adaptive assessment process. There are many knowledgeable professionals working on the Restudy, and there is a great deal of knowledge that has been developed during this study. It would be timely and well-advised to conduct a qualitative, limited scope, risk assessment of the recommended plan as soon as possible.

The next step beyond a qualitative risk assessment might be to conduct an ecological risk assessment. An ecological risk assessment is a flexible process for organizing and analyzing data, information, assumptions, and uncertainties to evaluate the likelihood that adverse ecological effects may occur as a result, in this case, of implementing the recommended plan. The EPA has recently published final Guidelines for Ecological Risk Assessment (EPA/630/R-95/002F April 1998) available at the EPA Home Page on the World Wide Web. Given the significant uncertainties attending this study and the value of the ecosystems at stake, an ecological risk assessment would be an appropriate future step to take, in our opinion.

The existing conceptual models could form the basis for an ecological risk assessment. It could be qualitative or quantitative. The guidelines are flexible and straightforward. Ecological risk assessment is a relatively new field of endeavor. Assessments of simple ecological risks can be difficult. No one has ever attempted an ecological risk assessment of the complexity and magnitude that would be required by this project. A formal ecological risk assessment would be expensive and difficult. It would also be an invaluable decision tool.

An initial risk assessment, qualitative and soon, is essential to identify risks associated with the recommended plan. A risk assessment team could structure an initial risk assessment in a cost effective and efficient manner. That might include a workshop that invites a broad base of study participants to take part in structured exercises aimed at identifying what can go wrong, how likely it is and what its consequences are, in an effort to gather a maximum amount of insight and information in as short a period of time as possible. There is any number of alternative approaches to this task.

Ultimately, it would be advisable to conduct a more detailed ecological risk assessment. This would focus specifically on the more important risks to the ecosystem, and it could be done in accordance with EPA Risk Assessment Guidelines.

O.5 CONCLUSIONS AND RECOMMENDATIONS

This analysis ends with a few conclusions and recommendations. The major conclusions follow.

- Conclusion: The Restudy team leaders are genuinely interested in and committed to identifying and reducing significant uncertainties.
- Conclusion: The Restudy has done an excellent job of reducing much of the massive amounts of uncertainty it faced at its initiation.
- Conclusion: Perceived uncertainties do not present a real problem to the decision process because they can be readily reduced through communication.
- Conclusion: There are numerous important but routine uncertainties that will be addressed in a timely and appropriate fashion during the course of future planning.
- Conclusion: Several significant and unique uncertainties, discussed in this report, remain and need to be addressed.
- Conclusion: Responsible members of the Restudy team are well aware of most of the remaining significant uncertainties.
- Conclusion: Reasonable and appropriate measures for addressing several of the remaining uncertainties have already been identified and initiated.

Each discussion of a unique uncertainty ends with a description of what is being or will be done or a general recommendation of what could be done. These are not all repeated here. The recommendations that follow should be considered by the Restudy team as additional ways to address the uncertainties identified in this Appendix.

- Recommendation: The Restudy team should continue to revise and develop the NSM and SFWMM models with a particular view toward eventually being able to investigate the results of alternative rainfall sequences on plan performance.
- Recommendation: The potential impacts of cumulative model uncertainties on critical decisions should be formally addressed.
- Recommendation: A process or decision structure that can assure that non-

water requirements of restoration will actually be met should be developed.

- Recommendation: A Seepage Management Issue Team should be formed to identify and address uncertainties associated with this technology.
- Recommendation: An initial, qualitative risk assessment of the recommended plan should be completed as soon as is practical.

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